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May 13, 2014

VIA EMAIL and HAND DELIVERY

Jeanine Townsend
Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, California 95814

commentletters@waterboards.ca.gov

Re: Comment Letter—Marina del Rey Harbor Toxic Pollutants TMDL

Dear Ms. Marcus:

This letter is submitted on behalf of the Marina del Rey Lessees Association.

We are writing to provide comments on the Final Basin Plan Amendment ("TMDL Amendment" or "Amendment") that was revised by the Los Angeles Regional Water Quality Control Board ("Regional Board") on February 6, 2014. While we support efforts to improve the water quality within the Marina del Rey Harbor ("the Marina"), we wish to express our concerns with the TMDL Amendment.

Our chief concern stems from the Amendment's language that names anchorages and boat owners as "responsible parties" for the load allocations for discharges of dissolved copper. *See* Final Basin Plan Amendment, 10.

This language should not be in the TMDL Amendment. "A TMDL does not, by itself, prohibit any conduct or require any actions." *City of Arcadia v. State Water Res. Control Bd.* (2006) 135 Cal.App.4th 1392, 1414 [38 Cal.Rptr.3rd 373]. In fact, the California Third District Court of Appeal, the Ninth Circuit, and the United States Environmental Protection Agency have all insisted that a TMDL is merely a technical document designed to inform further administrative actions. *See, e.g.*, *Pronsolino v. Nastri*, (9th Cir. 2002) 291 F.3d 1123, 1129 ("TMDLs are primarily informational tools."); *City of Arcadia*, *supra*, 135 Cal.App.4th at page 1414; 40 C.F.R. § 130.2(i). Thus, the TMDL Amendment, itself, is not the appropriate place for the Regional Board to assign liability for discharges. For these reasons, we request that the State Board direct the removal of all language in the TMDL that assigns responsibility and allocates liability to individual anchorages and boat owners.

We also would like to express our concern that the administrative process has suffered from serious notice violations. Pursuant to the California Administrative Procedures Act, a rulemaking agency must mail a notice of opportunity to comment to each person who has submitted written comments on the proposal, testified at a public hearing, or has asked to receive such notice. Cal. Code Regs. § 11346.4. Many commenters received no such notice. Additionally, only 4 of the 21 anchorages in the Marina received notice, and hundreds of boaters were not made aware of the changes being proposed and were not afforded an opportunity to comment before the Regional Board.

The hearing notice issued by the Regional Board stated that any additional materials or written comments must be submitted by January 27, ten days before the hearing held on February 6, 2014. We submitted supplemental materials on January 27th per the instructions of the hearing notice that contained important scientific information that the Regional Board must consider prior to adopting the TMDL Amendment. (Attachment A: Letter to Regional Board, dated January 27, 2014, Attachment 1: Exhibits A-Q, and Attachment 2; List of Documents Linked in Webpage Sites.) The Regional Board improperly refused to admit the supplemental letter and its attachments into the administrative record, nor give them any consideration.

Regarding our original comment letter dated January 15, 2014, the Regional Board only responded to five of the fourteen comments we raised prior to the January 27 supplemental materials deadline. And the Regional Board did not reply to the remainder of the comments until February 4th – only a day and half before the February 6th hearing.

Overall, the process the Regional Board followed was not an informed process. They began their outreach to the primary affected parties, the boaters, at the very end of their internal process. Then they gave the boaters little time to understand the proposal, and offered no time to consider the evidence they were trying to present to help the Regional Board make a more informed decision.

Below is a summary of each comment that we raised before the Regional Board and an explanation of why the Regional Board's response(s) to each comment was inadequate. For your ease of reference and review, we have attached a complete copy of our letter to the Regional Board as Attachment B.

1. *Significant Economic Impacts*. We commented that the TMDL Amendment will create serious socio-economic impacts that will ripple throughout the local Marina del Rey economy. In particular, we stressed that boaters will suffer from increased compliance and maintenance costs as well as from being named "responsible parties."

Inadequacy of the Regional Board's Response. The Regional Board's response is predicated on magical thinking and false data for three reasons. First, the Regional Board makes the bare assertion that, "It is not anticipated that the cost of complying with the proposed TMDL will result in a flight of boaters from Marina del Rey Harbor with a coinciding economic loss to local businesses."[1] The Regional Board cites no evidence – none whatsoever – to support this claim. Instead, in section 5.2, it first claims it "anticipates" grant funding to assist small and lower income boaters.[2] And then, in section 19.2, it definitively states that "grant funding … *will* help minimize expense to boaters."[3] There is no identification of the source or amount of those grants, and they appear far from guaranteed. Second, the Regional Board assumes facts that are false, such as paint stripping happens "the boat's normal course of operation and maintenance." However, the reality is that boats are only stripped only every 25 - 40 years as old paint applications flake and that most small boat owners never strip their boats due to the excessive cost. Third, the Regional Board states that it is "highly unlikely" that it will impose waste discharge requirements (WDRs) on boaters, as it would be "costly" and inefficient."[4] If that is the case, why are WDRs included in the TMDL Amendment at all? Even though the mere threat of additional regulatory burdens may drive boaters elsewhere, the Regional Board does not explain this at all. In sum, the Regional Board's responses to comments are deficient because they make inconsistent representations, lack a factual or evidentiary basis and do not take into account real-world considerations.

2. *Infeasible Implementation Time Frame*. We raised the concern that the attainment date for the Marina del Rey Toxics TMDL is infeasible, especially in light of Shelter Island Yacht Basin where attainment is behind schedule even though the area is smaller and phased-in loading targets are more reasonable.

   Inadequacy of the Regional Board's Response. The Regional Board's response is inadequate. To support its "ten-year schedule" the Regional Board notes that it met with "two boatyard owners in Marina del Rey" that estimated it would take 10 years to convert all the boats to non-copper paints.[5] This very unscientific survey method of chatting up two (2) boatyard owners— just two

[1] Regional Board, Comment Response 19.2.

[2] Regional Board, Comment Response 5.11.

[3] Regional Board, Comment Response 19.2.

[4] Regional Board, Comment Response 18.4.

[5] Regional Board, Comment Response 5.10.

- does not justify this timeline. Moreover, the questions posed to those boat owners was later refuted by them in written detail when they realized the previous casual discussion was taken totally out of context by the Regional Board. Yet, that more detailed robust information was ignored by the Regional Board.

The TMDL Amendment will affect over 5000 boats in the marina and tens of thousands of Californians who will work, live, and play on and around the harbor. Furthermore, we note that the Board stated that it was working on preparations for this TMDL Amendment for "over 6 years."[6] And yet, outreach to the affected boat owners was only commenced at the very end of this process. Boaters enjoying the recreational values of the Marina were given very little time to understand the proposal.

3. *Lack of Economic and Environmentally Protective Alternatives*. We provided information to the Regional Board regarding the lack of alternative non-biocide paints on the market; that such paints are soft, expensive, easily-damaged and have a short effective lifespan; and that boat yards are ill-equipped to haul boats with non-biocide (e.g. silicone) coatings.

   Inadequacy of the Regional Board's Response. The Regional Board did not address our argument that there are no viable, non-biocide bottom paints available for boats in Marina del Rey. Instead, it merely pointed to the SED to placate our concerns.[7] The SED, however, does not address site-specific considerations at Marina del Rey, including the fact that epoxy bottoms are not conducive to permanently moored vessels and that silicate paints will require significant investment, training and permitting (AQMD). The Regional Board also failed to give serious consideration to low biocide alternatives.

4. *The TMDL Is Inconsistent with the California DPR Standard for Copper*. We highlighted the fact that the numeric target for dissolved copper in the water column is 3.1 mg/L whereas DPR suggested that a concentration between 6.0 and 9.4 mg/L may be more appropriated.

   Inadequacy of the Regional Board's Response. The Regional Board did not explain why the 6.0 to 9.4 mg/L range could not be implemented in Marina

[6] Regional Board, Comment Response 5.6.

[7] Regional Board, Comment Response, 65.10.

del Rey Harbor. Instead, it dismissed our comment without any justification as it why it ignored the 2009 DPR study.[8]

5. *The TMDL Amendment Does Not Sufficiently Address Non-Point Sources*. We raised our concern that that the TMDL overlooked or downplayed many other sources of copper in Marina del Rey (e.g. urban storm water) and that it unfairly places burdens on boat owners and anchorages.

   <u>*Inadequacy of the Regional Board's Response.*</u> The Regional Board overly simplifies the causes of copper toxins in Marina del Rey Harbor. In section 29.3, it implies that storm water runoff is the cause of copper in the harbor's sediment whereas copper-based bottom paints are the cause of copper dissolved in the water column.[9] The data in the TMDL Amendment's supporting document does not corroborate such a clear distinction between sources of pollution.

6. *Scientific Data*. We explained the deficiencies in the scientific modeling on which the TMDL Amendment was based. Chief among these deficiencies was the lack of site-specific modeling and the failure to use EPA's Biotic Ligand Model.

   <u>*Inadequacy of the Regional Board's Response*</u>. The Regional Board argues that it incorporated "preliminary site-specific modeling" from DPR into the TMDL Amendment and that EPA has not approved the Biotic Ligand Model for copper in saltwater as a water quality criteria.[10] These responses expose two deficiencies in the Amendment's underlying data. First, the fact that the Regional Board has only relied on "preliminary" site-specific data from another agency underscores that the Regional Board has forged ahead to establish this Amendment without proper consideration of Marina del Rey and its unique characteristics (size, depth, flow, marine life, among others). Second, the fact that EPA has not approved the Biotic Ligand Model does not mean that it cannot be used to inform the development of this Amendment. In fact, the State Board features the Biotic Ligand Model on its website as an integral part of developing water quality standards for freshwater copper standards.[11] Given the size and importance of Marina del Rey to Southern

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[8] Regional Board, Comment Response, 64.2.

[9] Regional Board, Comment Response 29.3.

[10] Regional Board, Comment Response, 4.4.

[11] State Board, Water Quality Criteria: An Introduction to the BLM, http://www.waterboards.ca.gov/academy/courses/wqstandards/materials/mod9/09bioligmod.pdf (last visited May 13, 2014).

California's economy and culture, the Regional Board should employ the model to ensure the TMDL is appropriate, or at least explain why the Biotic Ligand Model should not be used to inform this Amendment's development.

7. *Non-Compliance with California Government Code § 11346.3.* We commented that the TMDL Amendment does not consider its impact on businesses, specifically whether it will create or eliminate jobs in California.

   Inadequacy of the Regional Board's Response. The Regional Board fails to distinguish between a "water quality control plan and guideline" and a TMDL. A TMDL, much less a TMDL Amendment, is a component of a water quality control plan, not a plan in and of itself.[12] Therefore, the Regional Board should have to comply with Cal. Gov. Code § 11353.

8. *Non-Compliance with California Water Code § 13242.* We pointed out that the TMDL Amendment failed to meet the California Water Code for two reasons. First, it lacked a schedule for implementation. Second, it lacked a description of surveillance.

   Inadequacy of the Regional Board's Response. The Regional Board claimed that a "deadline" constitutes a "schedule."[13] The dictionary eviscerates this response. A schedule is a "plan of procedure … with reference to the sequence of and time allotted for each item or operation necessary to its completion."[14] The plain meaning of schedule thereby implies many different deadlines along a plan of procedure. The Regional Board seemingly recognized its error by adding an "interim milestone" to implement dissolved copper load allocations, but this milestone alone is insufficient for a TMDL Amendment that will take at least ten years to implement.[15]

9. *Non-Compliance with State and Federal Antidegradation Policies*. We noted that the use of alternative biocide or non-biocide paints has been untested, and therefore, the Regional Board could not confirm that water quality would be maintained or protected. In the long-run, these alternatives may spur new forms of pollution or encourage propagation of invasive species.

   Inadequacy of the Regional Board's Response. The Regional Board admits that there is a "lack of evidence that non-biocide paint coatings will cause

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[12] *See generally* 33 U.S.C. § 1313; 40 C.F.R. § 130.6.

[13] Regional Board, Comment Response 65.27.

[14] Schedule, Dictionary.com (last visited May 13, 2014).

[15] Regional Board, Comment Response 65.27.

degradation of the existing water quality." We tried to provide some evidence to the Regional Board to consider on the water quality problems and the impact to important environmental values protected by Porter-Cologne and the Clean Water Act but the Regional Board refused to hear it. Had the Regional Board been truly interested in input from boaters and allowed sufficient time, we would have had the time to develop additional factual materials so that the Regional Board would not feel somehow compelled to pursue a TMDL based on a "lack of evidence."

10. *Potential for Impacts on Endangered or Threatened Species*. We emphasized why copper antifouling paints are used—to reduce the growth and transportation of invasive species on hulls. We asked the Regional Board to examine the TMDL Amendment's effect on the potential spread of invasive species to the detriment of California's threatened species.

    Inadequacy of the Regional Board's Response. The Regional Board's only response is that there is a "lack of evidence that non-biocide paint coating will cause degradation."[16] This is precisely our point. The Regional Board should be able to point to at least something—a study, model, etc.—that indicates that Marina del Rey will not experience degradation due to the use of non-biocide coatings. Rather, the Regional Board has ignored evidence that the use of that the use of non-biocide coatings will lead to an influx of invasive species.

11. *Non-Compliance with California Government Code § 11353.* We highlighted the fact that the Regional Board's supporting documents do not provide a summary of the necessity for the TMDL Amendment as required by law. In fact, the only time the supporting documents even used the word "necessary" was to point out the void of site-specific analyses: "Refinement of the model may be necessary as efforts to reduce copper pollution in Marina del Rey Harbor proceed and our understanding of the site-specific factors affecting copper in Marina del Rey improves."

    Inadequacy of the Regional Board's Response. The Regional Board's response is insufficient. We question the Regional Board's assertion that the basin plan amendment need not contain a summary of its necessity until after approval by the State Board. Isn't the purpose of the administrative process to allow the general public to be engaged in the lawmaking process? By reserving the right to add the "necessity" language from the public until the last minute, the Regional Board has refused to allow the public to comment on a crucial part of the TMDL Amendment.

[16] Regional Board, Comment Response 65.27.

12. *Non-Compliance with CEQA.* We stressed that the Regional Board failed to meet several CEQA requirements. In particular, the Regional Board failed to consider economic losses to businesses, the impacts of alternatives, a reasonable range of site-specific factors, and the proper scope of cumulative effects.

    Inadequacy of the Regional Board's Response. The Regional Board disagreed with our characterization of the SED, but it did not explain why its assessment failed to consider alternatives or potential environmental impacts.[17] It merely recounted the various sections of the SED as if listing the title of each chapter was sufficient to meet all of its CEQA responsibilities. On its face, such treatment is deficient.

13. *Lack of Peer Review*. We underscored that the TMDL Amendment must not be adopted until it has undergone external peer review as required by law.

    Inadequacy of the Regional Board's Response. The Regional Board claims it has satisfied external peer review requirements by relying on previously peer-reviewed scientific bases of the toxic pollutants TMDL. The Regional Board, however, did not expressly reference what, in fact, were the "previously scientific bases." Thus, there was no way to ensure that we were reviewing the correct sources. If the Regional Board was referring to the Shelter Island studies, this is inappropriate since these documents do not meet the external peer review standard since they were prepared for a different body of water and Marina del Rey, as a vast man-made marina, requires separate consideration.

14. *Preempted by FIFRA*. We pointed out that, with this TMDL Amendment, the Regional Board will usurp the authority of both DPR and EPA which have both approved the sale of copper-based hull paints. The Regional Board, alone, cannot effectively foreclose a class of products that have been sold and used in California for decades.

    Inadequacy of the Regional Board's Response. The Regional Board dances on the head of a pin in this comment response and wholly ignores the reality of the TMDL Amendment's effects. In reality, the TMDL Amendment prevent boat owners from buying copper-based paints. As such, copper-based paints, which have been approved by both EPA and DPR, will not be sold. The Regional Board should further explain how its actions will not, in effect, constitute a ban on the sale of copper-based paint.

[17] Regional Board, Comment Response, 65.37.

In conclusion, the Lessees Association respectfully requests that the State Board direct the Regional Board to review and revise the TMDL Amendment and address all the concerns raised and direct the removal of all language in the TMDL that assigns responsibility and allocates liability to individual anchorages and boat owners.

We appreciate the opportunity to express our concerns and appreciate your time to consider them.

Sincerely,

ALSTON & BIRD LLP

Maureen F. Gorsen

cc: Attachment A: Letter to Regional Board, dated January 27, 2014, Attachment 1: Exhibits A-Q, and Attachment 2; List of Documents Linked in Webpage Sites Enclosure

Attachment B: Letter to Regional Board, dated January 15, 2014

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January 27, 2014

Samuel Unger
Executive Officer
Los Angeles Regional Water Quality
Control Board
320 West 4th Street, Suite 200
Los Angeles, CA 90013

Re: Comment Letter – Marina del Rey Harbor Toxics TMDL Reconsideration

Dear Mr. Unger:

This letter supplements our January 15, 2014 comment letter that we submitted on behalf of the Marina del Rey Lessees Association. In addition to our Chair's (David Levine) email comments of this morning, we are submitting this letter in response to the Regional Water Board's notice of a public hearing on the Tentative Basin Plan Amendment for the Marina del Rey Harbor Toxic Pollutants TMDL ("TMDL Amendment" or "Amendment"). That hearing notice states that any additional materials or written comments must be submitted by January 27, 2014, ten days *before* the hearing.

At the outset, we note that applicable law allows any person who testifies at a public hearing to submit written materials and testimony at the hearing itself, and such materials cannot be precluded from inclusion in the administrative record by a directive by the agency that all written materials be submitted before the hearing. That approach does not afford the public adequate opportunity to present its views to the Board. For example, the Board only just published on January 24, 2014 its written responses to comment letters received on the Board's draft CEQA document for the proposed TMDL Amendment. Under the Board's approach, any written comments on those responses must be submitted by January 27, 2014, which affords the public only a weekend to review the responses. Yet, even a cursory review of the responses reveals inadequacies in the responses, which, with respect to the Association's comment letter, only responded to five of the thirteen categories contained in our comment letter.

The rushed responses and procedures by the RWQCB are disconcerting to say the least. The scientific issues presented by the TMDL Amendment proposal are quite complex and require deliberate study to avoid regrettable consequences that could result in greater harms to the environment. As we noted in our previous letter, some of these potential regrettable consequences are foreseeable and thus require careful study and deliberation, not rushed responses and knee jerk defenses.

The State Legislature debated these difficult policy issues and determined that the scientific uncertainty and risk of regrettable consequences was too great to establish a de facto ban on the use of copper anti-fouling paints. Similarly, the scientists in federal and California state expert agencies such as U.S. Environmental Protection Agency, the Department of Pesticide Regulation, as well as environmental agencies around the world in Australia, the European Union, have all been concerned enough about the potential regrettable consequences and have all come to the conclusion that action to preclude use of copper anti-fouling paints is premature and unwise in light of those potential consequences.

Enclosed please find a list of materials that the RWQCB must consider prior to further processing of the TMDL Amendment. Many of these materials are provided in attachments to this letter, however many are contained in links to websites provided in the attached list and incorporated by reference herein. All the documents are provided by link to the webpage sites listed and we request that they be included in the administrative record. We also offer to provide hard copies to the RWQCB upon request. See *Consolidated Irrigation District vs. Superior Court* (2012) 205 Cal. App. 4th 697 [a document specifically identified in a comment letter must be included in the administrative record if comment letter provides a webpage site containing the document(s)].

We reserve the right to add additional resources to this list up through and including any hearing before the Los Angeles Regional Water Quality Control Board.

Sincerely,

ALSTON & BIRD LLP

Maureen F. Gorsen

Enclosures (2)
Attachment 1: List of Documents Attached (Exhibits A-Q)
Attachment 2: List of Documents Linked in Webpage Sites

ATTACHMENT 1

Attachment 1: List of Documents Attached

The following sources are attached as Exhibits A through Q.

- Casey Capolupo, et al., *Copper Bioavailability and Toxicity to* Mytilus galloprovincialis *in Shelter Island Yacht Basin, San Diego, CA* ("Exhibit A")
- European Commission Heath & Consumer Protection Directorate-General, *Scientific Committee on Health and Environmental Risks* (2003) ("Exhibit B")
- Orange County Coastkeeper, *Lower Newport Bay Copper/Metals Marina Study* (July 2007) ("Exhibit C")
- Weston Solutions, Inc., *Shelter Island Yacht Basin Dissolved Copper Total Maximum Daily Load 2011 Monitoring and Progress Final Report* (March 2012) ("Exhibit D")
- Carolyn Culver, et al., *IPM for Boats: Integrated Pest Management for Hull Fouling in Southern California Coastal Marinas* (2012) ("Exhibit E")
- State Lands Commission, Notice of Proposed Regulatory Action—Biofouling Management Regulations for Vessels Operating in California Waters ("Exhibit F")
- International Maritime Organization, *Guidance for Minimizing the Transfer of Invasive Aquatic Species as Biofouling for Recreational Craft* (November 2012) ("Exhibit G")
- International Maritime Organization, Resolution MEPC.207 (July 2011) ("Exhibit H")
- New Zealand Environmental Protection Authority, Evaluation and Review Report—Antifouling Paints (May 2013) ("Exhibit I")
- Whitman Miller et al., Marine Invasive Species and Shipping (2007) ("Exhibit J")
- EPA, Revised Reregistration Eligibility Decision for Coppers (2009) ("Exhibit K")
- Washington State Invasive Species Council Strategic Plan Letter (Excerpt) ("Exhibit L")
- Washington Invasive Species Council, *Invaders at the Gate* (2008) ("Exhibit M")
- John Lewis, *Performance of the Tin-Free Antifouling Coating International* Ecoloflex *in DSTO/RAN Trials* (2008) ("Exhibit N")
- National Biofouling Management Guidance for Non-trading Vessels (April 2009) ("Exhibit O")

- Canning-Clode et al., *The Effects of Copper Pollution on Fouling Assemblage Diversity* (2011) ("Exhibit P")

- Ng et al., *Delayed Effects of Larval Exposure to Cu in the Bryozoan* Watersupora Subtorquata (2003) ("Exhibit Q")

ATTACHMENT 2

ATTACHMENT 2: List of Documents Linked in Webpage Sites

The following sources may be accessed online.

Sources Related to the Department of Pesticide Regulation's Copper Antifouling Paint Workgroup

- AB 425 ("An Act relating to Pesticides") http://www.leginfo.ca.gov/pub/13-14/bill/asm/ab_0401-0450/ab_425_bill_20131005_chaptered.pdf

- Assembly Committee on Environmental Safety and Toxic Materials (SB 623) (June 28, 2011) http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0601-0650/sb_623_cfa_20110627_144826_asm_comm.html

- California Copper Monitoring Studies with Potential Relevance to the Evaluation of Copper Antifouling Paint Pollution (January 2005) http://www.cdpr.ca.gov/docs/emon/surfwtr/caps/custudies.pdf

- Clarification of Leach Rate Determination--Copper Based Antifouling Paint Pesticides (March 23, 2011) http://www.cdpr.ca.gov/docs/registration/reevaluation/chemicals/example_letter.pdf

- Copper Sources in Urban Runoff and Shoreline Activities (November 2004), http://www.cdpr.ca.gov/docs/emon/surfwtr/copper1104.pdf

- Copper Antifouling Paint Sub-Workgroup 7/14/05 Meeting Notes, http://www.cdpr.ca.gov/docs/emon/surfwtr/caps/cu_mtg_notes71405.pdf

- Copper Antifouling Paint Sub-Workgroup (03/08/07) Meeting Notes http://www.cdpr.ca.gov/docs/emon/surfwtr/caps/coppermtg030807.pdf

- Copper Antifouling Paint Sub-Workgroup (01/12/06) Meeting Notes http://www.cdpr.ca.gov/docs/emon/surfwtr/caps/cumtgnote_011206.pdf

- Department of Pesticide Regulation's Action Plan Toward Addressing Copper Pollution from Antifouling Paint Use (December 2007) http://www.cdpr.ca.gov/docs/emon/surfwtr/caps/cumemo_warmerdam.pdf

- Earley et al., *Life Cycle Contributions of Copper from Vessel Painting and Maintenance Activities*, Biofouling Journal, (November 2013) http://www.tandfonline.com/doi/abs/10.1080/08927014.2013.841891

- New Copper Coatings Bill Introduced in California Legislature, http://www.coatingstech-digital.com/coatingstech/april_2013?pg=26#pg26

- Notice of Decision to Initiate Reevaluation of Copper Based Waterway Antifouling Paint Pesticides (July 2010) http://www.cdpr.ca.gov/docs/registration/canot/2010/ca2010-03.pdf

- Overview of Alternative Antifouling Strategies (January 2006) http://www.cdpr.ca.gov/docs/emon/surfwtr/caps/cuwkgrpnotes011206.pdf

- Overview of Non-Copper AFP Biocides (April 1, 2009), http://www.cdpr.ca.gov/docs/emon/surfwtr/caps/cu_overview040209.pdf

- Semiannual Report Summarizing the Reevaluation Status of Pesticide Products During the Period of January 1, 2013 Through June 30, 2013, http://www.cdpr.ca.gov/docs/registration/canot/2013/ca2013-14.pdf

- Singhasemanon et al., *Monitoring for Indicators of Antifouling Paint Pollution in California Marinas* (June 2009) http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/eh0805.pdf

- Third Reading (SB 623) (April 25, 2011) http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0601-0650/sb_623_cfa_20110527_163530_sen_floor.html

- Weston Solutions, *Final Report: Marina del Rey Harbor Sediment Characterization Study* (April 2008) http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/96_New/Final%20MdR%20Sediment%20Characterization%20Report_processed.pdf

Sources Related to the California State Lands Commission/Invasive Species

- Australian Shipowners Association. 2007. Assessment of Introduced Marine Pest Risks Associated with Niche Areas in Commercial Shipping. Final Report. 24 pgs. http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Documents/Australian%20Shipowners%20Association%202007.pdf

- Bradsher, K. 2009. Cargo ships treading water off Singapore, waiting for work. New York Times. Published 13 May 2009. Last viewed 28 June 2011. http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Documents/Bradsher%202009.pdf

- California State Lands Commission, *Biofouling Management Regulations for Vessels Operating in California Waters (Draft)* http://www.slc.ca.gov/Spec_Pub/MFD/Ballast_Water/Documents/Attachment_2_Biofouling_7June12.pdf

- California State Lands Commission, MISP Laws and Regulations, http://www.slc.ca.gov/spec_pub/mfd/ballast_water/laws_regulations.html

- California State Lands Commission, *California's Marine Invasive Species Program and the United States Federal Programs that Manage Vessels as Vectors of Nonindigenous Species* (December 2013) *available at* http://www.slc.ca.gov/Spec_Pub/MFD/Ballast_Water/Ballast_Water_Default.html

- C. Scianni, et al., *2013 Biennial Report on the California Marine Invasive Species Program* (February 2013) *available at* http://www.slc.ca.gov/Spec_Pub/MFD/Ballast_Water/Ballast_Water_Default.html

- California State Lands Commission, Economic Impact Assessment, http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Documents/ARTICLE4_7_EIAFINAL021012.pdf

- California State Lands Commission Marine Invasive Species Program, Development of Protocols to Verify Compliance with California's Ballast Water Performance Standards, Technical Advisory Group Meeting – November 15, 2011, Final Notes http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Documents/2_TAGnotes15nov11_final.pdf

- California State Lands Commission Marine Invasive Species Program, Input for Protocols to Verify Compliance with California's Ballast Water Performance Standards, Technical Advisory Group Meeting – October 4, 2011, Final Notes. http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Documents/3_04Oct11_TAG Notes_Final.pdf

- California State Lands Commission Marine Invasive Species Program, Protocols to Verify Compliance with California's Ballast Water Performance Standards, Final Technical Advisory Group Meeting Notes – August 11, 2011. http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Documents/4_FinalCSLCTAGNotes_8-11-2011.pdf

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January 15, 2014

Samuel Unger
Executive Officer
Los Angeles Regional Water Quality
Control Board
320 West 4th Street, Suite 200
Los Angeles, CA 90013

Re: Comment Letter – Marina del Rey Harbor Toxics TMDL Reconsideration

Dear Mr. Unger:

This law firm represents Marina del Rey Lessees Association.

We are writing to provide comments on the Tentative Basin Plan Amendment for the Marina del Rey Harbor Toxic Pollutants TMDL ("TMDL Amendment" or "Amendment").[1] While we support all reasonable efforts to improve the water quality of the Marina del Rey Harbor ("the Marina"), we wish to express our concerns with the TMDL Amendment.

The TMDL Amendment pushes too far, too fast. Not only is the Amendment unrealistic and overprotective, but the revised standards will chill the vibrant Marina del Rey Harbor local economy by driving boaters, visitors, and local businesses elsewhere.

There are many reasons why the Los Angeles Regional Water Quality Control Board ("RWQCB") should not proceed with the TMDL Amendment, but chief among those reasons is that the proposed standard for dissolved copper is not based on site-specific conditions and data. As the below comments show, the RWQCB has developed an arbitrary standard that should be reconsidered and revised once it collects and analyzes these conditions and data.

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1 While we make several comments below on the inadequacies of TMDL Amendment and the documents prepared for the TMDL Amendment, we reserve the right to make additional and further comments up through and including any hearing before the Los Angeles Regional Water Quality Control Board.

Comments on the TMDL Amendment

1. Significant Economic Impacts

The TMDL Amendment will have serious socio-economic impacts throughout the Marina, affecting boaters, local businesses, and recreational opportunities for the public.

Local boaters bear the brunt of the TMDL Amendments for two reasons. First, under the Amendment, 85% of the boats moored in the Marina, approximately 4,000 boats, will need to be stripped and painted with non-copper hull paints by 2024. The average cost to strip a 35 foot boat is $6,000 to $8,000, and the alternative paints not only cost up to $900 per gallon but may also require more frequent in-water cleaning and repainting. The excessive costs on boaters will result in many boaters leaving the Marina and choosing to dock at other harbors since there is no statewide regulation prohibiting use of copper hull paints, and in fact they are explicitly authorized for use as a duly registered pesticide in California.

Second, the TMDL Amendment will name each boater with a vessel moored in the Marina as a "responsible party." In accordance with the Nonpoint Source Implementation and Enforcement Policy, each responsible party may have to obtain a Waste Discharge Requirement ("WDR") permit to comply with the TMDL Amendment. The cost of a WDR permit is $1,097. 23 Cal. Code Regs. § 2200. Such an administrative burden is costly and time-intensive and will further drive boaters from the Marina, causing economic impacts on local businesses in the Marina, creating potential environmental cleanup liabilities and the loss of jobs.

The Marina's local economy depends boating, which the recession hit hard.[2] Recreational activities on the water attract locals, visitors, and tourists who dine at local restaurants, stay at local hotels, and shop at local businesses. The TMDL Amendment will drive boaters elsewhere and visitors with them. It is therefore critical that the economic impact be analyzed thoroughly and all reasonably feasible alternatives considered prior to any adoption.

2. Infeasible Implementation Time Frame

The TMDL Amendment lists March 22, 2024 as the attainment date for discharges of dissolved copper from boats. This deadline is infeasible.

In 2006, the San Diego Regional Water Quality Control Board allotted stakeholders seventeen years to achieve a 75% reduction of copper in the Shelter Island

[2] The Marina is still recovering from the recession. Currently, the overall vacancy rate in Marina del Rey is 17% and almost 30% for small boat slips. *See* Slip Vacancies (November 2013), http://file.lacounty.gov/dbh/docs/cms1_151852.pdf.

Yacht Basin while meeting phased-in loading targets of 10 percent and 40 percent in 2012 and 2017, respectively.[3] Although copper loading in the Shelter Island Basin has decreased, representatives of both the Regional Water Quality Control Board and the Shelter Island Basin admit that they will not meet the TMDL deadline.[4] Even the reductions that have occurred to date are attributable to the economic recession with fewer boaters and less maintenance being completed over the past eight years.

Despite the shortcomings of Shelter Island, a marina half the size of Marina del Rey, the RWQCB has set an even more aggressive deadline for compliance (10 years) with an even more aggressive cooper reduction target (85%). By giving the Marina's boaters only a decade to reduce copper by 85%, the RWQCB is setting them up for failure. At this time, there is no viable biocide-free bottom paint alternative and slip liners are of very limited use as they only work well for small vessels.[5] Also, slip liners only transfer the growth from the bottom of the boat to the bottom of the liner which itself must be either protected with a biocide or aggressively cleaned as well. At bottom, the RWQCB has proposed an infeasible deadline.

3. <u>Lack of Economic and Environmentally Protective Alternatives</u>

Alternatives to copper bottom paints present a host of problems that the RWQCB must consider before adopting the TMDL Amendment. Current alternatives include zinc formulations, organic formulations, and non-biocide coatings, such as epoxy and silicone formulations.

The RWQCB must analyze the potential impacts from alternatives. For instance, the United States Environmental Protection Agency ("EPA") has discredited both zinc and organic formulations as poor alternatives.[6] Although EPA has endorsed the use of non-biocide formulations, such non-biocide paints do not provide the same protection or cost-effectiveness as copper-based hull paints. Non-biocide paints are soft, easily damaged, have a short effective lifespan (8-12 months), and cost three times more than traditional bottom paint. Additionally, some boat yards refuse to haul out boats with silicon bottom finishes because they are so slippery that they can easily slide out of the Marine Travel Lift straps.

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[3] California Regional Water Quality Control Board, San Diego Region, *Total Maximum Daily Load for Dissolved Copper in Shelter Island Yacht Basin, San Diego Bay*, Resolution No. R9-2005-0019 (February 9, 2005).

[4] Taylor Hill, *Shelter Island Yacht Basin: Reducing Copper Levels*, The Log: California's Boating & Fishing News, January 16, 2013.

[5] *See infra.*

[6] United States Environmental Protection Agency, NP00946501-4, Safer Alternatives to Copper Antifouling Paints for Marine Vessels (January 2011).

There is a demand for less toxic anti-fouling bottom paints, and, in time, manufactures will develop paints with reasonable lifespans and costs that will serve as viable alternatives to biocide paints. But, right now, such alternatives are not viable. RWQCB can take a more reasonable and realistic approach to reducing copper loading in the Marina. For example, RWQCB could require boaters to use low copper bottom paints, such as Petit's Hydrocoat SR, and Ultima SR, that can last about as long as regular copper bottom paints and can immediately reduce the amount of copper leached into the Marina.

4. The TMDL Amendment is Inconsistent with the California Department of Pesticide Regulation's Standard for Copper.

The TMDL Amendment's numeric target for dissolved copper in the water column is 3.1 micrograms per liter. In its 2009 report, the California Department of Pesticide Regulation ("DPR") suggested that a concentration between 6.0 and 9.4 micrograms per liter may be a more appropriate standard.[7]

None of the materials on the Marina del Rey Harbor Toxics TMDL website even mention DPR's standard. The RWQCB should adopt a numeric target consistent with DPR. But at the very least, RWQCB should explain why the 6.0 to 9.4 micrograms per liter standard is insufficient for the Marina.

5. The TMDL Amendment Does Not Sufficiently Address Non-Point Sources.

The TMDL Amendment recognizes that many sources (e.g. storm water, passive leaching and hull cleaning, and direct deposits from airborne particles) contribute to the concentration of copper in the Marina. In particular, the Amendment highlights "urban storm water" as a "substantial source" of copper, and copper from storm water runoff can easily accumulate in marine sediments and then become a source due to sediment re-suspension.

Despite recognizing urban storm water as a substantial source of copper, the Amendment does not sufficiently address the non-point sources of urban storm water. Instead, the Amendment unfairly burdens boat owners in the Marina and disparately treats members of the Marina del Rey community.

6. Scientific Data

The scientific modeling that the TMDL Amendment is based on is plainly deficient. The Amendment's high socio-economic stakes demand that RWQCB gather as much site-specific data as possible to support a reasonable and workable standard. And

[7] California Department of Pesticide Regulation, EH08-05, Monitoring for Indicators of Antifouling Paint Pollution in California Marinas (2009).

yet, the RWQCB's "Draft Staff Report" and "Substitute Environmental Documents" contain no discussion of the proposed standard for dissolved copper with respect to site-specific factors at Marina del Rey.

The RWQCB has failed to consider any of the competing science introduced in response to Senator Kehoe's proposed bill (SB 623 (2011)) and the long-standing efforts of the broad-based State Executive Branch sponsored Copper Antifouling Paint Sub-Workgroup of the Non-Point Source Interagency Coordinating Committee's Marinas and Recreational Boating Workgroup (renamed "Antifouling Strategy Workgroup"). Efforts to pursue a ban on the use of copper-based paints in San Diego were abandoned by the Legislature due to many scientific issues raised in the legislative debates. The RWQCB must consider these scientific issues prior to any adoption of a TMDL. Also, the State science experts have been convening for nearly a decade (from 2004 to the present) as part of the State's Antifouling Strategy Workgroup and the science considered by that workgroup must be brought to bear in any determination by the RWQCB in developing a TMDL for copper-based paints.

The RWQCB has also failed to consider any of the science currently being developed by DPR pursuant to AB 425 (Atkins, 2013) which requires DPR to determine a leach rate for copper-based antifouling paint used on recreational vessels and to make recommendations for appropriate mitigation measures that may be implemented to protect aquatic environments from the effects of exposure to that paint if it is registered as a pesticide. DPR is required to release that report no later than February 1, 2014. Before proceeding with the TMDL Amendment, the RWQCB needs to reconcile its analysis with this science.

At a minimum, the RWQCB should do the following:

- Adopt the EPA's Copper Biotic Ligand Model to evaluate whether site-specific conditions affect the Marina's threshold for a copper TMDL;
- Perform benthic studies of indicator species beyond *mytilus edulis* to determine the real-world impact of dissolved copper on aquatic life in Marina del Rey;[8]
- Perform bioassay of indicator species beyond *mytilus edulis* to determine the real-world impact of dissolved copper on aquatic life in Marina del Rey;

[8] *See* D.J.H. Philips, *The Common Mussel* Mytilus Edulis *as an Indicator of Pollution by Zinc, Cadmium, Lead and Copper*, 38 Marine Biology 1, 71–80 (1976) (arguing that mussels are poor indicator species since their net uptake of copper is "extremely erratic").

- Consider emerging research on antifouling coatings to determine alternative means for controlling dissolved copper in the water column;[9] and
- Develop modeling for Marina del Rey that incorporates site-specific factors, such as the manmade impediments to flushing of the Marina.

Only after collecting and analyzing all this data can the RWQCB issue a proper standard for dissolved copper in Marina del Rey's water column. Without such information, the standard (3.1 micrograms per liter) is arbitrary, mere conjecture based on theoretical modeling originally drafted for Shelter Island.

7. Non-Compliance with California Government Code § 11346.3

The TMDL Amendment does not comply with California Government Code § 11346.3. Section 11346.3 requires state agencies to consider a regulatory proposal's "impact on business, with the consideration of industries affected including the ability of California businesses to compete with businesses in other states." Cal. Gov. Code § 11346.3(a)(2). Specifically, a state agency must assess whether a regulatory proposal will affect the creation and elimination of jobs in California, the creation of new business in California, and the expansion of business in California. *Id.* § 11346.2(b).

The Amendment and its supporting documents do not discuss the Amendment's potential impact on Marina del Rey's businesses. It is likely that the TMDL Amendment will have an economic effect of at least fifty million dollars in any single twelve month period between the date of filing the regulation with the Secretary of State and the date that the regulation will be fully implemented. *See* 1 Cal. Code. Regs. § 2000(g). Therefore, the agency must prepare a standardized regulatory impact analysis pursuant to the Department of Finance's guidelines. Cal. Gov. Code. § 11346.2(c)(1).

8. Non-Compliance with California Water Code § 13242

The TMDL Amendment was not drafted in accordance with California Water Code § 13242(b) or (c). The Water Code mandates that the program of implementation for achieving water quality objectives include "a time schedule for the actions to be taken." Cal. Water Code § 13242(b). The prior version of the TMDL included provisions describing what actions were to be taken at 6 months, 5 years, 6 years, and 7 years after the effective date. The TMDL Amendment does not have a "schedule" for implementing

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[9] *See, e.g.*, PF Early, et al., *Life Cycle Contributions of Copper from Vessel Painting and Maintenance*, 30 BIOFOULING 1, 51–68 (2014) (concluding that passive leach rates of copper peaked three days after both initial deployment and cleaning events followed by asymptotic levels on approximately day thirty).

the copper standards that affect boaters; it merely has a deadline—March 22, 2024. Thus, the TMDL Amendment does not comply with the Water Code.

In addition, the TMDL Amendment does not comply with California Water Code § 13242(c). Section 13242(c) requires that the program of implementation include a "description of surveillance to be undertaken to determine compliance with objectives." Cal. Water Code § 13242(c). As above, the TMDL Amendment is plainly devoid of any "description of surveillance," and therefore it fails to satisfy with the Water Code.

9. Non-Compliance with State and Federal Antidegradation Policies

The TMDL Amendment does not comply with the federal or state Antidegradation Policy. The federal Antidegradation Policy mandates that water use and quality "shall be maintained and protected." 40 C.F.R. § 131.12. Due to the lack of long term environmental testing on alternative biocide and non-biocide paint coatings, as well as the lack of site-specific testing at Marina del Rey, RWQCB cannot confirm that the TMDL Amendment, which requires the use of alternative biocide or non-biocide paints, will maintain or protect the water use in the Marina.

Similarly, the state Antidegradation Policy requires that any activity that may contribute to the concentration of waste must be controlled to assure that pollution or nuisance will not occur. State Water Board Resolution No. 68-16. Again, the RWQCB (or any other entity) has not performed sufficient testing on alternative biocide and non-biocide paint coatings to determine the long term effect of these compounds on the Marina or waters with comparable qualities. Accordingly, the RWQCB cannot ensure that the TMDL Amendment will not lead to increased or alternative forms of pollution or nuisance within the Marina.

10. Potential for Impacts on Endangered and Threatened Species

Copper-based antifouling paints have greatly reduced the transport of invasive species from marina to marina. Prior to adopting this TMDL Amendment, the RWQCB must examine the potential for the further spread of invasive species and the potential to harm endangered and threatened species, as well as ecologically sensitive habitat areas ("ESHAs"), along the California coast. The RWQCB should consult with the US Fish and Wildlife Service and the California Department of Fish and Wildlife regarding the potential for incidental take of federal or state-listed species, and with the California Coastal Commission regarding potential to impact ESHAs.

11. Non-Compliance with California Government Code § 11353.

The California Government Code mandates that the State Water Resource Control Board, when submitting regulatory provisions, must provide a "summary of the necessity for the regulatory provision." Cal. Gov. Code § 11353 [hereinafter "Necessity

Requirement"]. The RWQCB's Tentative Resolution purports to satisfy the Necessity Requirement by referring to the Table 7-18 and the TMDL staff report as a whole.

Neither document, however, sufficiently summarizes the necessity of this regulatory provision as to the amended copper standards. Table 7-18 lacks any succinct statement why the 3.1 micrograms per liter standard for copper in the Marina is "necessary." Likewise, the TMDL "Draft Staff Report" fails to summarize why such drastic copper reductions are "necessary."

Moreover, three of the five beneficial uses that the staff report purports to protect are not currently permitted in the marina. These are: swimming, sport fishing, and shellfish harvesting.

In fact, the TMDL staff report only uses the word necessary in relation to copper once: "Refinement of the model may be necessary as efforts to reduce copper pollution in Marina del Rey Harbor proceed and our understanding of the site-specific factors affecting copper in Marina del Rey improves."[10] This statement does not satisfy the Necessity Requirement, but it does underscore our earlier assertion that the RWQCB has not collected or analyzed data about site specific factors that may affect this standard for dissolved copper.

12. Non-Compliance with California Environmental Quality Act

The RWQCB fails to satisfy the requirements of the California Environmental Quality Act ("CEQA").[11]

The RWQCB has not analyzed the environmental impact of alternatives nor the reasonably foreseeable consequences of this regulation in the "Substitute Environmental Documents for Toxic Pollutants in Marina del Rey Harbor Waters Total Maximum Daily Load" ("CEQA Document"). *See* 14 Cal. Code Regs. §§ 15126.6 and 15187. For instance, the RWQCB failed to consider the economic losses to businesses in Marina del Rey when boaters will choose to dock their boats at nearby harbors that are not subject to this Amendment. More critically, the RWQCB fails to include an analysis of the impacts of the alternatives, and improperly defines away two reasonable alternatives as infeasible.

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[10] California Regional Water Quality Control Board, Los Angeles Region, *Reconsideration of the Total Maximum Daily Load for Toxic Pollutants in Marina del Rey Harbor*, Draft Staff Report 35 (November 5, 2013).

[11] *See generally* Cal. Pub. Res. Code § 21000 *et seq.*; 14 Cal. Code Regs. § 15251(g); 23 Cal. Code Regs. § 3782.

The CEQA Document does not pass muster under Cal. Pub. Res. Code § 21159(c). Section 21159(c) requires that an environmental analysis take into account a reasonable range of environmental, economic, and technical factors, population and geographic areas, and specific sites. The CEQA Document does not address enough specific-site factors (e.g. natural flushing rates of the Marina), and therefore does not satisfy Section 21159(c).

The CEQA Document does not have a proper scope of cumulative effects as defined in Section 15355 of the CEQA Guidelines. According to the CEQA Document, the only cumulative impacts of the project are noise and vibration, air quality, transportation and circulation, public service, and aesthetics. One overlooked impact is loss of recreation—dredging in the Marina and higher maintenance and administrative costs will impact the public's access to this recreation resource.

In sum, the RWQCB has not satisfied its requirements to review all feasible alternatives, to compare the potential impacts of alternatives under CEQA and must take the time and research necessary to determine the Amendment's true impact on Marina del Rey.

13. <u>Lack of Peer Review</u>

The TMDL Amendment has not undergone external peer review under California Health and Safety Code § 57004. Before this Amendment can be adopted, the Regional Board must consider and respond to all comments submitted by a peer review panel. See Cal. Health & Safety Code § 57004(d).

14. <u>Preempted by FIFRA</u>

The TMDL Amendment impermissibly restricts the sale of products that the federal and state government have approved. At a federal level, the EPA has authorized the sale of copper-based paints as pesticide products under the Federal Insecticide, Fungicide and Rodenticide Act (7 U.S.C. § 135 et seq.). And at the state level, the California Department of Pesticide Regulation (DPR") has authorized the sale of copper-based paints as pesticide products under 3 Cal. Code of Regs. § 6000 et seq. The RWQCB cannot usurp the authority of EPA and DPR and effectively foreclose a class of products that have been sold and used in California for decades. The RWQCB has not cited to any legal authority that gives it this power nor can it do this *sua sponte*.

In conclusion, much more work, analysis and study must be completed by the RWQCB before it can complete a TMDL Amendment for Marina del Rey. The public deserves a full analysis of the alternatives, their comparative environmental impacts, their economic impacts as well as a true understanding of their feasibility.

Sincerely,

ALSTON & BIRD LLP

Maureen F. Gorsen

Copper Bioavailability and Toxicity to *Mytilus galloprovincialis* in Shelter Island Yacht Basin, San Diego, CA

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[1]University of San Diego, [2]SPAWAR System Center Pacific, [3]San Diego State University Research Foundation

INTRODUCTION

Leaching of copper (Cu) from antifouling coatings on boats and vessels is a known source of copper to coastal waters and estuaries. Near marinas and ship berths, antifoulant leaching may elevate [Cu] above background to levels where toxicity may be a concern. Toxicity, however, is driven by the bioavailability of Cu, which is not adequately predicted by total or dissolved [Cu]

Shelter Island Yacht Basin (SIYB) in the San Diego Bay, which harbors approximately 2300 recreational boats, shows consistent elevations in [Cu] and has been the subject of various toxicological studies (Neira et al. 2009, Rivera-Duarte et al. 2005). This study examined the biological effects and chemical activity of Cu in SIYB and whether or not the dissolved [Cu], the form of copper monitored for regulatory compliance, poses a threat to organisms inhabiting this area. The findings of this research are important for making environmental decisions about Cu regulation by predicting potential effects of Cu loading on biological communities.

MATERIALS AND METHODS

Copper and a suite of chemical parameters were measured in filtered and unfiltered water, which was collected 1 m below the surface and 1 m above the bottom of SIYB (Figure 1) in two separate sampling events. The first event occurred March 22, 2011 (15 stations) and represents the wet season. The second event was on July 5, 2011 (16 stations) and represents the dry season.

Two approaches were used to assess toxicity, both of which employed 48 hour embryo-larval development toxicity tests using the mussel *Mytilus galloprovincialis*. In one approach, embryos were exposed to untreated (i.e., unspiked) unfiltered surface and bottom seawater from each of the stations to determine if ambient toxicity was present. A total of 62 ambient samples were tested for mussel embryo toxicity over two seasons. In the second approach, unfiltered surface seawater samples from four of the stations (Stations 1, 4, 10 and 12) were spiked with up to 10 copper concentrations to derive median effective concentrations (EC50 values) for calculating a site-specific criterion for Cu using the US Environmental Protection Agency's Water Effect Ratio (WER) procedure (USEPA 1994). Total and dissolved [Cu] in ambient and spiked samples were measured using in-line preconcentration Flow Injection Analysis with detection by ICP-MS.

The data from this study were compared to the marine Biotic Ligand Model (BLM) for Cu, which is a mathematical model that uses site-specific water chemistry parameters to predict toxicity (HydroQual 2011). Using the BLM, an $EC50_{BLM}$ and estimated chronic limit (ECL_{BLM}) for Cu were predicted for each station, and for the marina as a whole.

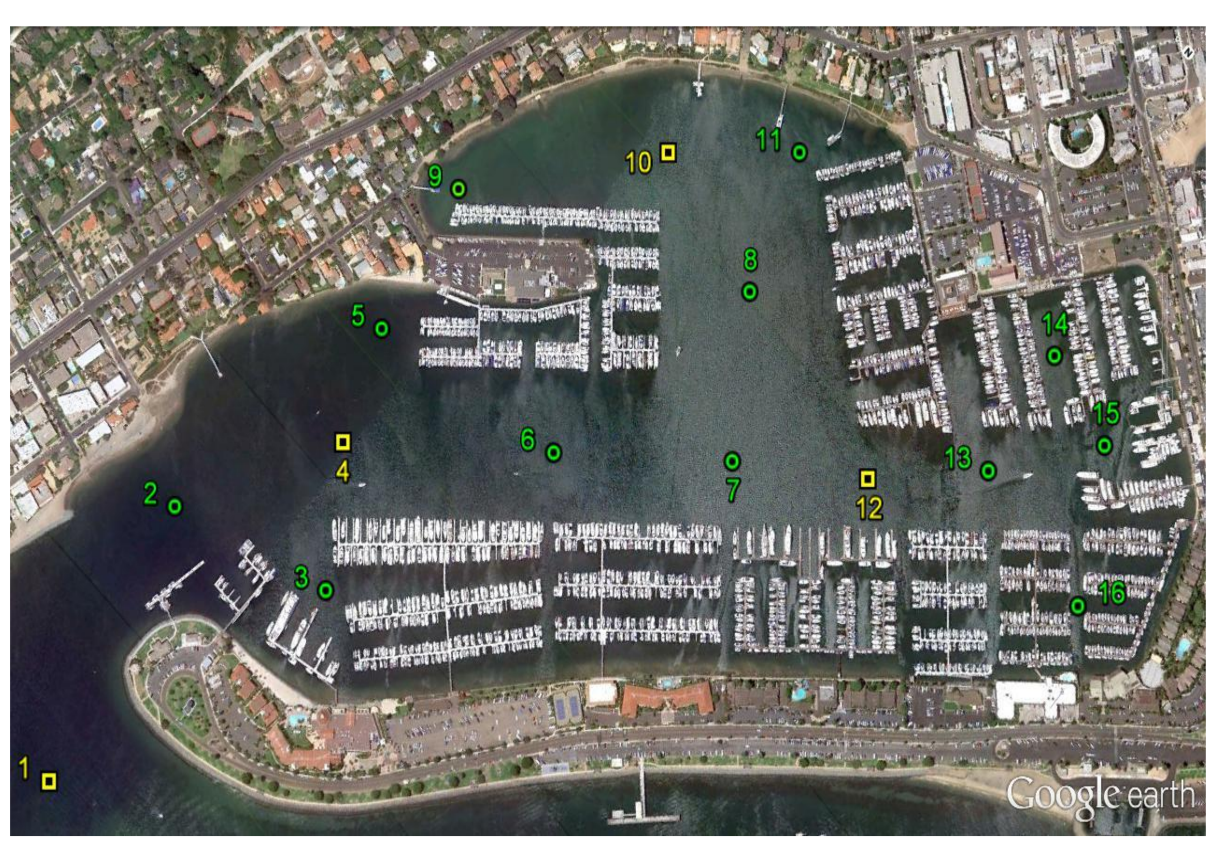

Figure 1. Aerial view of Shelter Island Yacht Basin (SIYB), in San Diego Bay, California. Location and number of the stations is presented, the yellow locations are those for the WER. View downloaded from Google Earth.

RESULTS

Total and Dissolved [Cu]

Concentration gradients in surface water show a general trend of total and dissolved [Cu] increasing from the mouth to the head of the basin (Figure 2a-d). There is also a radial gradient of Cu increasing from the main channel towards the inner boat slips (e.g., Stations 3 and 11 in figure 2c). In general, the [Cu] spatial distributions show three areas in SIYB, the mouth of SIYB with concentrations similar to those outside the basin (Stations 1 to 7), an area where [Cu] is at an intermediate concentration (Stations 9 to 12), and an area where there is a gradient of increasing concentrations (Stations 13 to 16).

Figure 2. Spatial distribution of total (orange squares) and dissolved (blue circles) [Cu] (µg L^{-1}), and dissolved organic carbon (mg L^{-1}; black diamonds). Figures a and b are for the wet season sampled on March 22, 2011. Figures c and d are for the dry season sampled on July 5, 2011

Ambient Toxicity Tests

Wet Season: The ambient water toxicity tests for both surface and bottom water in the wet season did not show toxicity. The mean % normal alive (percent of larvae surviving and achieving normal D-shape) was greater than 85% for all stations, and were not significantly lower than the laboratory control.

Dry Season: The ambient toxicity tests for the dry season showed no toxicity in bottom water but statistically lower (based on t-tests, α=0.05) normal development at 5 of the 16 surface water stations. Very low variability within treatments detected statistical differences at values of 92% normal alive. Using a biologically meaningful reduction (e.g. ,80%), only station 16 (74%) was deemed toxic (circled in orange).

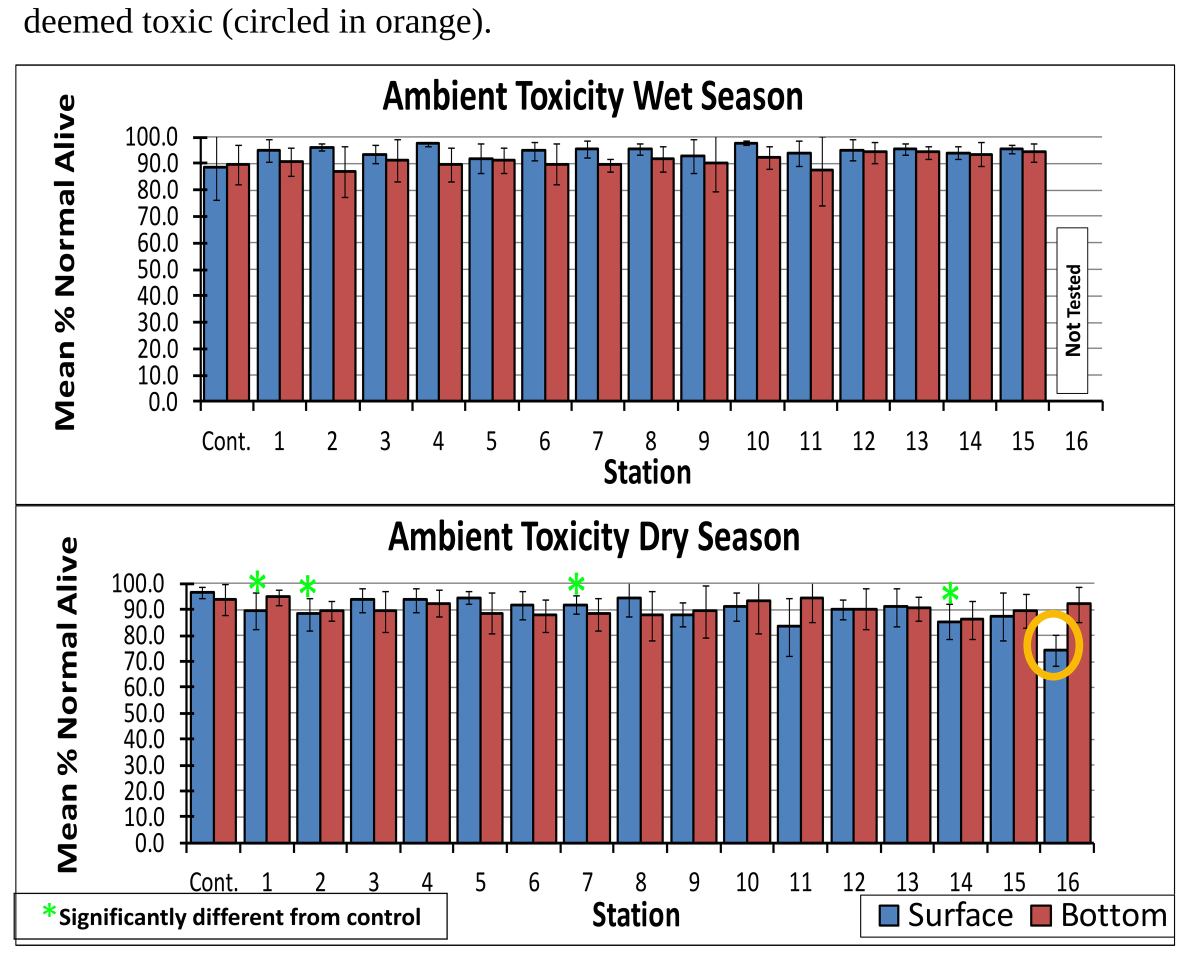

Figure 3 Ambient toxicity observed in SIYB in the wet and dry season sampling events.

EC50 Values and Site-Specific Criteria

The range in EC50 values was from 8.0 to 10.1 [Cu] µg L^{-1} in the wet season, with no spatial gradient. In contrast, during the dry season, the EC50 values ranged from 9.3 to 11.2 µg L^{-1}, with the stations located closer to the mouth having the lowest values. These EC50 values, however, were about twice the measured dissolved concentration of copper at those stations.

A site-specific criterion for SIYB was calculated from the WER results (SSC_{WER}). An estimated chronic limit (ECL_{BLM}) was calculated from the BLM output data for comparison to the SSC_{WER}. The SSC_{WER} was consistent with a spatial and temporal range from 3.2 to 5.0 [Cu] µg L^{-1} (geomean for both events = 4.0 µg L^{-1}). In comparison, ECL_{BLM} were more responsive to spatial and temporal variations, ranging from 4.8 to 11.0 [Cu] µg L^{-1} (Geomean for both events =8.6 [Cu] µg L^{-1}) and are up to two-fold larger than the SSC_{WER}. However, both criteria provide the level of protection intended by regulation, as both are lower than measured EC50 values with the most sensitive marine species- *Mytilus sp.*

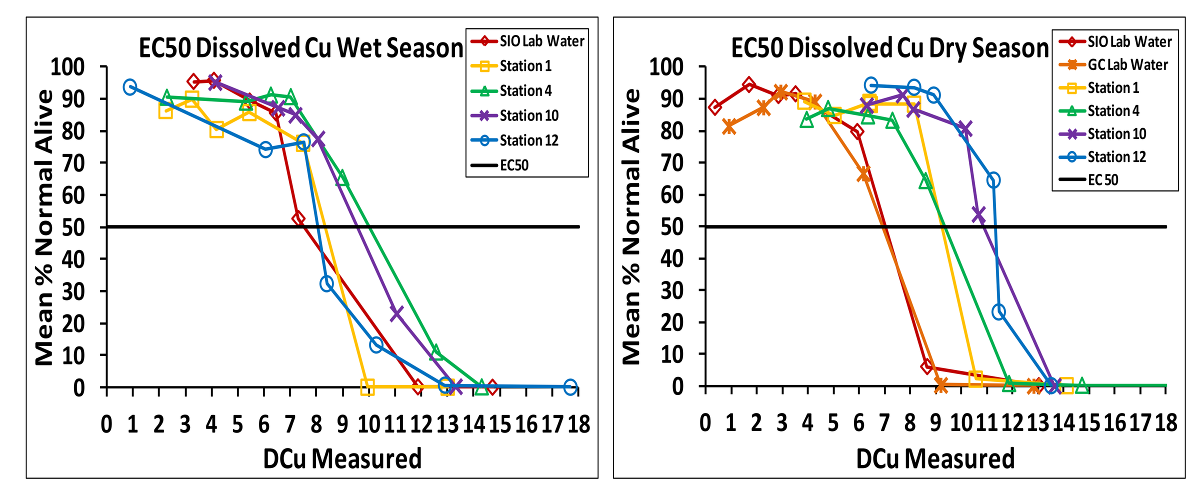

Figure 4. Results for the end point (EC50) measured for the WER under laboratory conditions.

Station	$EC50_{BLM}$	$EC50_{WER}$	95% LCL WER	95% UCL WER	ECL_{BLM}	SSC_{WER}
WET SEASON Dissolved Cu						
SIO (Lab Water)	-	7.9	7.8	8.0	-	-
1	9.4	8.0	7.9	8.1	7.5	3.2
4	8.7	10.1	10.0	10.2	6.9	4.0
10	12.1	9.6	9.4	9.7	9.6	3.8
12	6.1	8.2	8.1	8.3	4.8	3.2
DRY SEASON Dissolved Cu						
SIO (Lab Water)	-	7.0	6.9	7.1	-	-
GC (Lab Water)	-	6.9	6.8	7.0	-	-
1	13.8	9.3	9.3	9.3	11.0	4.1
4	10.3	9.5	9.4	9.6	8.2	4.2
10	9.6	11.2	11.1	11.2	7.6	5.0
12	10.2	11.1	11.1	11.2	8.2	5.0

Table 1 Site-Specific criteria for SIYB derived from the Biotic Ligand Model, and by the USEPA-approved WER approach.

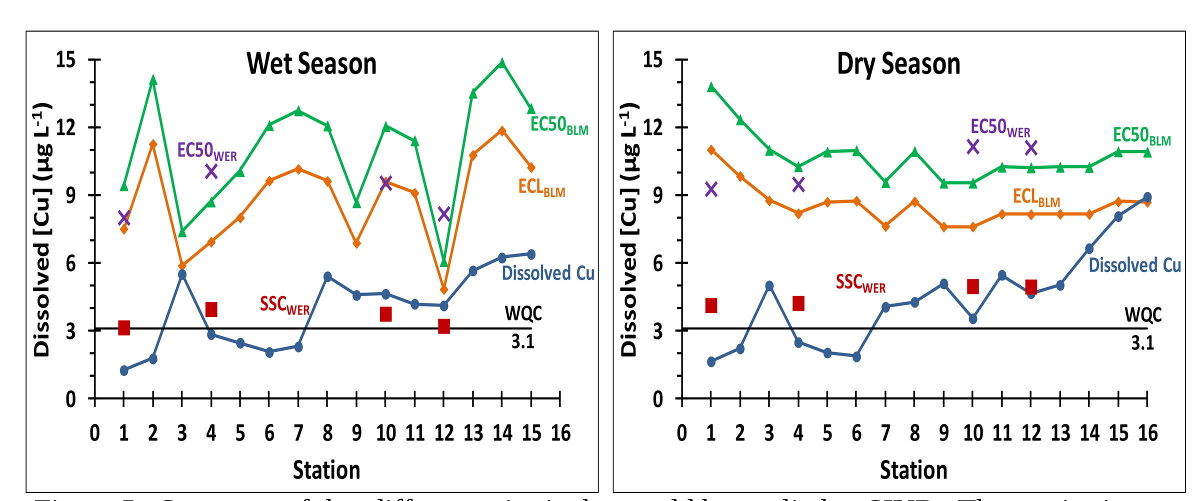

Figure 5. Summary of the different criteria that could be applied to SIYB. These criteria include the 3.1 µg L^{-1} WQC, WER derived and BLM calculated criteria. Dissolved [Cu] (µg L^{-1}) are included for comparison.

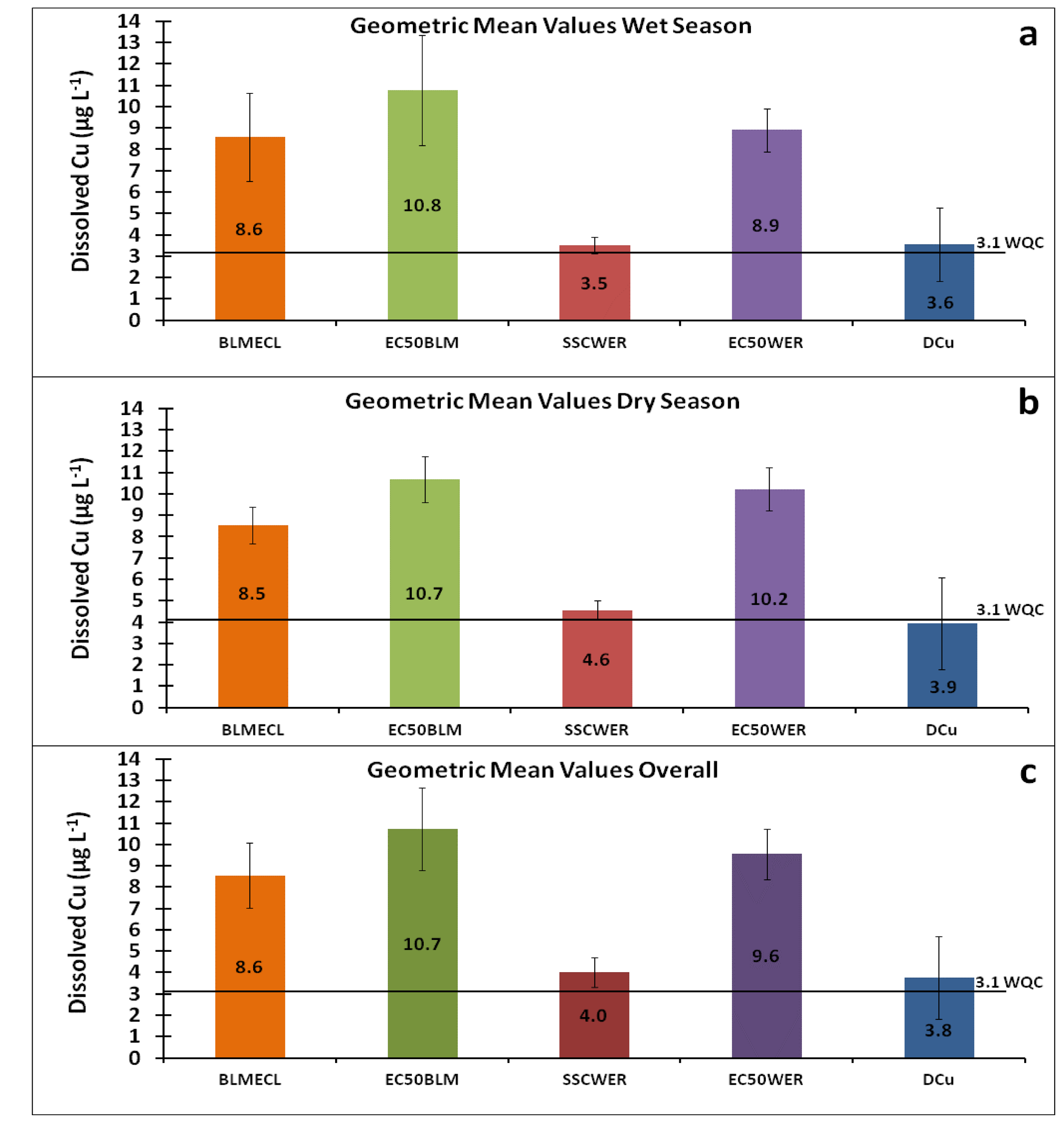

Figure 6. Geometric mean values for the site-specific criteria applied to the dry season (a), wet season (b), and the overall values (c).

CONCLUSIONS

- Two gradients are apparent in surface water total and dissolved [Cu] in SIYB, an increase from the mouth to the head, and an increase from the main channel towards the boats
- The elevated [Cu] at stations 3 and 8 (wet season) and stations 3 and 11 (dry season) appear to be related to proximity and density of boats surrounding the area
- Although [Cu] in SIYB are elevated in comparison to the main body of San Diego Bay, the ambient water is generally not toxic to mussel embryos (1 out of 62 samples somewhat toxic)
- Dissolved [Cu] as high as 8.8 µg L^{-1} were not toxic to mussel embryos
- The BLM estimated chronic limit (ECL) for Cu (mean of 8.6 µg L^{-1} for wet season and 8.5 µg L^{-1} for dry season) is protective of *M. galloprovincialis* based on the ambient toxicity data
- Traditional water effects ration calculation (SSC_{WER}) for Cu is overly conservative based on EPA's intended level of protection. EPA suggested WQC (3.1 µg L^{-1} dissolved Cu) is over conservative as well
- Lack of ambient toxicity and verified protection by BLM suggest that SIYB is not impaired due to copper

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Scientific Committee on Health and Environmental Risks

SCHER

Risk arising from the use of copper-based antifouling paints used in leisure boating

Dutch notification 2003/0201/NL

The SCHER adopted this opinion at its 15th plenary on 30 January 2007

About the Scientific Committees

Three independent non-food Scientific Committees provide the Commission with the scientific advice it needs when preparing policy and proposals relating to consumer safety, public health and the environment. The Committees also draw the Commission's attention to the new or emerging problems which may pose an actual or potential threat.

They are: the Scientific Committee on Consumer Products (SCCP), the Scientific Committee on Health and Environmental Risks (SCHER) and the Scientific Committee on Emerging and Newly-Identified Health Risks (SCENIHR) and are made up of external experts.

In addition, the Commission relies upon the work of the European Food Safety Authority (EFSA), the European Medicines Evaluation Agency (EMEA), the European Centre for Disease prevention and Control (ECDC) and the European Chemicals Agency (ECHA).

SCHER

Questions relating to examinations of the toxicity and ecotoxicity of chemicals, biochemicals and biological compound whose use may have harmful consequences for human health and the environment.

In particular, the Committee addresses questions related to new and existing chemicals, the restriction and marketing of dangerous substances, biocides, waste, environmental contaminants, plastic and other materials used for water pipe work (e.g. new organics substances), drinking water, indoor and ambient air quality. It addresses questions relating to human exposure to mixtures of chemicals, sensitisation and identification of endocrine disrupters.

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SCHER, Opinion on risk arising from the use of copper-based antifouling paints used in leisure boating, Dutch notification 2003/0201/NL, 30 January 2007.

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1. BACKGROUND

On 13 June 2003, the Dutch authorities notified within the framework of the "98/34 procedure for the provision of information in the field of technical standards and regulations and of rules on information society services" a draft text by which the Pesticides Licensing Board (PLB) intends to extend application of the standards and criteria laid down in the Decree on environmental licensing requirements for pesticides.

The Commission decided to consult the Scientific Committee for Toxicity, Ecotoxicity and the Environment (CSTEE) about several aspects of the notified draft. The CSTEE adopted the related opinion in its plenary meeting of 19 September 2003.

Based on the CSTEE opinion, the Commission delivered a detailed opinion pursuant to article 9.2 of Directive 98/34/EC against the Dutch draft on 27.11.2003. Therein, the Commission mainly concluded that the Dutch risk assessment has not provided sufficient sound scientific evidence to show that the use of copper-based antifouling products presents significant environmental risks to support the envisaged measure.

In its reply of 19.4.2004 to the Commission's detailed opinion, the Dutch government rejected the arguments put forward by the CSTEE.

In its analysis of the reaction of the Dutch authorities to its detailed opinion, the Commission came on 13.1.2005 to the conclusion that several important issues raised in the CSTEE's opinion have not been addressed fully in the Dutch reply. This concerns in particular the partly outdated database used in the risk assessment and the failure to take bioavailability into account. The Commission concluded that, being confronted with contradictory scientific information, no final position could be taken at that point in time.

In its reply of 18 January 2006, the Dutch Government provided the Commission with two additional documents on approaches to address bioavailability in the case of copper in risk assessments.

In its communication of 3 February 2006 the Commission indicated to the Dutch authorities that it needed to analyse the above mentioned RIVM Reports before taking a position. Having examined the reports and having heard the opinion of the interested economic operators, the Commission services decided to submit additional questions to the SCHER.

2. TERMS OF REFERENCE

The SCHER is requested to examine the following questions:

1. Is the SCHER of the opinion that the analysis of the four methods to determine bioavailability described in the RIVM report is scientifically sound and comprehensive, in particular with respect to the assessment criteria established by RIVM?

2. Does the SCHER share the conclusion drawn in the RIVM reports, in particular with respect to the uncertainties associated with the individual methods and their suitability to determine the bioavailability of copper in the context of environmental risk assessments for regulatory purposes?

3. Is the SCHER of the opinion that the additional information provided by the Dutch Government in its letter of 19 April 2004 now provides sufficient information on how the data for the effect assessment performed in the disputed risk assessment has been selected?

4. In the light of the SCHER's conclusion on questions 1 to 3, and all the submitted information including industry's comments', as well as other possible available information, does the SCHER maintain its opinion that the risk assessment performed by the Dutch government to justify the draft measure notified to the Commission does not provide sufficient sound scientific evidence to show that the use of copper-based antifouling paints in leisure boats presents significant environmental risks?

3. OPINION

3.1 General remarks

The SCHER has revisited the previous CSTEE opinion and the comments submitted by the Dutch Authorities, and as a general conclusion considers that the concerns expressed by the CSTEE have only partially been covered by the Dutch response.

The CSTEE was concerned by the lack of transparency in the selection of the effect assessment data. The Dutch response focuses mostly on the applicability of SSD approaches for setting quality standards such as the MPR employed by the Dutch authorities. It should be clear that both, the SCHER and the CSTEE are fully supportive of the SSD approach when feasible and have recommended this methodology in several occasions.

The concern expressed by the CSTEE was related to the selection of data, not to the methodology itself. This selection is particularly relevant for an essential metal such as copper, particularly when bioavailability corrections have not been taken into account.

The clarification presented now by the Dutch authorities provides some clarification regarding the criteria for checking the quality of the data, but not on the selection criteria required for a metal and particularly for an essential metal.

Regarding the availability of data, the ongoing voluntary risk assessment for copper under the existing substances legislation clearly confirms the CSTEE statement indicating that there is a significantly amount of data on copper ecotoxicity that has not been included in the Dutch assessment. It should be noted that this information is available to all Member States.

The SCHER fully supports the CSTEE opinion regarding the need for considering bioavailability issues in the risk assessment of copper; this approach has been employed for other metals as well as in the voluntary risk assessment of copper under the Existing Substances regulation.

A similar situation should be considered for the exposure assessment part. The main concern from the CSTEE was the lack of justification for some assumptions included in the report. The SCHER welcomes the clarifications, but still considers that data and assumptions should be clearly presented and the rationale for the selected values should be well justified. The main role of the Scientific Committees is to address the scientific quality of the assessments, including methodologies and input data, and the lack of transparency means that the Committee is unable to do this.

Regarding the measured data, the information provided by the Dutch authorities indicates that all measurements have been done in the same area, and all water measurements inside the yacht area are from the same location. Regardless the total number of measurements, the monitoring programme is very limited in terms of spatial cover, and the relevance of the site, not only in terms of emissions of copper from anti-fouling paints but from all other sources.

Regarding the methodology employed for the risk characterization, the Dutch authorities present a long discussion on the rationale for the approach, suggesting a misunderstanding from the CSTEE. The method considers the relative contribution of the source, copper in antifouling paints, but the same correction is applied to the exposure and the effect assessments. As stressed by the CSTEE, this approach in reality means that independent of the contribution of each source, the proposed method assumes that the risk of any specific source is finally expressed as “the total measured concentration divided by the total MPR”, as recognised in the Dutch comments.

In the opinion of the SCHER, this approach is useful for an overall assessment of the risk coming from all sources, but, as pointed out by the CSTEE, this approach is not useful for addressing the risk of independent sources, as it allocates exactly the same risk to a contribution representing 0.01% or less of the total emissions as to a contribution representing 50% or more; risk management measures on sources contributing 0.01% or 50% of the total emission would have obvious differences on the overall risk.

Therefore the SCHER suggests that other alternatives should be selected for quantifying the risk of each source by considering their specific contribution above background levels.

Finally, as stressed by the Scientific Steering Committee (2000 and 2003) the risk characterization should consider not only the risk estimation but also the uncertainty associated with the assessment. From a scientific perspective, the assumption that a risk quotient of 0.99 is perfectly acceptable and a risk quotient of 1.01 is fully unacceptable cannot be supported. Obviously, the consequences of being slightly above the trigger or orders of magnitude above the trigger are not similar.

The SCHER may agree that actions should be taken when the risk quotients exceeds the regulatory trigger, but the actions should be different for a risk quotient based on conservative approaches which slightly exceed the threshold than for a risk based on realistic estimations and indicating a high likelihood for effects on populations and communities. The uncertainty assessment and the options for risk refinement are particularly relevant when the risk quotients are close to the trigger.

3.2 Questions 1 and 2

1. Is the SCHER of the opinion that the analysis of the four methods to determine bioavailability described in the RIVM report is scientifically sound and comprehensive, in particular with respect to the assessment criteria established by RIVM?

2. Does the SCHER share the conclusion drawn in the RIVM reports, in particular with respect to the uncertainties associated with the individual methods and their suitability to determine the bioavailability of copper in the context of environmental risk assessments for regulatory purposes?

Response to questions 1 and 2

Four methods for assessing bioavailability in freshwater systems (one for sediments and three for the pelagic compartment) are presented in the RIVM report.

Of the three methods for the water, the first one represents the procedure used by the Dutch Board for the Authorisation of Pesticides (CTB), based on total metal concentrations and thus does not account for bioavailability. The second method (Kopertox) is based on the empirical relationship between Cu toxicity and dissolved organic carbon (DOC) concentrations and can thus be considered as a simplification of the third method: i.e. the Biotic Ligand Model (BLM) approach.

The SCHER considers that only this latter method represents the state-of-the science and as such the committee will only comment on the analysis of the scientific soundness and comprehensiveness of this part of the report.

The SCHER notes that the RIVM report does not present a balanced or complete review of all available data. For example, the report states '*It must be concluded that the most problematic aspect is that although the BLM method is in principle usable, a valid BLM for copper is not currently available for certain trophic levels.[ ] This means that for the second-line assessment, too, the influence of bioavailability cannot currently be included in the risk assessment for surface water.*' The SCHER would like to point out that this statement is not correct, as chronic BLMs have been developed and validated for all three trophic levels and have subsequently been successfully used and validated for other species such as rotifers, various other crustaceans and algal species (Bossuyt et al. 2004a, 2004b, 2005; De Schamphelaere and Janssen 2004a, 2004b, 2006; De Schamphelaere et al. 2004, 2005, 2006; Villavicencio et al. 2005).

Concerning the numerous remarks on the uncertainties associated with for example DOC, lab to field extrapolations and relevance of the physico-chemical characteristics of the surface waters tested in the various validation studies, the SCHER finds that some data were misinterpreted and not all available data were taken into consideration. This has lead to an incorrect assessment of the uncertainty associated with the use of BLMs.

Irrespective of the numerous factors which may affect bioavailability assessment the value of any method/model is - as noted in the criteria set out in the RIVM report - in the predictive capacity of the method/model under realistic conditions. An objective evaluation of all available data and literature demonstrates that, both using laboratory test media and real surface waters that the chronic BLMs (for fish, crustaceans and algae) accurately predict copper toxicity for approximately 80 to 90 % of the samples tested. This means that the species-specific variability of a factor 10 to 100 observed when using total Cu concentrations is reduced, through the use of BLMs, to a factor of approximately 2. This predictive capacity is, despite the concerns expressed in the RIVM report, obtained with most types of waters and natural DOC tested so far.

The evaluation also shows that the models were developed with and validated for waters which cover the 10 and 90 percentile of the EU range of the main factors affecting Cu bioavailability (pH, hardness and DOC). Taking into account the water characteristics of the majority of Dutch surface waters it is concluded that these models are applicable to Dutch waters.

Finally the SCHER notes that bioavailability has been accounted for in the EU risk assessments (RA) of Cd (hardness correction) and Zn (BLMs) and is presently being considered the EU RAs of Ni and Cu (both through BLMs).

On the assessment of copper bioavailability in sediments the RIVM report states '*In relation to sediment, bioavailability, including correction for AVS, is conceptually important. The AVS method is, however, not yet suitable for use in the generic risk assessment for copper owing to the risk of temporal variation in AVS (AVS only plays a role under anaerobic conditions), which means that metals nevertheless become available.* The RIVM report consequently concludes that no bioavailability assessment of copper in sediments can be made.

In the draft EU RAR on copper, to which the RIVM refers, a clear relationship between AVS and chronic Cu toxicity to several benthic organisms was established. A similar relationship was found between sediment organic carbon content and Cu toxicity. Because of experimental and analytical problems, however, this dataset does not allow to quantitatively develop a robust AVS –copper toxicity model which may be useful for RA purposes. The RAR did demonstrate that accounting for sediment organic carbon (OC) content and assuming low AVS significantly reduced the variability in the dataset, illustrating that – for copper - OC normalisation may be a useful method to account for it's bioavailability in sediments. It should be clear that this approach is, because of the low AVS assumption, conservative in nature.

The SCHER notes that the Acid Volatile Sulphide model was used in the RA of zinc under the Existing Substances Regulation.

In conclusions, the SCHER is of the opinion that the analysis of bioavailability models described in the RIVM report is insufficiently comprehensive and sometimes lack scientific rigor to support the conclusion that bioavailability cannot be taken into account in the environmental risk assessment of copper.

The SCHER is of the opinion that the 'total metal' approach (not accounting for bioavailability) - as currently used by CTB – does not accurately assess the environmental risks of copper from antifouling paints and that incorporation of bioavailability will reduce the uncertainty associated with the current assessment.

3.3 Question 3

Is the SCHER of the opinion that the additional information provided by the Dutch Government in its letter of 19 April 2004 now provides sufficient information on how the data for the effect assessment performed in the disputed risk assessment has been selected?

Response to question 3

It is opinion of the SCHER that in the document of the Dutch Government sufficient additional information is not provided to reply to the objections posed by the CSTEE Opinion of 19 September 2003.

In particular, no answers have been provided to the request for more transparency on the criteria for the selection of data for inclusion in the effects assessment.

In the Dutch reply it is confirmed that the MPR was based on the application of the SSD approach, assuming a protection level of 95% of the species of the ecosystem. For applying the SSD approach it is also confirmed that data from the Crommentuijn (1997) report were used. Nevertheless, there is no mention on the criteria used for the selection of data.

Even if the SCHER supports the scientific validity of the approach used, it must also be highlighted that, for the SSD application, the transparency of criteria for data selection is a key point to ensure the validity of the results.

Moreover, a revision of the assessment is also mentioned, but the rationale for that is not clarified.

It is confirmed, without any additional justification, that the equilibrium partitioning method for sediment effect assessment was used. In the CSTEE Opinion it of was highlighted that the equilibrium partitioning method is poorly applicable to metals for deriving the MPR for sediments. The suggestion of the CSTEE of using some recent toxicity data on benthic organisms has been totally ignored.

Therefore, it is opinion of the SCHER that all uncertainties connected with the derivation of MPR still exist.

Besides doubts on effects, many aspects need to be clarified about exposure. This is particularly relevant if one takes into account that PEC/PNEC ratios were only marginally in excess of one. In these cases, there is the need for a higher-tier assessment, by reducing unrealistic worst case assumptions, in order to confirm the occurrence of a risk.

In the Dutch document, it is stated that the assessment is a higher-tier assessment, being based on measured exposure data. However, many objections can be made on that.

1. If the risk assessment is based on measured data, the contribution from antifouling paints cannot be assessed. To evaluate the real role of antifouling paints, an assessment of many factors is needed (leaching rate, time that pleasure crafts spend in port, etc.). It is opinion of the SCHER that all these items are overestimated. No satisfying answers have been provided to the questions posed in the CSTEE Opinion.
2. Measured data refer to total copper, without any assessment of bioavailability. The relevance of this point has been underlined under questions 1 and 2.
3. The Dutch document states that the assessment is based on more than 500 experimental data. It appears that:
   - most of these data refer to sediments outside of marinas and a minor amount refer to water outside of marinas;
   - only 8 samples are available for sediments inside of marinas;
   - only in one sampling station the water column was measured inside of a marina;

- corrections are made for background values, but inconsistencies between the "standard" background used for effects and those used for exposure are not clarified;
- it was assumed that outside marinas copper contribution from antifouling is 35% of the total, but this assumption is not adequately supported.

Therefore it is opinion f the SCHER that exposure has not been adequately evaluated for a higher tier assessment.

3.4 Question 4

In the light of the SCHER's conclusion on questions 1 to 3, and all the submitted information including industry's comments', as well as other possible available information, does the SCHER maintain its opinion that the risk assessment performed by the Dutch government to justify the draft measure notified to the Commission does not provide sufficient sound scientific evidence to show that the use of copper-based antifouling paints in leisure boats presents significant environmental risks?

Response to question 4

The SCHER confirms the previous opinion of the CSTEE and considers that the Dutch authorities have not properly addressed the concerns expressed by the CSTEE.

The Committee suggests that the risk assessment for copper in anti-fouling paints:

- Should be based on a transparent use of all available information
- Must consider the bioavailability issue following the methodology agreed for other metals at the EU level, and
- Requires a proper risk characterization for addressing the risk of copper in anti-fouling paints in combination with other copper sources, expressing the contribution of the source to the overall risk.

These issues have not been properly considered in the assessment conducted by the Dutch authorities; therefore, the SCHER concludes that the risk assessment performed by the Dutch government to justify the draft measure notified to the Commission does not provide sufficient sound scientific evidence to show that the use of copper-based antifouling paints in leisure boats presents significant environmental risks.

4. CONCLUSIONS

The SCHER concludes that the risk assessment performed by the Dutch government to justify the draft measure notified to the Commission does not provide sufficient sound scientific evidence to show that the use of copper-based antifouling paints in leisure boats presents significant environmental risks.

5. LIST OF ABBREVIATIONS

NOEC	No Observed Effect Concentration
PEC	Predicted Environmental Concentration
PNEC	Predicted No Effect Concentration
RAR	Risk Assessment Report
TGD	Technical Guidance Document
WWTP	Waste Water Treatment Plant

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Lower Newport Bay Copper/Metals Marina Study

Final Report

July 2007

Prepared for the City of Newport Beach
by
Orange County Coastkeeper

Special thanks to the following individuals for their help in completing this project: Linda Candelaria PhD. of the Santa Ana Regional Water Quality Board. Rich Gossett of CRG Laboratory, Steve Bay, Darrin Greenstein, Keri Ritter of SCCWRP, and O.C.Coastkeeper interns; Dustine Min, Holly Doo, Peter Pham, Elijah Rosenthal, Alex Ramirez, Chris Lopez, and Shannon Penna. This project was funded by the State Water Resources Control Board and the City of Newport Beach.

Executive Summary

A Toxics TMDL for Newport Bay was promulgated in June 2002 by USEPA, and a Metals TMDL for Newport Bay is currently under development by the Santa Ana Regional Board staff. Metals listed in this TMDL for the Lower Newport Bay include Cu, Pb and Zn (Cd, Cu, Pb, and Zn in Rhine Channel). Recent studies have shown that metals are present in Newport Bay at levels that raise concerns for the health of the bay ecosystem (Bay, 2003-2004).

The goal of this project was to determine if Cu antifouling boat paints are a significant source of Cu contamination to the water column and sediments in marinas, and Lower Newport Bay in general, and to determine the amount of Cu and other metals present in marina waters and sediments.

Water and sediment samples were collected from eight representative marinas and adjacent channel sites (potential control sites) in Newport Bay in May, August, and December of 2007 and tested for metals, Dissolved Organic Carbon, Total Suspended Solids, temperature and salinity. The results were then examined for exceeding California Toxics Rule standards for water or National Oceanic and Atmospheric Administration Sediment Quick Reference Tables (NOAA SQRT) for sediment. Additionally, a statistical analysis of the data using the ANOVA test was conducted to determine if observed differences in the data are statistically significant. Toxicity testing was done on a subset of the water and sediment samples (dry weather) by SCCWRP.

Water column

The data shows that dissolved copper is the only metal with concentrations elevated above the CCC (chronic) (67% of all samples) and CMC (acute) (30% of all samples) CTR standards in the bay water. To break it down further, 75.4 % of the marina samples and 48.1 % of the channel samples exceeded the dissolved chronic Cu CTR standard with samples from all marinas and four channel sites exceeding the chronic standard greater than 50% of the time. Also 26% of the marinas samples and 14.8% of the channel samples exceeded the acute CTR in samples from two marinas(Lido Village and Lido Yacht Anchorage) and one channel site (Lido Village) exceeding the acute standard greater than 50% of the time. Although mean Cu concentrations in each marina are mostly above the corresponding channel Cu concentrations, ANOVA statistical analysis shows that there is no statistically significant difference in dissolved copper levels in the marinas and the adjacent channel sites. This may be a function of the variability in marina and channel data since marina means are mostly higher than channel means. The dissolved copper data may also indicate that copper leached from the boats in the marinas is not being quickly diluted as it leaves the marinas.

Sediment

An examination of all the project sediment data showed that Cu, As, Cd, Cr, Hg, Pb and Zn were elevated above NOAAs TEL and ERL standards, and Cu, Hg, and Zn were elevated above the ERM in the bay sediments. In statistical comparisons of marina vs. channel samples at each marina, only three marinas, Balboa Yacht Basin, Harbor Marina and H&J moorings, did not show significant differences in the metals concentrations between the marina and its adjacent channel site. This was due to the high metal concentrations in both marinas and channels in the west bay. In statistical comparisons of the entire sediment dataset for each marina vs. the other marinas, the data shows that there are significant differences in sediment metals in the marinas of west Newport Bay (Harbor, Lido Village, and Lido Yacht Anchorage) compared to the other project marinas. Poor water circulation in the area is a likely reason for the elevated metal levels for dissolved copper and sediment metals found in the west bay; a large storm drain located in Harbor marina may also be a factor. In a statistical comparison of wet vs. dry weather metals data at the marina sites, higher dissolved metal concentrations were found in the west bay during dry weather and the combined wet and dry data, while in wet weather the trend is reversed with the Newport Dunes and De Anza marinas showing significantly higher dissolved metals than the west Newport Bay This could be due to the strong influence that runoff from San Diego Creek has on the area during wet weather.

Toxicity

Water, sediment-water interface and sediment toxicity tests were conducted for 10 sites (8 marina, 2 channel sites) in August, and pore water (10 sites) and sediment toxicity tests (6 sites) were conducted in November. Significant sediment toxicity (amphipod test) was found in 80% of the sites tested -(6/8) marina stations and all (2/2) channel stations, and the stations with highest toxicity were at Newport Dunes and De Anza Marina. In November, significant sediment toxicity (amphipod test) was also found at all 6 stations tested (4-Newport Dunes, 2-DeAnza Marina). No toxicity was found for water, sediment-water interface or porewater tests for 10 stations tested (mussel embryo tests); however, 3/10 SWI tests and 2/10 pore water tests showed reduced percent normal alive embryos. A TIE was run on the Newport Dunes site to attempt to identify the source of the toxicity. The results of the TIE test determined that the most likely source of the toxicity found at the Newport Dunes Marina is a combination of metals and pesticides.

Additionally the pore water was extracted from the sediment collected and examined for metals. Copper was the only metal found to be exceeding CTR values in the pore water. It exceeded the chronic CTR standard at two sites, one each at Lido Yacht Anchorage and the H&J moorings. The acute CTR standard was exceeded only at the H&J moorings site.

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Background

A Toxics TMDL for Newport Bay was promulgated in June 2002 by USEPA, and a Metals TMDL for Newport Bay is currently under development by Santa Ana Regional Water Board staff. Metals shown to exceed the CTR values in Lower Newport Bay include Cu, Pb and Zn (Cd, Cu, Pb, and Zn in Rhine Channel). Recent studies have shown that metals are present in Newport Bay at levels that raise concerns for the health of the bay ecosystem (Bay, 2003-2004, USEPA 303d list). Cu and other metals are known to be toxic to fish and other aquatic species. Cu antifouling boat paints are a known source of Cu to the Lower Bay. These paints are designed to leach Cu into the water, mostly as cuprous oxide, to reduce the fouling of boat bottoms with barnacles and algae. The leaching of Cu from antifouling boat paints is well documented and has been quantified in a study by SCCWRP (SCCWRP report, Schiff et al 2003; Port of San Diego Report 2006). However, the question remains as to the disposition of Cu once it is released into the marina – Does the Cu remain in the marina, adsorb onto the sediments, or flush out of the bay with the tides? In addition, Zn plates are installed on all boats and serve as sacrificial anodes to prevent corrosion of other metal parts. Seawater reacts with the Zn anodes which corrode and settle to the marina sediments.

Copper or other metals in the water may remain in the dissolved phase, adsorb to suspended particles and settle, form salt precipitates or be flushed out of the marina. Benthic organisms that lie in the sediment may ingest these metals, and filter feeders, such as mollusks, may accumulate metals from the water. In addition, sediments may be re-suspended and release metals back into the water.

An additional source of metals to Newport Bay is urban runoff which may enter the Bay via storm drains or surface runoff. Metal inputs to the Bay from storm water inputs can be significant in winter. Over 200 storm drains empty into

Newport Bay and studies show high metal concentrations around storm drains in the Rhine Channel section of the bay (Bay 2003, OCCK 2004). Two marinas with storm drains in Lower Bay were sampled to investigate the impact of storm drain inputs into marinas to determine if storm drains significantly affect metals concentrations in marinas.

Boatyards are another potential source of Cu to Newport Bay; boat hulls are cleaned, scraped and sandblasted near the water, and there is a potential for discharge into the Bay (although a no discharge rule is in effect via the State Board's general industrial storm water permit). According to marina data, higher levels of Cu have been found near maintenance area drains and fuel docks than at other locations suggesting that these two areas are sources of potential metal pollution of water and good targets for pollution prevention practices (Shelter Island TMDL SDRWQCB 2004). Other metals such as lead, copper, arsenic, zinc, mercury, nickel, lead, chromium and tin have many functions in boat operation, maintenance, and repair. There are two active boatyards in Lower Newport Bay that are not in the Rhine Channel; the Rhine Channel has been investigated extensively in previous projects (Bay 2003, O.C.Coastkeeper 2005). The largest is located next to the Balboa Yacht Basin Marina and the water and sediment near this boatyard was tested as part of this project. The other is located on West Pacific Coast Highway and is not close to marinas included in this project.

Sampling Design

The goal of this project was to determine if Cu antifouling boat paints are a significant source of Cu contamination to the water column and sediments in marinas, and Lower Newport Bay in general, and to determine the amount of Cu and other metals present in marina waters and sediments.

To achieve this goal we selected eight representative marinas from over forty marinas in Newport Bay. We established representative sample sites in each of the eight marinas along with a site in the channel adjacent to the marina to serve as a reference outside each marina. The marinas are spatially distributed throughout the Lower Bay (and lower Upper Bay) and include linear and block marina designs. One set of moorings was also included to cover all types of marina designs in Newport Bay. To represent other factors that may influence metals concentrations, we selected two marinas with large storm drains that emptied into the marinas and one with a shipyard located next door to determine if there was a significant difference between marina sites without storm drains or shipyard influences and marina sites with storm drains or near a shipyard. Additionally, we scheduled the sampling events to represent wet and dry weather conditions in the bay. Sampling events for all sites were in May, August and December; the May sampling event was within three weeks of a rain event and the December sampling event was within seventy-two hours of a rain event. The August event was in the middle of the dry season. By using this design, we were able to make data comparisons of each marina vs. its channel site, marina vs. marina, dry vs. wet weather, and marinas with storm drains or shipyards vs. marinas without.

This design is critical to answering our primary question, to determine if Cu antifouling boat paints are a significant source of Cu contamination to the water column and sediments in marinas, and Lower Newport Bay in general, and to determine the concentrations of Cu and other metals present in marina waters and sediments.

If the Cu remains in the marina waters or settles into the marina sediments then there could be a significant difference between the marina and channel data. If the Cu from the bottom paint is quickly flushed out of the marinas, there may not be a significant difference in marina and channel sediment Cu concentrations. If storm drains or shipyards are a significant source of metals to the marinas they are located in or near then marina sites closest to the storm drain (or shipyard) and may have higher metal concentrations than sites further from the storm drain (or shipyard). The wet and dry season sampling events will allow us to determine if the concentrations of metals levels fluctuate during the year.

Methodology

Sampling Events and Sites

For this study, water and sediment samples were collected from thirty-five sites in Newport Bay including sites in eight marinas and adjacent channels, two stormdrains, and one shipyard. A list of marinas is detailed in Table 1. There were 3 major sampling events on May 10th, August 22nd and 23rd and December 18th for all marina/channel sites, and a 4th sampling event, November 17th, was added later to collect additional toxicity samples. For the May, August and December events water and sediment samples were analyzed for dissolved and total metals in water, metals in sediment, Total Suspended Solids, Dissolved Organic Carbon, water temperature, and salinity in water. In addition to the metal testing, the August event included toxicity testing and organics testing on a subset of 10 sites (Table 1). Water and sediment samples were analyzed for toxicity, PCBs, and PAHs; grain size, TOC, and acid volatile sulfides in sediment were also run. After analysis of the August toxicity results, the November sampling event was added to collect sediment samples for additional toxicity and TIE testing. Metals in pore water were also analyzed in the November sediment samples.

The May and December samples represent wet weather conditions with the December collection occurring within 72 hours of a storm event and the May sampling occurring within 3 weeks of a rain event. The August sampling event was representative of dry weather conditions. During both the August and November events samples were collected from a subset of the total sites (10 in August and 12 sites in November) for toxicity testing, with the November sample site locations based on the toxicity test results from the August sampling event.

Sample Collection and Analyses

All water samples were collected from one meter below the surface using a clean 500ml poly bottle mounted on a six foot PVC sampling pole. All sediment samples were collected using a petite ponar grab sampler with the samples collected from the undisturbed top 10cm of the sediment collected. The larger sediment samples necessary for toxicity testing were composites from the multiple grabs required to generate the amount of sediment necessary.

In May, August and December, the water and sediment samples for chemical analysis were collected and delivered to CRG Marine Laboratories the same day. The water samples were analyzed for total and dissolved title 22 metals including copper, nickel, chromium, lead, arsenic, nickel, tin, cadmium, mercury and zinc, using EPA method 1640 by ICPMS (Fe, Pd extraction), DOC using EPA method 415.1, and TSS using SM2540D. Temperature and salinity measurements were taken in the field. Sediments were analyzed for total metals (title 22 metals) using EPA method 6020 by ICPMS. In August, additional amounts of water and sediment were collected from 10 sites, and a split of those samples was analyzed for PCBs and PAHs using EPA method 625(m)/6270C(m), particle size using SM2560D, Percent Solids using EPA method160.3, TOC using EPA method 415.1, and acid volatile sulfides.

The water and sediment samples collected for toxicity testing during August and November were sent to the Southern California Coastal Watershed Research Project (SCCWRP) for toxicity and TIE testing. The initial toxicity testing was done in August for ten sites, one at each of the eight marinas, along with two channel sites, one each outside Lido Village Marina and Lido Yacht Anchorage marina. Toxicity tests were conducted on water, the sediment water interface, and whole sediment. Based on the initial toxicity testing results, additional sites were tested in November. Newport Dunes site number three was selected for a sediment TIE due to its high sediment toxicity in the August testing, and pore water toxicity testing was run on two sites each in Newport dunes and De Anza

Marinas and at one site from each of the other six project marinas (no channel sites) for a total of ten pore water tests. Also, six whole sediment tests were run, at four Newport Dunes sites and two De Anza sites.

Toxicity Tests

Mussel Embryo Development Test

The mussel embryo development test (USEPA 1995) was used to evaluate acute toxicity on water column, sediment-water interface and pore water samples. This test measures toxic effects on mussel embryos, as a reduction in their ability to normally develop from fertilized eggs. The mussels (Mytilus galloprovincialis) test consisted of a 48 hour exposure of fertilized eggs to marina water samples. (See Appendix B for test details.)

Sediment-Water Interface (SWI) Test

This is a 48 hour, whole sediment test. Whole sediment from the 10 stations was loaded into five replicate polycarbonate core tubes with laboratory seawater and equilibrated overnight. The next day, fertilized mussel eggs were added. After 48h, embryos were observed. (See Appendix B for test details.)

Whole Sediment Toxicity Test

For whole sediment, a ten day chronic toxicity measurement using exposure with amphipods (Eohaustorius estuarius) was conducted. The exposure was conducted on the same sediment as the SWI testing. This test measures toxic effects on amphipods by their survival and activity level. (See Appendix B for test details.)

Whole Sediment Toxicity Identification Evaluation

A reduced volume and duration (7 day) initial amphipod survival test was performed on two stations to determine if toxicity was present at a high enough level to justify conducting a TIE.

A whole sediment toxicity identification evaluation (TIE) was conducted on station 6013 from the Newport Dunes Marina. This station was found to be very toxic to amphipods for the initial sample collected in August and again in November when the station was re-sampled. (See Appendix B for test details.)

Pore Water Toxicity Tests

Pore water samples were extracted from whole sediment by centrifugation, and the supernatant was removed. The pore water samples were tested using the mussel embryo development test as described above. In addition to the testing of pore water, a "mini-TIE" was performed by adding EDTA to an aliquot of pore water from each station. (See Appendix B for test details.)

Split samples sent to SCCWRP in August for toxicity testing were also sent to CRG for metals and other analyses as described above. In November, additional samples were sent to SCCWRP for toxicity testing and only pore water samples were sent to CRG Marine Labs for metals analyses.

Data Analysis Methods

Data analysis was done using two different methods. The first is a basic determination of whether the data for each site exceeds the criteria selected for comparison. For water the criteria selected are the California Toxics Rule (CTR) water quality objectives for the Criterion Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC). For sediment the criteria selected are the NOAA SQRT objectives for the Threshold Effects Level (TEL), Effects Range Low (ERL) and Effects Range Medium (ERM). Table one details the type of sites associated with each marina and the toxicity testing done. The metals analyzed for exceedence and the corresponding objectives are detailed in the table two and three. Several metals including Nickel (Ni), Selenium (Se) and Tin (Sn) were included in the statistical analysis but were not analyzed for exceedences. The parameters measured other than metals are intended to support the metals and toxicity analysis and do not have criteria for comparison.

Table 1- Marina and channel sites and toxicity test sites.

Marinas	Marina Sites	Channel sites	Stormdrain or Shipyard sites	Toxicity sites – Aug	Porewater Toxicity sites - Nov	Sediment Toxicity & TIE sites - Nov
Newport Dunes	3	1	0	1	2	1(TIE) 4 Tox
De Anza	3	2	0	1	2	2 Tox
Balboa Yacht Basin	3	1	1 (SY)	1	1	
Bahia Corinthian	3	1	1 (SD)	1	1	
Harbor	2	1	1 (SD)	1	1	
Lido Village	3	1	0	1+ 1ch	1	
Lido Yacht Anchorage	3	1	0	1+ 1ch	1	
H&J Moorings	1	1	0	1	1	

Table 2 Water Criteria

Dissolved Metals CTR Saltwater Criteria (µg/L)		
Element	CMC	CCC
As (Arsenic)	69	36
Cd (Cadmium)	42	9.3
Cr-tot (Chromium –Total)	1100	50
Cu (Copper)	4.8	3.1
Pb (Lead)	210	8.1
Hg (Mercury)	1.8	.94
Ag (Silver)	1.9	
Se (Selenium)	290	71
Zn (Zinc)	90	81
Ni (Nickel)	74	8.2

Table 3 Sediment Criteria

NOAA SQRT VALUES (Sediment Criteria)(µg/dry g)			
Element	Salt TEL	Salt ERL	Salt ERM
As(Arsenic)	7.24	8.2	70
Cd (Cadmium)	0.067	1.2	9.6
Cr-tot(Chromium –Total)	52.3	81	370
Cu(Copper)	18.7	34	270
Pb (Lead)	30.2	46.7	218
Hg (Mercury)	0.13	0.15	0.71
Ag (Silver)	0.73	1	3.7
Zn (Zinc)	124	150	410

California Toxics Rule (CTR) criteria are the Criterion Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC). The sediment criteria are Threshold Effects Level (TEL), Effects Range Low (ERL) and Effects Range Medium (ERM).

In order to determine if observed differences in the data sets were truly significant, the second type of analysis done for this project was a statistical analysis of the data. Marina vs channel, marina vs. marina and dry vs. wet season data were compared statistically. This analysis was done with the SYSTAT 11 statistical analysis program using the Analysis of Variance (ANOVA) test with a Bonferroni Adjustment. Using this method we analyzed the data for all of the metals in the above tables to determine if the concentrations of metals in the water and sediment of the bay show identifiable patterns.

Results

Objective Exceedence Discussion

As described above, an evaluation for exceedence of CTR Dissolved Metals criteria and NOAA Sediment Quality criteria (SQRT) was conducted for all the metals in tables 2 and 3. The objectives used for determining an exceedence are the CCC (chronic) and CMC (acute) for dissolved metals in water and the

TEL, ERL and ERM for sediment. To aid in the identification of the exceedences found, table 4 below has been prepared detailing the number of exceedences for each metal at each marina and channel site for both the sediment and water standards. For this narrative we will limit the discussion of the analysis to the broad trends found in the data.

Water Column

Copper was the only metal to exceed CTR values, both the Criterion Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC) criteria. The CCC is used for long term exposure (chronic), while the CMC is intended as a short term maximum level (acute). Dissolved Copper concentrations exceeded the CCC level in all marinas (75% of marina samples) and in 5/9 channel sites (48% of channel samples). Samples at four of the eight channel sites (all at the west end of the bay) exceeded the CCC at least 50% of the time. CMC exceedences of Cu occurred at all marinas, except Newport Dunes and Bahia Corinthian (30% of marina samples), and at the Harbor, Lido Village, and Lido Yacht Anchorage channel sites (15% of channel samples). The marinas with exceedences of the CMC for Cu for more than 50% of the samples were confined to the west Newport Bay area containing the Lido Village, and Lido Yacht Anchorage marinas

Sediment

The Sediment data was analyzed against the TEL, ERL and ERM criteria. The TEL criteria are the most protective and the USEPA was initially using TELs for TMDL work; the ERL criteria are only slightly higher. The ERM criteria are the most significant from a regulatory perspective as they are the sediment criteria used by the State to list an impaired waterbody. Since the ERMs denote impairment, the ERLs are the criteria of choice for TMDLs since they are more protective of waterbodies than the ERMs. The sediment data shows concentrations above the TEL in at least 50% of the samples for As, Cd, Cu, and Zn in all of the marinas and for Pb and Hg in four of the eight marinas (all at the west end of the bay). At the channel sites, the data shows concentrations above the TEL in at least 50% of the samples for Cd, Cu and Zn at all channel sites and for As and Hg at five of the eight channel sites.

While the ERL criteria are not much higher than the TEL, it made a big difference in the number of exceedences. There were reductions in the number of exceedences for all metals discussed above with As, Cd and Cr and Pb seeing the largest reductions in exceedences; however, all of the metals that exceeded the TEL also exceeded the ERL in both the marina and channel sites, just at fewer sites. The following marinas and the adjacent channels had exceedences of the ERLs for the metals listed for over 50% of the samples:

Newport Dunes marina Cd(100%) Cu (100%) Zn (77.8%), (<50% -As)

Newport Dunes Channel Cu (100%); (<50% -Cd, Zn)

De Anza marina; As (66.7) Cd (55.6%), Cu (100%) Zn (100%), (<50% -Hg)

De Anza inner channel Cu (100%), Zn (66.7%), (<50% -As, Cd)

Balboa Yacht Basin marina; As (88.99%), Cu (88.9%), Hg (100%) Zn (88.9%),

Balboa Yacht Basin Channel; Cu (100%), Hg (66.7%) Zn (100%), (<50% -As)

Bahia Corinthian marina; As (77.8%),Cd (88.9%),Cu (100%),Zn (100%), (<50% -Hg)

Bahia Corinthian channel; Cu (100%),Hg (100%), (<50% -Hg)

Harbor marina; As(83.3%), Cd(83.3%), Cu(83.3%), Pb(66.7%), Zn, (83.3%) (<50% -Hg)

Harbor marina channel; As(100%), Cd(66.7%), Cu(100%), Pb(66.7%), Hg(100%), Zn, (100%),

Lido Village marina; As(100%), Cu(100%), Pb(66.7%), Hg(100%),Zn, (100%),

Lido village channel; As(66.7%), Cu(100%), Hg(100%), Zn, (66.7%), (<50% -Pb)

Lido Yacht Anchorage; As(100%), Cu(100%), Hg(100%),Zn, (100%), (<50% -Cd, Pb)

Lido Yacht Anchorage channel; As(100%), Cu(100%), Hg(100%),Zn, (100%), (<50% -Cd, Pb)

H&J Mooring; As(77.8%), Cu(100%), Hg(100%),Zn, (100%),

H&J Mooring channel; As(100%), Cu(100%), Hg(100%),Zn, (100%) (<50% -Cd).

The ERM criteria are significantly higher than the TEL or ERL. This is also the criteria used by the State Water Resources Control Board for impaired waterbody listing purposes. At the ERM level only Cu, Hg, and Zn still exceeded the criteria. With the exception of Hg (22%) in the Balboa Yacht Basin Marina and Cu (11%) in Bahia Corinthian Marina, all of the exceedences occurred in the West Newport area. At Harbor Marina, the samples collected exceeded for Cu (33%),Hg (16%), and Zn (66%) in the marina and Hg (33%) at the channel site. In Lido Village Marina the samples collected exceeded for Hg (33%) equally in the marina and channel sites. At Lido Yacht Anchorage samples collected exceeded for Cu (89%), Hg (100%) and Zn (66%) in the marina and Hg (100%) exceeded at the channel site. At the H&J Moorings the samples collected exceeded for Hg (44%) and Zn (11%) in the moorings, but there were no exceedences at the channel site.   The overall exceedence analysis shows that dissolved copper concentrations exceeded the CTR, CCC, and CMC criteria in the bay water at most marinas and some channel sites; Cu, Hg, and Zn exceeded the ERMs, and Cu, As, Cd, Cr, Hg, Pb, Zn exceeded both the TELs and ERLs in the bay sediments. Additionally Cu, Hg, and Zn are elevated in West Newport Bay marinas at levels high enough to meet the impaired waterbody listing requirements for marine sediment.

Graphs for dissolved copper and the metals exceeding the ERL in sediment discussed above are presented in graph set 1. An examination of the graphs shows that metal concentrations are significantly higher in the marinas and channel sites in the west end of the Lower Bay.

Table 4 Exceedences of CTR (Dissolved) and SQRT (Sediment) objectives

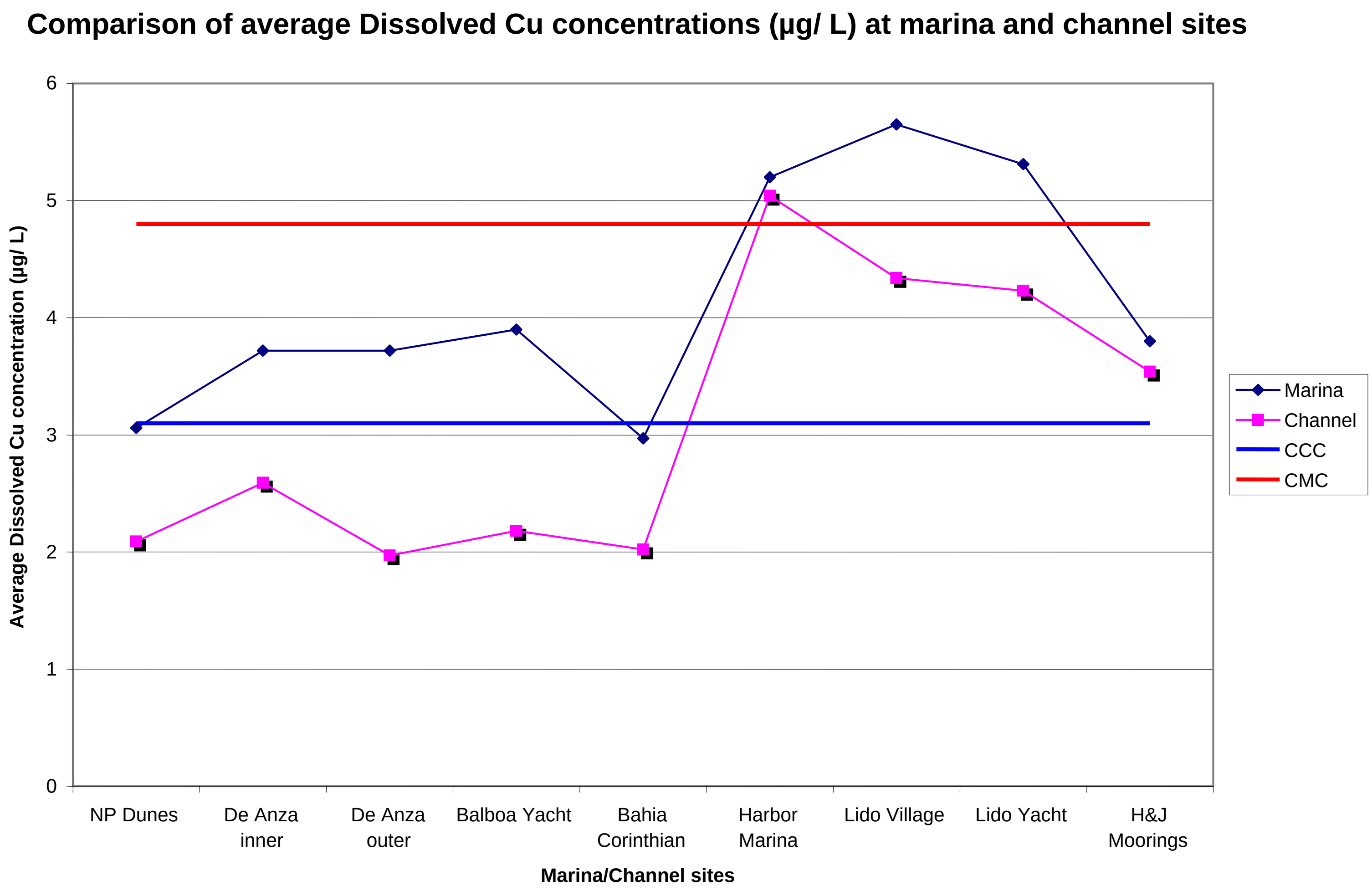
Sample Site	Newport Dunes Sediment (TEL)/(ERL)/(ERM)	Newport Dunes Dissolved [CCC/CMC]	Newport Dunes (Channel) Sediment (TEL/ERL/ERM)	Newport Dunes (Channel) Dissolved [CCC/CMC]	De Anza Marina Sediment [TEL/ERL/ERM]	De Anza Marina Dissolved [CCC/CMC]	De Anza Marina Channel (IN) Sediment [TEL/ERL/ERM]
Arsenic (As)	7/9;2/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	9/9;6/9;0/9	0/9;0/9	1/3;1/3;0/3
Cadmium (Cd)	9/9;9/9;0/9	0/9;0/9	3/3;1/3;0/3	0/3;0/3	9/9;5/9;0/9	0/9;0/9	3/3;1/3;0/3
Chromium (Cr)	2/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	1/9;0/9;0/9	0/9;0/9	1/3;1/3;0/3
Copper (Cu)	9/9;9/9;0/9	5/9;0/9	3/3;3/3;0/3	0/3;0/3	9/9;9/9;0/9	6/9;2/9	3/3;3/3;0/3
Lead (Pb)	0/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	0/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3
Mercury (Hg)	0/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	1/9;1/9;0/9	0/9;0/9	0/3;0/3;0/3
Nickel (Ni)		0/9;0/9		0/3;0/3		0/9;0/9	
Silver (Ag)	0/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	0/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3
Zinc (Zn)	9/9;7/9;0/9	0/9;0/9	2/3;1/3;0/3	0/3;0/3	9/9;9/9;0/9	0/9;0/9	2/3;2/3;0/3

Sample Site	De Anza Marina (Channel IN) Dissolved [CCC/CMC]	De Anza Marina (Channel OUT) Sediment [TEL/ERL/ERM]	De Anza Marina (Channel OUT) Dissolved [CCC/CMC]	Balboa Yacht Basin Sediment [TEL/ERL/ERM]	Balboa Yacht Basin Dissolved [CCC/CMC]	Balboa Yacht Basin (Channel) Sediment [TEL/ERL/ERM]	Balboa Yacht Basin (Channel) Dissolved [CCC/CMC]	Bahia Corinthian Sediment [TEL/ERL/ERM]	Bahia Corinthian Dissolved [CCC/CMC]
Arsenic (As)	0/3;0/3	0/3;/03;0/3	0/3;0/3	8/9;8/9;0/9	0/9;0/9	3/3;1/3;0/3	0/3;0/3	7/9;7/9;0/9	0/9;0/9
Cadmium (Cd)	0/3;0/3	3/3;0/3;0/3	0/3;0/3	9/9;0/9;0/9	0/9;0/9	3/3;0/3;0/3	0/3;0/3	9/9;8/9;0/9	0/9;0/9
Chromium (Cr)	0/3;0/3	0/3;0/3;0/3	0/3;0/3	1/9;0/9;0/9	0/9;0/9	1/3;0/3;0/3	0/3;0/3	2/9;0/9;0/9	0/9;0/9
Copper (Cu)	2/3;0/3	3/3;1/3;0/3	0/3;0/3	8/9;8/9;0/9	6/9;3/9	3/3;3/3;0/3	0/3;0/3	9/9;9/9;1/9	5/9;0/9
Lead (Pb)	0/3;0/3	0/3;0/3;0/3	0/3;0/3	3/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	1/9;0/9;0/9	0/9;0/9
Mercury (Hg)	0/3;0/3	0/3;0/3;0/3	0/3;0/3	9/9;9/9;2/9	0/9;0/9	3/3;2/3;0/3	0/3;0/3	2/9;2/9;0/9	0/9;0/9
Nickel (Ni)	0/3;0/3		0/3;0/3		0/9;0/9		0/3;0/3		0/9;0/9
Silver (Ag)	0/3;0/3	0/3;0/3;0/3	0/3;0/3	0/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	0/9;0/9;0/9	0/9;0/9
Zinc (Zn)	0/3;0/3	0/3;0/3;0/3	0/3;0/3	8/9;8/9;0/9	0/9;0/9	3/3;3/3;0/3	0/3;0/3	9/9;9/9;0/9	0/9;0/9

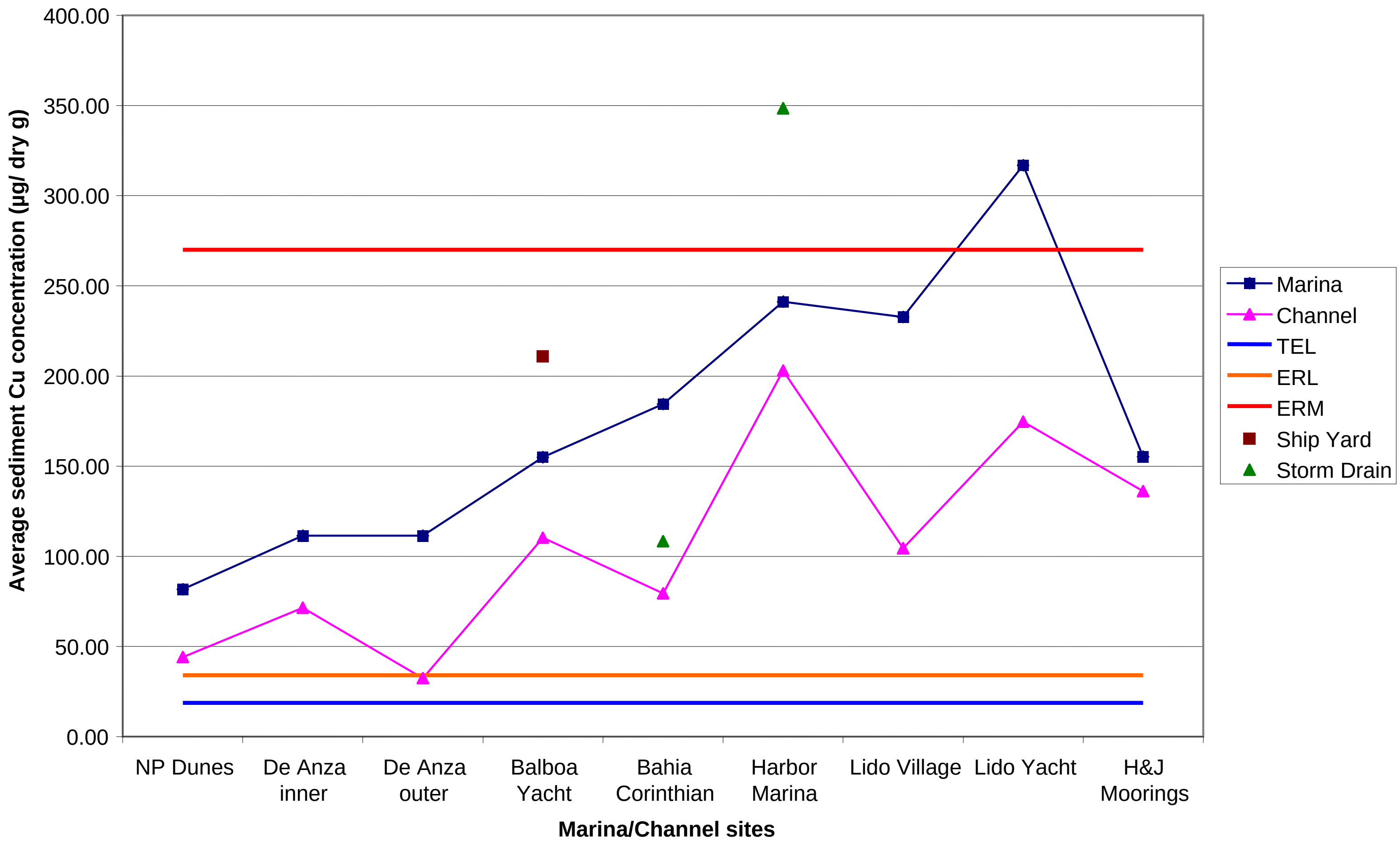
Sample Site	Bahia Corinthian (Channel) Sediment [TEL/ERL/ERM]	Bahia Corinthian (Channel) Dissolved [CCC/CMC]	Harbor Marina Sediment [TEL/ERL/ERM]	Harbor Marina Dissolved [CCC/CMC]	Harbor Marina (Channel) Sediment [TEL/ERL/ERM]	Harbor Marina (Channel) Dissolved [CCC/CMC]	Lido Village Sediment [TEL/ERL/ERM]	Lido Village Dissolved [CCC/CMC]	Lido Village (Channel) Sediment
Arsenic (As)	0/3;0/3;0/3	0/3;0/3	5/6;5/6;0/6	0/6;0/6	3/3;3/3;0/3	0/3;0/3	9/9;9/9;0/9	0/9;0/9	2/3;2/3;0/3
Cadmium (Cd)	3/3;0/3;0/3	0/3;0/3	6/6;5/6;0/6	0/6;0/6	3/3;2/3;0/3	0/3;0/3	9/9;0/9;0/9	0/9;0/9	3/3;0/3;0/3
Chromium (Cr)	0/3;0/3;0/3	0/3;0/3	1/6;0/6;0/6	0/6;0/6	1/3;0/3;0/3	0/3;0/3	2/9;0/9;0/9	0/9;0/9	1/3;0/3;0/3
Copper (Cu)	3/3;3/3;0/3	0/3;0/3	6/6;5/6;2/6	6/6;2/6	3/3;3/3;0/3	3/3;1/3	9/9;9/9;0/9	9/9;6/9	3/3;3/3;0/3
Lead (Pb)	0/3;0/3;0/3	0/3;0/3	4/6;4/6;0/6	0/6;0/6	2/3;2/3;0/3	0/3;0/3	6/9;6/9;0/9	0/9;0/9	1/3;1/3;0/3
Mercury (Hg)	3/3;3/3;0/3	0/3;0/3	3/6;2/6;1/6	0/6;0/6	3/3;3/3;1/3	0/3;0/3	9/9;9/9;3/9	0/9;0/9	3/3;3/3;1/3
Nickel (Ni)		0/3;0/3		0/6;0/6		0/3;0/3		0/9;0/9	
Silver (Ag)	0/3;0/3;0/3	0/3;0/3	0/6;0/6;0/6	0/6;0/6	1/3;1/3;0/3	0/3;0/3	3/9;3/9;0/9	0/9;0/9	1/3;1/3;0/3
Zinc (Zn)	0/3;0/3;0/3	0/3;0/3	5/6;5/6;4/6	0/6;0/6	3/3;3/3;0/3	0/3;0/3	9/9;9/9;0/9	0/9;0/9	2/3;2/3;0/3

Sample Site	Lido Village (Channel) Dissolved [CCC/CMC]	Lido Yacht Anchorage Sediment [TEL/ERL/ERM]	Lido Yacht Anchorage Dissolved [CCC/CMC]	Lido Yacht Anchorage (Channel) Sediment [TEL/ERL/ERM]	Lido Yacht Anchorage (Channel) Dissolved [CCC/CMC]	H & J Moorings Sediment [TEL/ERL/ERM]	H & J Moorings Dissolved [CCC/CMC]	H & J Moorings (Channel) Sediment [TEL/ERL/ERM]	H & J Moorings (Channel) Dissolved [CCC/CMC]
Arsenic (As)	0/3;0/3	9/9;9/9;0/9	0/9;0/9	3/3;3/3;0/3	0/3;0/3	8/9;7/9;0/9	0/9;0/9	3/3;3/3;0/3	0/3;0/3
Cadmium (Cd)	0/3;0/3	9/9;4/9;0/9	0/9;0/9	3/3;0/3;0/3	0/3;0/3	9/9;0/9;0/9	0/9;0/9	3/3;1/3;0/3	0/3;0/3
Chromium (Cr)	0/3;0/3	3/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	0/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3
Copper (Cu)	3/3;2/3	9/9;9/9;8/9	9/9;6/9	3/3;3/3;0/3	3/3;1/3	9/9;9/9;0/9	6/9;2/9	3/3;3/3;0/3	2/3;0/3
Lead (Pb)	0/3;0/3	6/9;3/9;0/9	0/9;0/9	2/3;0/3;0/3	0/3;0/3	5/9;0/9;0/9	0/9;0/9	1/3;0/3;0/3	0/3;0/3
Mercury (Hg)	0/3;0/3	9/9;9/9;9/9	0/9;0/9	3/3;3/3;3/3	0/3;0/3	9/9;9/9;4/9	0/9;0/9	3/3;3/3;0/3	0/3;0/3
Nickel (Ni)	0/3;0/3		0/9;0/9		0/3;0/3		0/9;0/9		0/3;0/3
Silver (Ag)	0/3;0/3	2/9;2/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3	0/9;0/9;0/9	0/9;0/9	0/3;0/3;0/3	0/3;0/3
Zinc (Zn)	0/3;0/3	9/9;9/9;4/9	0/9;0/9	3/3;3/3;0/3	0/3;0/3	9/9;9/9;1/9	0/9;0/9	3/3;3/3;0/3	0/3;0/3

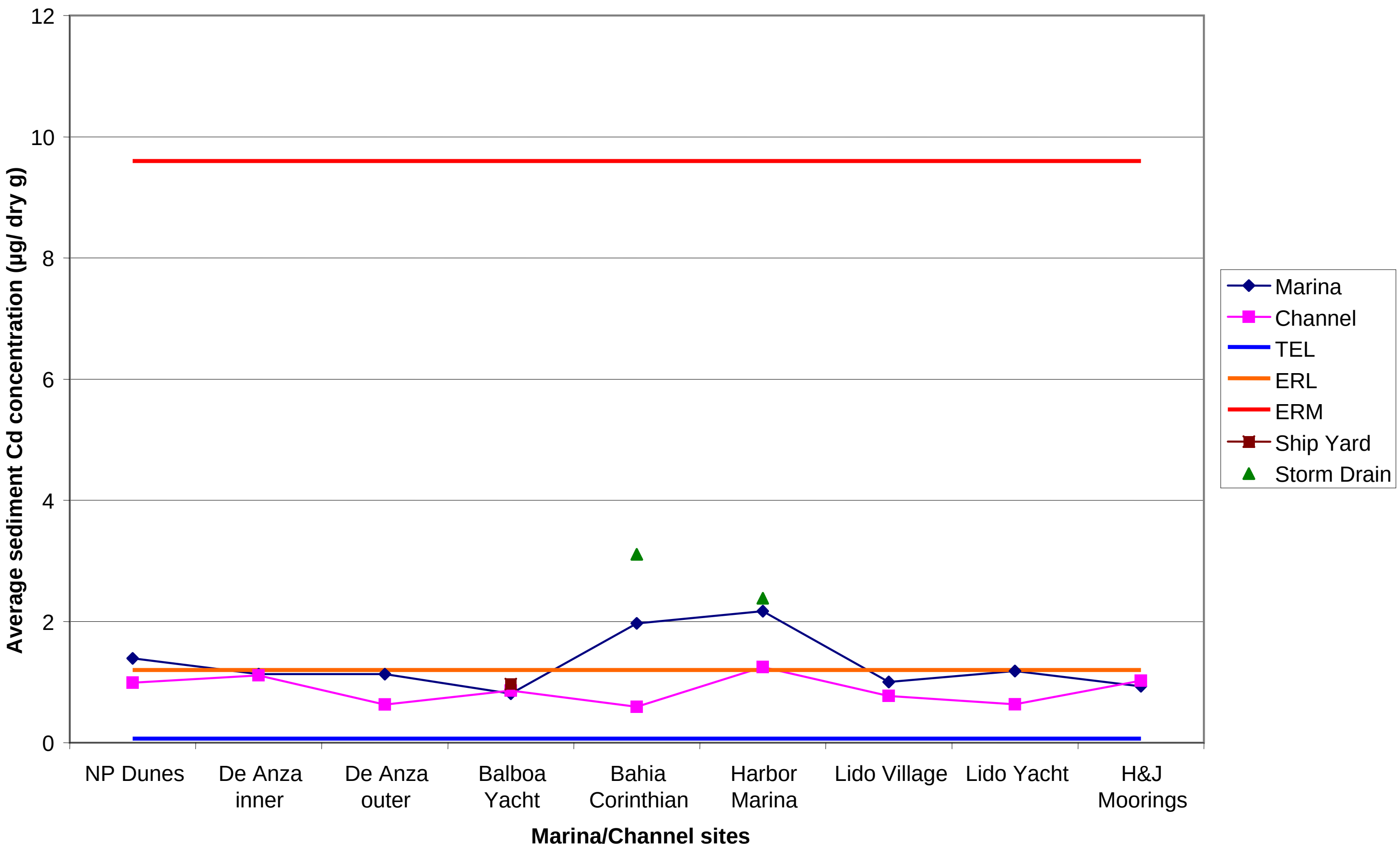
Graph set 1 Average Dissolved and Sediment Metals Concentrations



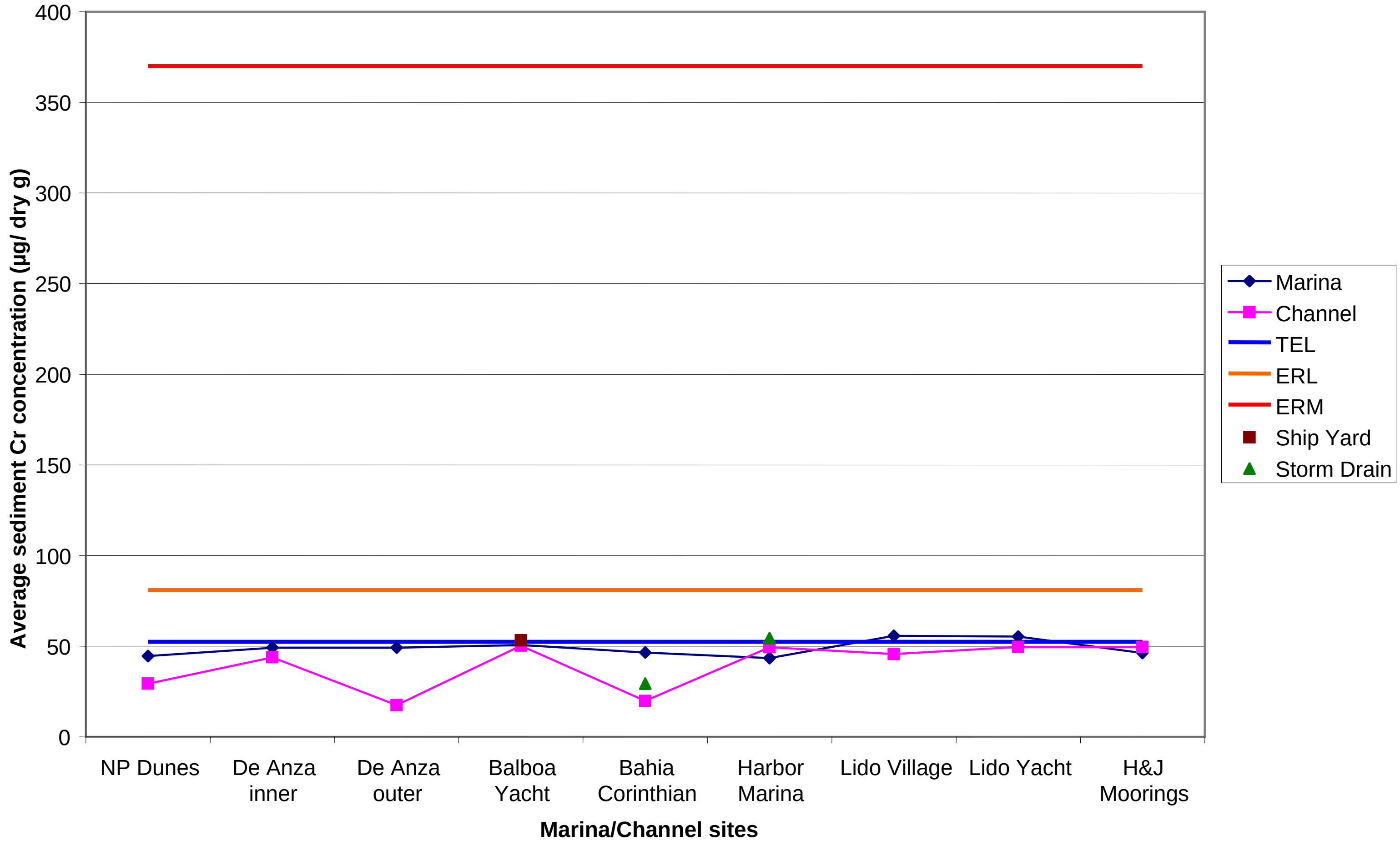
Comparison of average sediment Cu concentrations (µg/ dry g) at marina and channel sites



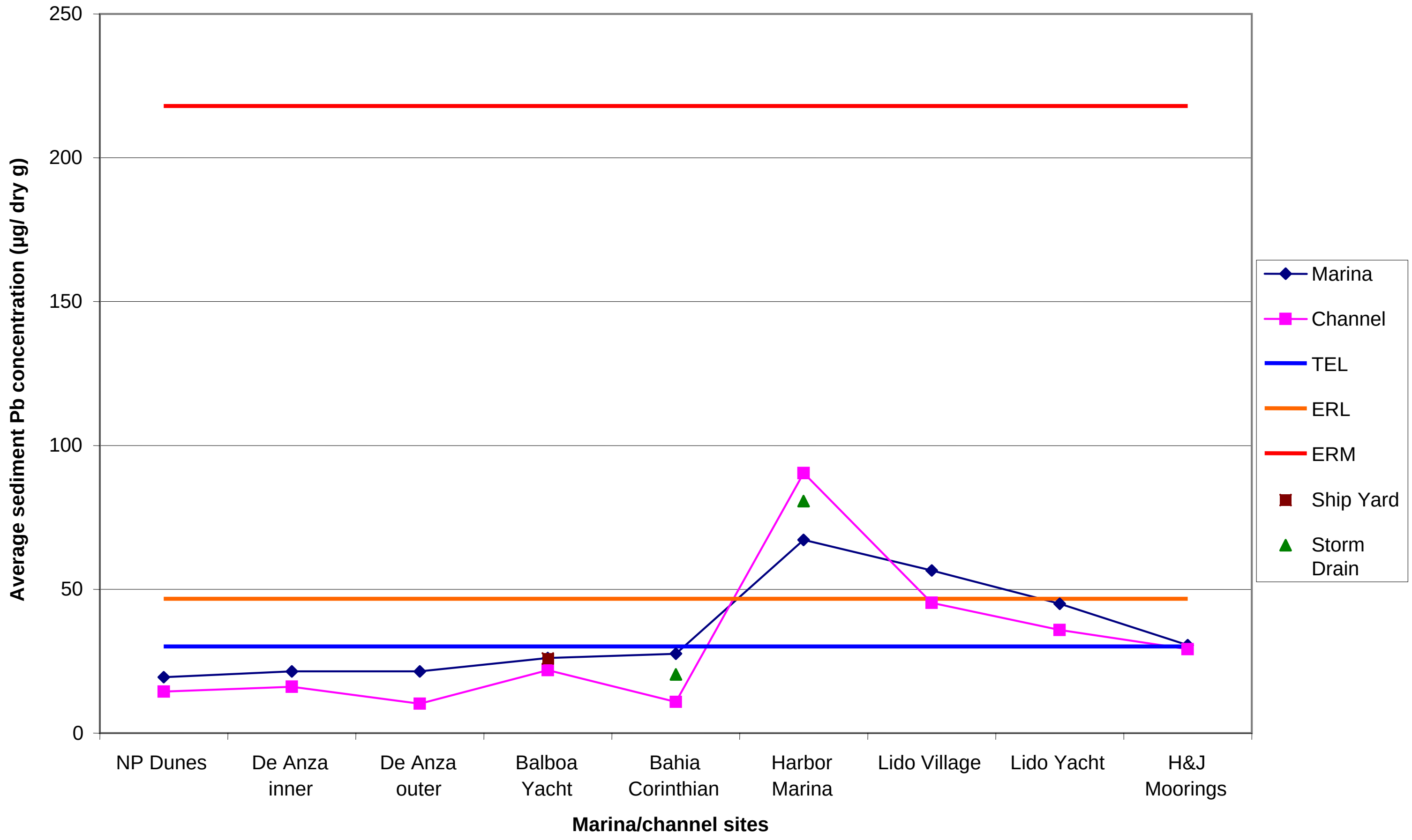
Comparison of average sediment Cd concentrations (µg/ dry g) at marina and channel sites

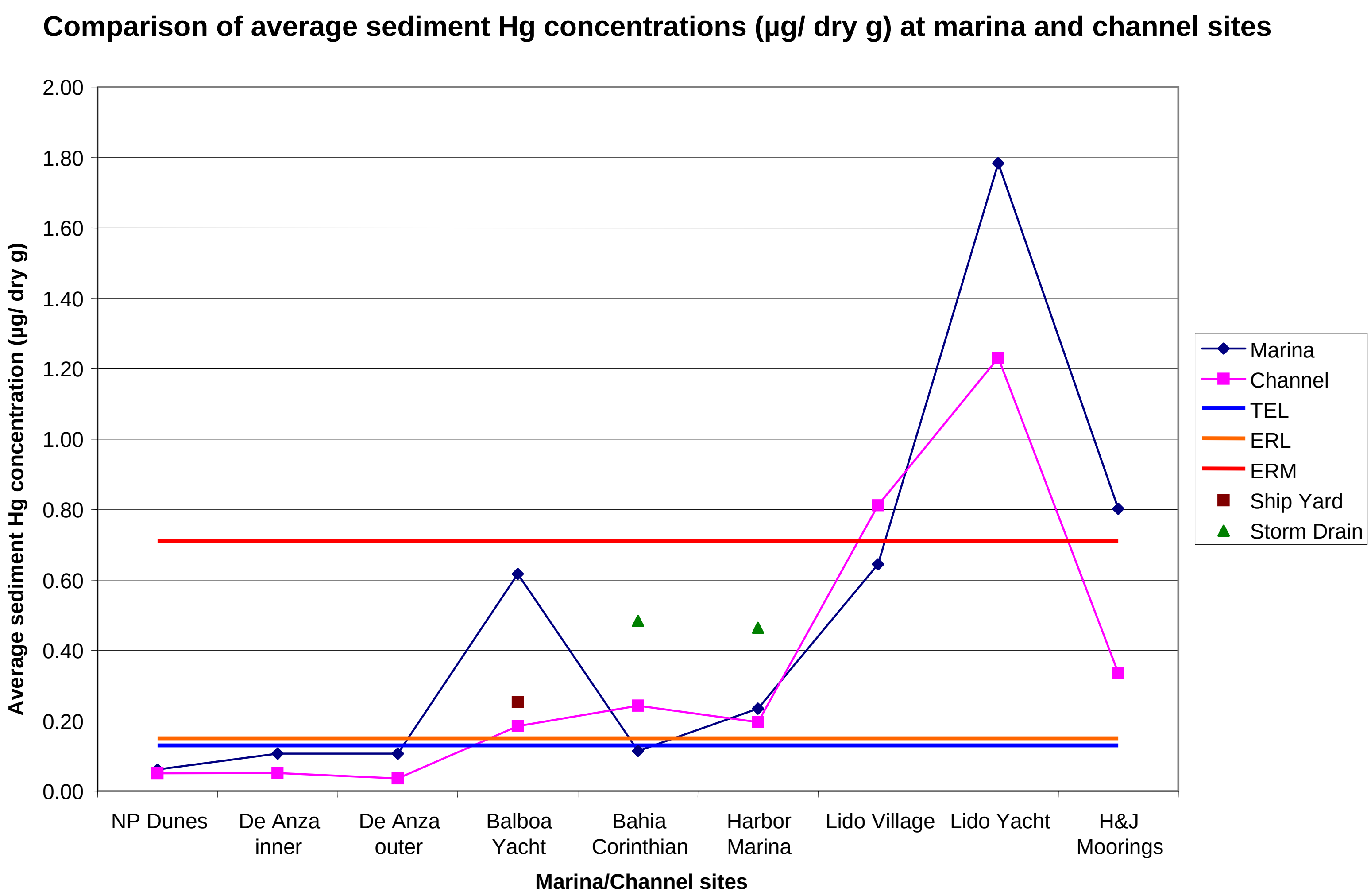


Comparison of average sediment Cr concentrations (µg/ dry g) at marina and channel sites



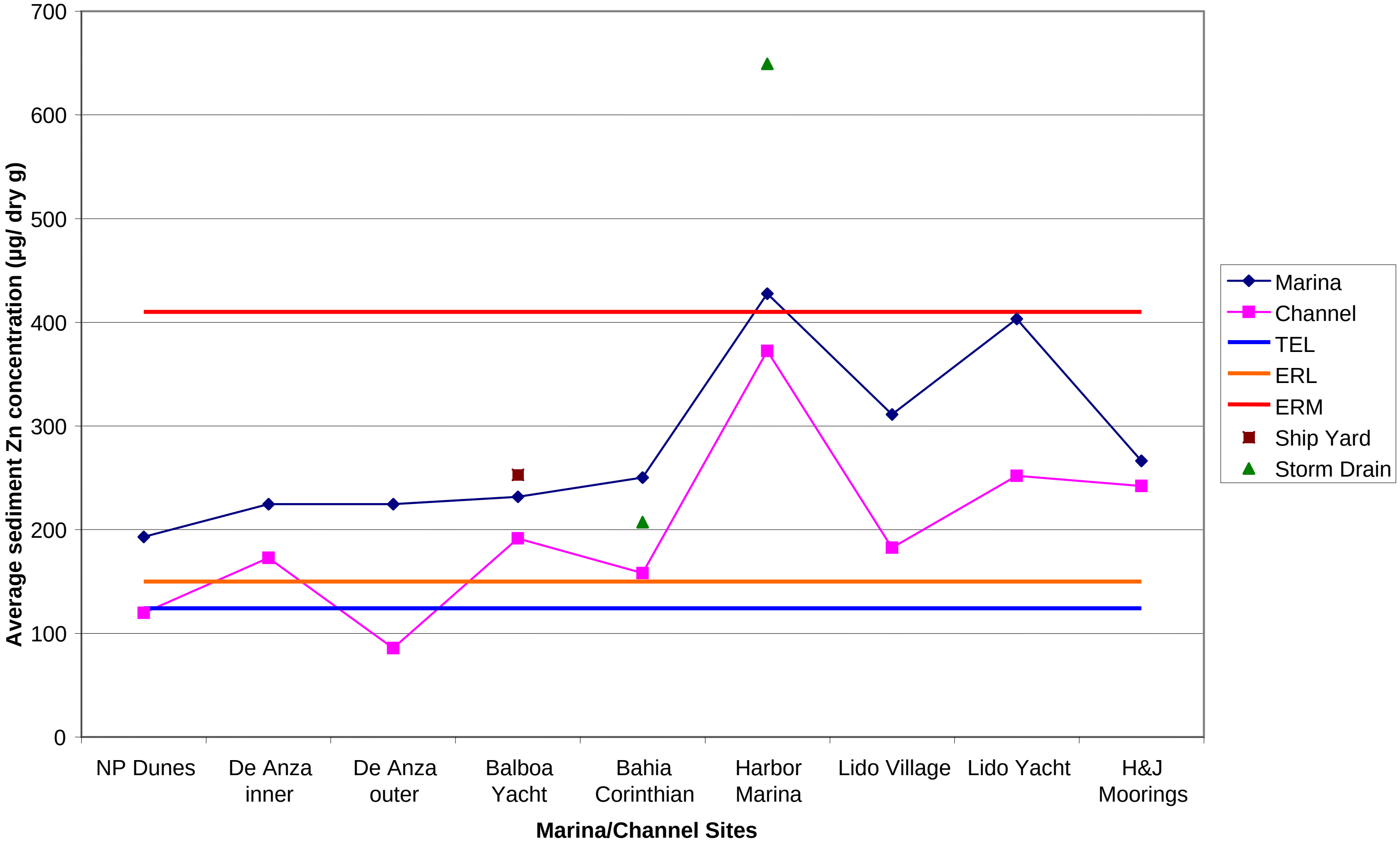
Comparison of average sediment Pb concentrations (µg/ dry g) at marina and channel sites



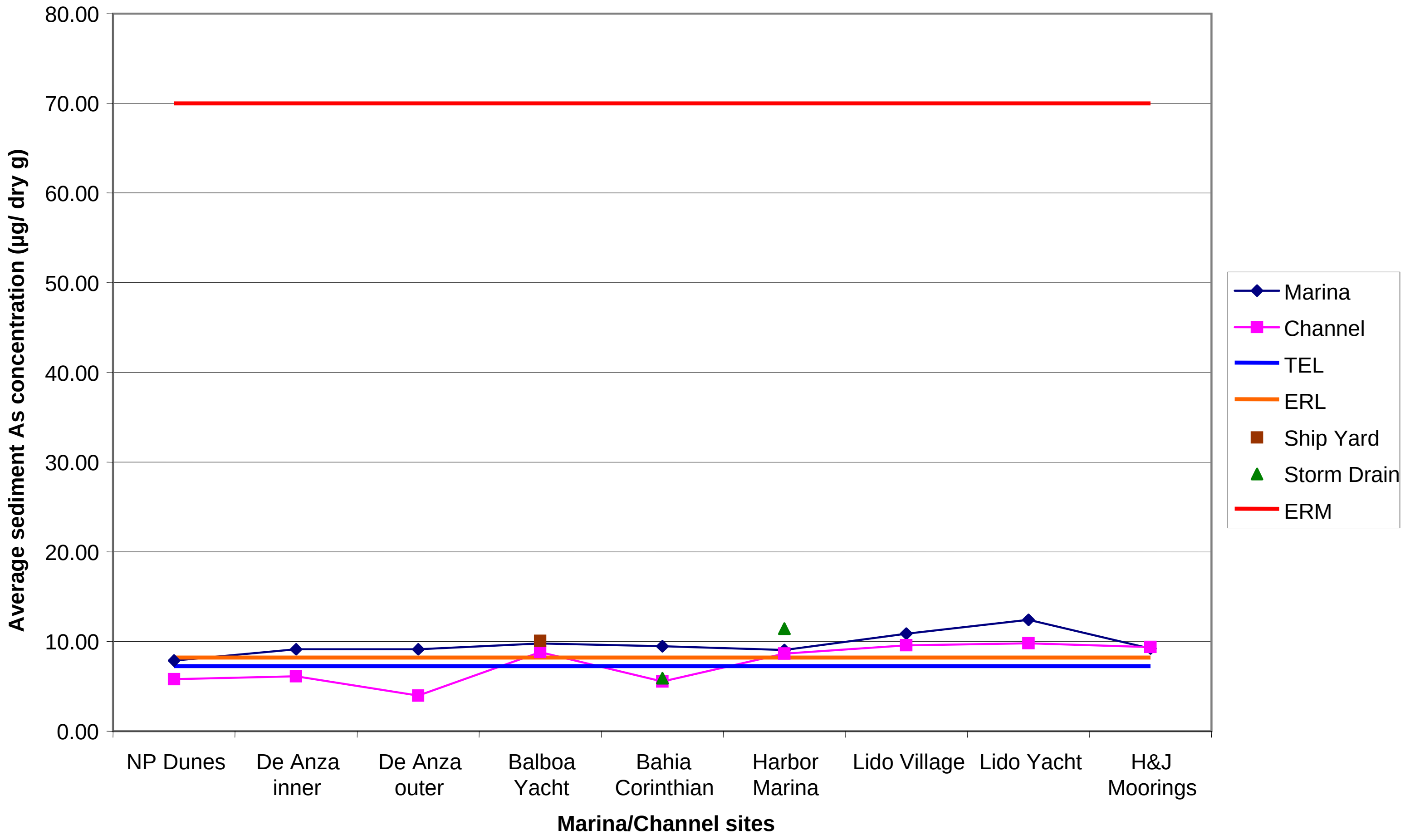


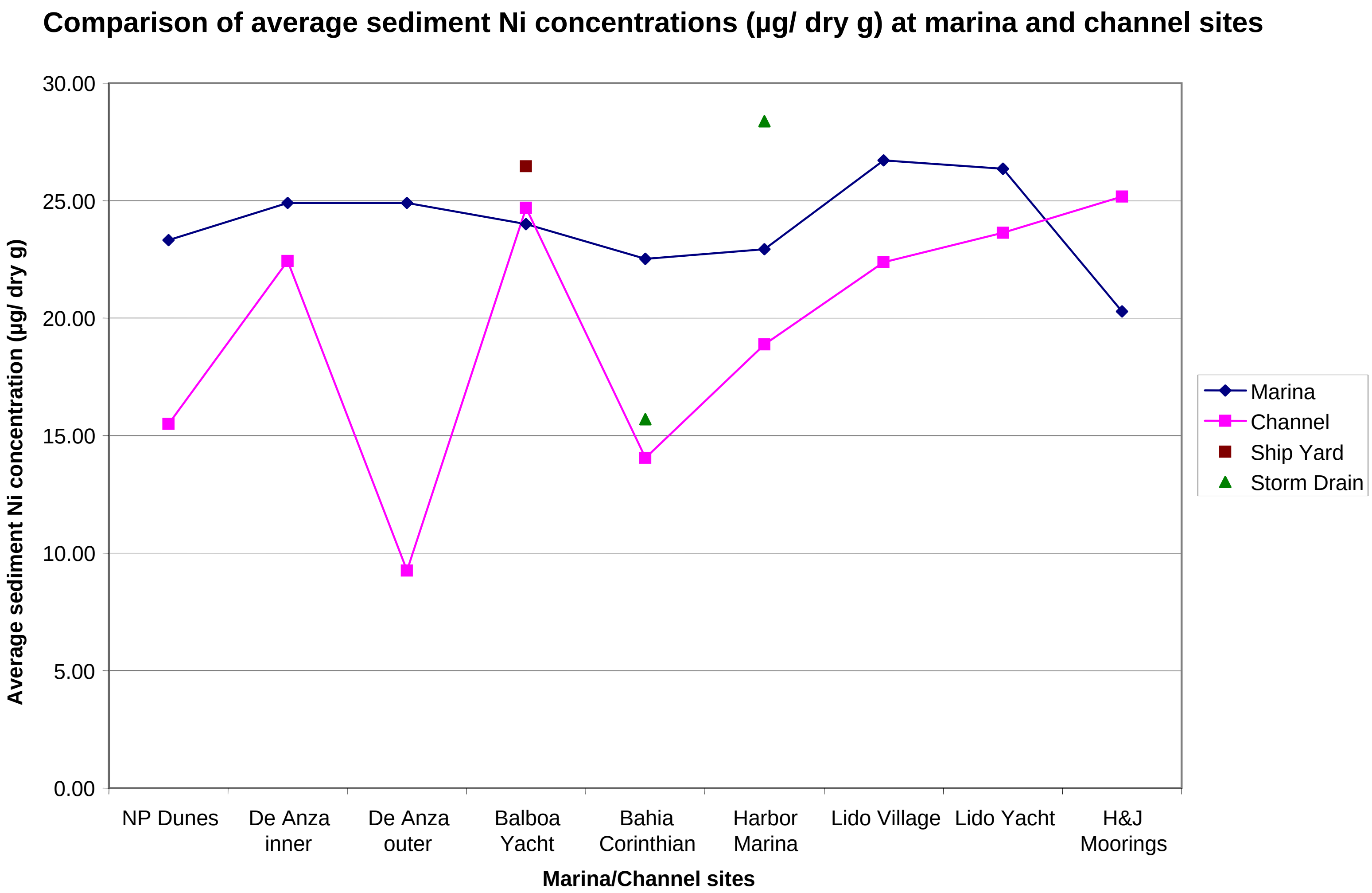
Comparison of average sediment Hg concentrations (µg/ dry g) at marina and channel sites
Average sediment Hg concentration (µg/ dry g)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
NP Dunes
De Anza inner
De Anza outer
Balboa Yacht
Bahia Corinthian
Harbor Marina
Lido Village
Lido Yacht
H&J Moorings
Marina/Channel sites
Marina
Channel
TEL
ERL
ERM
Ship Yard
Storm Drain

Comparison of average sediment Zn concentrations (µg/ dry g) at marina and channel sites

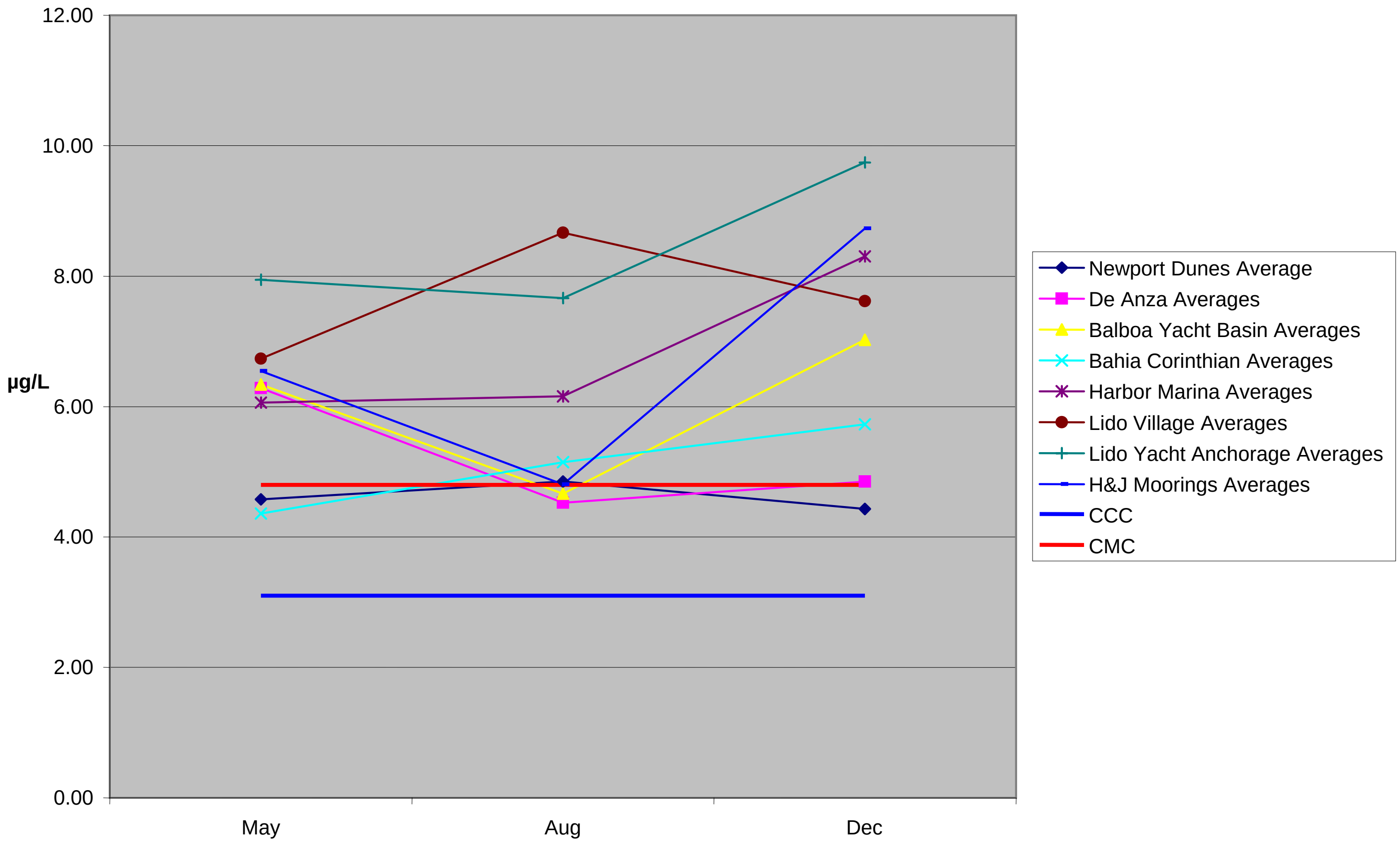


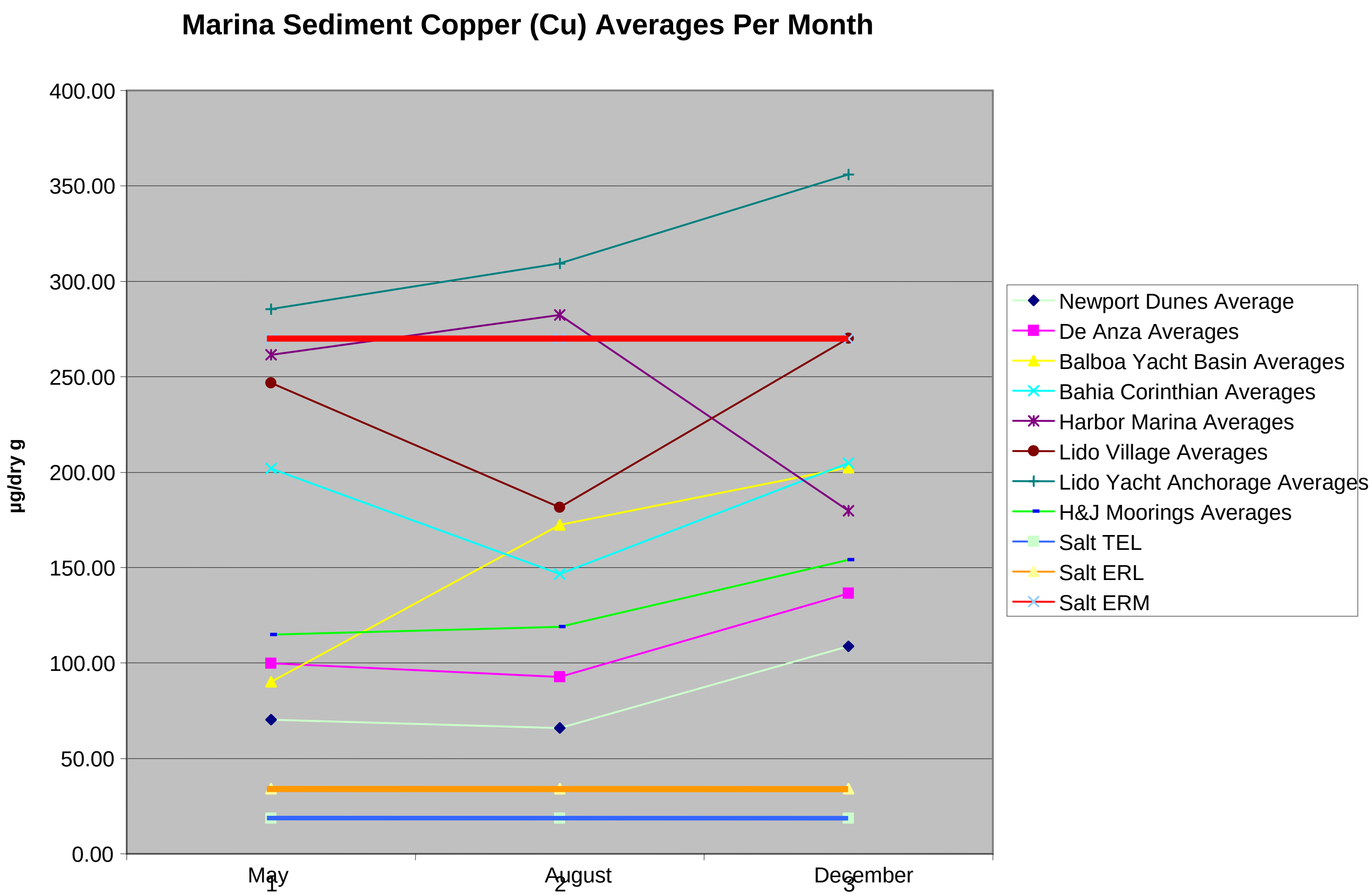
Comparison of average sediment As concentrations (µg/ dry g) at marina and channel sites




Comparison of average sediment Ni concentrations (µg/ dry g) at marina and channel sites
Average sediment Ni concentration (µg/ dry g)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
NP Dunes
De Anza inner
De Anza outer
Balboa Yacht
Bahia Corinthian
Harbor Marina
Lido Village
Lido Yacht
H&J Moorings
Marina/Channel sites
Marina
Channel
Ship Yard
Storm Drain

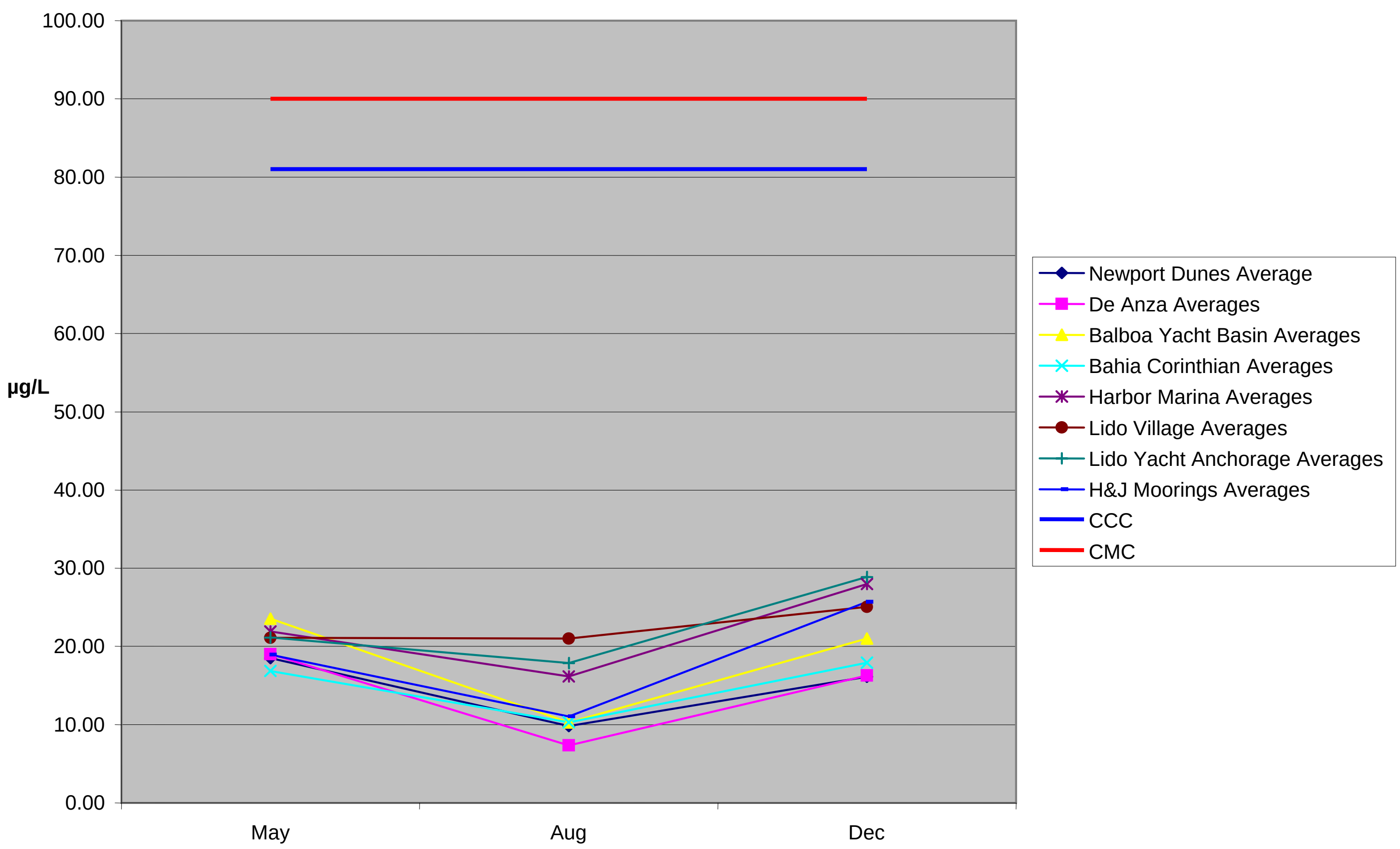
Marina Dissolved Copper (Cu) Averages Per Month



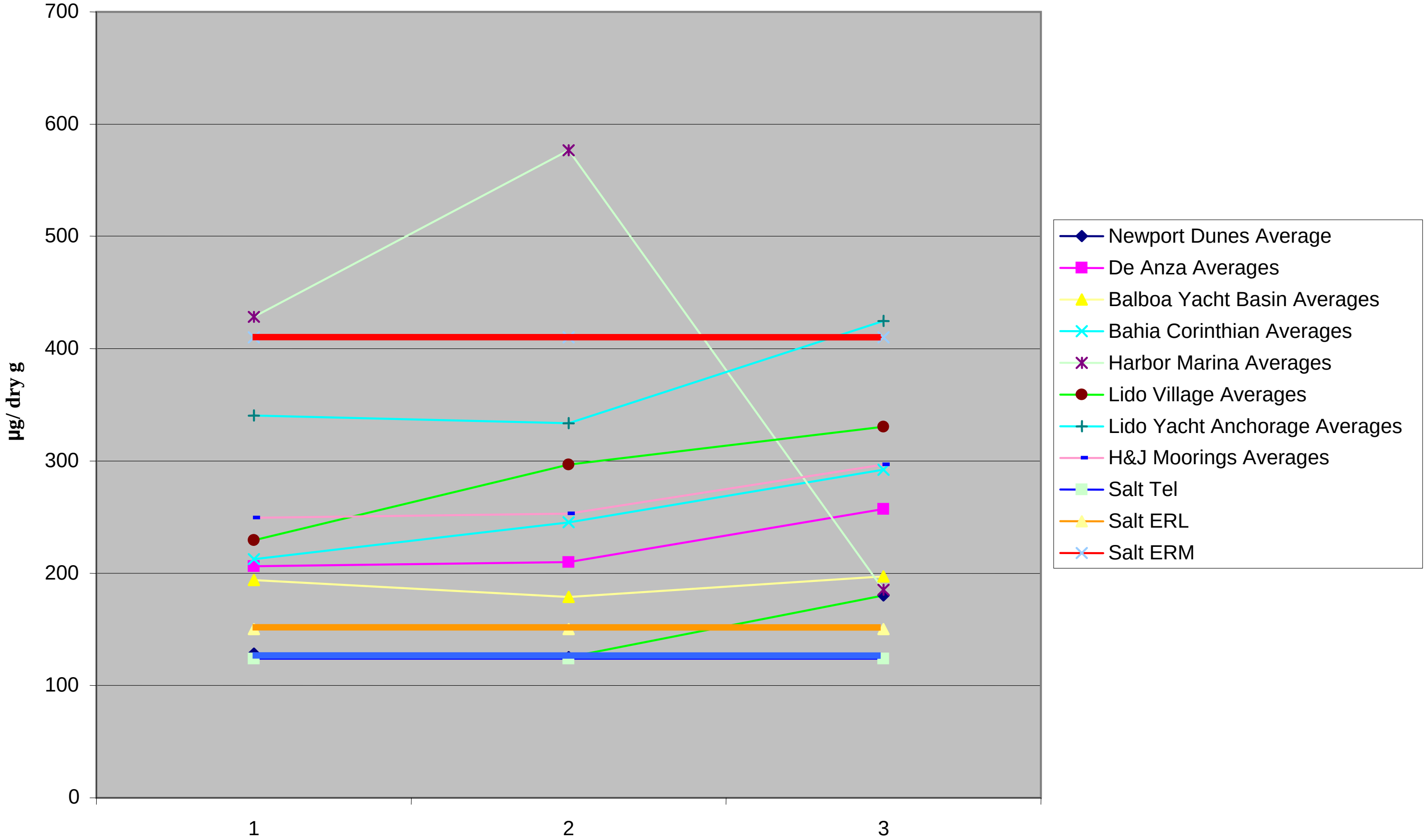


Marina Sediment Copper (Cu) Averages Per Month
µg/dry g
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
May
1
August
2
December
3
Newport Dunes Average
De Anza Averages
Balboa Yacht Basin Averages
Bahia Corinthian Averages
Harbor Marina Averages
Lido Village Averages
Lido Yacht Anchorage Averages
H&J Moorings Averages
Salt TEL
Salt ERL
Salt ERM

Marina Dissolved Zinc (Zn) Averages Per Month



Marina Sediment Zinc (Zn) Averages Per Month



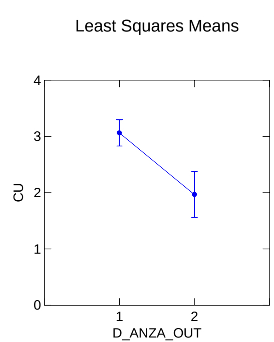
Statistical Analysis Discussion

A statistical analysis was conducted to determine if the observed differences in the data sets from various project sites were truly significant. The analysis focused on differences in metals concentrations in four scenarios: marina sites vs. their adjacent channel site, differences between project marina sites (Marina Vs. Marina), marinas with storm drains or shipyards vs. marinas without, and wet weather vs. dry weather data. For each of the scenarios, the results of the statistical analysis is discussed separately for dissolved metals and sediment metals, with the dissolved metals discussed first.

Marinas vs. Adjacent Channel Sites

The dissolved and sediment metals (listed in table 2 and 3) in marina samples were compared to those in adjacent channel samples.

The analysis found that for **dissolved** metals there were no significant differences in metal concentrations between the marina and channels sites except at De Anza Marina, where the outer channel site (separated by an island from the marina) showed a significant difference in copper concentrations from the marina. Since copper was the only dissolved metal to exceed the CTR criteria, the lack of a significant difference between the marina and channel sites suggests that copper from the boats in the marinas is not being quickly diluted as it leaves the marinas. The graph below illustrates the output from the statistical program used for DeAnza marina vs outer channel.



The same analysis for metal concentrations in **sediment** samples from the marinas and adjacent channel sites shows a different pattern. Five marinas had significant differences in metal concentrations between the marina and channel sites; however, the metals with significant differences differed depending on the marina examined. A significant difference occurred in sediment metal concentrations between the marina and channel sites at Newport Dunes for Cd, Cr, Cu, Pb, and Zn; at Bahia for all metals tested except Ag; at Lido Village for Cu and Zn; at Lido Yacht Anchorage for As, Cd, Cu, Pb, Zn; and at DeAnza In for Pb and DeAnza Out for all metals tested. De Anza was designed with two channel sites (De Anza (In) and De Anza (Out)) on either side of a small island that separates the marina from the main channel. This gave us an opportunity to see if a physical barrier would make a difference in the channel data. For the DeAnza (In) site Pb was the only metal that was significantly different in the marina and channel sites. At the De Anza (Out) site there was a significant difference from the marina in all of the metals analyzed. This suggests that the physical barrier may be restricting the movement of contaminated sediment from the marina or that Cu and Zn from boats is settling in marina sediments. All of the significant differences in marinas vs. channels are summarized in table 3. There was no significant difference in sediment metal concentrations between marina and channel sites at Balboa Yacht Basin, Harbor marina, and H and J moorings. This was likely due to high metal concentrations in both marina and channel sites; for example, the Cu ERL was exceeded in marina and channel sites at BYB (9/9 marina, 3/3 channel, 3/3 shipyard), at Harbor (5/6 marina, 3/3 ch, 3/3 stormdrain) and H & J (9/9 marina, 3/3 ch). Other ERLs were also exceeded at both marinas and channels at these sites including As, Cu, Hg, Zn at BYB, Harbor and H&J, and Cd and Pb at Harbor. (ERMs were exceeded for both marinas and channels for Hg at Harbor, Lido Village, and Lido Yacht Anchorage. (ERMs were exceeded for ‘marinas only’ for Cu at Harbor, Lido Yacht Anchorage and Bahia; for Zn at Harbor, Lido Yacht Anchorage and H&J moorings; and for Hg at H&J moorings and Balboa Yacht Basin.) Table 4 summarizes the significant differences found for dissolved and sediment metals between marinas and their adjacent channel site.

Marina vs. Marina

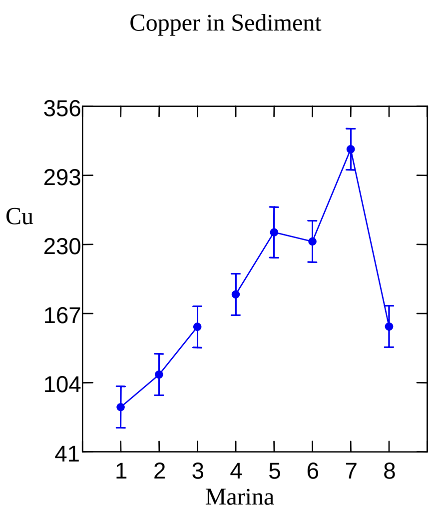
The dissolved and sediment metals (listed in table 2 and 3) in samples within each marina were compared to all the other marinas individually, and there are very clear patterns. (Channel data comparison was not analyzed.) The findings for dissolved and sediment metals are discussed separately.

The analysis for **dissolved** metals shows that Copper and Zinc concentrations in Harbor, Lido Village and Lido Yacht Anchorage Marinas are significantly higher than the other marinas, although Zn concentrations are below the CTR water quality criteria. Cadmimum is significantly higher at Bahia Corinthian Marina than at all the other marinas, and Nickel concentrations were significantly higher at Newport Dunes and significantly lower at Balboa Yacht Basin than at all the other marinas. Selenium is significantly higher at Newport Dunes and De Anza than at all the other marinas. For the other dissolved metals, there are no significant differences in the data between marinas.

The analysis for **sediment** metals shows that metal concentrations for copper increase in a stepwise fashion from Newport Dunes to Harbor marina and level off at Lido Village before increasing significantly at Lido Yacht Anchorage Marina, then decreasing at the H&J mootings (see Statistical Graph on pg. 34). Sediment metals are significantly higher for Cd in Bahia Corinthian and Harbor marina, Cr in Lido Village and Lido Yacht Anchorage, Pb and Cu in Harbor, Lido Village, and Lido Yacht Anchorage marinas with Harbor Marina significantly higher than both of the others for Pb. For Hg, the Balboa Yacht Basin, Lido Village, and Lido Yacht Anchorage marinas and the H&J moorings show significantly higher levels than the other marinas with the concentrations at Lido Yacht Anchorage by far the highest. For Se and Ag, the Lido Village and Lido

Yacht Anchorage are significantly higher. Sn (not shown in tables) and Zn are higher at Harbor, Lido Village , and Lido Yacht Anchorage.

Table 5 summarizes the significant differences found for dissolved and sediment metals for the project marinas, and the graph below provides an example of the output from the statistical program for the Marina vs. Marina analysis for copper.



Stormdrains and shipyards

To determine if stormdrains or shipyards are significant factors in the concentration of metals in marinas or the adjacent channel sites, we included two marinas with large stormdrains, Harbor and Bahia Corinthian on opposite ends of the harbor, and one marina with a shipyard next door, Balboa Yacht Basin. With over two hundred stormdrains located throughout the bay, all of the marinas are affected by urban runoff. However, a few large stormdrains account for the majority of the stormdrain flow into the bay, and by including two in the project design the significance of the stormdrain contribution of metals in their respective marinas can be measured. Shipyards were also identified as potentially significant sources of metals (Shelter Island TMDL 2002). There are only six shipyards left in Newport bay with four of those located in the Rhine Channel area (not included in this study). The larger of the two shipyards located in the main body of the bay was included in the study to measure the impact it may have on the marina metal concentrations.

An examination of the marina vs. marina data described above, taking into account the location of the stormdrain and shipyard sites, shows the presence of a large stormdrain or shipyard in the marina to be insignificant with respect to dissolved and sediment metal concentrations compared to marinas without stormdrain or shipyard influence. The Balboa Yacht Basin marina where the shipyard is located and the Bahia Corinthian Marina, that has one of the major stormdrains, do not show a significant difference in most metal concentrations in either water or sediment from the majority of marinas. Harbor marina, the other marina with a major stormdrain, does show significantly higher concentrations of metals in both water and sediment compared to other marinas; this may be related to both the presence of the stormdrain and the geographic location of the marina in the west end of harbor (an area where circulation is poor). All of the marinas in the west end of the bay had elevated metal concentrations in marina and channel sediments (Harbor, Lido Village, Lido Yacht Anchorage and H&J Moorings). Lido Village and Lido Yacht Anchorage which do not have either of these structures in them also, have elevated metal concentrations with respect to other marinas, however, they are both near the stormdrain in Harbor marina and could be affected by flows from this stormdrain.

Table 4 Significant Differences Between Marina And Channel Sites

S= Marina sites metals concentration significantly were higher than channel sites metals concentration

N= no significant difference.

Sample Site	Newport Dunes Sediment	Newport Dunes Dissolved	De Anza IN Sediment	De Anza IN Dissolved	De Anza Out Sediment	De Anza Out Dissolved	Balboa Yacht Basin Sediment	Balboa Yacht Basin Dissolved	Bahia Corinthian Sediment	Bahia Corinthian Dissolved	Harbor Marina Sediment
Arsenic (As)	N	N	N	N	S	N	N	N	S	N	N
Cadmium (Cd)	S	N	N	N	S	N	N	N	S	N	N
Chromium (Cr)	S	N	N	N	S	N	N	N	S	N	N
Copper (Cu)	S	N	N	N	S	S	N	N	S	N	N
Lead (Pb)	S	N	S	N	S	N	N	N	S	N	N
Mercury (Hg)	N		N		S		N		S		N
Nickel (Ni)		N		N		N		N		N	
Silver (Ag)	N		N		S		N		N		N
Zinc (Zn)	S	N	N	N	S	N	N	N	S	N	N

Sample Site	Harbor Marina Dissolved	Lido Village Sediment	Lido Village Dissolved	Lido Yacht Anchorage Sediment	Lido Yacht Anchorage Dissolved	H & J Moorings Sediment	H & J Moorings Dissolved
Arsenic (As)	N	N	N	S	N	N	N
Cadmium (Cd)	N	N	N	S	N	N	N
Chromium (Cr)	N	N	N	N	N	N	N
Copper (Cu)	N	S	N	S	N	N	N
Lead (Pb)	N	N	N	S	N	N	N
Mercury (Hg)		N		N		N	
Nickel (Ni)	N		N		N		N
Silver (Ag)		N		N		N	
Zinc (Zn)	N	S	N	S	N	N	N

Table 5 Significant Differences- Marina vs. Marina

The numbers 1-8 represent the marinas being compared to the named marina in the row above. The number for each marina is in parenthesis next to each marina name. S= Sites in named marina have a significantly higher metals concentration than the sites in the numbered marina it is compared to. Italic S= Sites in named marina have a significantly lower metals concentration than the sites in the numbered marina it is compared to. N= no significant difference in metals concentrations**.** Dissolved Hg, Pb, and Ag were not statistically analyzed due to numerous non detects.

Dissolved Metals

Dissolved

Sample Site	Newport Dunes (1)								De Anza (2)								Balboa Yacht Baasin (3)								Bahia Corinthian (4)							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Arsenic (As)		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N		N	N	N	N
Cadmium (Cd)		N	N	S	N	N	N	N	N		N	S	N	N	N	N	N	N		S	N	N	N	N	*S*	*S*	*S*		*S*	*S*	*S*	*S*
Chromium (Cr)		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N		N	N	N	N
Copper (Cu)		N	N	N	S	S	S	N	N		N	N	S	S	S	N	N	N		N	S	S	S	N	N	N	N		S	S	S	N
Nickel (Ni)		S	S	S	S	S	S	S	S		S	N	N	N	N	N	S	S		S	N	N	N	N	S	N	S		N	N	N	N
Selenium (Se)		S	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S		N	N	N	N	N	S	S	N		N	N	N	N
Zinc (Zn)		N	S	N	S	S	S	N	N		N	N	S	S	S	N	S	N		N	S	S	S	N	N	N	N		S	S	S	N

Sample Site	Harbor (5)								Lido Village (6)								Lido Yacht Anchorage (7)								H&J Moorings (8)							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Arsenic (As)	N	N	N	N		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N	
Cadmium (Cd)	N	N	N	S		N	N	N	N	N	N	S	N		N	N	N	N	N	S	N	N		N	N	N	N	S	N	N	N	
Chromium (Cr)	N	N	N	N		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N	
Copper (Cu)	S	S	S	S		N	N	S	S	S	S	S	N		N	S	S	S	S	S	N	N		S	N	N	N	N	S	S	S	
Nickel (Ni)	S	N	N	N		N	N	N	S	N	N	N	N		N	N	S	N	N	N	N	N		N	S	N	N	N	N	N	N	
Selenium (Se)	S	S	N	N		N	N	N	S	S	N	N	N		N	N	S	S	N	N	N	N		N	S	S	N	N	N	N	N	
Zinc (Zn)	S	S	S	S		N	N	S	S	S	S	S	N		N	S	S	S	S	S	N	N		S	N	N	N	N	S	S	S	

Sediment Metals

Sediment

Sample Site	Newport Dunes (1)								De Anza (2)								Balboa Yacht Basin (3)								Bahia Corinthian (4)							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Arsenic (As)																																
Cadmium (Cd)		N	S	S	S	N	N	S	N		N	S	S	N	N	N	S	N		S	S	N	N	N	S	S	S		N	S	S	S
Chromium (Cr)		N	N	N	N	S	S	N	N		N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N		N	S	S	N
Copper (Cu)		N	S	S	S	S	S	S	N		N	S	S	S	S	N	S	N		N	S	S	S	N	S	S	N		N	N	S	N
Lead (Pb)		N	N	N	S	S	S	S	N		N	N	S	S	S	N	N	N		N	S	S	S	N	N	N	N		S	S	S	N
Mercury (Hg)		N	S	N	N	S	S	S	N		S	N	N	S	S	S	S	S		S	N	N	S	N	N	N	S		N	S	S	S
Nickel (Ni)		N	N	N	N	N	N	N	N		N	N	N	N	N	S	N	N		N	N	N	N	N	N	N	N		N	S	S	N
Silver (Ag)		N	N	N	N	S	S	N	N		N	N	N	S	S	N	N	N		N	N	S	S	N	N	N	N		N	S	S	N
Zinc (Zn)		N	N	N	S	S	S	S	N		N	N	S	S	S	N	N	N		N	S	S	S	N	N	N	N		S	N	S	N

Sample Site	Harbor (5)								Lido Village (6)								Lido Yacht Anchorage (7)								H&J Moorings (8)							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Arsenic (As)																																
Cadmium (Cd)	S	S	S	N		S	S	S	N	N	N	S	S		N	N	N	N	N	S	S	N		N	N	N	N	S	S	N	N	
Chromium (Cr)	N	N	N	N		S	S	N	S	N	N	S	S		N	S	S	N	N	S	S	N		S	N	N	N	N	N	S	S	
Copper (Cu)	S	S	S	N		N	S	S	S	S	S	N	N		S	S	S	S	S	S	S	S		S	S	N	N	N	S	S	S	
Lead (Pb)	S	S	S	S		S	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S		S	S	N	N	N	S	S	S	
Mercury (Hg)	N	N	N	N		N	S	S	S	S	N	S	N		S	N	S	S	S	S	S	S		S	S	S	N	S	S	N	S	
Nickel (Ni)	N	N	N	N		N	N	N	N	N	N	S	N		N	S	N	N	N	N	N	N		S	N	S	N	N	N	S	S	
Silver (Ag)	N	N	N	N		S	N	N	S	S	S	S	S		N	S	S	S	S	S	N	N		S	N	N	N	N	N	S	S	
Zinc (Zn)	S	S	S	S		S	N	S	S	S	S	N	S		S	N	S	S	S	S	N	S		S	S	N	N	N	S	N	S	

Wet vs. Dry Weather

Differences in metals concentrations during wet and dry weather at sites in marinas was another factor analyzed. The samples collected in May and December were considered wet weather samples and the August samples represented dry weather. As in all the previous statistical analysis the metals in table 2 and 3 were analyzed. The samples collected within each marina were compared to the samples in each of the other marinas. Channel data was not analyzed for wet vs dry comparison. The statistical analysis of the data shows that there are significant differences in wet vs. dry weather metal concentrations in all marinas during wet and dry weather although all dissolved metal concentrations, except Cu, were below the CTR water quality criteria (CMC and CCC).

For **dissolved** metals, all metals except Cu were below the water quality criteria, however, there were significant differences between wet vs dry data and metal concentrations were significantly higher in the wet weather. The most significant difference is for Chromium. Dissolved Chromium levels are significantly higher in all marinas during wet weather. Dissolved Zn levels are higher during wet weather in Newport Dunes, De Anza, Balboa Yacht Basin and Bahia Corinthian Marinas. Dissolved Nickel levels are higher in wet weather in De Anza and Balboa Yacht Basin Marinas, dissolved Arsenic levels are higher in wet weather in Balboa Yacht Basin Marina**,** and dissolved Pb levels are higher in wet weather in Harbor Marina. Other than Chromium, the higher wet weather dissolved metals levels are restricted to Newport Dunes, De Anza, Balboa Yacht Basin, Bahia Corinthian and Harbor Marinas. This is the opposite of the pattern that was found for the combined wet and dry dissolved metals data where the higher levels of metals were found in the West Newport Bay marinas.

The **sediment** data also shows significant differences in wet vs. dry weather with dry weather having the higher concentrations of metals for most marinas. Lido

Village had significant differences in Cr, Cu, Hg, and Pb with the dry weather concentrations being higher. Lido Yacht Anchorage had significant differences in Cr and Sn with dry weather readings higher. De Anza marina had higher dry weather levels of Cr and Cu, and Balboa Yacht Basin had significantly higher Pb and Hg in dry weather. Newport Dunes had significant differences in Ag, As, and Cr with wet weather being higher. Harbor and Bahia Corinthian marinas along with the H and J Moorings showed no significant differences in wet and dry sediment metal concentrations. This data also reinforces the lack of significance of stormdrains, since the marinas with stormdrains do not show consistent differences from the other marinas during wet weather. The differences for both dissolved and sediment metals are summarized in table 6.

Table 6 Significant differences in wet vs. dry weather

S= Sites in named marina have a significantly higher metals concentration during dry weather. Italic *S*= Sites in named marina have a significantly higher metals concentration during wet weather. N= no significant difference in metals concentrations.

Sample Site	Newport Dunes Sediment	Newport Dunes Dissolved	De Anza Marina Sediment	De Anza Marina Dissolved	Balboa Yacht Basin Sediment	Balboa Yacht Basin Dissolved	Bahia Corinthian Sediment	Bahia Corinthian Dissolved	Harbor Marina Sediment	Harbor Marina Dissolved	Lido Village Sediment
Arsenic (As)	*S*	N	N	N	N	*S*	N	N	N	N	N
Cadmium (Cd)	N	N	N	N	N	N	N	N	N	N	N
Chromium (Cr)	*S*	*S*	S	*S*	N	*S*	N	*S*	N	*S*	S
Copper (Cu)	N	N	S	N	N	N	N	N	N	N	S
Lead (Pb)	N	N	N	N	S	N	N	N	N	*S*	S
Mercury (Hg)	N		N		S		N		N		S
Nickel (Ni)		N		*S*		*S*				N	
Silver (Ag)	*S*		N		N		N		N		N
Zinc (Zn)	N	*S*	N	*S*	N	*S*	N	*S*	N	N	N

Sample Site	Lido Village Dissolved	Lido Yacht Anchorage Sediment	Lido Yacht Anchorage Dissolved	H & J Moorings Sediment	H & J Moorings Dissolved
Arsenic (As)	N	N	N	N	N
Cadmium (Cd)	N	N	N	N	N
Chromium (Cr)	*S*	S	*S*	N	*S*
Copper (Cu)	N	N	N	N	N
Lead (Pb)	N	N	N	N	N
Mercury (Hg)		N		N	
Nickel (Ni)	N		N		N
Silver (Ag)		N		N	
Zinc (Zn)	N	N	N	N	N

Toxicity Testing

The Toxicity testing was conducted by Steve Bay and Darrin Greenstein of SCCWRP with funding provided by the California Department of Pesticide Regulation. During the August sampling session, additional water and sediment samples were collected from one site in each marina and from two channel sites, Lido Village and Lido Yacht Anchorage, and were sent to SCCWRP for toxicity testing. In November, additional sediment samples were collected for toxicity testing and one TIE test based on the results from the August testing. A detailed description of the testing methods and results are provided in appendix B in the toxicity testing report prepared by SCCWRP.

To summarize the results, the first round of toxicity testing found significant sediment toxicity (amphipod test) at eight out of ten sites -six of the eight marinas (all except for Balboa Yacht Basin and Lido Yacht Anchorage) and both the channel sites tested (Lido Village and Lido Yacht Anchorage). No toxicity was found in water toxicity tests (mussel embryos) at any of the ten sites tested, or insediment-water interface tests (mussel embryos); however, reduced percent normal alive embryos were found at three out of ten sites (Harbor marina, H&J moorings and the Lido Yacht Anchorage Channel site). During the second round of testing, no significant toxicity was found in the pore water extracted from the sediment (mussel embryo test), however, reduced percent normal alive embryos were found at two of the ten sites tested (Newport Dunes and Lido Yacht Anchorage). Sediment toxicity (amphipod test) was found at all six sites tested (four sites at Newport Dunes and two sites at De Anza marina). Additionally, the pore water was analyzed for metals. Copper was the only metal found to be in exceedence of CTR values in the pore water. It exceeded the chronic CTR standard at two sites, one each at Lido Yacht Anchorage and the H&J moorings. The acute CTR standard was exceeded only at the H&J moorings site.

A TIE test run on the Newport dunes site (selected due to its high level of toxicity in previous testing) found that a combination of metals and pesticides are most likely responsible for the toxicity.

Conclusions

The data shows that dissolved copper is the only metal with concentrations elevated above CTR standards (CMC and CCC) in the bay water, and that As Cd, Cr, Cu, Hg, Pb, and Zn exceeded the ERL in many marinas and Cu, Hg, and Zn concentrations are elevated above the ERM in the bay sediments in several marinas, mostly in western Newport Bay (Harbor, Lido Village, Lido Yacht Anchorage, H&J moorings and BYB).

The statistical analysis shows that there is no significant difference in dissolved copper levels in the marinas and their adjacent channel sites. This may be due to the seasonal variability of the data over all marinas and channels as the metal concentrations for most sites varied seasonally. This leads to the conclusion that dissolved copper from boat bottom paint from the boats in the marinas is not being quickly diluted as it leaves the marinas. The differences in marina vs. channel sites for copper suggest that Cu may be settling in marina sediments.

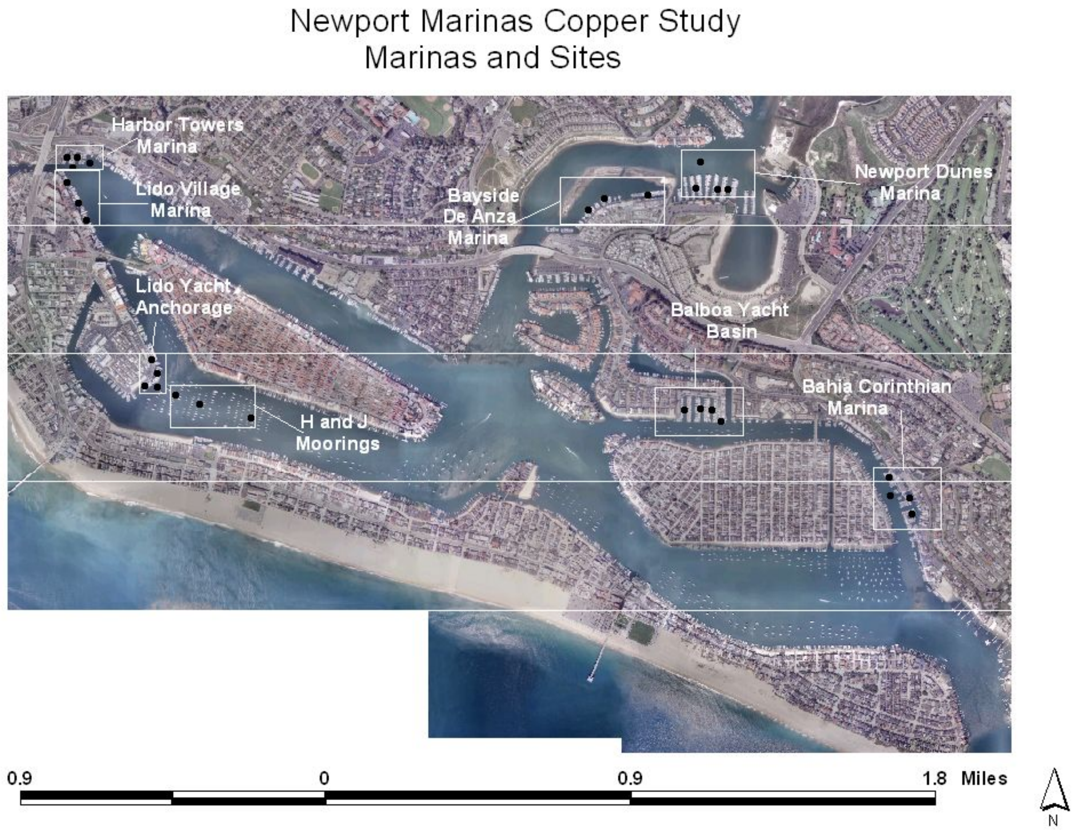
The analysis of marina vs. the adjacent cannel for sediments shows significantly higher sediment metal concentrations at the marina sites compared to the channel site at Newport Dunes for Cd, Cr, Cu, Pb, and Zn; at Bahia Corinthian Marina for all metals tested except Ag; at Lido Village Marina for Cu and Zn; at Lido Yacht Anchorage marina for As, Cd, Cu, Pb, Zn; and at DeAnza marina at the (In)channel site for Pb and the (Out) channel site for all metals tested. De Anza was designed with two channel sites (De Anza (In) and De Anza (Out)) on either side of a small island that separates the marina from the main channel. The differences found between these two sites suggest that the physical barrier may be restricting the movement of contaminated sediment from the marina or that Cu and Zn from boats is settling in marina sediments.

Statistical analysis of the marinas against each other shows that dissolved Cu and Zn are higher in the west bay than the rest of the bay. Sediment data shows that there are also significantly higher levels of sediment metals in the marinas of west Newport Bay compared to other marinas. The higher metal levels in the sediments of these marinas may be partially related to the presence of a large stormdrain in Harbor Marina; however, the large stormdrain in Bahia Corinthian does not appear to increase the sediment metal concentrations in that marina. Poor water circulation in the west Newport area is a likely reason for the elevated metals levels for dissolved copper and sediment metals found there.

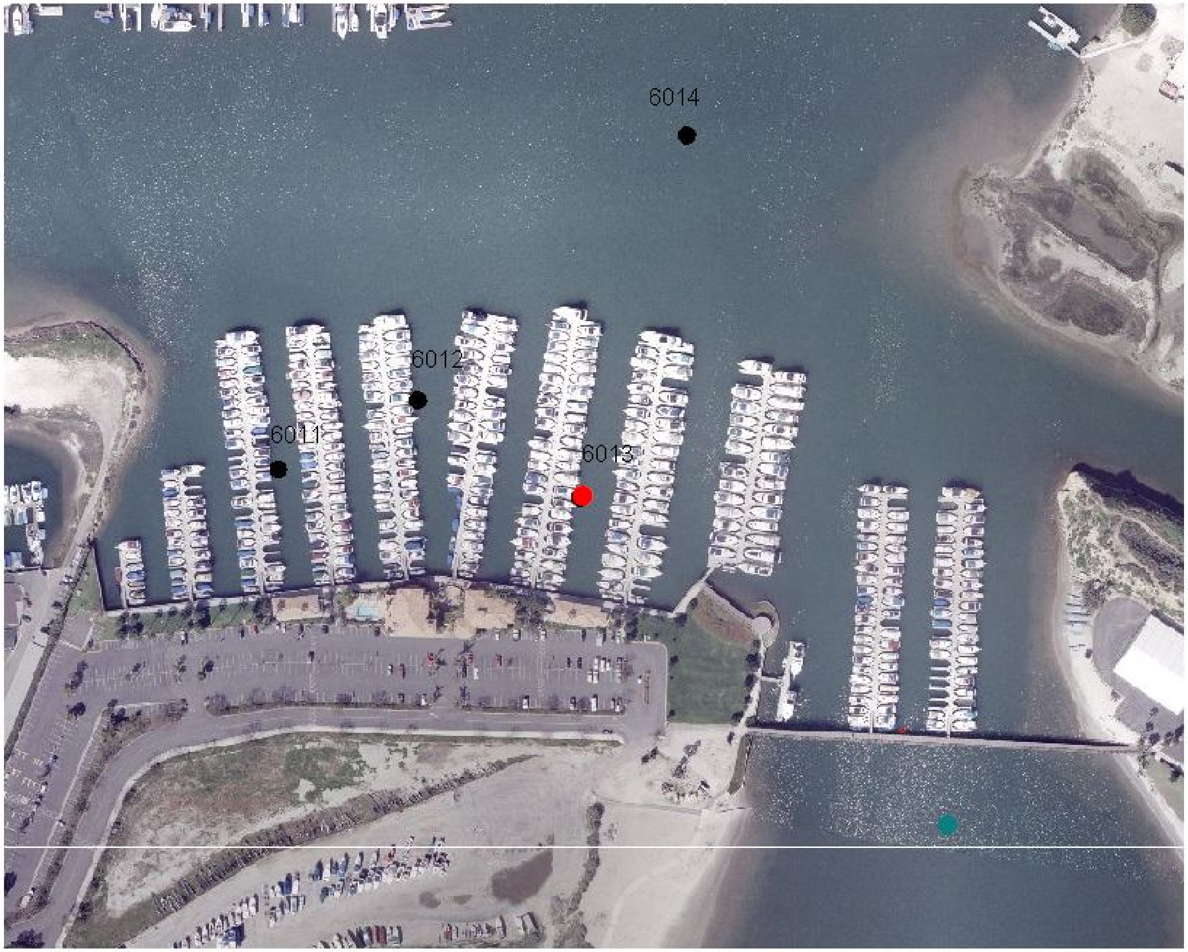
In wet weather, the Newport Dunes and DeAnza marinas showed higher levels of dissolved metals than the other marinas in the bay, which is the reverse of the trend during dry or combined wet and dry weather where significantly higher dissolved metals were found in the west bay. This could be due to the strong influence that runoff from San Diego Creek has on the area during wet weather. There were no other significant differences between wet and dry weather results.

Significant sediment toxicity (amphipod test) was found in 80% of the sites tested -(6/8) marina stations and all (2/2) channel stations, and the stations with highest toxicity were at Newport Dunes and De Anza Marina. In November, significant sediment toxicity (amphipod test) was also found at all 6 stations tested (4-Newport Dunes, 2-DeAnza Marina). No water, sediment/water interface or porewater toxicity was found for 10 stations tested (mussel embryo test), however, 3/10 SWI tests and 2/10 pore water tests showed reduced percent normal alive embryos. A TIE was run on the Newport Dunes site to attempt to identify the source of the toxicity. The results of the TIE test determined that the most likely source of the toxicity found at the Newport Dunes Marina is a combination of metals and pesticides.

Appendix A
Sample Site Maps



Newport Dunes Marina

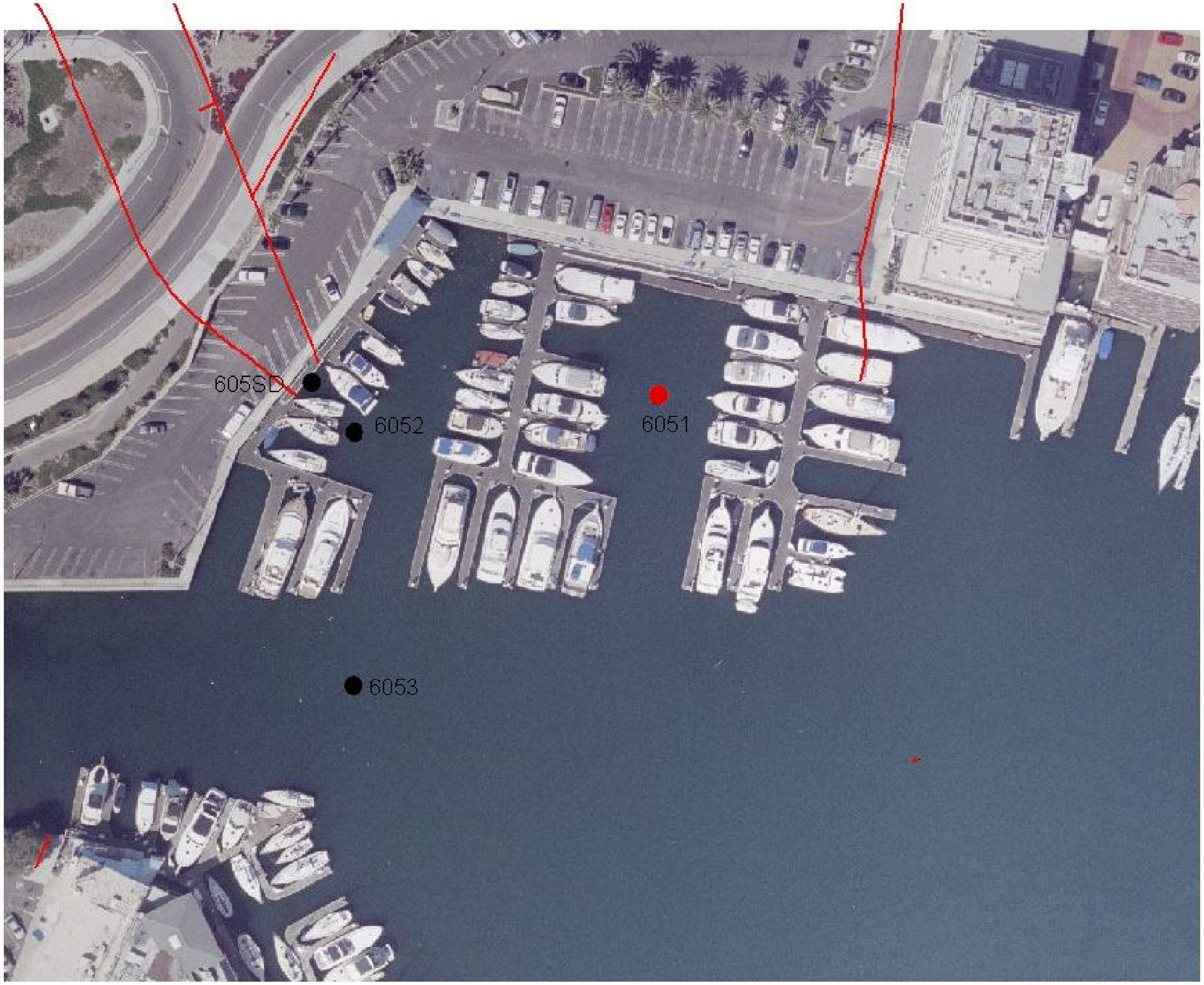


De Anza Marina

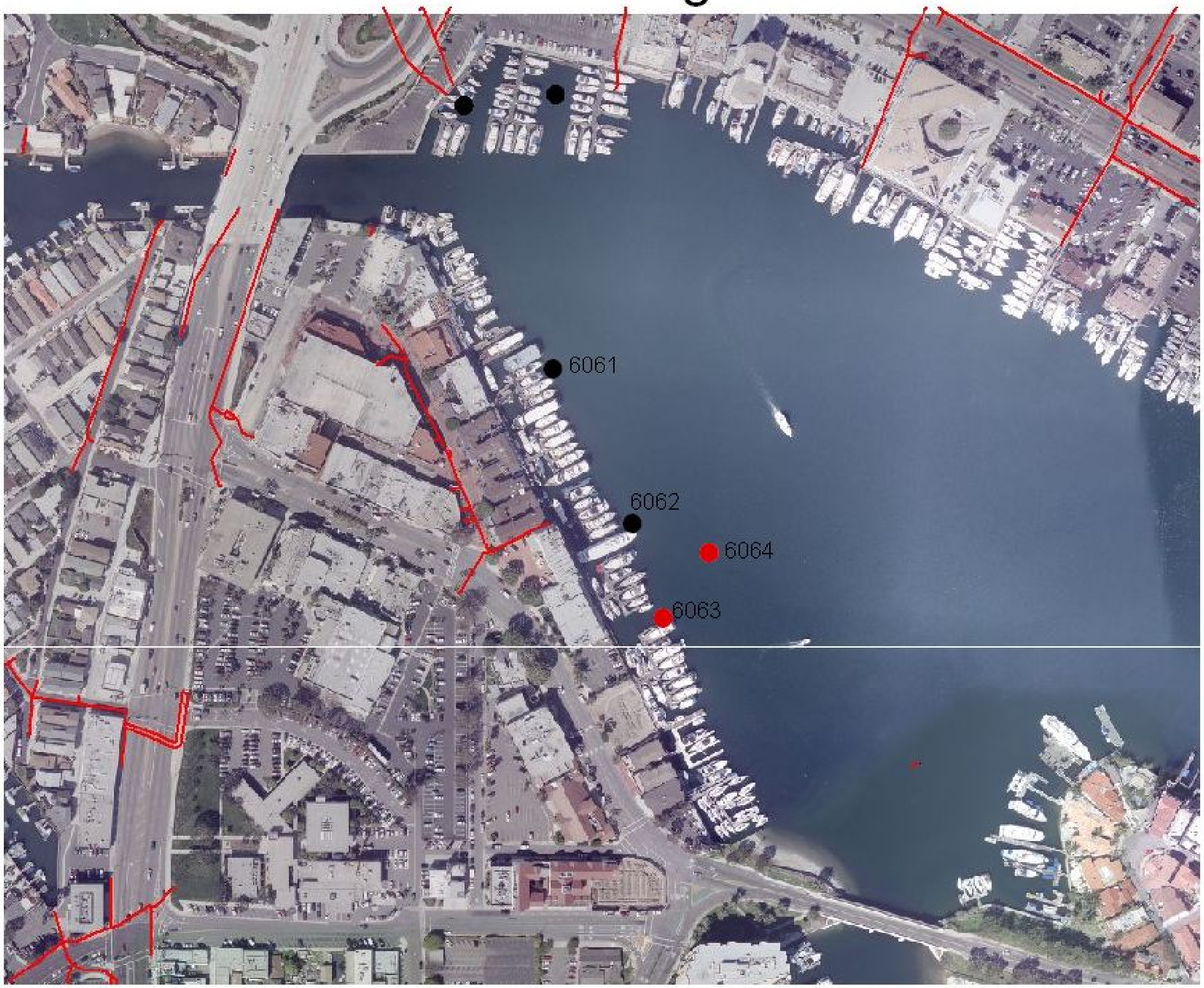
Balboa Yacht Basin

Bahia Corinthian

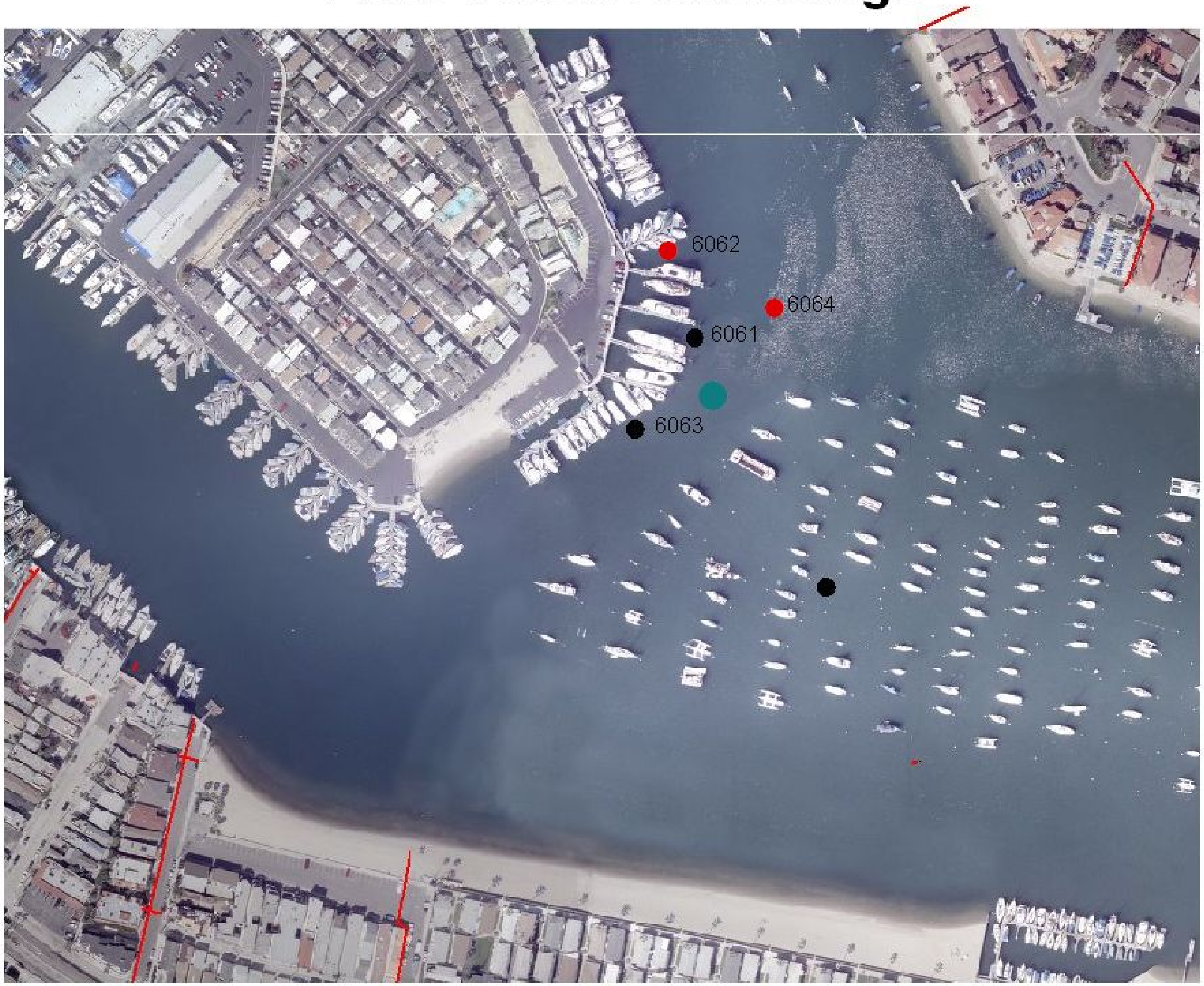
Harbor Marina



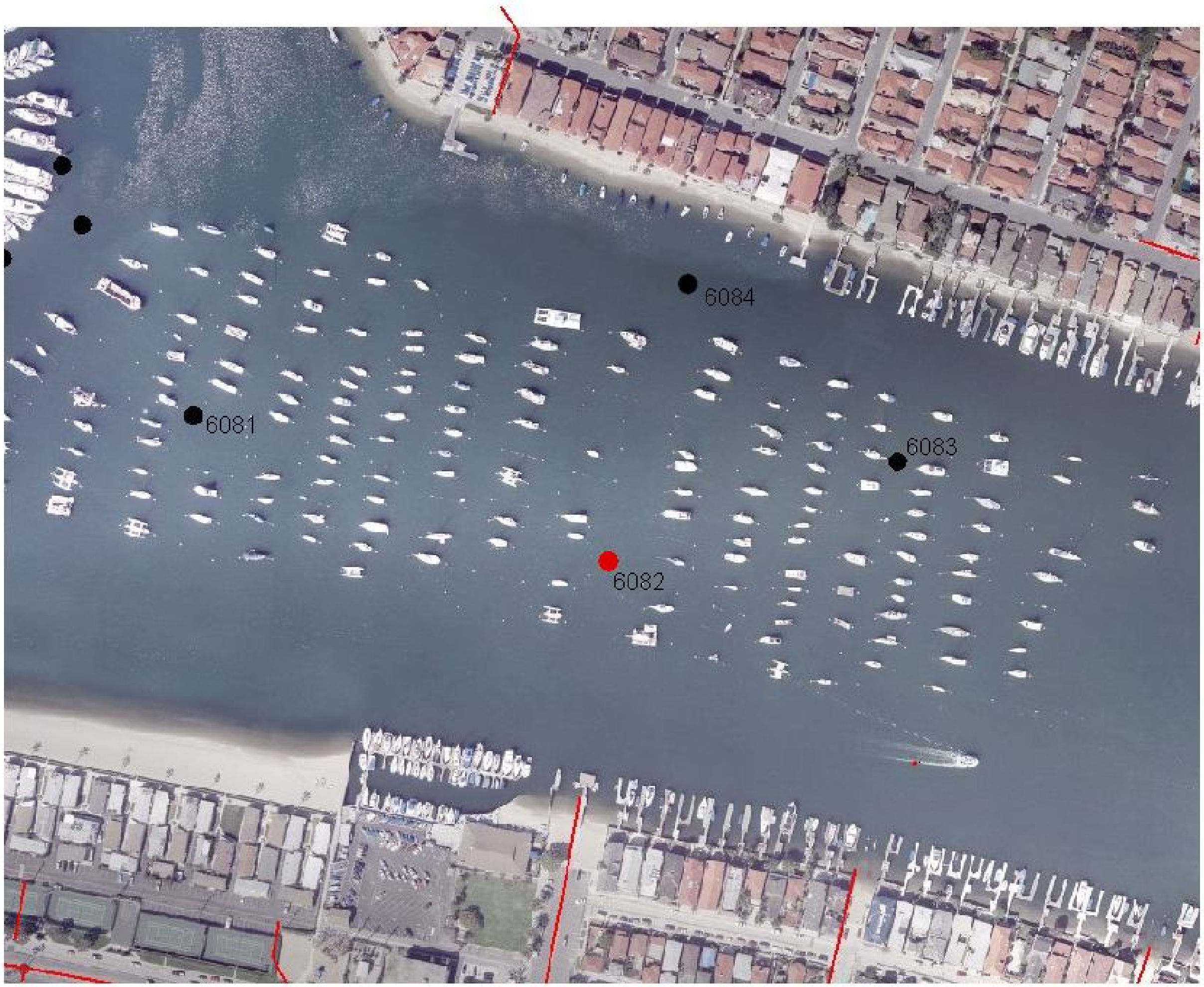
Lido Village



Lido Yacht Anchorage

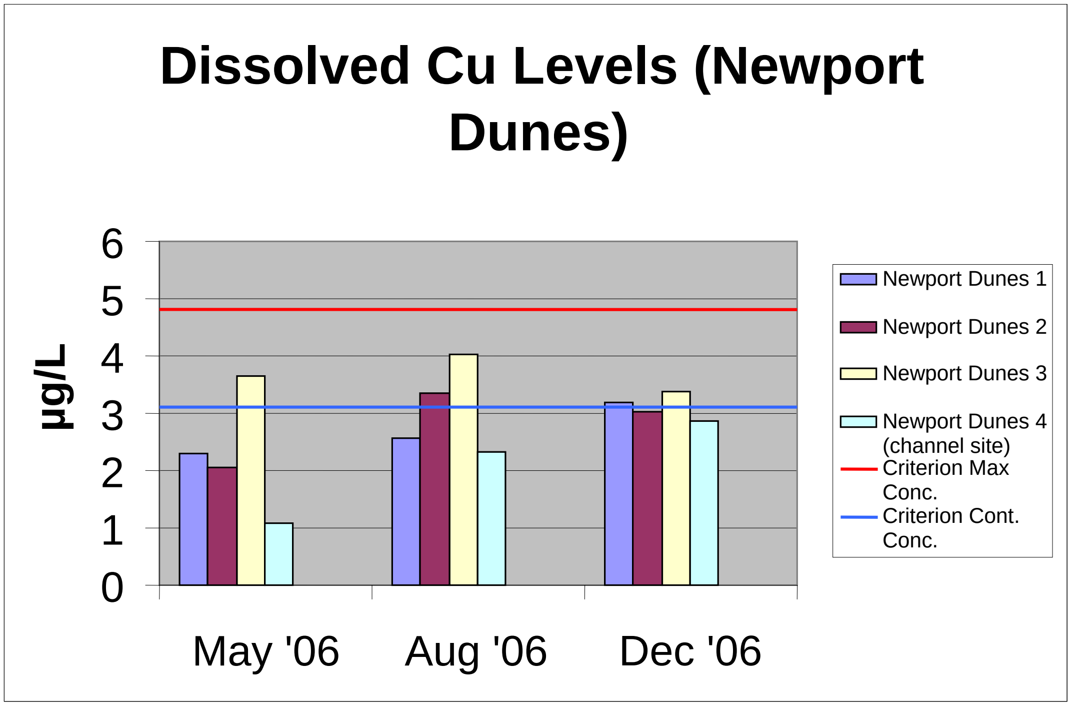


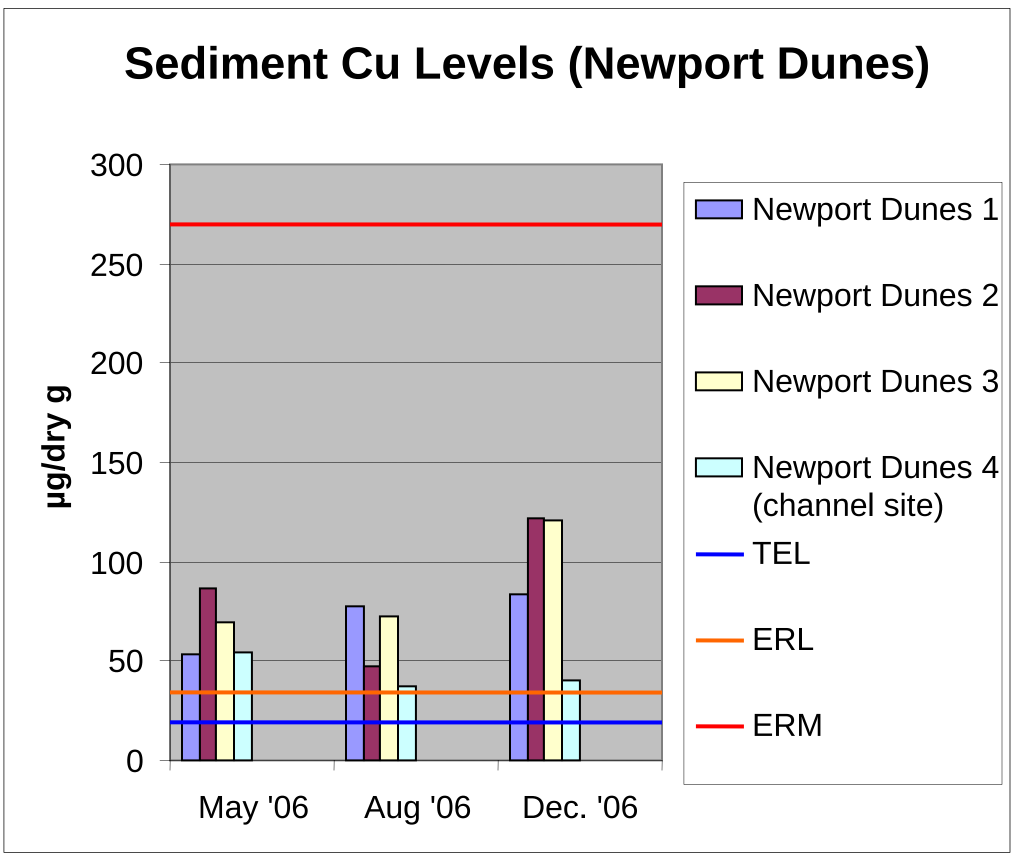
H and J Moorings

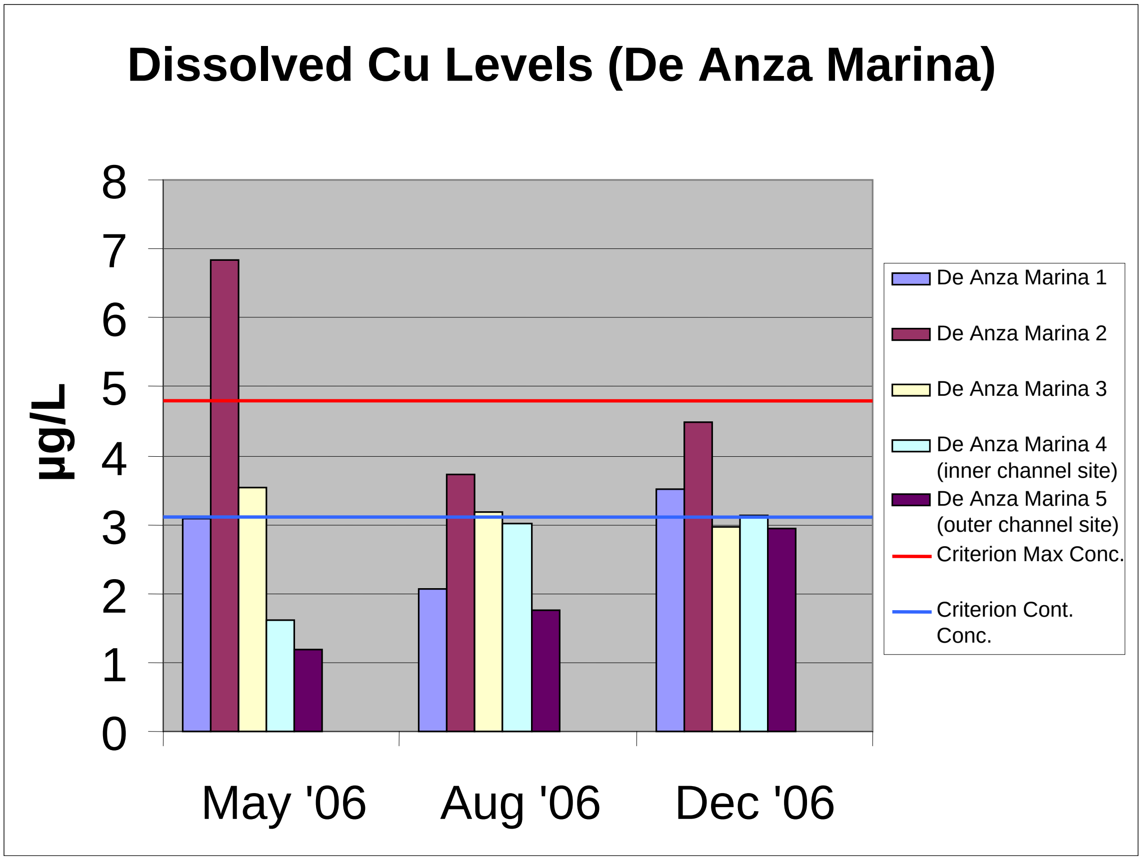


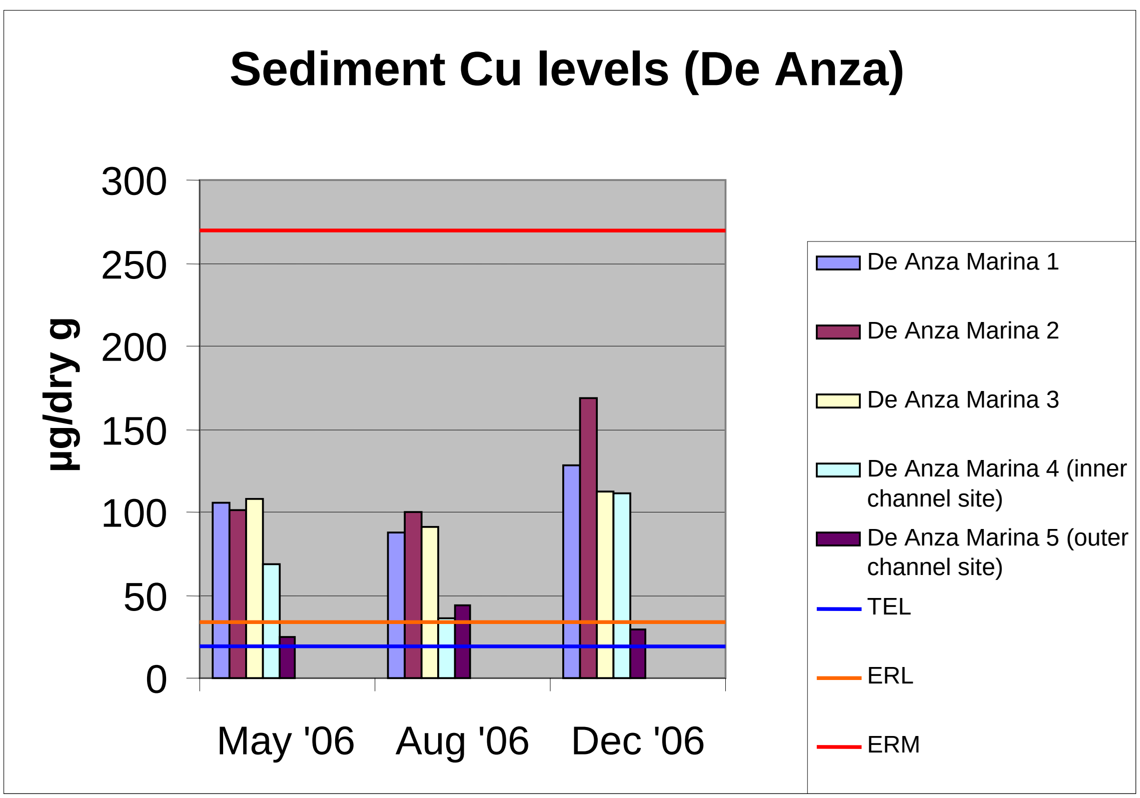
Appendix B

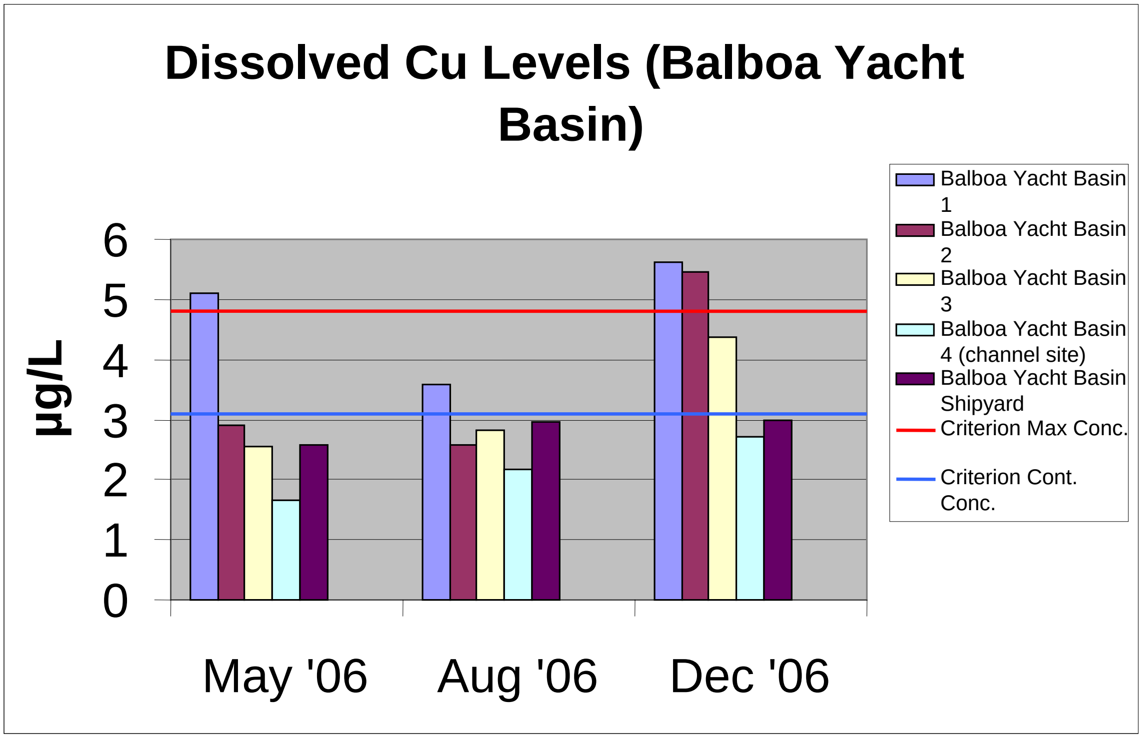
Appendix C

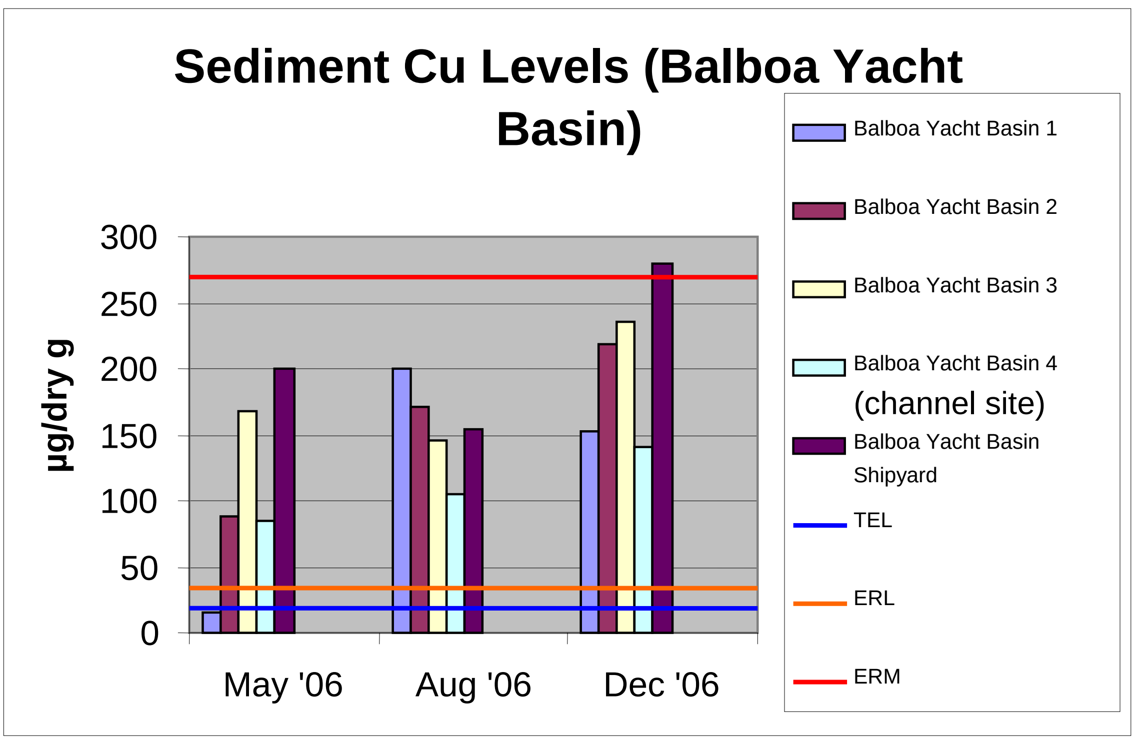

Dissolved Cu Levels (Newport Dunes)
µg/L
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
Newport Dunes 1
Newport Dunes 2
Newport Dunes 3
Newport Dunes 4 (channel site)
Criterion Max Conc.
Criterion Cont. Conc.

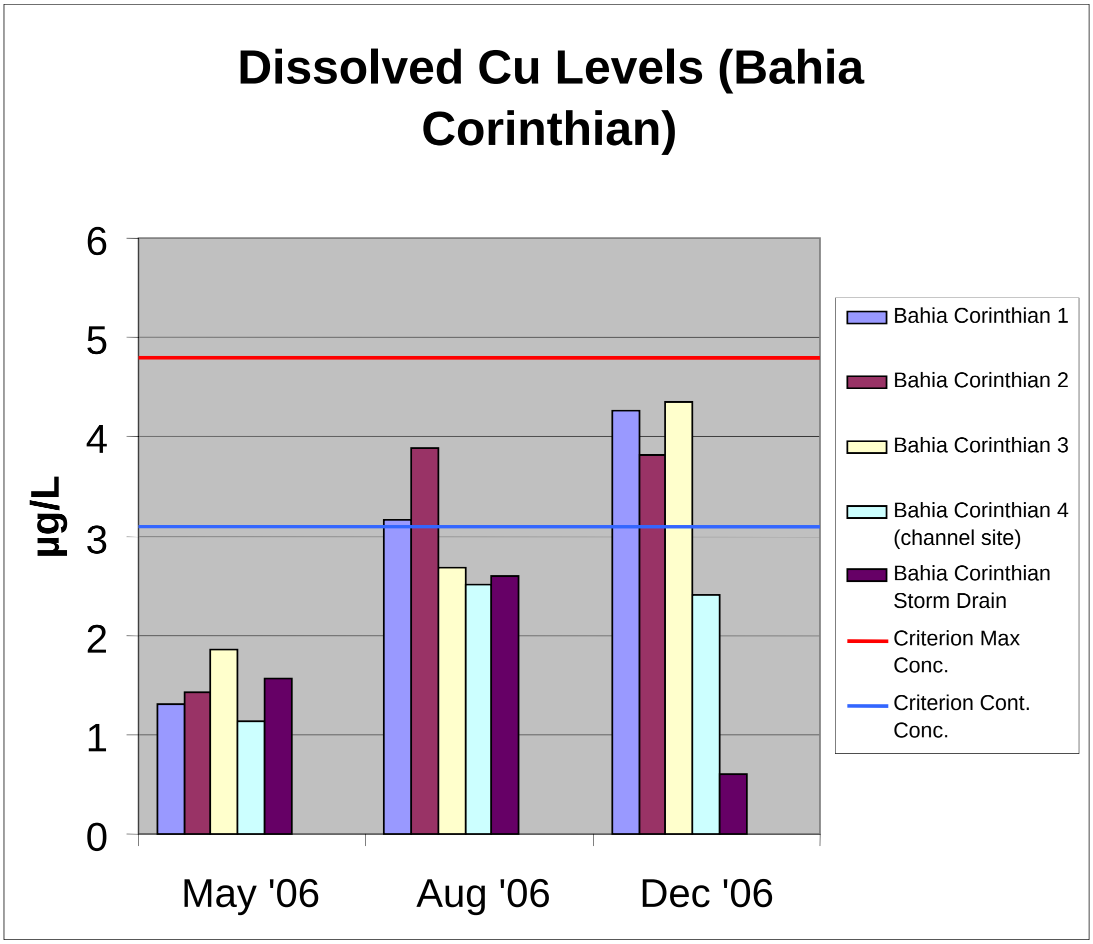

Sediment Cu Levels (Newport Dunes)
µg/dry g
300
250
200
150
100
50
0
May '06
Aug '06
Dec. '06
Newport Dunes 1
Newport Dunes 2
Newport Dunes 3
Newport Dunes 4 (channel site)
TEL
ERL
ERM

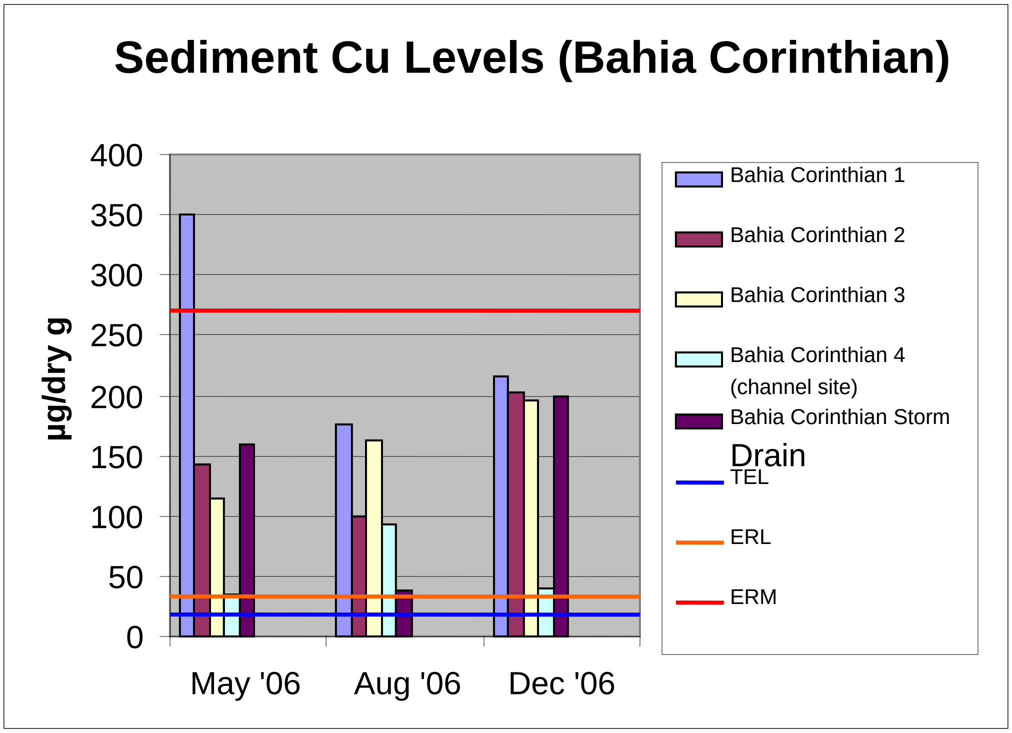

Dissolved Cu Levels (De Anza Marina)
µg/L
8
7
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
De Anza Marina 1
De Anza Marina 2
De Anza Marina 3
De Anza Marina 4 (inner channel site)
De Anza Marina 5 (outer channel site)
Criterion Max Conc.
Criterion Cont. Conc.

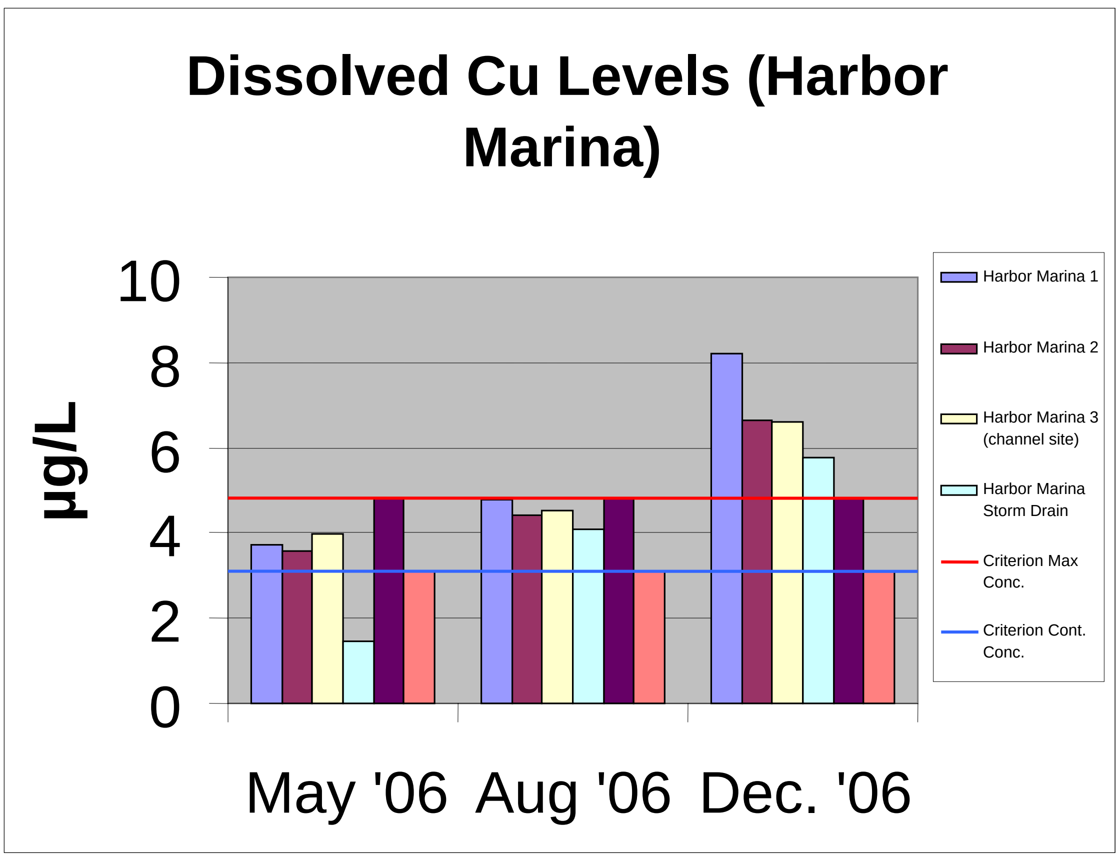

Sediment Cu levels (De Anza)
µg/dry g
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
De Anza Marina 1
De Anza Marina 2
De Anza Marina 3
De Anza Marina 4 (inner channel site)
De Anza Marina 5 (outer channel site)
TEL
ERL
ERM

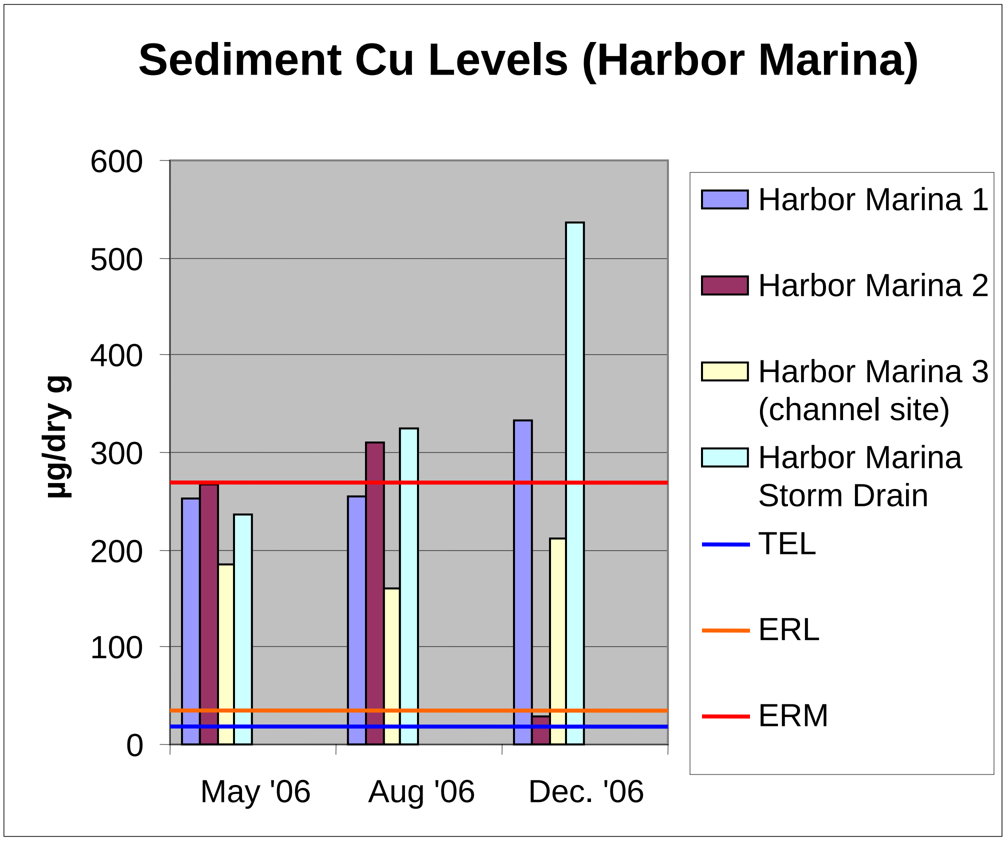

Dissolved Cu Levels (Balboa Yacht Basin)
µg/L
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
Balboa Yacht Basin 1
Balboa Yacht Basin 2
Balboa Yacht Basin 3
Balboa Yacht Basin 4 (channel site)
Balboa Yacht Basin Shipyard
Criterion Max Conc.
Criterion Cont. Conc.

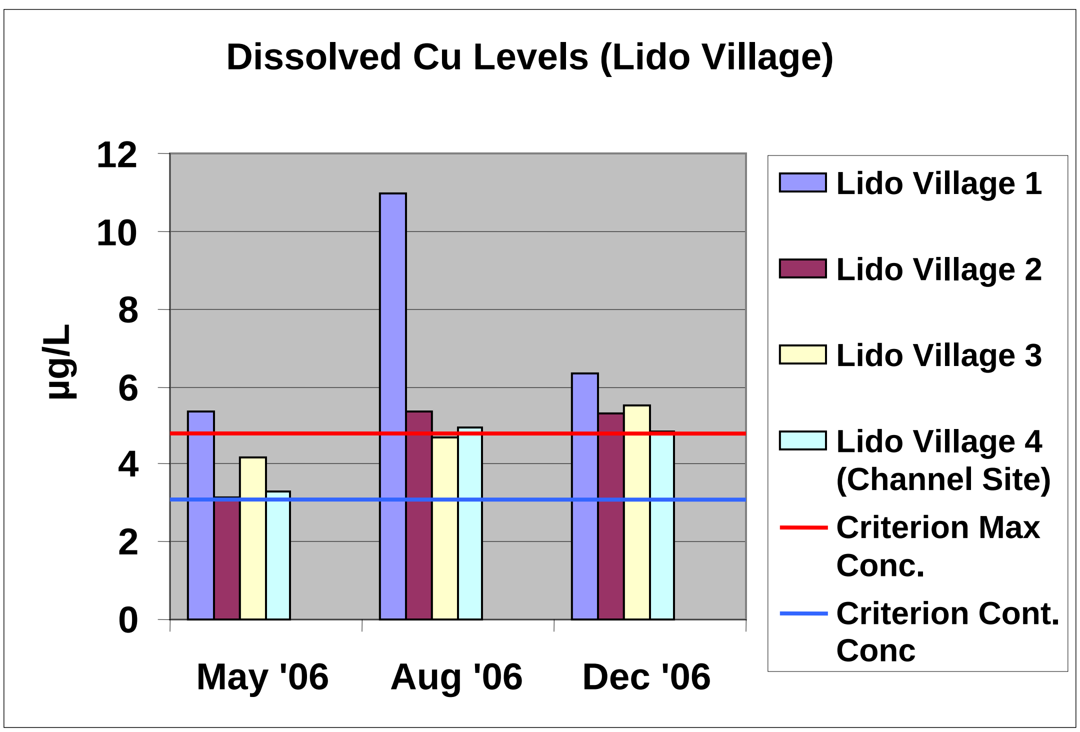

Sediment Cu Levels (Balboa Yacht Basin)
µg/dry g
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
Balboa Yacht Basin 1
Balboa Yacht Basin 2
Balboa Yacht Basin 3
Balboa Yacht Basin 4 (channel site)
Balboa Yacht Basin Shipyard
TEL
ERL
ERM

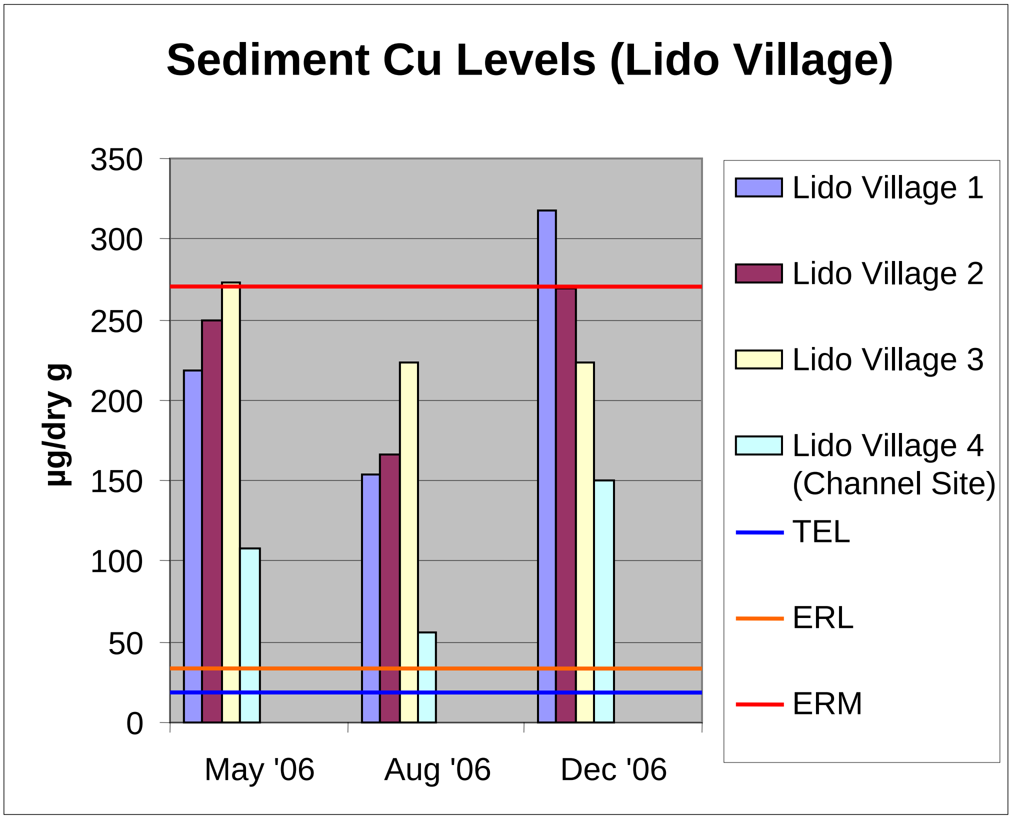

Dissolved Cu Levels (Bahia Corinthian)
µg/L
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
Bahia Corinthian 1
Bahia Corinthian 2
Bahia Corinthian 3
Bahia Corinthian 4 (channel site)
Bahia Corinthian Storm Drain
Criterion Max Conc.
Criterion Cont. Conc.

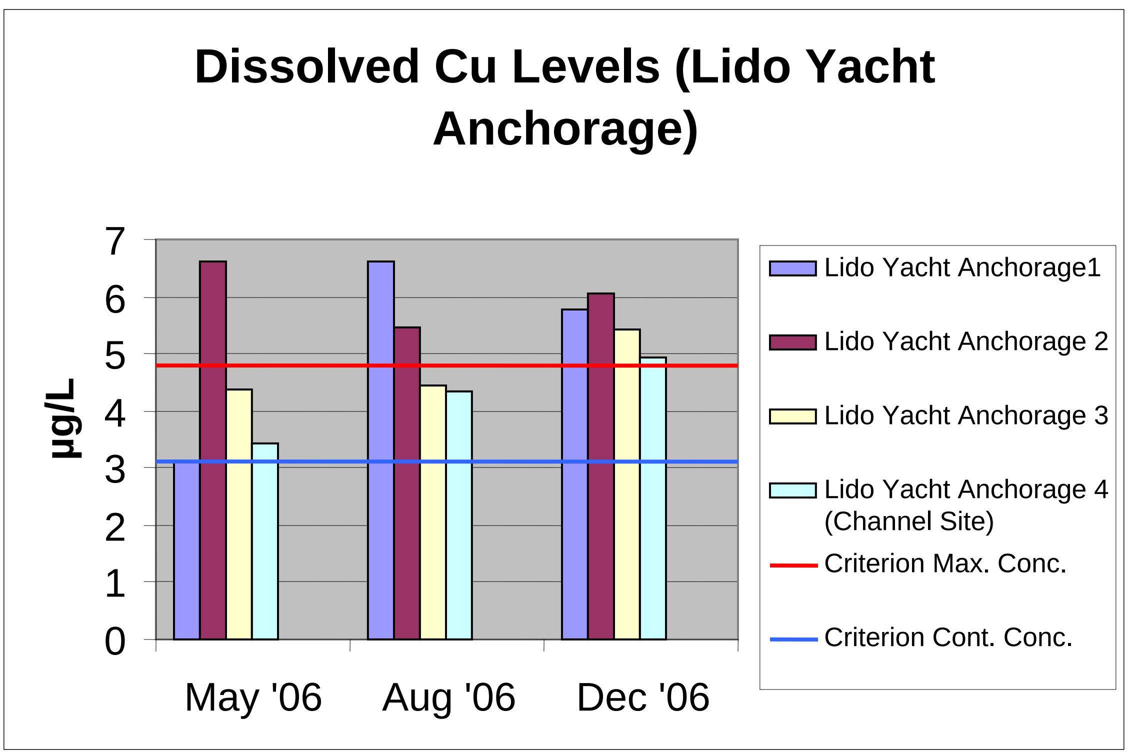

Sediment Cu Levels (Bahia Corinthian)
µg/dry g
400
350
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
Bahia Corinthian 1
Bahia Corinthian 2
Bahia Corinthian 3
Bahia Corinthian 4 (channel site)
Bahia Corinthian Storm Drain
TEL
ERL
ERM

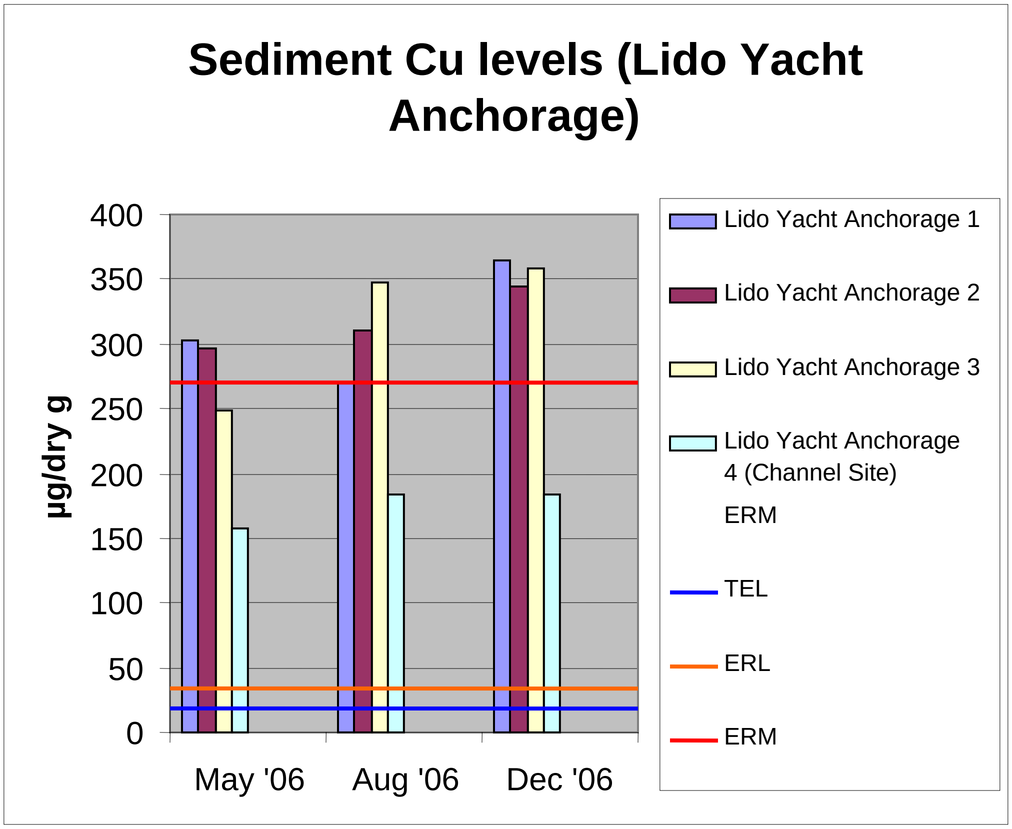

Dissolved Cu Levels (Harbor Marina)
µg/L
10
8
6
4
2
0
May '06
Aug '06
Dec. '06
Harbor Marina 1
Harbor Marina 2
Harbor Marina 3 (channel site)
Harbor Marina Storm Drain
Criterion Max Conc.
Criterion Cont. Conc.


Sediment Cu Levels (Harbor Marina)
µg/dry g
600
500
400
300
200
100
0
May '06
Aug '06
Dec. '06
Harbor Marina 1
Harbor Marina 2
Harbor Marina 3 (channel site)
Harbor Marina Storm Drain
TEL
ERL
ERM

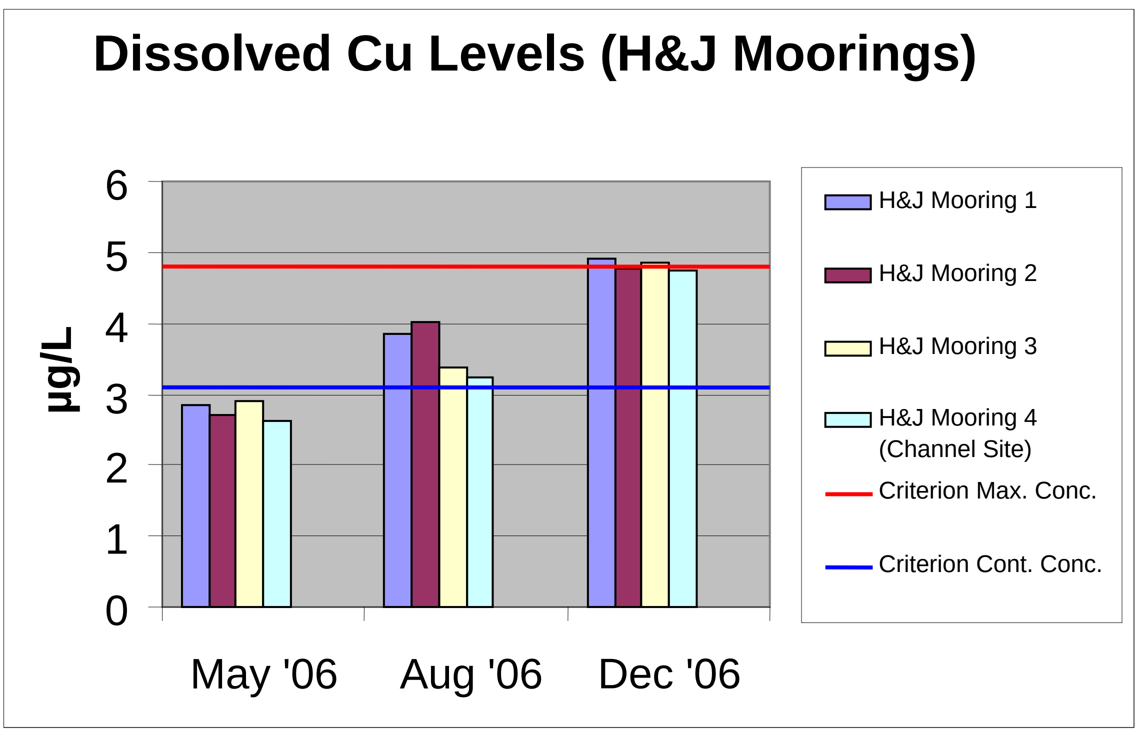

Dissolved Cu Levels (Lido Village)
µg/L
12
10
8
6
4
2
0
May '06
Aug '06
Dec '06
Lido Village 1
Lido Village 2
Lido Village 3
Lido Village 4 (Channel Site)
Criterion Max Conc.
Criterion Cont. Conc


Sediment Cu Levels (Lido Village)
µg/dry g
350
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
Lido Village 1
Lido Village 2
Lido Village 3
Lido Village 4 (Channel Site)
TEL
ERL
ERM

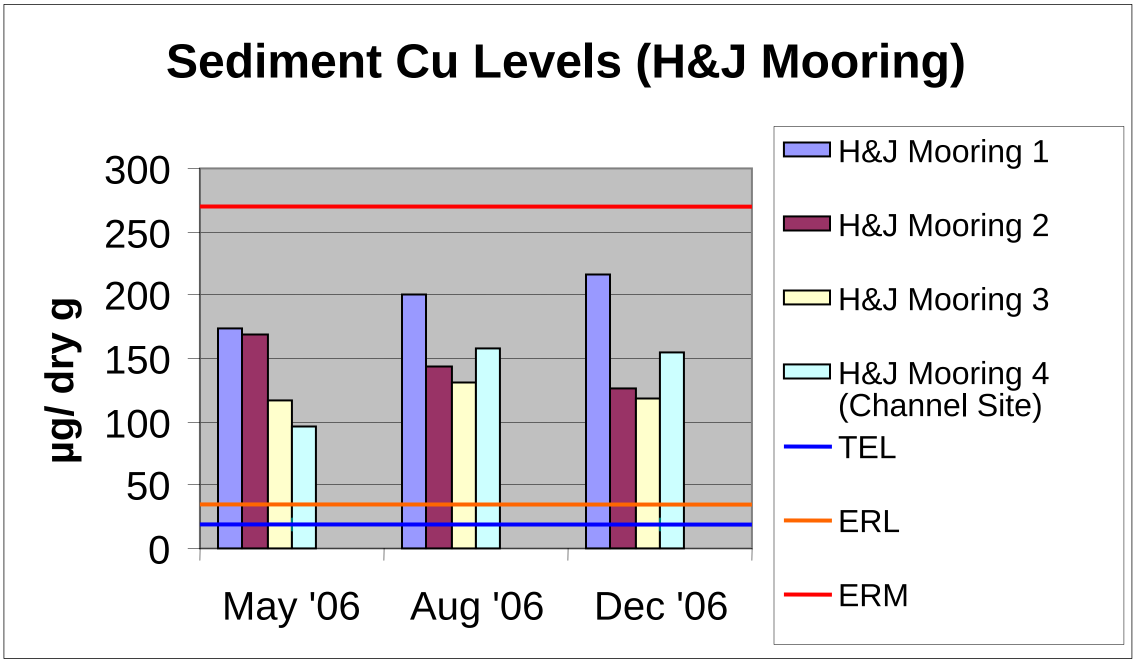

Dissolved Cu Levels (Lido Yacht Anchorage)
µg/L
7
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
Lido Yacht Anchorage1
Lido Yacht Anchorage 2
Lido Yacht Anchorage 3
Lido Yacht Anchorage 4 (Channel Site)
Criterion Max. Conc.
Criterion Cont. Conc.



Sediment Cu levels (Lido Yacht Anchorage)
µg/dry g
400
350
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
Lido Yacht Anchorage 1
Lido Yacht Anchorage 2
Lido Yacht Anchorage 3
Lido Yacht Anchorage 4 (Channel Site)
ERM
TEL
ERL
ERM



Dissolved Cu Levels (H&J Moorings)
µg/L
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
H&J Mooring 1
H&J Mooring 2
H&J Mooring 3
H&J Mooring 4 (Channel Site)
Criterion Max. Conc.
Criterion Cont. Conc.



Sediment Cu Levels (H&J Mooring)
µg/ dry g
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
H&J Mooring 1
H&J Mooring 2
H&J Mooring 3
H&J Mooring 4 (Channel Site)
TEL
ERL
ERM

Appendix D
Metals Means TSS,DOC,Turbidity,Salinity Means

Dissolved Metals Means

Sample Sites	Newport Dunes1	Newport Dunes2	Newport Dunes3	Newport Dunes Marina		Newport Dunes4 (Channel Site)		DeAnza 1	De Anza 2	De Anza 3	De Anza Marina	
	mean	mean	mean	mean	standard deviation	mean	standard deviation	mean	mean	mean	mean	standard deviation
Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aluminum (Al)					8.17		15.06	12.28		9.61	10.95	9.68
Antimony (Sb)	0.30	0.26	0.23	0.26	0.21	0.23	0.23	0.26	0.21	0.21	0.23	0.18
Arsenic (As)	1.19	1.19	1.18	1.19	0.06	1.20	0.08	1.23	1.16	1.21	1.20	0.15
Beryllium (Be)											0.00	0.00
Cadmium (Cd)	0.04	0.04	0.08	0.05	0.04	0.04	0.02	0.04	0.04	0.06	0.05	0.02
Chromium (Cr)	0.31	0.32	0.33	0.32	0.14	0.31	0.15	0.31	0.35	0.35	0.34	0.13
Cobalt (Co)	0.26	0.27	0.27	0.26	0.05	0.26	0.05	0.24	0.24	0.24	0.24	0.05
Copper (Cu)	2.68	2.82	3.69	3.06	0.65	2.09	0.92	2.89	5.02	3.23	3.72	1.34
Iron (Fe)				0.88	0.01						0.52	
Lead (Pb)	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01		0.01	0.00
Manganese (Mn)	26.09	27.66	29.01	27.59	5.61	23.04	5.69	17.81	20.49	20.67	19.66	5.93
Mercury (Hg)												
Molybdenum (Mo)	11.29	11.49	11.66	11.48	1.70	11.72	2.53	10.79	11.15	10.76	10.90	0.97
Nickel (Ni)	0.74	0.81	0.83	0.79	0.09	0.77	0.17	0.63	0.66	0.63	0.64	0.07
Selenium (Se)	0.16	0.16	0.16	0.16	0.02	0.14	0.05	0.11	0.09	0.10	0.10	0.03
Silver (Ag)				0.03								
Thallium (Tl)				0.00	0.00						0.00	0.00
Tin (Sn)											0.01	0.00
Titanium (Ti)	0.53	0.46	0.62	0.54	0.23	0.53	0.17	0.48	0.54	0.55	0.52	0.16
Vanadium (V)	2.78	2.84	2.88	2.83	0.16	2.77	0.12	2.66	2.67	2.67	2.67	0.25
Zinc (Zn)	12.63	12.77	16.92	14.11	4.22	11.38	3.33	14.89	15.60	12.98	14.49	4.84

Sample Sites	De Anza 4 (Inner Channel Site)		De Anza 5(Outer Channel Site)		Balboa Yacht Basin 1	Balboa Yacht Basin 2	Balboa Yacht Basin 3	Balboa Yacht Marina		Balboa Yacht Basin 4 (channel site)		Balboa Yacht Basin Ship Yard	
	mean	standard deviation	mean	standard deviation	mean	mean	mean	mean	standard deviation	mean	standard deviation	mean	standard deviation
Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aluminum (Al)	10.74	11.64		10.90	8.80			8.80	7.04	9.95	10.98		10.47
Antimony (Sb)	0.25	0.24	0.23	0.25	0.22	0.20	0.24	0.22	0.19	0.20	0.21	0.00	0.22
Arsenic (As)	1.26	0.21	1.20	0.32	1.12	1.15	1.14	1.13	0.16	1.13	0.20	1.17	0.22
Beryllium (Be)								0.01		0.00			
Cadmium (Cd)	0.04	0.02	0.04	0.02	0.15	0.05	0.05	0.08	0.10	0.04	0.02	0.04	0.02
Chromium (Cr)	0.41	0.21	0.39	0.19	0.34	0.38	0.37	0.36	0.18	0.38	0.24	0.38	0.25
Cobalt (Co)	0.25	0.02	0.23	0.03	0.18	0.18	0.18	0.18	0.04	0.20	0.05	0.19	0.04
Copper (Cu)	2.59	0.85	1.97	0.90	4.78	3.66	3.25	3.90	1.27	2.18	0.54	2.85	0.24
Iron (Fe)		0.03											
Lead (Pb)	0.01	0.01	0.01	0.00	0.02	0.01	0.02	0.02	0.00	0.01	0.01	0.01	0.00
Manganese (Mn)	19.82	4.64	18.61	10.53	10.88	10.74	10.84	10.82	3.22	13.51	4.05	12.46	3.55
Mercury (Hg)													
Molybdenum (Mo)	10.71	1.34	11.89	2.64	9.91	10.30	9.27	9.83	0.85	10.27	0.95	10.37	1.00
Nickel (Ni)	0.65	0.06	0.66	0.15	0.50	0.58	0.42	0.50	0.12	0.53	0.02	0.57	0.10
Selenium (Se)	0.12	0.03	0.12	0.07	0.05	0.06	0.06	0.06	0.01	0.07	0.01	0.06	0.01
Silver (Ag)													
Thallium (Tl)								0.01	0.00	0.01		0.01	
Tin (Sn)												0.01	
Titanium (Ti)	0.48	0.21	0.44	0.12	0.39	0.44	0.45	0.43	0.13	0.42	0.12	0.40	0.14
Vanadium (V)	2.75	0.41	2.72	0.74	2.31	2.35	2.38	2.35	0.25	2.40	0.33	2.36	0.40
Zinc (Zn)	13.75	3.41	10.96	4.66	20.95	15.99	15.90	17.61	5.70	10.73	2.06	13.88	3.93

Sample Sites	Bahia Corinthian 1	Bahia Corinthian 2	Bahia Corinthian 3	Bahia Corinthian Marina		Bahia Corinthian 4 (channel site)		Bahia Corinthian Storm Drain		Harbor Marina 1	Harbor Marina 2	Harbor Marina	
	mean	mean	mean	mean	standard deviation	mean	standard deviation	mean	standard deviation	mean	mean	mean	standard deviation
Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aluminum (Al)		8.79	10.04	9.41	6.58	11.82	9.39		7.81		8.71	9.31	5.90
Antimony (Sb)	0.21	0.22	0.18	0.20	0.18	0.17	0.14	0.18	0.15			0.24	0.19
Arsenic (As)	1.15	1.15	1.18	1.16	0.19	1.16	0.21	1.13	0.21	1.02	1.03	1.09	0.16
Beryllium (Be)	0.01	0.01	0.00	0.01	0.00	0.01		0.01				0.05	
Cadmium (Cd)	0.09	0.05	0.29	0.14	0.16	0.07	0.04	0.30	0.24	0.04	0.05	0.05	0.02
Chromium (Cr)	0.41	0.39	0.38	0.39	0.20	0.42	0.31	0.41	0.27	0.27	0.28	0.28	0.10
Cobalt (Co)	0.16	0.16	0.17	0.16	0.03	0.17	0.05	0.16	0.04	0.18	0.18	0.18	0.01
Copper (Cu)	2.91	3.05	2.96	2.97	1.21	2.02	0.77	1.59	0.99	5.57	4.84	5.20	1.84
Iron (Fe)	0.60			0.60		5.86						1.78	
Lead (Pb)	0.03	0.02	0.01	0.02	0.02	0.01	0.00	0.01	0.00			0.02	0.01
Manganese (Mn)	9.56	9.37	11.45	10.13	2.92	10.58	2.96	12.06	1.94	14.25	15.11	14.68	3.81
Mercury (Hg)													
Molybdenum (Mo)	10.13	9.88	10.32	10.11	0.61	10.02	0.72	10.38	0.14	10.46	11.29	10.87	1.60
Nickel (Ni)	0.55	0.52	0.83	0.63	0.24	0.47	0.04	0.83	0.28	0.57	0.58	0.58	0.13
Selenium (Se)	0.06	0.06	0.08	0.07	0.02	0.07	0.01	0.07	0.02	0.06	0.08	0.07	0.03
Silver (Ag)													
Thallium (Tl)	0.01	0.01	0.01	0.01	0.00	0.00		0.00				0.01	0.00
Tin (Sn)												0.01	
Titanium (Ti)	0.42	0.39	0.41	0.41	0.09	0.41	0.13	0.38	0.06	0.38	0.42	0.40	0.13
Vanadium (V)	2.30	2.26	2.40	2.32	0.30	2.37	0.48	2.33	0.43	2.13	2.19	2.16	0.47
Zinc (Zn)	12.95	13.63	16.14	14.24	2.95	11.49	0.74	11.60	3.87	25.66	24.67	25.16	4.65

Sample Sites	Harbor Marina 3 (channel site)		Harbor Marina Storm Drain		Lido Village 1	Lido Village 2	Lido Village 3	Lido Village Marina		Lido Village 4 (channel Site)		Lido Yacht Anchorage 1
	mean	standard deviation	mean	standard deviation	mean	mean	mean	mean	standard deviation	mean	standard deviation	mean
Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aluminum (Al)	16.44	11.37		6.60			8.26	15.07	9.65		1.84	13.63
Antimony (Sb)	0.26	0.20		0.26				0.29	0.23		0.28	0.23
Arsenic (As)	1.12	0.27	1.07	0.19	1.04	1.08	1.07	1.06	0.17	1.08	0.18	1.06
Beryllium (Be)	0.00		0.01					0.01	0.00			0.01
Cadmium (Cd)	0.05	0.02	0.09	0.04	0.07	0.04	0.06	0.06	0.02	0.05	0.00	0.07
Chromium (Cr)	0.35	0.12	0.31	0.10	0.31	0.35	0.32	0.32	0.12	0.30	0.17	0.30
Cobalt (Co)	0.19	0.01	0.19	0.01	0.18	0.18	0.18	0.18	0.01	0.18	0.02	0.19
Copper (Cu)	5.04	1.39	3.77	2.18	7.55	4.60	4.78	5.64	2.20	4.35	0.93	5.15
Iron (Fe)	0.68		1.09					0.70	0.12			
Lead (Pb)	0.01	0.01	0.01	0.01				0.03	0.01	0.01	0.01	0.02
Manganese (Mn)	13.66	4.98	19.53	9.17	12.32	13.04	12.38	12.58	3.40	13.08	3.63	13.32
Mercury (Hg)												
Molybdenum (Mo)	11.39	1.64	19.98	17.46	11.10	10.72	10.82	10.88	0.68	11.02	0.97	11.03
Nickel (Ni)	0.56	0.09	0.75	0.40	0.61	0.55	0.57	0.58	0.10	0.56	0.11	0.56
Selenium (Se)	0.08	0.04	0.06	0.03	0.07	0.07	0.07	0.07	0.03	0.06	0.03	0.06
Silver (Ag)												
Thallium (Tl)	0.00		0.01					0.01	0.00			0.01
Tin (Sn)												0.00
Titanium (Ti)	0.43	0.08	0.39	0.04	0.48	0.38	0.41	0.42	0.13	0.38	0.15	0.43
Vanadium (V)	2.30	0.74	2.14	0.59	2.23	2.22	2.27	2.24	0.52	2.24	0.65	2.32
Zinc (Zn)	23.29	7.82	21.31	6.81	28.18	20.95	20.55	23.23	4.83	19.48	2.06	22.03

Sample Sites	Lido Yacht Anchorage 2	Lido Yacht Anchorage 3	Lido Yacht Maina		Lido Yacht Anchorage 4 (channel site)		H&J Moorings 1	H&J Moorings 2	H&J Moorings 3	H&J Moorings Marina		H&J Moorings 4 (channel site)	
	mean	mean	mean	standard deviation	mean	standard deviation	mean	mean	mean	mean	standard deviation	mean	standard deviation
Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aluminum (Al)		125.40	69.51	119.78	8.36	5.88	8.73	9.06		10.57	7.12		4.10
Antimony (Sb)	0.24	0.23	0.23	0.15	0.22	0.21	0.22	0.26		0.24	0.16		0.20
Arsenic (As)	1.11	1.07	1.08	0.18	0.98	0.12	1.00	1.00	1.04	1.01	0.13	1.03	0.17
Beryllium (Be)		0.02	0.02	0.01									
Cadmium (Cd)	0.04	0.05	0.06	0.02	0.07	0.06	0.04	0.05	0.05	0.05	0.01	0.04	0.02
Chromium (Cr)	0.31	0.50	0.37	0.23	0.31	0.14	0.28	0.28	0.31	0.29	0.12	0.26	0.08
Cobalt (Co)	0.18	0.21	0.20	0.03	0.19	0.02	0.19	0.19	0.19	0.19	0.01	0.18	0.01
Copper (Cu)	6.04	6.27	5.82	1.94	4.23	0.76	3.87	3.83	3.72	3.81	0.89	3.54	1.08
Iron (Fe)		326.80	326.80		0.64								
Lead (Pb)	0.01	0.19	0.08	0.16	0.02		0.01	0.02	0.01	0.01	0.01	0.02	0.01
Manganese (Mn)	12.12	13.24	12.89	3.84	12.61	4.30	13.64	12.36	12.78	12.93	2.75	13.29	2.62
Mercury (Hg)								0.01		0.01			
Molybdenum (Mo)	10.65	10.84	10.84	0.69	10.84	0.75	10.87	10.68	10.83	10.79	0.74	10.68	0.96
Nickel (Ni)	0.55	0.64	0.58	0.14	0.65	0.10	0.57	0.57	0.58	0.57	0.07	0.87	0.44
Selenium (Se)	0.06	0.07	0.06	0.02	0.07	0.03	0.07	0.09	0.08	0.08	0.03	0.08	0.03
Silver (Ag)													
Thallium (Tl)	0.00	0.01	0.01	0.00	0.01		0.01	0.01		0.01	0.00		
Tin (Sn)		0.02	0.01	0.01	0.01		0.01	0.01		0.01	0.00		
Titanium (Ti)	0.37	7.14	2.65	6.69	0.61	0.24	0.60	0.49	0.45	0.51	0.12	0.40	0.11
Vanadium (V)	2.36	2.68	2.45	0.76	2.33	0.63	2.30	2.37	2.29	2.32	0.49	2.21	0.53
Zinc (Zn)	23.44	22.22	22.56	4.19	19.33	7.16	17.95	17.56	16.81	17.44	4.28	16.50	5.19

Sediment Metals Means

Sample Sites	Newport Dunes1	Newport Dunes2	Newport Dunes3	Newport Dunes Marina		Newport Dunes Channel Site		DeAnza 1	De Anza 2	De Anza 3	De Anza Marina	
	mean	mean	mean	mean	standard deviation	mean	standard deviation	mean	mean	mean	mean	standard deviation
Units	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g
Aluminum (Al)					4535.77							12373.53
Antimony (Sb)	0.57	0.56	0.58	0.57	0.34	0.43	0.42	0.52	0.53	0.44	0.50	0.25
Arsenic (As)	7.97	7.75	7.83	7.85	0.85	5.79	1.15	7.90	11.04	8.41	9.12	1.93
Barium (Ba)	152.10	136.23	141.23	143.19	22.24	97.75	44.36	135.43	135.40	116.01	128.95	28.81
Beryllium (Be)	1.15	1.10	1.05	1.10	0.43	0.61	0.18	1.10	1.33	1.01	1.15	0.48
Cadmium (Cd)	1.44	1.38	1.36	1.40	0.12	0.99	0.38	1.21	1.20	0.99	1.13	0.20
Chromium (Cr)	44.61	44.25	45.55	44.81	8.79	29.31	11.69	46.96	54.44	45.79	49.06	9.72
Cobalt (Co)	10.49	9.67	9.92	10.02	1.58	6.81	1.68	10.02	11.69	9.62	10.44	2.00
Copper (Cu)	72.12	85.17	87.70	81.66	25.85	44.07	9.37	107.03	123.27	103.73	111.34	24.75
Iron (Fe)	38315.67	36469.00	38252.33	37679.00	5626.71	24635.67	8257.56	38862.33	44005.67	36529.00	39799.00	7058.66
Lead (Pb)	18.28	19.31	21.14	19.58	2.84	14.46	4.27	21.16	23.18	20.31	21.55	2.67
Manganese (Mn)	317.07	302.07	318.57	312.57	54.20	215.97	53.85	309.33	328.70	277.67	305.23	59.69
Mercury (Hg)	0.06	0.06	0.07	0.06	0.02	0.05	0.01	0.07	0.09	0.16	0.11	0.05
Molybdenum (Mo)	2.12	2.16	1.81	2.03	0.30	1.53	0.79	1.82	3.07	1.83	2.24	0.69
Nickel (Ni)	23.73	22.87	23.37	23.32	3.98	15.50	4.64	24.20	27.66	22.84	24.90	4.61
Selenium (Se)	1.17	1.11	1.14	1.14	0.17	0.85	0.12	1.31	1.39	1.04	1.25	0.24
Silver (Ag)	0.23	0.24	0.26	0.24	0.08	0.18	0.13	0.32	0.34	0.24	0.30	0.10
Strontium (Sr)	83.10	78.96	81.48	81.18	7.38	67.90	20.86	80.63	78.58	65.37	74.86	11.05
Thallium (Tl)	0.33	0.33	0.34	0.33	0.03	0.23	0.08	0.37	0.40	0.33	0.37	0.06
Tin (Sn)	2.81	2.75	2.96	2.84	0.31	1.85	0.82	2.99	3.55	2.70	3.08	0.52
Titanium (Ti)	1275.83	1215.17	1263.57	1251.52	683.11	1054.23	770.43	1193.23	1218.23	1248.93	1220.13	677.90
Vanadium (V)	100.86	94.27	96.93	97.35	19.41	64.43	29.67	98.54	112.67	95.16	102.12	21.30
Zinc (Zn)	176.46	199.62	202.82	192.97	43.90	119.79	26.22	215.69	259.69	198.19	224.52	40.47

Sample Sites	De Anza Inner Channel Site		De Anza Outer Channel Site		Balboa Yacht Basin 1	Balboa Yacht Basin 2	Balboa Yacht Basin 3	Balboa Yacht Basin Marina		Balboa Yacht Basin Channel Site	
	mean	standard deviation	mean	standard deviation	mean	mean	mean	mean	standard deviation	mean	standard deviation
Units	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g
Aluminum (Al)		#DIV/0!		#DIV/0!					8531.33		
Antimony (Sb)	0.45	0.36	0.28	0.16	0.45	0.39	0.53	0.46	0.25	0.48	0.36
Arsenic (As)	6.13	2.87	3.96	0.85	10.14	9.39	9.82	9.78	1.64	8.81	1.80
Barium (Ba)	79.76	57.16	69.38	7.32	117.92	107.05	120.55	115.18	31.74	128.90	19.17
Beryllium (Be)	1.12	0.60	0.35	0.05	1.02	1.09	1.14	1.09	0.47	1.14	0.63
Cadmium (Cd)	1.11	0.09	0.63	0.15	0.80	0.73	0.89	0.81	0.19	0.86	0.03
Chromium (Cr)	43.84	14.42	17.42	3.01	51.18	49.12	51.81	50.70	8.13	50.22	8.29
Cobalt (Co)	9.53	2.14	4.24	0.82	9.36	8.99	9.52	9.29	1.73	9.83	1.83
Copper (Cu)	71.47	37.86	32.38	9.71	123.13	158.93	182.80	154.96	68.04	110.23	28.37
Iron (Fe)	36429.00	8974.65	15445.67	2651.23	38812.33	36902.33	39455.67	38390.11	6644.32	39339.00	6406.82
Lead (Pb)	16.09	3.04	10.32	2.90	26.30	22.36	29.85	26.17	6.02	21.93	1.97
Manganese (Mn)	298.07	77.21	146.67	11.41	281.10	278.90	283.33	281.11	47.93	301.00	60.71
Mercury (Hg)	0.05	0.02	0.04	0.01	0.58	0.30	0.98	0.62	0.57	0.18	0.05
Molybdenum (Mo)	1.92	0.43	0.94	0.14	1.83	1.74	1.87	1.81	0.30	1.77	0.20
Nickel (Ni)	22.43	5.70	9.25	1.95	24.26	22.96	24.77	24.00	4.33	24.69	4.53
Selenium (Se)	0.93	0.22	0.56	0.06	1.14	1.19	0.91	1.08	0.32	1.01	0.16
Silver (Ag)	0.24	0.16	0.09	0.03	0.31	0.30	0.29	0.30	0.14	0.27	0.14
Strontium (Sr)	77.69	18.23	56.49	19.54	70.01	69.24	73.96	71.07	11.86	73.88	5.64
Thallium (Tl)	0.33	0.04	0.18	0.02	0.35	0.33	0.34	0.34	0.08	0.36	0.04
Tin (Sn)	3.54	1.79	1.33	0.25	4.43	3.64	3.85	3.97	0.84	3.19	0.07
Titanium (Ti)	1213.17	772.97	730.13	290.51	1314.03	1193.00	1343.10	1283.38	549.18	1259.53	507.24
Vanadium (V)	95.40	26.86	37.90	6.17	98.86	93.67	100.64	97.72	17.65	101.13	13.22
Zinc (Zn)	172.69	61.89	85.75	21.87	227.39	220.92	246.49	231.60	50.13	191.56	40.33

Sample Sites	Balboa Yacht Basin Ship Yard		Bahia Corinthian 1	Bahia Corinthian 2	Bahia Corinthia n 3	Bahia Corinthian Marina		Bahia Corinthian Channel Site	
	mean	standard deviation	mean	mean	mean	mean	standard deviation	mean	standard deviation
Units	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g
Aluminum (Al)		16193.45					7874.35		276.48
Antimony (Sb)	0.57	0.32	0.71	0.58	0.85	0.72	0.38	0.83	1.09
Arsenic (As)	10.05	1.35	11.65	8.70	8.01	9.45	2.92	5.53	1.86
Barium (Ba)	132.63	27.88	124.20	126.93	105.16	118.76	27.67	80.10	56.11
Beryllium (Be)	1.19	0.64	0.86	0.75	0.66	0.76	0.25	0.41	0.12
Cadmium (Cd)	0.97	0.16	1.72	1.66	2.52	1.97	0.57	2.35	3.17
Chromium (Cr)	53.16	11.83	52.64	44.30	42.47	46.47	8.78	27.01	15.33
Cobalt (Co)	10.24	2.11	8.50	7.85	7.45	7.93	1.55	5.08	1.83
Copper (Cu)	210.83	63.45	247.57	148.27	157.53	184.46	73.51	79.42	69.79
Iron (Fe)	41449.00	6997.31	34112.33	31755.67	28322.33	31396.78	5930.91	18642.33	7611.61
Lead (Pb)	25.95	0.75	26.21	25.65	31.01	27.62	3.94	21.92	21.07
Manganese (Mn)	315.53	64.40	259.40	167.10	218.87	215.12	87.43	157.93	55.54
Mercury (Hg)	0.25	0.01	0.12	0.13	0.09	0.11	0.04	0.24	0.19
Molybdenum (Mo)	82.40	139.95	2.31	1.91	3.31	2.51	1.23	2.96	3.75
Nickel (Ni)	26.46	5.61	24.10	22.05	21.41	22.52	4.23	14.05	6.98
Selenium (Se)	1.05	0.13	1.43	1.12	1.35	1.30	0.23	0.95	1.02
Silver (Ag)	0.40	0.08	0.31	0.24	0.30	0.28	0.16	0.25	0.26
Strontium (Sr)	80.48	6.23	75.89	71.12	60.12	69.04	12.26	48.86	23.29
Thallium (Tl)	0.40	0.01	0.38	0.37	0.34	0.36	0.05	0.24	0.12
Tin (Sn)	3.66	0.35	3.67	3.44	4.16	3.76	0.62	2.21	1.80
Titanium (Ti)	1210.97	717.77	1111.53	1014.80	939.50	1021.94	517.40	860.97	479.80
Vanadium (V)	101.77	23.54	87.85	80.63	73.27	80.58	16.48	49.92	27.88
Zinc (Zn)	252.99	54.56	259.22	226.86	264.22	250.10	50.23	158.13	137.64

Sample Sites	Bahia Corinthian Storm Drain		Harbor Marina 1	Harbor Marina 2	Harbor Marina		Harbor Marina Channel Site		Harbor Marina Storm Drain		Lido Village 1
	mean	standard deviation	mean	mean	mean	standard deviation	mean	standard deviation	mean	standard deviation	mean
Units	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g
Aluminum (Al)		10105.26				15453.63		#DIV/0!		18264.57	
Antimony (Sb)	0.63	0.16	1.59	1.89	1.74	1.32	2.99	3.83	2.03	0.14	0.77
Arsenic (As)	5.91	2.38	10.63	7.46	9.05	3.87	8.65	1.84	11.44	2.81	11.05
Barium (Ba)	72.05	15.57	133.96	90.89	112.43	52.97	107.96	4.15	148.46	31.74	125.14
Beryllium (Be)	0.48	0.32	0.87	0.38	0.62	0.34	0.66	0.46	0.90	0.57	1.13
Cadmium (Cd)	3.11	2.73	2.02	2.33	2.17	1.20	1.32	0.07	2.38	1.25	1.02
Chromium (Cr)	29.27	11.74	52.78	33.92	43.35	18.66	42.20	10.69	54.41	16.19	55.96
Cobalt (Co)	5.49	2.43	9.06	6.22	7.64	3.07	7.34	2.41	9.22	2.62	10.24
Copper (Cu)	108.40	83.32	280.73	201.68	241.21	109.12	203.03	38.51	348.47	176.91	230.00
Iron (Fe)	19979.00	8141.09	36842.67	20527.33	28685.00	12426.49	27829.33	9431.61	34596.00	10269.26	41816.00
Lead (Pb)	20.42	6.48	83.23	51.10	67.17	30.20	86.38	5.23	80.72	13.74	63.66
Manganese (Mn)	170.07	60.05	258.63	161.99	210.31	69.41	258.83	55.80	247.13	76.41	288.23
Mercury (Hg)	0.48	#DIV/0!	0.41	0.06	0.23	0.28	0.20	0.20	0.46	0.50	0.69
Molybdenum (Mo)	3.80	2.64	3.07	7.60	5.33	5.05	45.59	74.83	7.78	5.01	2.45
Nickel (Ni)	15.70	7.03	26.17	19.70	22.93	9.70	18.88	8.88	28.38	6.57	26.76
Selenium (Se)	1.00	0.45	1.53	1.54	1.54	0.69	6.90	9.78	1.92	0.79	1.42
Silver (Ag)	0.19	0.10	0.46	0.36	0.41	0.21	64.95	111.76	0.63	0.23	0.61
Strontium (Sr)	51.80	10.03	74.34	55.66	65.00	23.65	39.77	33.85	85.73	16.71	109.00
Thallium (Tl)	0.24	0.06	0.37	0.23	0.30	0.14	38.86	66.80	0.33	0.11	0.38
Tin (Sn)	2.67	1.05	9.41	7.54	8.47	3.34	5.19	4.34	13.56	2.27	7.06
Titanium (Ti)	793.57	352.33	1188.97	715.20	952.08	611.94	718.60	272.72	1206.77	718.96	1178.63
Vanadium (V)	51.93	16.80	88.41	52.09	70.25	32.84	322.18	427.88	88.03	26.71	104.90
Zinc (Zn)	207.12	132.72	443.42	411.74	427.58	203.49	372.26	87.60	649.19	356.88	316.09

Sample Sites	Lido Village 2	Lido Village 3	Lido Village Marina		Lido Village Channel Site		Lido Yacht Anchorage 1	Lido Yacht Anchorage 2	Lido Yacht Anchorage 3	Lido Yacht Anchorage Marina	
	mean	mean	mean	standard deviation	mean	standard deviation	mean	mean	mean	mean	standard deviation
Units	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g
Aluminum (Al)				13461.00		16426.09					10935.44
Antimony (Sb)	0.82	0.79	0.79	0.57	0.58	0.48	0.60	0.76	0.51	0.63	0.43
Arsenic (As)	11.26	10.33	10.88	1.03	9.57	2.79	13.05	12.06	12.14	12.42	1.39
Barium (Ba)	132.40	115.81	124.45	36.00	110.85	62.25	117.24	124.03	113.05	118.11	22.90
Beryllium (Be)	1.11	0.99	1.08	0.37	0.96	0.54	1.12	1.24	1.11	1.16	0.47
Cadmium (Cd)	0.99	0.98	1.00	0.11	0.77	0.32	1.19	1.17	1.19	1.18	0.21
Chromium (Cr)	60.14	51.16	55.75	9.75	45.59	20.75	56.31	57.47	52.15	55.31	7.76
Cobalt (Co)	10.86	9.43	10.18	1.07	8.73	3.06	10.57	10.77	9.81	10.38	1.78
Copper (Cu)	228.37	239.97	232.78	51.85	104.43	47.15	312.63	319.83	318.13	316.87	40.04
Iron (Fe)	45396.00	38946.00	42052.67	5833.58	36609.33	13826.61	44206.00	44669.33	41366.00	43413.78	4396.85
Lead (Pb)	58.89	47.05	56.53	15.94	45.28	21.68	43.40	43.54	48.10	45.01	4.30
Manganese (Mn)	305.50	260.03	284.59	33.94	253.80	88.15	295.83	303.17	273.53	290.84	40.77
Mercury (Hg)	0.65	0.60	0.64	0.33	0.81	0.57	1.55	1.52	2.28	1.78	0.58
Molybdenum (Mo)	2.57	2.60	2.54	0.70	2.07	0.67	3.89	3.22	3.02	3.38	1.01
Nickel (Ni)	28.32	25.06	26.71	2.89	22.37	8.47	26.71	27.28	25.08	26.36	4.00
Selenium (Se)	1.55	1.35	1.44	0.19	0.97	0.30	1.62	1.93	1.55	1.70	0.28
Silver (Ag)	0.71	0.66	0.66	0.35	0.43	0.27	0.55	0.66	0.44	0.55	0.20
Strontium (Sr)	91.68	80.09	93.59	25.75	68.09	20.47	102.00	140.28	89.74	110.67	33.88
Thallium (Tl)	0.41	0.37	0.39	0.08	0.40	0.12	0.43	0.42	0.38	0.41	0.05
Tin (Sn)	6.65	5.50	6.41	1.71	4.23	2.40	5.65	5.30	5.11	5.35	0.65
Titanium (Ti)	1346.87	1089.57	1205.02	643.91	1113.00	946.00	1147.90	1243.20	1041.30	1144.13	513.90
Vanadium (V)	114.60	97.47	105.66	21.06	92.20	43.30	108.43	108.87	99.60	105.63	12.88
Zinc (Zn)	311.76	305.12	310.99	35.17	182.49	63.18	396.49	401.89	411.39	403.26	64.79

Sample Sites	Lido Yacht Anchorage Channel Site		H&J Moorings 1	H&J Moorings 2	H&J Moorings 3	H&J Moorings Marina		H&J Moorings 4 (channel site)	
	mean	standard deviation	mean	mean	mean	mean	standard deviation	mean	standard deviation
Units	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g	µg/ dry g
Aluminum (Al)		#DIV/0!					7435.83		#DIV/0!
Antimony (Sb)	0.49	0.34	0.52	0.45	0.53	0.50	0.34	0.56	0.40
Arsenic (As)	9.79	0.89	10.16	8.61	8.88	9.22	1.56	9.37	0.61
Barium (Ba)	117.49	32.38	116.13	129.57	132.66	126.12	40.13	143.66	48.87
Beryllium (Be)	1.01	0.27	0.89	0.82	0.90	0.87	0.17	1.04	0.13
Cadmium (Cd)	0.63	0.15	0.99	0.93	0.87	0.93	0.23	1.01	0.19
Chromium (Cr)	49.47	1.36	48.16	44.79	45.76	46.23	9.76	49.61	7.94
Cobalt (Co)	9.46	0.97	9.03	8.65	9.00	8.90	1.34	10.00	0.27
Copper (Cu)	174.70	15.33	196.73	146.97	122.00	155.23	36.42	136.07	34.81
Iron (Fe)	39552.67	712.94	39139.33	36902.67	37409.33	37817.11	7207.23	41666.00	4442.98
Lead (Pb)	35.94	5.36	35.07	28.83	27.75	30.55	5.30	29.17	1.87
Manganese (Mn)	279.93	14.21	262.77	257.30	271.40	263.82	45.18	296.67	16.76
Mercury (Hg)	1.23	0.31	1.06	0.51	0.84	0.80	0.60	0.34	0.09
Molybdenum (Mo)	1.56	0.29	1.83	1.65	1.75	1.74	0.51	1.73	0.43
Nickel (Ni)	23.64	1.88	23.12	21.66	16.06	20.28	6.49	25.17	1.00
Selenium (Se)	1.17	0.25	1.21	0.93	0.99	1.04	0.27	1.27	0.33
Silver (Ag)	0.42	0.20	0.40	0.30	0.31	0.33	0.17	0.41	0.20
Strontium (Sr)	74.47	9.94	94.50	103.60	94.32	97.47	39.39	85.71	10.93
Thallium (Tl)	0.37	0.09	0.39	0.40	0.45	0.41	0.10	0.44	0.09
Tin (Sn)	3.97	0.45	4.23	3.47	3.60	3.77	0.83	3.54	0.60
Titanium (Ti)	1194.67	649.75	1134.57	1139.40	1156.00	1143.32	678.80	1096.20	843.57
Vanadium (V)	95.81	8.31	94.65	91.59	91.75	92.66	24.46	100.83	23.20
Zinc (Zn)	252.02	32.44	354.86	238.96	205.46	266.42	94.57	242.16	47.00

Newport Dunes

Sample Sites	Newport Dunes1				Newport Dunes2				Newport Dunes3				Marina Averages	Newport Dunes4 (Channel Site)			
Date	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**		May	Aug	Dec	**Ave**
DOC	4.58	1.09	5.15	**3.61**	3.84	0.99	5.00	**3.28**	4.20	1.39	5.24	**3.61**	**5.25**	3.97	1.38	5.18	**3.51**
TOC (%)										1.80							
Salinity (ppm)	33	32.5	32	**32.5**	33	33	29	**31.7**	32	33.5	29	**31.5**	**31.9**	31	34	27	**30.7**
Turbidity (FAU)	4	6	5	**5**	3	1	4	**2.7**	1	3	4	**2.7**	**3.5**	28	7	2	**12.3**
TSS (mg/L)	4.9	52.3	6.3	**21.2**	6.9	43.75	7.7	**19.45**	2.8	48.5	6.5	**19.27**	**19.96**	8.3	60.5	7	**25.3**

De Anza

Sample Sites	DeAnza 1				De Anza 2				De Anza 3				Marina Averages	De Anza 4 (Inner Channel Site)				De Anza 5(Outer Channel Site)			
Date	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**		May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**
DOC	3.54	0.60	3.3	**2.48**	3.56	1.05	3.14	**2.58**	3.38	1.04	3.41	**2.61**	**2.56**	3.32	0.68	3.28	**2.43**	3.39	0.55	3.60	**2.51**
TOC (%)						1.74															
Salinity (ppm)	33	34	32	**33**	32.5	33	33	**32.8**	32.5	33	32	**32.5**	**32.8**	33	34	32	**33**	32.5	33	31	**32.2**
Turbidity (FAU)	0	10	3	**4.3**	0	1	3	**1.3**	0	5	0	**1.7**	**2.4**	0	6	ND	**3**	1	13	4	**6**
TSS (mg/L)	5.1	43.5	4.3	**17.63**	5.2	31	6	**14.07**	3.6	46.3	4.5	**18.12**	**16.61**	5.7	34	5.3	**15**	7	48.8	15.3	**23.7**

Balboa Yacht Basin

Sample Sites	Balboa Yacht Basin 1				Balboa Yacht Basin 2				Balboa Yacht Basin 3				Marina Averages	Balboa Yacht Basin 4 (channel site)				Balboa Yacht Basin Ship Yard			
Date	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**		May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**
DOC	2.75	0.52	2.38	**1.88**	2.92	0.49	2.56	**1.99**	2.45	0.69	2.39	**1.84**	**1.90**	2.57	0.55	3.00	**2.04**	3.17	0.52	2.77	**2.15**
TOC (%)										1.54											
Salinity (ppm)	33.5	34	32	**33.2**	33	34	32	**33**	33.5	38	31	**34.2**	**33.5**	33.5	34.5	32	**33.3**	33	35	33	**33.7**
Turbidity (FAU)	0	0	3	**1**	5	5	1	**3.7**	0	7	5	**4**	**2.9**	5	2	4	**3.7**	0	0	4	**1.3**
TSS (mg/L)	5.3	4.5	3.5	**4.43**	9.4	34.8	3.5	**15.88**	6.1	3.8	34.8	**14.9**	**11.73**	4.5	8.5	6.3	**6.43**	4.3	11.8	6.7	**7.58**

Bahia Corinthian

Sample Sites	Bahia Corinthian 1				Bahia Corinthian 2				Bahia Corinthian 3				Marina Averages	Bahia Corinthian 4 (channel site)				Bahia Corinthian Storm Drain			
Date	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**		May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**
DOC	2.79	0.60	2.97	**2.12**	4.73	0.68	2.50	**2.64**	3.79	0.61	2.98	**2.46**	**2.41**	2.62	0.55	2.64	**1.94**	3.98	0.57	3.00	**2.52**
TOC (%)		2.72																			
Salinity (ppm)	33	35	33	**33.7**	33.5	35	32	**33.5**	33	34	30	**32.3**	**33.2**	33	34	33	**33.3**	33.5	33	32	**32.8**
Turbidity (FAU	0	1	0	**0.3**	0	1	ND	**0.5**	0	5	ND	**1.7**	**0.8**	0	0	0	**0**	0	2	3	**1.7**
TSS (mg/L)	7.8	3.5	3	**4.77**	7.7	8.25	3.6	**6.52**	5.6	33.25	4.2	**14.35**	**8.46**	8.6	39.5	6.3	**18.1**	6.6	10	4	**6.87**

Harbor Marina

Sample Sites	Harbor Marina 1				Harbor Marina 2				Marina Averages	Harbor Marina 3 (channel site)				Harbor Marina Storm Drain			
Date	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**		May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**
DOC	3.50	0.69	2.97	**2.39**	2.31		2.58	**2.45**	**2.42**	2.68	0.57	2.56	**1.94**	3.17	0.55	2.73	**2.15**
TOC (%)		4.74															
Salinity (ppm)	33.5	35	32	**33.5**	33	34	30	**32.3**	**32.9**	34	33	32	**33**	33.5	33	31	**32.5**
Turbidity (FAU)	3	0	0	**1**	2	0	0	**0.7**	**0.9**	0	0	0	**0**	0	0	0	**0**
TSS (mg/L)	2.3	1.5	2.8	**2.3**	3.47	3.33	4.35	**3.72**	**3.01**	2.7	3.5	4.5	**3.57**	2.3	7	3.2	**4.17**

Lido Village

Sample Sites	Lido Village 1				Lido Village 2				Lido Village 3				Marina Averages	Lido Village 4 (channel Site)			
Date	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**		May	Aug	Dec	**Ave**
DOC	2.68	0.59	2.38	**1.88**	2.69	0.57	2.40	**1.89**	2.97	0.70	2.41	**2.02**	**1.93**	2.86	0.66	2.44	**1.99**
TOC (%)										2.79					1.06		
Salinity (ppm)	34	33	32	**33**	33	34	33	**33.7**	33.5	33	31	**32.5**	**33.1**	33	34	33	**33.3**
Turbidity (FAU)	3	0	0	**1**	0	1	0	**0.3**	6	1	0	**0.3**	**0.5**	0	1	4	**1.7**
TSS (mg/L)	2.5	2	4.3	**2.93**	2.9	5.75	3.7	**4.12**	2.2	2.25	4	**2.82**	**3.29**	1.6	5	5	**3.87**

Lido Yacht Anchorage

Sample Sites	Lido Yacht Anchorage 1				Lido Yacht Anchorage 2				Lido Yacht Anchorage 3				Marina Averages	Lido Yacht Anchorage 4 (channel site)			
Date	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**		May	Aug	Dec	**Ave**
DOC	2.84	0.60	2.27	**1.90**	4.35	0.74	2.39	**2.49**	4.39	0.58	2.85	**2.61**	**2.33**	2.58	0.73	2.70	**2.00**
TOC (%)						2.44									2.03		
Salinity (ppm)	33	34	32	**33**	33	33	33	**33**	33.5	34	33	**33.5**	**33.2**	34	32	32	**32.7**
Turbidity (FAU)	0	1	4	**1.7**	2	2	3	**2.3**	0	2	7	**3**	**1.4**	0	2	ND	**1**
TSS (mg/L)	3.8	13.8	9.2	**8.92**	2.9	4.5	7.8	**5.07**	3.3	3.5	9.5	**5.43**	**6.47**	4.4	7.5	11.8	**7.9**

H&J Mooring

Sample Sites	H&J Moorings 1				H&J Moorings 2				H&J Moorings 3				Marina Averag	H&J Moorings 4 (channel site)			
Date	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**	May	Aug	Dec	**Ave**		May	Aug	Dec	**Ave**
DOC	2.43		2.58	**2.51**	3.73	0.64	2.32	**2.23**	3.18	0.85	2.32	**2.12**	**2.29**	3.31	0.61	1.99	**1.97**
TOC (%)						1.79											
Salinity (ppm)	32.5	34	30	**32.2**	33	35	31	**33**	33.5	35	31	**33.2**	**32.8**	33.5	32	32	**32.5**
Turbidity (FAU)	2	11	0	**4.3**	0	5	0	**1.7**	1	10	0	**3.7**	**3.2**	0	2	0	**0.7**
TSS (mg/L)	5.3	56.5	7	**22.93**	7.2	5.25	8.5	**6.98**	4.3	6.25	10	**6.85**	**12.25**	3.9	37	11.3	**17.4**

Appendix E
Organics, Grain Size, Pore Water Metals, Acid Volatile Sulfides

PAH(Seawatwer)

Sample ID	MDL	42956	42959	42978	42981	43239	43240	43242	43244	43246	43249
Client Sample ID		NB6013W	NB6022W	NB6033W	NB6041W	NB 6063 W	NB 6064 W	NB 6072 W	NB 6074 W	NB 6082 W	NB 6051 W
Replicate Number		R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Date Sampled		8/22/2006	8/22/2006	8/22/2006	8/22/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006
Matrix		Seawater	Seawater	Seawater	Seawater	Seawater	Seawater	Seawater	Seawater	Seawater	Seawater
Units	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
(d10-Acenaphthene)		96	84	91	92	92	99	88	93	88	98
(d10-Phenanthrene)		96	95	99	98	98	101	96	105	98	89
(d12-Chrysene)		82	105	109	87	94	98	100	105	98	86
(d12-Perylene)		75	105	103	80	77	82	81	91	87	71
(d8-Naphthalene)		86	76	86	84	83	91	81	88	81	95
1-Methylnaphthalene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	28.1
1-Methylphenanthrene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,3,5-Trimethylnaphthalene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,6-Dimethylnaphthalene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2-Methylnaphthalene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	33.1
Acenaphthene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3.6
Acenaphthylene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	73.7
Anthracene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benz_a_anthracene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo_a_pyrene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo_b_fluoranthene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo_e_pyrene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo_g,h,i_perylene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo_k_fluoranthene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Biphenyl	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	5.5
Chrysene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenz_a,h_anthracene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzothiophene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluorene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	10.9
Indeno_1,2,3-c,d_pyrene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	172
Perylene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phenanthrene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	10.2
Pyrene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Detectable PAHs	NA	0	0	0	0	0	0	0	0	0	337

PAH (Sediment)

Sample ID	MDL	43255	43255	43256	43258	43260	43262	43265	43298	43301	43307	43310
Client Sample ID		NB 6063 S	NB 6063 S	NB 6064 S	NB 6072 S	NB 6074 S	NB 6082 S	NB 6051 S	NB6013 S	NB6022 S	NB6033 S	NB6041 S
Replicate Number		R1	R2	R1	R1	R1	R1	R1	R1	R1	R1	R1
Date Sampled		8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/22/2006	8/22/2006	8/22/2006	8/22/2006
Matrix		Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
(d10-Acenaphthene)		59	56	80	56	68	51	56	66	38	79	40
(d10-Phenanthrene)		82	93	83	70	81	70	63	86	65	93	56
(d12-Chrysene)		104	101	108	111	101	99	102	106	96	109	80
(d12-Perylene)		98	94	96	104	96	94	96	105	87	100	73
(d8-Naphthalene)		42	33	60	38	39	32	46	40	24	57	31
1-Methylnaphthalene	1	1.8	0.9	<1	<1	<1	<1	9.6	<1	0.2	0.3	<1
1-Methylphenanthrene	1	1	0.8	<1	0.6	<1	<1	9.8	0.3	0.5	2.3	2.9
2,3,5-Trimethylnaphthalene	1	1	0.3	<1	<1	<1	<1	5.5	<1	<1	<1	<1
2,6-Dimethylnaphthalene	1	3.4	2.3	0.6	0.7	<1	<1	18.6	0.5	0.5	<1	0.3
2-Methylnaphthalene	1	<1	<1	<1	<1	<1	<1	12.8	<1	<1	<1	<1
Acenaphthene	1	1.5	1.1	0.6	1	<1	<1	4.7	0.6	0.6	1.5	2.1
Acenaphthylene	1	1.2	1	0.8	4.3	0.9	1	2.8	0.4	0.4	2.2	1.4
Anthracene	1	4.1	3.6	1.8	9.9	1.1	1.3	18.4	1.5	1	6.3	6.8
Benz_a_anthracene	1	21	16.1	5.7	28.1	4.6	4.5	93.3	8	5	25.3	33.7
Benzo_a_pyrene	1	31.1	21.2	8.4	37.4	6.3	4.7	126	11.8	7.6	34.5	43.5
Benzo_b_fluoranthene	1	31.1	22.9	10.9	40.7	6.8	6	129	13	6.9	33.4	39.9
Benzo_e_pyrene	1	31.5	22.9	9.4	35.4	6.5	5.3	126	11.8	4.6	32.2	38.7
Benzo_g,h,i_perylene	1	43.6	27.6	11.1	32.3	7.3	6.7	150	16.9	9.5	37.6	41.6
Benzo_k_fluoranthene	1	36.4	25.7	10.5	47.6	6.9	6.3	149	13.2	8.5	48.2	53.1
Biphenyl	1	0.9	<1	<1	0.4	<1	<1	2.1	0.6	0.5	0.3	0.3
Chrysene	1	35.9	25.3	10	59	7.6	14.5	166	14.6	7.7	42	54.5
Dibenz_a,h_anthracene	1	9.7	5.8	1.4	9	<1	<1	29.5	2.9	<1	7.1	8.4
Dibenzothiophene	1	<1	<1	<1	<1	<1	<1	4.7	0.5	<1	<1	<1
Fluoranthene	1	40.7	29.1	11	32	7.1	7.7	252	15.1	8.6	52.7	70.3
Fluorene	1	<1	<1	<1	0.3	<1	0.3	3.9	<1	0.5	2.1	1.2
Indeno_1,2,3-c,d_pyrene	1	32.3	21.4	8	31.8	5.4	4.6	121	14.2	8.4	34	33.5
Naphthalene	1	2.6	0.8	0.6	2.7	1	0.4	6.4	2	1.5	1.7	1.2
Perylene	1	10.2	6	2.5	14.5	1.5	1.2	44.4	5.9	2.6	10.5	13.3
Phenanthrene	1	13.1	9.1	2.1	6.9	<1	<1	101	3.9	3.6	22	27.7
Pyrene	1	45.8	33.4	13.1	38.6	8.7	8	259	17.2	10	52.8	72.1
Total Detectable PAHs	NA	400	277	108	433	71.7	72.5	1845	155	88.7	449	546

PCB (seawater)

Sample ID	MDL	42956	42959	42978	42981	43239	43240	43242	43244	43246	43249
Client Sample ID		NB6013W	NB6022W	NB6033W	NB6041W	NB 6063 W	NB 6064 W	NB 6072 W	NB 6074 W	NB 6082 W	NB 6051 W
Replicate Number		R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Date Sampled		8/22/2006	8/22/2006	8/22/2006	8/22/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006
Matrix		Seawater	Seawater	Seawater	Seawater	Seawater	Seawater	Seawater	Seawater	Seawater	Seawater
Units		ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
PCB018	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB028	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB031	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB033	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB037	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB044	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB049	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB052	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB066	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB070	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB074	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB077	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB081	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB087	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB095	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB097	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB099	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB101	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB105	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB110	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB114	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB118	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB119	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB123	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB126	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB128+167	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB138	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB141	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB149	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB151	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB153	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB156	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB157	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB158	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB168+132	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB169	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB170	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB177	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB180	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB183	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB187	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB189	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB194	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB200	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB201	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB206	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Detectable PCBs	NA	0	0	0	0	0	0	0	0	0	0

PCB (sediment)

Sample ID	MDL	43255	43255	43256	43258	43260	43262	43265	43298	43301	43307
Client Sample ID		NB 6063 S	NB 6063 S	NB 6064 S	NB 6072 S	NB 6074 S	NB 6082 S	NB 6051 S	NB6013 S	NB6022 S	NB6033 S
Replicate Number		R1	R2	R1	R1	R1	R1	R1	R1	R1	R1
Date Sampled		8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/23/2006	8/22/2006	8/22/2006	8/22/2006
Matrix		Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
Units		ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
PCB018	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB028	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB031	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB033	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB037	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB044	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB049	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB052	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB066	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB070	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB074	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB077	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB081	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB087	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB095	1	<1	<1	<1	<1	<1	<1	1.2	<1	<1	<1
PCB097	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB099	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB101	1	1.8	<1	<1	<1	<1	<1	<1	<1	<1	1.7
PCB105	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB110	1	1.4	<1	<1	<1	<1	<1	1.3	<1	<1	1.5
PCB114	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB118	1	<1	1.5	<1	1	<1	<1	<1	<1	<1	1.8
PCB119	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB123	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB126	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB128+167	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB138	1	2.7	2.7	1	2.8	<1	<1	<1	<1	<1	2.3
PCB141	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB149	1	1.8	1.6	<1	1.1	<1	<1	<1	<1	1.2	1.1
PCB151	1	<1	<1	<1	<1	<1	<1	<1	<1	1.3	<1
PCB153	1	2.1	2.7	1.1	2.1	<1	<1	1.6	<1	<1	1.8
PCB156	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB157	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB158	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.5
PCB168+132	1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB169	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB170	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB177	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB180	1	2.6	<1	<1	1.2	<1	<1	3.5	<1	<1	1.4
PCB183	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB187	1	1.3	1	<1	<1	<1	<1	1	<1	<1	<1
PCB189	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB194	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB200	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB201	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB206	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Detectable PCBs	NA	15.7	9.5	2.1	8.2	0	0	8.6	0	2.5	13.1

Grain Size

		phi Size <-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	>12
		Microns >2000	1410	1000	710	500	354	250	177	125	88.4	62.5	44.2	31.3	22.1	15.6	11.1	7.8	5.5	3.9	2.8	1.95	1.38	0.98	0.69	0.46	0.35	<0.24
Sample ID	Lab Rep.	coarse Sand	coarse sand	med sand	med sand	med sand	med sand	fine sand	very fine sand	very fine sand	very fine sand	very fine sand	very fine sand	coarse silt	coarse silt	coarse silt	silt	fine silt	very fine silt	very fine silt	clay	clay	clay	clay	clay	clay	clay	clay
NB 6013 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	3.20	8.07	11.91	13.28	13.90	12.75	10.60	7.52	6.28	3.81	2.05	2.14	2.11	1.31	0.48	0.00
NB 6013 S	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	1.22	3.98	6.90	8.43	9.02	9.64	10.26	11.04	10.20	8.70	6.00	5.07	3.17	1.75	1.68	1.57	1.01	0.39	0.00
NB 6022 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	3.37	6.63	8.93	10.49	11.47	12.48	11.73	9.94	7.12	5.96	3.62	1.95	1.95	1.96	1.14	0.37	0.00
NB 6033 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.96	2.82	5.07	7.17	9.02	10.70	11.72	12.35	10.92	8.70	5.94	4.85	2.96	1.65	1.71	1.76	1.16	0.43	0.00
NB 6041 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	1.43	3.47	5.91	7.30	8.21	9.26	10.41	10.99	11.18	9.47	7.19	4.66	3.61	2.12	1.17	1.16	1.17	0.75	0.19	0.00
NB 6051 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	1.48	3.86	6.11	6.70	6.94	7.95	9.77	11.42	12.32	10.46	7.68	4.82	3.66	2.13	1.19	1.14	1.11	0.77	0.32	0.00
NB 6063 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	1.25	3.94	7.50	11.03	13.55	15.06	13.46	10.51	7.01	5.64	3.38	1.86	1.96	2.01	1.28	0.46	0.00
NB 6063 S	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.11	2.60	4.67	7.17	10.23	12.91	14.66	13.15	10.21	6.80	5.52	3.36	1.87	1.93	1.91	1.25	0.48	0.00
NB 6064 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	1.31	2.86	4.72	6.74	9.10	11.26	13.20	12.83	10.87	7.72	6.47	3.98	2.17	2.25	2.27	1.42	0.50	0.00
NB 6072 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	1.84	3.51	4.73	6.05	8.10	10.84	12.96	13.81	11.54	8.48	5.40	4.19	2.46	1.37	1.41	1.44	0.92	0.33	0.00
NB 6074 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	2.25	4.74	7.53	10.53	12.92	14.51	13.11	10.31	6.91	5.58	3.37	1.87	1.96	2.03	1.27	0.44	0.00
NB 6082 S	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	1.49	3.74	6.16	8.31	10.35	11.84	12.96	11.88	9.71	6.77	5.63	3.46	1.91	1.98	2.01	1.21	0.41	0.00

			Summary					Percentile (microns)					Percentile (phi)					micron			phi			Dispersion Sorting Index	Distributior (phi)	
Sample ID	Lab Rep.	Analysis Date	Gravel*	Sand	Silt	Clay	Silt-Clay	5%	16%	50%	84%	95%	5%	16%	50%	84%	95%	Mean	Median	Mode	Mean	Median	Mode		Skewness	Kurtosis
NB 6013 S	1.00	13-Sep-06	0.00	0.51	81.31	18.18	99.49	0.83	2.47	7.99	19.54	29.61	10.26	8.67	6.97	5.68	5.08	10.69	7.99	9.37	6.55	6.97	6.74	1.50	-0.28	-2.73
NB 6013 S	2.00	13-Sep-06	0.00	12.30	73.05	14.65	87.70	1.05	3.02	10.97	37.99	64.72	9.91	8.38	6.51	4.72	3.95	19.32	10.97	9.31	5.70	6.51	6.75	1.83	-0.45	-2.63
NB 6022 S	1.00	13-Sep-06	0.00	4.25	78.79	16.96	95.75	0.91	2.64	8.80	25.64	42.52	10.12	8.58	6.83	5.29	4.55	13.58	8.80	9.27	6.21	6.83	6.76	1.64	-0.38	-2.69
NB 6033 S	1.00	13-Sep-06	0.00	8.93	76.54	14.52	91.07	0.97	3.04	10.35	31.46	57.84	10.03	8.37	6.60	4.99	4.11	17.14	10.35	9.41	5.87	6.60	6.74	1.69	-0.43	-2.75
NB 6041 S	1.00	13-Sep-06	0.00	18.45	71.38	10.17	81.55	1.51	4.12	13.93	49.66	90.61	9.38	7.93	6.17	4.33	3.46	25.90	13.93	9.53	5.27	6.17	6.72	1.80	-0.50	-2.64
NB 6051 S	1.00	13-Sep-06	0.00	18.31	71.37	10.32	81.69	1.49	4.05	12.65	49.80	92.46	9.40	7.96	6.31	4.33	3.43	25.15	12.65	9.43	5.31	6.31	6.73	1.82	-0.55	-2.65
NB 6063 S	1.00	13-Sep-06	0.00	1.36	82.06	16.58	98.64	0.86	2.70	8.26	19.97	32.13	10.19	8.54	6.93	5.65	4.96	11.25	8.26	9.31	6.48	6.93	6.75	1.45	-0.31	-2.81
NB 6063 S	2.00	13-Sep-06	0.00	3.89	79.80	16.31	96.11	0.88	2.74	8.49	21.90	40.72	10.16	8.52	6.89	5.51	4.62	12.76	8.49	9.28	6.30	6.89	6.76	1.50	-0.39	-2.84
NB 6064 S	1.00	13-Sep-06	0.00	4.50	76.44	19.06	95.50	0.78	2.36	7.70	22.07	42.62	10.33	8.74	7.03	5.50	4.55	12.63	7.70	9.11	6.31	7.03	6.78	1.62	-0.44	-2.79
NB 6072 S	1.00	13-Sep-06	0.00	10.70	77.18	12.12	89.30	1.23	3.55	10.72	32.68	68.77	9.68	8.15	6.55	4.94	3.86	18.84	10.72	9.48	5.73	6.55	6.73	1.61	-0.51	-2.81
NB 6074 S	1.00	13-Sep-06	0.00	2.92	80.55	16.53	97.08	0.86	2.71	8.42	21.52	38.00	10.19	8.54	6.90	5.54	4.72	12.24	8.42	9.28	6.36	6.90	6.76	1.50	-0.36	-2.82
NB 6082 S	1.00	13-Sep-06	0.00	5.41	77.98	16.60	94.59	0.88	2.69	8.95	26.01	45.93	10.16	8.55	6.81	5.27	4.44	14.12	8.95	9.30	6.15	6.81	6.75	1.64	-0.40	-2.74

Table 10. Pore water dissolved metals from Newport Bay marina sediment samples. All values are expressed in µg/L.

MDL	RL		6011	6013	6021	6022	6032	6042	6051	6063	6073	6082	Lab Blank
3	6	Aluminum (Al)	11	12	12	9	11	14	11	11	11	14	ND
0.01	0.015	Arsenic (As)	4.33	6.71	4.47	2.57	2.02	2.38	2.98	1.30	2.59	2.49	3.32
0.005	0.01	Beryllium (Be)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.261
0.025	0.05	Chromium (Cr)	0.38	0.44	0.40	0.44	0.40	0.38	0.41	0.37	0.51	0.39	3.19
0.005	0.01	Cobalt (Co)	0.46	0.438	0.424	0.457	0.392	0.341	0.343	0.369	0.336	0.356	0.263
0.01	0.02	Manganese (Mn)	505.5	332.5	198.3	382.3	115.6	85.83	127.2	87.46	51.4	118.5	0.580
0.02	0.04	Silver (Ag)	0.624	0.641	0.674	0.639	0.609	0.596	0.569	0.555	0.511	0.478	0.590
0.005	0.01	Thallium (Tl)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
0.035	0.07	Titanium (Ti)	0.529	0.977	0.739	0.674	0.498	0.455	0.540	0.408	1.047	0.327	2.949
0.02	0.04	Vanadium (V)	1.03	1.51	1.27	0.50	0.34	0.39	0.93	0.24	3.04	0.4	3.61
0.005	0.01	Zinc (Zn)	3.149	3.784	4.135	3.710	3.256	3.605	3.059	2.926	3.760	3.173	8.835
0.005	0.01	Cadmium (Cd)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.135
0.01	0.02	Copper (Cu)	1.48	1.84	1.86	1.95	1.60	1.60	1.52	1.44	4.56	6.20	3.16
0.005	0.01	Lead (Pb)	0.03	0.037	0.037	0.011	0.013	0.057	0.045	0.01	0.028	0.012	ND
0.005	0.01	Nickel (Ni)	1.185	1.26	1.207	0.979	0.837	1.054	0.957	0.981	0.673	0.925	ND
0.01	0.015	Selenium (Se)	1.22	1.48	1.32	1.38	1.28	1.15	1.12	1.29	1.74	1.13	5.87
0.005	0.01	Tin (Sn)	0.025	0.026	0.033	0.033	0.027	0.021	0.032	0.026	0.14	0.14	0.051

Table 9. Acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) from Newport Bay Marina sediment samples.

	NB6013		NB6022		NB6033		NB6041		NB6063	
	umoles/dry g	mg/kg	umoles/dry g	mg/kg	umoles/dry g	mg/kg	umoles/dry g	mg/kg	umoles/dry g	mg/kg
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	0.0041	0.461
Copper	0.0325	2.07	ND	ND	0.192	12.2	ND	ND	0.0703	4.47
Lead	0.0253	5.24	ND	ND	0.0434	8.99	ND	ND	0.0679	14.1
Nickel	0.0379	2.23	0.05	2.94	0.0298	1.75	0.0426	2.50	0.0517	3.04
Zinc	1.01	66.3	1.77	116	1.65	108	1.76	115	2.57	168
Total SEM	1.11	75.8	1.80	119	1.90	131	1.80	118	2.76	190
AVS	5.00	160	9.56	306	6.88	220	7.19	230	1.92	61.6

Table 9. (continued)

	NB6064		NB6072		NB6074		NB6082		NB6051	
	umoles/dry g	mg/kg	umoles/dry g	mg/kg	umoles/dry g	mg/kg	umoles/dry g	mg/kg	umoles/dry g	mg/kg
Cadmium	0.0021	0.236	ND	ND	0.0028	0.315	0.0028	0.315	0.005	0.562
Copper	0.0314	2.00	ND	ND	0.0157	1.00	0.0161	1.02	ND	ND
Lead	0.0335	6.94	0.0217	4.50	0.036	7.46	0.0254	5.26	0.0835	17.3
Nickel	0.0209	1.23	0.0489	2.87	0.0423	2.48	0.0397	2.33	0.0556	3.26
Zinc	0.652	42.6	3.17	207.3	2.36	154	1.83	120	3.66	239
Total SEM	0.740	53.0	3.24	214.6	2.46	165	1.91	129	3.80	260
AVS	0.516	16.5	18.9	606	0.741	23.7	1.92	61.5	7.91	253

ND = Not Detected

Unified Port
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March 29, 2012

Executive Officer
California Regional Water Quality Control Board
San Diego Region
9174 Sky Park Court, Suite 100
San Diego, CA 92123-4340
Attn: Mr. Wayne Chiu, Southern Watershed Unit

Subject: Shelter Island Yacht Basin Dissolved Copper Total Maximum Daily Load 2011 Monitoring and Progress Final Report

Dear Mr. Chiu:

Please find enclosed a CD containing the Port of San Diego Shelter Island Yacht Basin Dissolved Copper Total Maximum Daily Load 2011 Monitoring and Progress Final Report. The report also includes an addendum to clarify and correct certain data/references that were identified after the report had been finalized. The Port believes that this report and the addendum satisfy the 2011 reporting obligations of Investigative Order No. R9-2011-0036.

Please contact me at (619) 725-6073 or kholman@portofsandiego.org if you have any questions about the CD or its contents.

Sincerely,

Karen Holman
Manager, Environmental Programs
Environmental & Land Use Management

KH/JH
CD Attachment
cc: Darlene Nicandro
Karen Holman

March 2012

Shelter Island Yacht Basin Dissolved Copper Total Maximum Daily Load 2011 Monitoring and Progress Final Report

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Randa Coniglio
Executive Vice President, Operations

Shelter Island Yacht Basin Dissolved Copper Total Maximum Daily Load 2011 Monitoring and Progress Final Report

Prepared for:
California Regional Water Quality Control Board,
San Diego Region

Prepared by:
Weston Solutions, Inc.

In Coordination with:
Port of San Diego

March 2012

Shelter Island Yacht Basin Dissolved Copper Total Maximum Daily Load 2011 Monitoring and Progress Final Report

Prepared for:
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Port of San Diego

Prepared by:

Weston Solutions, Inc.
2433 Impala Drive
Carlsbad, California 92010

March 2012

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ACRONYMS AND ABBREVIATIONS

APHA	American Public Health Association
ASTM	American Society for Testing and Materials
Basin Plan	*Water Quality Control Plan for the San Diego Basin – Region 9*
BLM	Biotic Ligand Model
BMP	best management practice
CD	compact disk
COC	chain-of-custody
CTR	California Toxics Rule
Cu	Copper
Cu-ISE	copper-ion selective electrode
Cu^{2+}	free copper
dGPS	differential global positioning system
DO	dissolved oxygen
DOC	dissolved organic carbon
DPR	Department of Pesticide Regulation
EC_{50}	median effective concentration
ELAP	California Environmental Laboratory Accreditation Program
FY	fiscal year
HDPE	high-density polyethylene
Implementation Plan	SIYB Dissolved Copper TMDL Implementation Plan
Investigative Order	Investigative Order No. R9-2011-0036
L_h	hull cleaning annual loading
L_p	passive leaching annual loading
L_v	average annual loading per vessel
LC_{50}	median lethal concentration
LOEC	lowest observed effect concentration
MAR	marine habitat
Monitoring Plan	SIYB Dissolved Copper TMDL Monitoring Plan
MSDS	material safety data sheet
N_v	number of vessels
NOEC	no observed effect concentration
OAL	Office of Administrative Law
pH	hydrogen ion concentration
pMSD	percent minimum significant difference
Port	San Diego Unified Port District
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
QC	quality control
RHMP	Regional Harbor Monitoring Program
Regional Board	San Diego Regional Water Quality Control Board
SB	Senate Bill
SIYB	Shelter Island Yacht Basin
SM	Standard Methods
SOP	standard operating procedure

SSO	site-specific objectives
State Board	State Water Resources Control Board
SUSMP	Standard Urban Storm water Management Plan
SWAMP	Surface Water Ambient Monitoring Program
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TOC	total organic carbon
USEPA	U.S. Environmental Protection Agency
WESTON	Weston Solutions, Inc.
WILD	wildlife habitat
WQO	water quality objective

UNITS OF MEASURE

°C	degrees Celsius
ft	feet or foot
kg/yr	kilogram per year
µg/L	microgram per liter
m	meter
m^2	square meter
mg/L	milligram per liter
mL	milliliter
mV	millivolt
ppt	parts per thousand
psu	practical salinity unit
yr	year
%	percent

EXECUTIVE SUMMARY

The Shelter Island Yacht Basin (SIYB) Dissolved Copper Total Maximum Daily Load (TMDL) Annual Monitoring and Progress Report was prepared in compliance with Investigative Order No. R9-2011-0036 (Investigative Order), issued by the San Diego Regional Water Quality Control Board (Regional Board) to the San Diego Unified Port District (Port) on March 11, 2011. The Investigative Order\ states that TMDL implementation progress is to be determined through tracking data on the number of boat hulls converted from copper-based antifouling paints to alternatives to assess required dissolved copper loading reductions and monitoring dissolved copper concentrations and toxicity in the water column to determine when water quality objectives are attained and beneficial uses restored. The Port, as the steward of San Diego Bay, is committed to continue Investigative Order-required monitoring to ensure that water quality conditions in SIYB continue to improve. The 2011 SIYB TMDL Monitoring and Progress Report provides information on vessel conversions; best management practice (BMP) implementation in SIYB, San Diego Bay, and beyond; and water quality monitoring, as required in the Investigative Order.

Vessel Conversions

Annual dissolved copper loading reduction was assessed through tracking of conversions of hull paints from copper to non-copper or low-copper (i.e., <40% copper) products for vessels moored in SIYB. The transition of a vessel to non-copper hull paint was assumed to reduce annual loading by 0.9 kg/yr, based on the assumptions of the SIYB TMDL, and transition to low-copper hull paint reduced loading by 0.45 kg/yr. Vessel tracking indicates that there has been a nearly 27% (i.e., 563 kg/yr) reduction in annual dissolved copper loading from vessels to SIYB, which exceeds the required 2012 interim loading reduction target of 10%. The dissolved copper loading reduction was due primarily to a reduced occupancy (approximately 19% lower dissolved copper loading) and secondarily to transitions to non-copper and low copper hull paints (up to 8.7% loading reduction, assuming 100% occupancy).

Best Management Practice Implementation

BMPs implemented by the Port and the Shelter Island Master Leaseholders TMDL Group to reduce dissolved copper loading and improve water quality included:

- Formulation of policies, regulations, and incentives to reduce copper loading, such as the San Diego Bay-wide hull cleaning permit and marina/yacht club alternative paint wait list priority and financial incentives.
- Sponsorship and implementation of alternative hull paint studies.
- Hull paint transitions to non-copper and low-copper products.
- Extensive education and outreach, such as hosting educational booths, developing brochures and educational materials, and presenting at conferences and workshops.
- Leading and participating in multi-agency activities, such as the state-wide copper sub-workgroup and the Regional Harbor Monitoring Program.

Water Quality Monitoring

Water quality sampling was conducted at six stations and one reference station in the main channel of San Diego Bay adjacent to SIYB to determine dissolved copper concentrations in the basin, test for acute and chronic toxicity, and assess water quality trends over time. Dissolved copper concentrations at all stations exceeded the numeric water quality objective (WQO) of 3.1 µg/L; however, there was very little evidence of toxicity (i.e., only one station exhibited during the October 2011 survey showed evidence of chronic toxicity to mussel larvae). The absence of acute toxicity at dissolved copper concentrations up to 11.5 µg/L and detection of chronic toxicity at only one station with a dissolved copper concentration of 8.08 µg/L underscores the importance of considering site-specific factors that regulate copper bioavailability in the TMDL. Additionally, while not shown to be statistically significant, monitoring showed that there has been an approximately 15% reduction in the average dissolved copper concentration measured in 2011 surveys (7.01 µg/L) from the baseline average dissolved copper concentration (8.28 µg/L) as described in the SIYB TMDL Monitoring Plan. Monitoring provides evidence that vacancies and vessel hull paint conversions are becoming effective in reducing dissolved copper loading and improving water quality.

In summary, the 2011 SIYB TMDL monitoring findings provide evidence that trends in both copper loading and water quality are improving from baseline conditions in SIYB. Dissolved copper loading reductions were due to a combination of vessel conversions to alternative hull paints and reduced occupancy. While dissolved copper concentrations still exceeded both acute and chronic CTR thresholds in SIYB, concentrations appear to be declining from baseline conditions. Most notably, toxicity in the basin was extremely rare, since only one station was found to have surface water that inhibited normal development of mussel larvae. There is an increasing body of evidence that the 3.1 µg/L WQO is overly protective of water quality beneficial uses in SIYB and San Diego Bay, as determined by water-effects ratio (WER) and biotic ligand model (BLM) studies, as well as reevaluations of more recent toxicity data used to establish the current numeric WQO. However, given that dissolved copper concentrations are still well above the existing WQO, further studies are needed to understand how site-specific factors affect copper bioavailability in SIYB.

1.0 INTRODUCTION

The Shelter Island Yacht Basin (SIYB) Dissolved Copper Total Maximum Daily Load (TMDL) annual monitoring and progress report was prepared in compliance with Investigative Order No. R9-2011-0036 (Investigative Order), issued by the San Diego Regional Water Quality Control Board (Regional Board) to the San Diego Unified Port District (Port) on March 11, 2011. The Investigative Order issued under §13225 of the Porter-Cologne Water Quality Control Act requires that the Port provide technical reports on the progress of the SIYB TMDL. TMDL implementation progress is to be determined through (1) tracking data on the number of boat hulls converted from copper-based antifouling paints to alternatives to assess required dissolved copper loading reductions and (2) monitoring dissolved copper concentrations and toxicity in the water column to determine when water quality objectives are attained and beneficial uses restored.

The SIYB TMDL Monitoring and Progress Report provides information on (1) TMDL Implementation, including an evaluation, interpretation, and tabulation of data collected by Named Parties (i.e., Dischargers) on vessel conversions and SIYB best management practice (BMP) Implementation; (2) San Diego Bay-wide BMP Implementation; and (3) SIYB TMDL Monitoring for water quality. Results of the vessel tracking program will be used to assess both interim and final compliance with the TMDL loading reduction requirements for dissolved copper into SIYB. Water quality monitoring will be used to assess annual improvements in dissolved copper concentrations and toxicity levels, while also determining progress towards final TMDL compliance numeric and narrative objectives, as defined in Resolution No. R9-2005-0019 in which the Regional Board incorporated the dissolved copper TMDL into the *Water Quality Control Plan for the San Diego Basin – Region 9* (Basin Plan; Regional Board, 2005).

1.1 Compliance Schedule

Under Resolution R9-2005-0019, the SIYB TMDL requires that loading of dissolved copper into the water column be reduced by 76 percent (%) to 567 kilograms per year (kg/yr) over a 17-yr period (Regional Board, 2005). Based on the official TMDL approval date[1] of February 9, 2005, this time period is set to end in 2022. No reductions in dissolved copper loading were required during the initial two-year orientation period (2005-2007). The subsequent 15-year period requires incremental loading reductions. A 10% reduction in dissolved copper loading is required within seven years, a 40% reduction in loading is required within 12 years, and a 76% reduction within 17 years (Table 1-1).

[1] For a TMDL to be incorporated into the Basin Plan, it must be approved by the Regional Board, State Water Resources Control Board (State Board), Office of Administrative Law (OAL), and United States Environmental Protection Agency (USEPA) Region 9. The official TMDL approval date is when the OAL approves the document.

Table 1-1. Loading Targets for TMDL Attainment

Stage	Time Period	Percent Reduction from Current Estimated Loading	Reduction to be Attained by end of Year	Estimated Interim & Final Target Loading (kg/yr of Dissolved Copper)
1	2005-2007	0%	N/A	N/A
2	2007-2012	10%	7	1,900
3	2012-2017	40%	12	1,300
4	2017-2022	76%	17	567

1.2 Sources of Dissolved Copper

Based on the Regional Board's source analysis, the total mass load of dissolved copper to SIYB was determined to be 2,163 kg/yr, of which 98% of inputs were attributable to copper-based hull paints from recreational vessels (Table 1-2).

Table 1-2. Sources of Dissolved Copper to SIYB

Source	Mass Load (kg/yr)	Contribution (% Dissolved Copper)
Passive Leaching	2,000	93
Hull Cleaning	100	5
Urban Runoff	30	1
Background	30	1
Direct Atmospheric Deposition	3	<1
Sediment	0	0
Total	**2,163**	**100**

1.3 Water Quality Objective Criteria

The numeric water quality objectives (WQOs) for dissolved copper in SIYB are equal to the California Toxics Rule (CTR) water quality values for dissolved copper within seawater (U.S. Environmental Protection Agency [USEPA], 2000). Continuous or chronic exposures may not exceed 3.1 micrograms per liter (µg/L) over a 4-day average, while acute exposures should not exceed 4.8 µg/L over a 1-hour average. In addition, numeric WQOs must not be exceeded more than once every three years. Based on these numeric targets and existing monitoring data at the enactment of the TMDL, the final waste load allocation was determined to be 567 kg/yr. This includes a 10% margin of safety calculated to be 57 kg/yr. In addition to numeric WQOs, the Basin Plan established narrative WQOs for toxicity and pesticides (Regional Board, 1994):

> ***Toxicity Objective****: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Board.*

> ***Pesticide Objective**: No individual pesticide or combination of pesticides shall be present in the water column, sediments, or biota at concentration(s) that adversely affect beneficial uses. Pesticides shall not be present at levels which will bioaccumulate in aquatic organisms to levels which are harmful to human health, wildlife or aquatic organisms.*

Beneficial uses within SIYB threatened by elevated dissolved copper concentrations include marine habitat (MAR) and wildlife habitat (WILD). The Regional Board indicated that if numeric WQOs are met for dissolved copper, then narrative WQOs will also be met. However, since numeric WQOs are not site specific, direct assessments of toxicity as well as SIYB biota provide direct indications of basin-wide attainment of beneficial uses and narrative WQOs.

1.4 Monitoring Purpose

Tracking of vessel conversions from copper to non-copper or low-copper hull paints is being used to assess compliance with interim and final TMDL loading-reduction targets on a basin-wide basis. Water quality monitoring assesses long-term improvements in water quality, as measured by surface-water dissolved copper concentrations and toxicity levels. Additionally, water quality monitoring will be used to determine final compliance with both numeric and narrative WQOs throughout the basin. By conducting both vessel tracking and water quality monitoring on an annual basis, the program will be able to evaluate the relationship between load reductions and water quality improvements. Additionally, this approach will provide the data needed to assess the overall TMDL implementation effectiveness and success in attaining both loading reductions and numeric WQOs that are protective of the basin's MAR and WILD beneficial uses.

2.0 METHODS

This section details the methods used to track load reductions (i.e., vessel tracking) and monitor water quality.

2.1 Vessel Tracking

Annual reduction was assessed through tracking of conversions of hull paints from copper to non-copper or low-copper (i.e., <40% copper) products for vessels moored in SIYB since transitions from copper paints result in simultaneous reductions in copper inputs from both passive leaching and hull cleaning. Named Parties operating facilities that aggregate vessels in SIYB (i.e., marina and yacht club owners and operators) reported to the Port vessel tracking data collected from January 1 to approximately December 31, 2011. Required vessel tracking data are provided in Table 2-1.

Table 2-1. Required Vessel Tracking Data

Element	Vessel Tracking Data
1	Name of marina or yacht club
2	Date of report
3	Total number of slips or buoys in facility available to be occupied by vessels
4	Slip/mooring occupation data
4a	Percent of time unoccupied
4b	Percent of time occupied by vessel(s) with known copper hull paint
4c	Percent of time occupied by vessel(s) with documented low-copper hull paint
4d	Percent of time occupied by vessel(s) with documented non-copper hull paint
5	Vessel-specific information
5a	Document or registration numbers of vessels moored in slips/moorings
5b	Vessel type (sail, power, multi-hull, etc.)
5c	Vessel length
5d	Vessel beam width

As a data quality assurance/quality control (QA/QC) and confirmation check, additional information on paint type and application was to be provided for vessels reported to have low-copper (less than 40% copper) or non-copper hull paints (Table 2-2).

Table 2-2. Required Low-Copper and Non-Copper Hull Paint Vessel Data

Element	Low-Copper and Non-Copper Vessel Hull Paint Confirmation Data
1	Vessel document or registration number
2	Hull paint name
3	Product number
4	Name of boatyard that applied paint
5	Painting date
6	Percent copper if low-copper hull paint is indicated

Vessel tracking data from SIYB Named Parties responsible for aggregating vessels were compiled to report on the percent of time that slips were unoccupied or were occupied by vessels with copper, low-copper, non-copper, or unknown hull paints as required by the Investigative Order (Table 2-3).

A quality control (QC) check of vessel tracking data reported by Named Parties to the Port was performed with the specific purpose of confirming the category of hull paint reported. Low-copper and non-copper hull paints were considered to be confirmed if the required supporting data were reported and the material safety data sheet (MSDS) for a given paint confirmed the copper content of a reported paint type. Otherwise, the paint type was listed as either unconfirmed low copper or unconfirmed non copper. These data were used to calculate the annual dissolved copper load to SIYB from vessels, the number of vessels converted from copper to low-copper or non-copper hull paints, and the reduction in dissolved copper loading achieved annually, as described in Section 2.1.1.

Table 2-3. Investigative Order Required Vessel Tracking Data for Annual Reporting

Element	Vessel Tracking Data
1	Total number of slips or buoys in facility available to be occupied by vessels
2	Number of unoccupied slips or buoys and length of time unoccupied during each year
3	Number of vessels confirmed with copper-based hull paints and approximate length of time occupying a slip or buoy in facility each year
4	Number of vessels confirmed with alternative hull paints, by hull paint type, and approximate length of time occupying a slip or buoy in facility each year
5	Number of vessels with unconfirmed information about hull paints and approximate length of time occupying a slip or buoy in facility each year
6	Estimate of the dissolved copper load reduction achieved for the year (kg/yr and %)

2.1.1 Annual Dissolved Copper Load Analysis

Compliance with interim and final TMDL loading reduction goals was assessed through tracking the number of vessels with non-copper, copper, and low-copper hull paints, as well as the number of vacant slips in SIYB. The tracking program took a conservative approach to estimating loading reductions. If the hull paint name and type was unknown, the paint was assumed to be copper-based. Additionally, if the occupancy time of a slip or mooring was not reported, the slip or mooring was assumed to be occupied 100% of the time (i.e., 365 days). Paint categories for transient vessels visiting the Port-operated transient vessel dock and temporary anchorage were not collected; therefore, all vessels were assumed to have copper hull paints.

The following TMDL assumptions were used for comparisons to baseline dissolved copper loading to SIYB (Appendix 2 of Regional Board 2005).

- All 2,363 SIYB slips or buoys were occupied by vessels (N_v).
- All 2,363 recreational vessels moored within SIYB have copper-based paints 100% of the time.

- Annual loading from passive leaching basin wide (L_p) equals 2000 kg/year.
- Annual loading from hull cleaning (L_h) equals100 kg/yr.
- Avg. annual loading (L_v) per vessel with copper hull paint equals 0.9 kg/yr. Where $L_v = (L_p + L_h)/N_v$.

In accordance with the TMDL, this loading reduction analysis assumed that there was an average loading reduction of 0.9 kg/yr for every vessel in SIYB that converted from copper-based to non-copper-based paints. The use of low-copper hull paints (i.e., hull coatings with less than 40% copper) also was recognized in the TMDL as a viable means of reducing copper loading to the basin. This loading reduction analysis also assumed that each vessel transitioned to low-copper hull paints on average reduced annual dissolved copper loading by 0.45 kg/yr. Thus, calculations of annual dissolved copper loading were based on the following assumptions (Table 2-4).

Table 2-4. Dissolved Copper Loading Calculation Assumptions

Dissolved Copper Loading Assumptions
1. All vessels moored in SIYB at the enactment of the TMDL had copper hull paints.
2. Average annual dissolved copper load from a vessel with copper paint equals 0.9 kg/yr.
3. Vessels with unknown hull paints were assumed to have copper.
4. Slips/moorings for which occupancy data were not provided were assumed to be 100% occupied.
5. Annual dissolved copper load from a vessel with non-copper hull paint equals 0 kg/yr.
6. Low copper hull paints include paints with less than 40% copper.
7. Average annual dissolved copper load from a vessel with low-copper paint equals 0.45 kg/yr.
8. Annual loads were normalized by the percent of time vessels are in SIYB.

Annual loading was calculated for each slip by multiplying the reported dissolved annual loading for a given hull paint category by the percent of time a slip was reported to be occupied (e.g., the product of 0.9 kg/yr for copper hull paints and 90% occupancy results in an annual loading of 0.81 kg/yr). In the case of the Port-operated anchorage, data on the number of three-day permits issued weekly were used to calculate annual occupancy and loading. For each issued permit, it was assumed that the vessel occupied the anchorage for an average of two days, and since no hull paint data were collected, all vessels were assumed to have copper paints. Therefore, annual dissolved copper loading was calculated by multiplying the annual dissolved copper load (0.9 kg/yr) by the average number of vessels occupying the anchorage weekly in 2011 and the average percentage of time slips were occupied.

2.2 SIYB Best Management Practice Implementation

Named Parties selected the BMPs and other actions to be implemented that indirectly or directly contribute to dissolved copper load reductions and/or water quality improvements. Selection, implementation, and effectiveness assessments of BMPs were at the sole discretion of each Named Party. In compliance with the Investigative Order reporting requirements, Named Parties were required to submit information annually to the Port on the BMPs and actions implemented to reduce dissolved copper loads to SIYB. The Port then compiled the list of implemented and planned BMPs into the annual monitoring report.

2.3 San Diego Bay-Wide BMP Implementation

The report describes BMPs or other actions that were implemented by the Port to reduce dissolved copper discharges from boat hulls into harbors or marinas within San Diego Bay. The Port also reported actions that were taken to reduce dissolved copper discharges to marinas beyond San Diego Bay, including actions with statewide or national applicability.

2.4 Water Quality Monitoring

Water quality sampling was conducted to determine the average concentration of dissolved copper in the basin and assess water quality trends over time. The monitoring was performed using methods consistent with prior studies conducted by the Regional Board in SIYB, as reported in the TMDL (Appendix 6 of Regional Board 2005). To be consistent with these prior studies, water quality monitoring was performed at six stations and one reference station in the main channel of San Diego Bay adjacent to SIYB. These station locations were similar to those sampled by the Regional Board and met the Investigative Order requirement of being spatially representative of dissolved copper concentrations in SIYB, as described in the SIYB Dissolved Copper TMDL Monitoring Plan (Monitoring Plan; Weston Solutions, Inc. [WESTON], 2011a).

As required in the TMDL, dissolved copper concentrations were compared to the baseline level of 8.28 ± 1.36 (mean ± standard error). This value was calculated using water quality data collected between 2005 and 2008 from stations located in the immediate vicinity of the Regional Board monitoring network (WESTON 2011a).

2.4.1 SIYB Sample Locations

The SIYB water quality monitoring network was comprised of six stations within SIYB (i.e., SIYB-1 to 6) and one station in the main channel of San Diego Bay outside of the mouth of the basin (SIYB-REF) (Table 2-5 and Figure 2-1).

Table 2-5. Sampling Station Coordinates

Station	Latitude	Longitude
SIYB-1	32.71821	-117.22601
SIYB-2	32.71412	-117.22921
SIYB-3	32.71550	-117.22989
SIYB-4	32.71683	-117.23203
SIYB-5	32.71217	-117.23297
SIYB-6	32.70858	-117.23514
SIYB-REF	32.70406	-117.23232

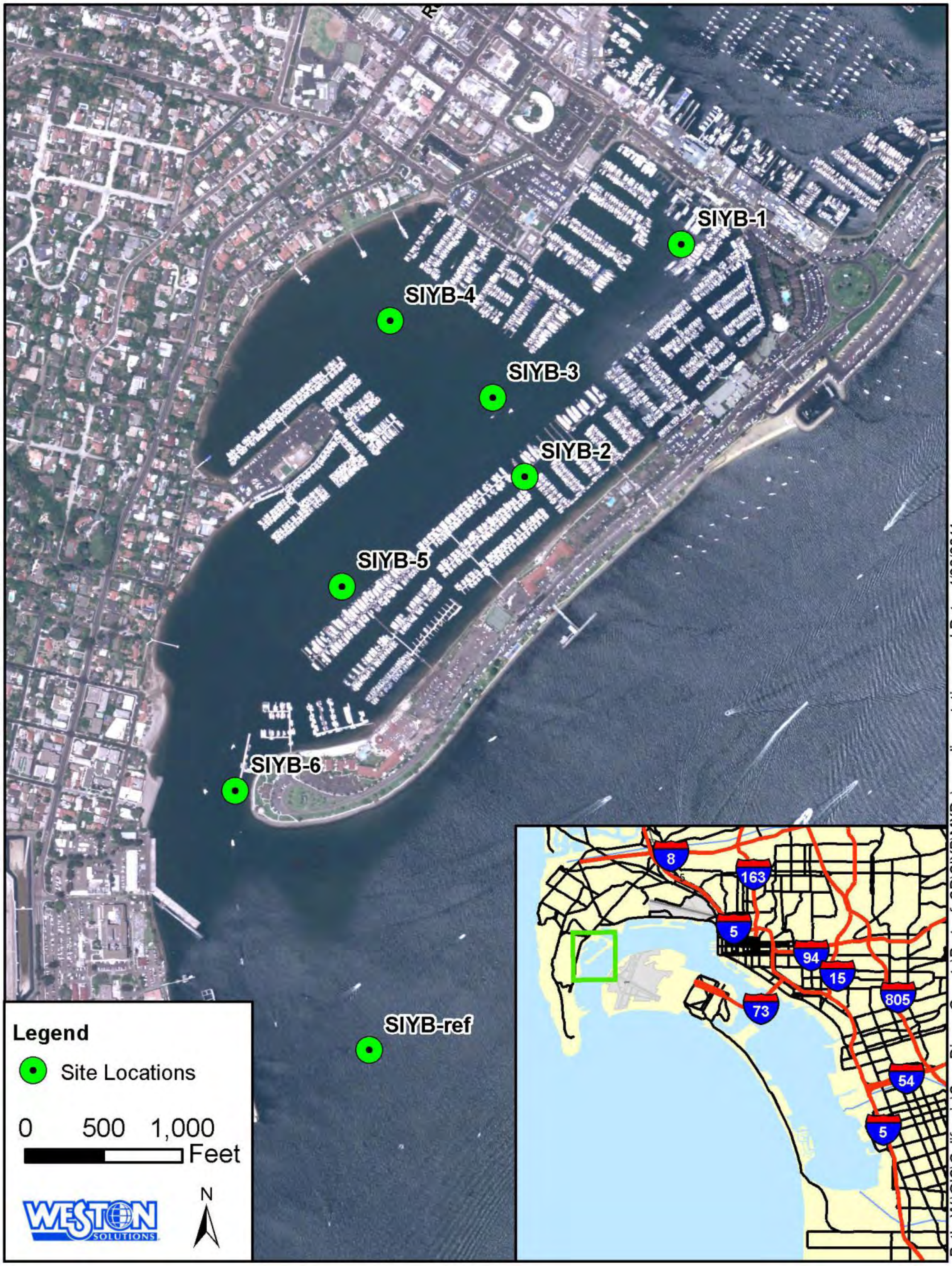

Figure 2-1. Shelter Island Yacht Basin Spatially-Representative Monitoring Network

2.4.2 Sampling Dates

Sampling was conducted at the seven water quality monitoring stations (six SIYB stations and one San Diego Bay reference station) on August 22, 2011. In accordance with the Monitoring Plan, sampling was performed at slack high tide during the summer. By conducting sampling in the summer, dissolved copper concentrations were expected to be at the highest level in the water column due to higher release rates of copper from antifouling paints at higher sea surface temperatures and greater frequency of hull cleaning. This sampling design provides the most conservative estimate for dissolved copper concentrations for SIYB. Due to equipment malfunction during *in situ* assessments of free copper, a second monitoring event was conducted on October 26, 2011.

2.4.3 Sample Collection

Discrete water samples were collected at each station using "clean hands" techniques with a Niskin bottle deployed from a sampling vessel. All stations were located using differential global positioning system (dGPS). Samples were collected within one meter (m) of the surface. Upon collection, water samples were transferred to labeled containers for analysis of total and dissolved copper, total and dissolved zinc, total organic carbon (TOC), dissolved organic carbon (DOC), and toxicity testing.

In situ measurements of free copper (Cu^{2+}), salinity, and hydrogen ion concentration (pH) were performed at all stations (Table 2-6). Field measurements of pH and salinity were made using a YSI data sonde. An Orion copper-ion selective electrode (Cu-ISE) was used to measure concentrations of Cu^{2+} in surface water (i.e., within 1 m of the surface). The Cu-ISE measures pCu, where pCu = $\log_{10}(Cu^{2+})$, when calibrated with glycine and ethylenediamine copper buffers (Belli and Zirino, 1993; DeMarco et al., 1997). The precision of the Cu-ISE is ± 0.06 pCu units (Zirino et al., 1998), and the electrode is effective at total copper concentrations < 3 nM (Zirino et al., 2002). Readings were taken three minutes apart at each station and the average of these readings was used to convert the resulting value in millivolts (mV) to pCu units, using the calibration formula: pCu = -0.0448 (voltage in mV) + 9.7329. A detailed description of the method used to measure Cu^{2+} is provided by Delgadillo-Hinojosa et al. (2008).

Table 2-6. In Situ Analytical Methods and Detection Limits

Water Quality Measurement	Method	Method Detection Limit	Reporting Limit
Free Copper	Orion Cu-ISE	<3 n/M	<3 n/M
Salinity	YSI Sonde	N/A	PSU
pH	YSI Sonde	N/A	0.2 pH unit

All water samples were logged on a chain-of-custody (COC) form and placed in a cooler on ice. Samples were stored at 4 degrees Celsius (°C) in the dark until shipped or delivered to the appropriate laboratory for analysis, within 24 hours of collection.

2.4.4 Equipment Decontamination and Cleaning

The Niskin bottle was cleaned prior to sampling using clean soapy water and thoroughly rinsing with deionized water. Upon deployment, the Niskin bottle received a site water rinse prior to sample collection. After collection, water samples were transferred from the Niskin bottle to laboratory-certified, contaminant-free, high-density, polyethylene (HDPE) bottles.

2.4.5 Chemical Analysis

Water samples were transferred to the laboratory for analysis of total and dissolved copper, total and dissolved zinc, TOC, and DOC, following USEPA or Standard Methods (SM; American Public Health Association [APHA], 1998) (Table 2-7). The measurement of DOC, salinity, and pH can be entered into the Biotic Ligand Model (BLM) to estimate the bioavailable fraction of dissolved copper present in SIYB and predict toxicity. Zinc is commonly used as an alternative biocide in antifouling paints and therefore total and dissolved zinc were measured to determine if concentrations are increasing as vessel hull paints are converted from copper-based to non-copper based paints.

Table 2-7. Laboratory Analytical Methods and Detection Limits

Water Quality Measurement	Method	Method Detection Limit	Reporting Limit
Total Copper	USEPA 1640	0.01 µg/L	0.02 µg/L
Dissolved Copper	USEPA 1640	0.01 µg/L	0.02 µg/L
Total Zinc	USEPA 1640	0.005 µg/L	0.01 µg/L
Dissolved Zinc	USEPA 1640	0.005 µg/L	0.01 µg/L
Total Organic Carbon	SM5310 B	0.1 mg/L	0.2 mg/L
Dissolved Organic Carbon	SM5310 B	0.1 mg/L	0.2 mg/L

2.4.6 Toxicity Testing

Toxicity testing consisted of a 96-hour acute bioassay test using topsmelt (*Atherinops affinis*) to be consistent with the TMDL guidance (Regional Board, 2005). Additionally, a 48-hour chronic bioassay test using the mussel (*Mytilus galloprovincialis*) was performed since previous studies have generally used the 48-hour mussel chronic test as the primary indicator of toxicity. Both tests were used to assess compliance with the narrative toxicity objective since both species have ecological relevance to the marina environment and previously have been found to be sensitive to copper.

2.4.6.1 Topsmelt 96-Hour Acute Bioassay

A 96-hour acute bioassay with topsmelt was performed for samples collected during the August Survey. Tests were initiated on August 23, 2011 for samples collected at SIYB-1 and SIYB-2 and August 24, 2011 for SIYB-3, SIYB-4, SIYB-5, SIYB-6, and SIYB-REF following the procedures described in *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms* (USEPA, 2002).

Topsmelt were exposed for 96 hours to five sample concentrations (0.5 dilution series) and a control. Each concentration was run with four replicates and ten topsmelt per replicate. Water quality was conducted daily and included dissolved oxygen (DO), temperature, pH, and salinity. Test conditions are summarized in Table 2-8. After 96 hours, percent survival was calculated. The test was considered acceptable if $\geq$90% of organims survive in the controls.

Table 2-8. Conditions for the 96-Hour Topsmelt Bioassay

Test Results 96-Hour Acute Bioassay			
Samples Tested		SIYB-1, SIYB-2	SIYB-3, SIYB-4, SIYB-5, SIYB-6, SIYB-REF
Date Sampled		August 22, 2011	
Date Received at Weston's Laboratory		August 23, 2011	
Test Species		***Atherinops affinis***	
Test Procedures		EPA-821-R-02-012 (USEPA, 2002)	
Test Type/Duration		Acute static-renewal /96-hours	
Supplier		Aquatic Biosystems, Fort Collins, CO	
Control Water Source		Scripps Pier seawater, 3 µm filtered, Ultra Violet (UV) sterilized	
Date Acquired		August 23, 2011	August 24, 2011
Acclimation/Holding Time		0 days	0 days
Age Class		12 days	13 days
Test Location		Carlsbad Laboratory, Room 3	
Test Dates		August 23-27, 2011	August 24-28, 2011
Water Quality Measurements	Temperature	20.9 – 22.4°C	20.6 – 22.4 °C
	Salinity	32.8 – 33.5 ppt	31.3 – 33.2 ppt
	Dissolved Oxygen	5.3 – 8.5 mg/L	5.5 – 8.4 mg/L
	pH	7.6 – 8.1	6.0 – 8.5
Replicates/Sample		4	
Concentration of Organisms per Replicate (Zero Time Range)		10	
Exposure Volume		250 mL	
Protocol Deviations		Samples SIYB-3, SIYB-4, SIYB-5, SIYB-6, and SIYB-REF were started outside of the recommended holding time due to a shortage of test organisms. Temperatures of samples SIYB-2, SIYB-3, SIYB-4, SIYB-5, SIYB-6, and SIYB-REF at receipt were above the protocol limit. Sample SIYB-5 chlorine was not measured at 48 or 72 hours due to technician error.	

A 96-hour reference toxicity test using copper sulfate was conducted concurrently with the project samples to evaluate the relative sensitivity of test organisms. Copper sulfate reference toxicant tests were conducted at concentrations of 0, 25, 50, 100, 200 and 400 µg/L concurrently with each batch of test organisms. At test termination, the median lethal concentration (LC_{50}) was calculated and compared to historical laboratory reference toxicant test data for this species. Test organisms were considered to be responsive and appropriately sensitive if the test LC_{50} was within two standard deviations of the historical laboratory standard.

2.4.6.2 Bivalve 48-Hour Bioassay

The 48-hour bivalve larvae test was performed for samples collected at all stations during the August survey and at a subset of stations (i.e., SIYB-1, SIYB-3, and SIYB-5) during the October survey. Bioassay tests were performed in accordance with procedures outlined in *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and ASTM E724-98 (ASTM, 2009). The test was run for 48 hours to ensure development of the bivalve larvae to the D-hinge stage in the control. Bivalves were exposed to five sample concentrations and a control. Each concentration was run with four replicates and 150-300 larvae were targeted for inoculation into each replicate. Water quality included DO, temperature, pH, and salinity at test initiation and termination and temperature at 24 hours. Test conditions are summarized in Table 2-9.

Table 2-9. Conditions for the 48-Hour Mussel Bioassay

Test Results 48-Hour Chronic Bioassay			
Samples Tested		SIYB-1, SIYB-2, SIYB-3, SIYB-4, SIYB-5, SIYB-6, SIYB-REF	SIYB-1, SIYB-3, SIYB-5
Date Sampled		August 22, 2011	October 26, 2011
Date Received at Weston's Laboratory		August 23, 2011	October 27, 2011
Test Species		***Mytilus galloprovincialis***	
Test Procedures		EPA/600/R-95/136 (USEPA 1995), ASTM E724-98 (ASTM 2009)	
Test Type/Duration		Bivalve Larvae – Static / 48 hours	
Supplier		Taylor Shellfish, Shelton, WA	
Sample Storage Conditions/Holding Time		4°C, dark, minimal head space/36 hours	
Date Acquired		August 23, 2011	October 27, 2011
Acclimation/Holding Time		0 days	0 days
Age Class		<4 hour old embryos	
Test Location		Carlsbad Laboratory, Room 2	
Test Dates		August 23 – 25, 2011	October 27 – 29, 2011
Actual Water Quality Measurements	Temperature	14.3 – 16.6 °C	13.5 – 15.9 °C
	Salinity	30.0 – 35.5 ppt	29.8 – 33.3 ppt
	Dissolved Oxygen	7.5 – 8.3 mg/L	7.2 – 7.9 mg/L
	pH	7.9 – 8.1	8.0 – 8.2
Concentration of Organisms per Replicate (Zero Time Range)		218	211
Protocol Deviations		Control normality for the samples run on August 23, 2011 was slightly below the acceptability criterion of ≥90 percent. Temperatures of samples SIYB-2, SIYB-3, SIYB-4, SIYB-5, SIYB-6, and SIYB-REF at receipt on August 23, 2011 were above the protocol limit. Test temperatures and salinities occasionally fell slightly outside of protocol range. The pMSD for survival for the August 23, 2011 sample SIYB-REF test was slightly above the acceptability criterion of ≤25%.	

After test termination, percent survival and percent normal development were calculated to determine if significant mortality or reduction in normality existed. The test was considered acceptable if $\geq$50% of larvae survived and $\geq$90% of the surviving larvae showed normal development in the controls.

A 48-hour reference toxicity test using copper sulfate was conducted concurrently with the project samples to evaluate the relative sensitivity of test organisms. The copper sulfate reference toxicant test was conducted at concentrations of 0, 2.5, 5.0, 10, 20 and 40 µg Cu^{2+}/L. At test termination, the survival LC_{50} and the normality median effective concentration (EC_{50}) were calculated and compared to historical laboratory reference toxicant test data for this species. Test organisms were considered to be responsive and appropriately sensitive if the test LC_{50} and EC_{50} were within two standard deviations of the respective historical laboratory standards.

2.4.7 Water Quality Analysis

Analysis of water quality data included calculations of average dissolved copper concentrations to determine basin-wide compliance with the CTR dissolved copper chronic target (3.1 µg/L). 2011 monitoring data were compared to the 2005-2008 dissolved copper baseline concentration data reported in the Monitoring Plan (WESTON, 2011a) to determine whether conditions improved or degraded over the intervening period.

Determinations of toxicity using the 96-hour topsmelt and 48-hour mussel bioassays were statistically assessed using ToxCalc to compare survival (topsmelt and mussel) and normal development (mussel) of test organisms exposed to the multi-concentration dilution series of SIYB seawater (i.e., treatments) to control organisms exposed to filtered seawater. Results were used to determine No Observed Effect Concentration (NOEC), Lowest Observed Effect Concentration (LOEC), LC_{50}, and EC_{50} values. If survival and normality of the control did not differ significantly from that of the treatments and/or were greater than 90%, then conditions within were considered nontoxic at the station.

2.5 Quality Assurance/Quality Control Procedures

Sampling process QA/QC included proper collection of the samples to minimize the possibility of contamination. The sampling team was trained in and followed field sampling standard operating procedures (SOPs), as described in the SIYB Quality Assurance Project Plan (QAPP) (WESTON, 2011b). Additionally, the field staff members were made aware of the significance of the project's detection limits and the requirement to avoid contamination of samples at all times. Field staff wore powder-free nitrile gloves at all times during sample collection. All samples were collected in laboratory-supplied, laboratory-certified, contaminant-free sample bottles. Field measurement equipment was checked for operation in accordance with the manufacturer's specifications, and was inspected for damage prior to use and when returned from use.

Chemistry and toxicity samples were uniquely identified with sample labels in indelible ink. All sample containers were identified with the project title, appropriate identification number, date and time of sample collection, and preservation method. All samples were kept on ice from the time of sample collection until delivery to the analytical laboratory for analysis within method-specified holding times (Table 2-10). Duplicate samples were also analyzed to assess variability in sampling and to remain compliant with Surface Water Ambient Monitoring Program (SWAMP) protocols.

Table 2-10. Sample Holding Times

Analyte	Holding Time
Field Measurements	
Free Copper	-
pH	-
Salinity	-
Water	
Total Organic Carbon	28 days
Dissolved Organic Carbon	28 days
Total Copper	180 days
Dissolved Copper	48 hrs
Total Zinc	180 days
Dissolved Zinc	48 hrs
48-hour acute bioassay	36 hours
96-hour chronic bioassay	36 hours

Samples were analyzed by a laboratory certified by the California Environmental Laboratory Accreditation Program (ELAP) for the analyses of inorganics, toxic chemical elements, and organics in wastewater. The quality assurance (QA) objectives for chemical analysis conducted by the participating analytical laboratories are detailed in their Laboratory QA Manuals. The objectives for accuracy and precision involved all aspects of the testing process, including the following:

- Methods and SOPs;
- Calibration methods and frequency;
- Data analysis, validation, and reporting;
- Internal QC;
- Preventive maintenance; and
- Procedures to ensure data accuracy and completeness.

Results of all laboratory QC analyses are reported herein. Any QC samples that failed to meet the specified QC criteria in the methodology or QAPP were identified, and the corresponding data were appropriately qualified. All QA/QC records for the various testing programs will be kept on file for review by regulatory agency personnel.

2.6 Chain-of-Custody Procedures

Chain-of-custody procedures were used for all samples throughout the collection, transport, and analytical process. The principal documents used to identify samples and to document possession were COC records, field logbooks, and field tracking forms. Chain-of-custody procedures were initiated during sample collection. A COC record was provided with each sample or group of samples. Each person who had custody of the samples signed the form and ensured that the samples were not left unattended unless properly secured. Documentation of sample handling and custody included the following:

- Sample identifier;
- Sample collection date and time;
- Any special notations on sample characteristics or analysis;
- Initials of the person collecting the sample;
- Date the sample was sent to the analytical laboratory; and
- Shipping company and waybill information.

Completed COC forms were placed into a plastic envelope and kept inside the cooler containing the samples. Upon delivery to the analytical laboratory, the COC form was signed by the person receiving the samples. Chain-of-custody records were included in the final reports prepared by the analytical laboratories.

Upon completion of analysis, any remaining sample material was stored until the holding time expired. At that point, samples were properly disposed.

2.7 Data Review and Management

Field and laboratory data were reviewed for completeness and accuracy prior to analysis and reporting, and were stored in a database, as described below.

2.7.1 Data Review

After each survey, field data sheets were removed from the field log books and were checked for completeness and accuracy. In the laboratory, technicians documented sample preparation activities in bound laboratory notebooks or on bench sheets. Data validation included dated and signed entries by technicians on the data sheets and logbooks used for samples, the use of sample tracking and numbering systems to track the progress of samples through the laboratory, and the use of QC criteria to reject or accept specific data. Data for laboratory analyses were entered directly onto data sheets. Data sheets were filled out in ink and signed by the technician, who was responsible for checking the sheet to ensure completeness and accuracy. The technician who generated the data had the prime responsibility for the accuracy and completeness of the data. Each technician reviewed the data to ensure the following:

- Sample description information was correct and complete.
- Analysis information was correct and complete.
- Results were correct and complete.

- Documentation was complete.

All data were reviewed and verified by participating team laboratories to determine whether data quality objectives had been met, and that appropriate corrective actions had been taken when necessary.

2.7.2 Data Management

All laboratories supplied analytical results electronic formats. After completion of the data review by participating team laboratories, laboratory results were stored in WESTON's database system. Records will be maintained for at least five years or transferred according to agreement between the Port and WESTON.

3.0 RESULTS

This section describes SIYB TMDL implementation activities and results of water quality monitoring performed in 2011.

3.1 SIYB TMDL Implementation

An evaluation, interpretation, and tabulation of data and information on SIYB TMDL activities undertaken by the Named Parties including vessel conversions, SIYB BMP implementation, and San Diego Bay-wide BMP implementation are provided as follows.

3.1.1 Vessel Conversions

Slip occupancy, vessel conversion, and loading reductions were based on data provided by facility operators for SIYB marinas and yacht clubs, as well as Port-maintained data for Port vessels, transient slips, and mooring buoys. The 2011 survey results showed that there were 2,328 berths available to be occupied by vessels in SIYB, inclusive of a Port-operated anchorage that holds up to 40 vessels. This was a reduction in total berth count by 35 vessels compared to the 2,363 slips and moorings reported in the TMDL. Of these slips and moorings, 253 slips were reported to be unoccupied (or vacant) year round (or at least at the time the survey was completed), leaving 2,075 berths that were occupied for at least a portion of time in 2011 (Table 3-1). On average, slips and moorings were occupied 81.1 ± 0.7% (mean ± standard error) of the year (296 ± 3 days). Excluding slips reported to be vacant, occupied slips were reported to contain vessels on average 91 ± 0.3% of the year (332 ± 1 days).

There were 1,803 slips/moorings in SIYB reported to have vessels with copper or unknown (assumed to be copper) hull paints, comprising 77% of SIYB berths. One hundred forty (140) vessels were reported to have low-copper paint (confirmed + unconfirmed) (6%), and 132 berths housed vessels with either non-copper paints (confirmed + unconfirmed) or no paint at all (6%). Occupancy rates for each hull paint type are shown in Table 3-1.

The average size vessel in SIYB in 2011, based on reported lengths and beam widths, was calculated to be 38.4 feet (11.7 m, total length) by 12.2 feet (3.7 m, beam width) (Appendix A). The average wetted hull surface area of 2011 SIYB vessels was calculated to be 36.8 m^2, which was nearly equivalent to the wetted hull surface area used in loading calculations in the SIYB TMDL (i.e., 35.3 m^2), validating the use of the TMDL per vessel loading of 0.9 kg/yr.

The annual dissolved copper load from vessel hull paints was calculated to be of 1,537 kg/yr in 2011. The SIYB TMDL calculated annual dissolved copper loads from vessel hull paints of 2,100 kg/yr. Thus, the estimate of 2011 copper loads is 563 kg/yr (26.8%) lower than the TMDL-established loads. Vacancy and lower occupancy percentages were calculated to reduce loads by 408 kg/yr (19%), and vessel conversions to non-copper and low-copper hull paints reduced loads by 162 kg/yr (7.7%).

Since vessels can occupy slips up to 100% of the time, conversion of vessels to non-copper paints had the potential to reduce annual dissolved copper loads by up to 119 kg/yr (5.7%), which was calculated by taking the product of non-copper vessels (132) and annual loading reduction of 0.9 kg/yr/vessel. Similarly, conversion to low-copper hull paints was calculated to reduce annual dissolved copper loads by up to 63 kg/yr (3%), which was similarly calculated by taking the product of the number of vessels reported with low-copper paints and annual loading reduction of 0.45 kg/yr. Therefore, vessel conversions to non-copper and low-copper hull paints had the potential to reduce copper loads by up to 182 kg/yr (8.7%) in SIYB when occupying berths 100% of the time.

Table 3-1. 2011 Vessel Tracking Results Summary

Vessel Hull Paint	Number of Vessels	Average Time Occupied (%)	Average Time Occupied (days/year)	Annual Copper Load per Vessel (kg/yr/vessel)	Annual Copper Load (kg/yr)	Annual Reduction in Copper Loading (kg/yr)
Copper	1,018	92	336	0.9	843	0
Unknown (assumed copper)	785	90	328	0.9	636	0
Low-copper	86	92	336	0.45	36	35.6
Low-copper (unconfirmed)	54	92	336	0.45	22	22.3
Non-copper	76	88	277	0	0	60.2
Non-copper (unconfirmed)	56	87	318	0	0	43.8
Total	2,075	91*	332*	–	1,537	162

*Average is reported, not total.

3.1.2 SIYB BMP Implementation

The Named Parties, including the Port and marina and yacht club owners and operators, implemented or are in the process of planning and implementing the following categories of BMPs and actions to reduce dissolved copper discharges to SIYB.

- Hull Paint Transition
- Hull Cleaning
- Structural and Mechanical
- Education and Outreach
- Alternative Hull Paint Studies
- Monitoring
- Reporting
- Lease Updates
- Policy / Regulation

The Shelter Island Master Leaseholders (SIML) TMDL Group was formed to represent the nine master leaseholder marinas and yacht clubs in SIYB. The group's purpose is to compile information from marinas and yacht clubs, as well as more than 2,000 individual boat owners and six local boatyards, for TMDL Investigative Order reporting requirements. SIML reported the following BMPs and actions as a component of their TMDL BMP Plan (Appendix B):

- Formation of the SIML TMDL group.
- Attendance of SIYB TMDL stakeholder meetings since 2005.
- All SIMLs are certified Clean Marinas or in the process of becoming certified.

- Collection and reporting of vessel hull paint tracking data as required by the Investigative Order.
- Oversee hull cleaner permit compliance at facilities, including:
  - Ensure all divers have valid Port Hull Cleaning Permits prior to entering leaseholds.
  - Report hull cleaner who arrive via boat and do not check in with Dockmaster's Office to the Port.
  - Report hull cleaners to the Port who do not use proper BMPs or create visible paint plumes during hull cleaning.
  - Post diver BMP signs on leaseholds.
- Boater Education and Outreach through newsletters, workshops, and readily available literature
- Require boaters to use only Port-permitted hull cleaners.
- Perform regular BMP effectiveness assessments.
- Provide ongoing staff training.
- Planning alternative paint incentive programs, which include wait list priority and financial incentives.

BMPs and other actions implemented by the Port to reduce dissolved copper levels are listed below and described in detail in Appendix B.

- Formulation of policies and regulations to reduce copper loading.
  - Enactment of a San Diego Bay In-water Hull Cleaning Permit.
  - Sponsoring of Copper Hull Paint Legislation – SB 623 (Kehoe).
  - Supporting Brake Pad Legislation – SB 346 (Kehoe).
- Sponsorship and implementation of alternative hull paint studies.
  - USEPA-funded "Safer Alternatives to Copper Antifouling Paints" Project.
  - Panel testing program to evaluate new and emerging coatings.
  - Hornblower Cruises testing partnership.
  - Environmental Fund sponsorship of antifouling coating research.
- Implementation and facilitation of hull paint transitions.
  - Transitioned Port fleet to non-copper hull paints.
  - Implementing 319(h) hull conversion project.
- Extensive education and outreach.
  - Partnership with California State University, San Diego Master of Business Administration (MBA) program to develop marketing strategy for encouraging boaters to transition hull paints.
  - Hosting of education and outreach booths at public events and meetings.
  - Development of brochures and educational material on copper pollution, alternative hull coatings, etc.
  - Presenting at conferences on copper reduction and alternative hull paint programs.
- Leading and participating in agency-wide activities.
  - Participation in a state-wide copper sub-workgroup led by DPR.
  - Ensure all construction projects on Port Tidelands submit SWPPPs and are in compliance with the General Stormwater Construction Permit and Municipal Stormwater Permit.

    - Commercial business inspections to educate facility operators on approaches to reduce inputs of pollutants and identify potential sources and pollution prevention actions.
    - Ensure all redevelopment projects on Port Tidelands comply with SUSMP requirements.
- Serve as the lead agency for the Regional Harbor Monitoring Program (RHMP) to assess conditions in San Diego Bay, Mission Bay, Oceanside Harbor, and Dana Point, and implement special studies on copper bioavailability, toxicity, and flux dynamics.

3.2 San Diego Bay-wide BMP Implementation

The Port has initiated and is in the process of planning and implementing a number of BMPs and actions to reduce dissolved copper discharges into harbors or marinas beyond SIYB, including throughout San Diego Bay as well as statewide (Table). These actions include the following:

- Enactment of a San Diego Bay In-water Hull Cleaning Permit.
- Sponsoring of Copper Hull Paint Legislation – SB 623 (Kehoe).
- Supporting Brake Pad Legislation – SB 346 (Kehoe).
- Completion of EPA-funded "Safer Alternatives to Copper Antifouling Paints" project and creation of the "How to Select an Alternative Hull Paint" brochure.
- Implementation of hull paint testing and development programs to evaluate new and emerging coatings and technologies.
- Partnership with California State University, San Diego MBA Consulting Program to develop marketing strategy for encouraging boaters to transition hull paints.
- Hosting education and outreach booths at public events and meetings.
- Development of brochures and educational material on copper pollution, alternative hull coatings, etc.
- Participation in a state-wide copper sub-workgroup led by DPR.
- Ensure all construction projects on Port Tidelands submit SWPPPs and are in compliance with the General Stormwater Construction Permit and Municipal Stormwater Permit.
- Commercial business inspections to educate facility operators on approaches to reduce inputs of pollutants and identify potential sources and pollution prevention actions in compliance with Regional Municipal Stormwater Permit R9-2007-0001.
- Ensure all redevelopment projects on Port Tidelands comply with SUSMP requirements.
- Serve as the lead agency for the RHMP to assess conditions in San Diego Bay, Mission Bay, Oceanside Harbor, and Dana Point and implement special studies on copper bioavailability, toxicity, and flux dynamics.

3.3 SIYB TMDL Monitoring

Water quality monitoring was performed to assess dissolved copper concentrations and toxicity, as well as other physical and chemical water parameters that may affect toxicity.

3.3.1 Surface Water Chemistry

Water quality surveys were performed in August and October 2011. The Monitoring Plan specifies that annual monitoring be performed in August; however, due to an equipment malfunction during Cu^{2+} assessments, a subsequent survey was performed in October.

3.3.1.1 August 2011 Survey

Chemistry results and *in situ* water quality measurements for SIYB surface water samples collected on August 22, 2011 are presented in Table 3-2, with detailed chemistry results provided in Appendix C. Dissolved copper concentrations ranged from 7.22 to 11.48 µg/L, with an average concentration of 7.49 ± 1.05 µg/L (mean ± standard error). All stations were in exceedance of both the CTR chronic threshold of 3.1 µg/L and acute CTR threshold of 4.8 µg/L (Table 3-2). The dissolved copper concentration measured for the reference sample, collected within the main channel of San Diego Bay outside the mouth of SIYB, was 2.1 µg/L.

Dissolved zinc concentrations measured in SIYB surface waters during the August survey ranged from 23.8 to 33.6 µg/L, which were approximately three times greater than at the reference station (7.46 µg/L). While dissolved zinc concentrations were found to be higher in the basin, they were, on average, three times lower than the chronic CTR threshold of 81 µg/L.

DOC values, which are an indicator of the bioavailability of free copper, ranged from 0.21 to 0.23 mg/L. Chemistry reports indicated that TOC was detected at levels below the reporting limit for all samples.

In situ measurements of Cu^{2+}, salinity, temperature, and pH were collected in addition to chemical analysis. However, due to an equipment error resulting from an inadequate connection to the Cu-ISE, voltage measurements could not be meaningfully converted to Cu^{2+}, and, therefore, were not included in the analysis of August 2011 samples. Salinity and pH values were all highly consistent within SIYB, while surface temperatures increased slightly moving from the mouth to the head of the basin.

Table 3-2. Chemistry Results for SIYB Surface Waters, August 2011 Event.

Station	Dissolved Copper (µg/L)	Total Copper (µg/L)	Dissolved Zinc (µg/L)	Total Zinc (µg/L)	DOC (mg/L)	TOC (mg/L)	Salinity (ppt)[1]	Temp. (°C)[1]	pH[1]
SIYB-1	11.48	13.8	33.566	33.51	0.22	0.81	34.1	21.6	7.9
SIYB-2	7.22	10.53	22.743	25.455	0.23	0.78	34.3	21.2	8.0
SIYB-3	7.55	10.37	22.684	24.377	0.22	0.75	34.2	21.2	8.0
SIYB-4	7.81	10.7	23.842	25.028	0.21	0.74	34.2	21.1	8.0
SIYB-5	8.72	11.19	29.392	30.252	0.21	0.65	34.2	21.0	7.9
SIYB-6	7.48	9.51	23.896	24.895	0.22	0.66	34.1	20.8	7.9
SIYB-REF	2.14	3.05	7.458	8.37	0.23	0.65	34.3	20.4	7.9

[1] *In situ* measurements.

3.3.1.2 October 2011 Survey

Due to the anomalous Cu^{2+} measurements observed during the August monitoring event, a second event was conducted on October 26, 2011. A summary of chemistry results and *in situ* water quality measurements obtained during this event is presented in Table 3-3, with detailed chemistry results provided in Appendix C. *In situ* measurements were collected at all six sampling locations and the reference location. Three of the six stations (SIYB-1, SIYB-3, and SIYB-5) were selected for chemical and toxicological analyses (48-hour mussel bioassay) to assess potential differences in dissolved copper concentrations in SIYB from the August monitoring event. Dissolved copper concentrations again were measured above both the chronic and acute CTR water quality values at each of the locations evaluated during the October event. Concentrations ranged from 5.01 to 8.08 µg/L, with an average concentration of 6.53 ± 0.89 µg/L.

Analyses of DOC and TOC of the October 2011 samples were conducted in two laboratories to assess the validity of the results of the August monitoring event. DOC results from SunStar Laboratories, Inc. ranged from 0.38 to 0.55 mg/L, and results from Calscience Environmental Laboratories, Inc. ranged from 1.2 to 1.3 mg/L. Chemistry reports from SunStar Laboratories, Inc. indicated that TOC was detected at levels below the reporting limit for all samples. DOC was also detected below the reporting limit for samples SIYB-3 and SIYB-5.

In situ measurements of Cu^{2+}, salinity, temperature, and pH were collected in addition to chemical analysis. Free copper values ranged from 10.71 to 10.02 pCu; levels below 11.0 pCu are predicted to have potential toxic effects to sensitive marine organisms, such as bivalve larvae. The average free copper value measured at the reference station (10.29 pCu) was in the middle of the range of those measured within SIYB. Salinity, temperature, and pH measurements of the October survey were all lower than those of the August survey. Salinity and pH values were largely consistent among stations, while temperatures increased from the mouth to the head of the basin.

Table 3-3. Chemistry Results for SIYB Surface Waters, October 2011 Event.

Station	Dissolved Copper (µg/L)	DOC, SSL[1] (mg/L)	DOC, CEL[2] (mg/L)	TOC, SSL[1] (mg/L)	TOC, CEL[2] (mg/L)	Free Copper (pCu)[3]	Salinity (ppt)[3]	Temp.S (°C)[3]	pH[3]
SIYB-1	8.08	0.55	1.2	0.41	ND	10.47	33.6	17.6	7.7
SIYB-2						10.71	33.7	17.4	7.7
SIYB-3	6.51	0.45	1.3	0.34	1	10.22	33.6	17.4	7.3
SIYB-4						10.37	33.7	17.1	7.7
SIYB-5	5.01	0.38	1.3	0.35	ND	10.09	33.7	17.3	7.7
SIYB-6						10.02	33.7	16.8	7.6
SIYB-REF						10.29	33.6	14.4	7.4

ND Non-detect
[1] SSL – SunStar Laboratories
[2] CEL – Calscience Environmental Laboratory
[3] In Situ measurements

3.3.1.3 Baseline Comparison

Average dissolved copper concentrations within SIYB were 7.49 ± 1.05 µg/L in August 2011 and 6.53 ± 0.89 µg/L in October 2011. The average 2011 dissolved copper concentration of 7.01 µg/L was 15% lower than the baseline average concentration of 8.28 ± 1.36 µg/L (mean ± standard error) (Figure 3-1), although differences were not statistically significant (one-way Analysis of Variance, $p = 0.571$).

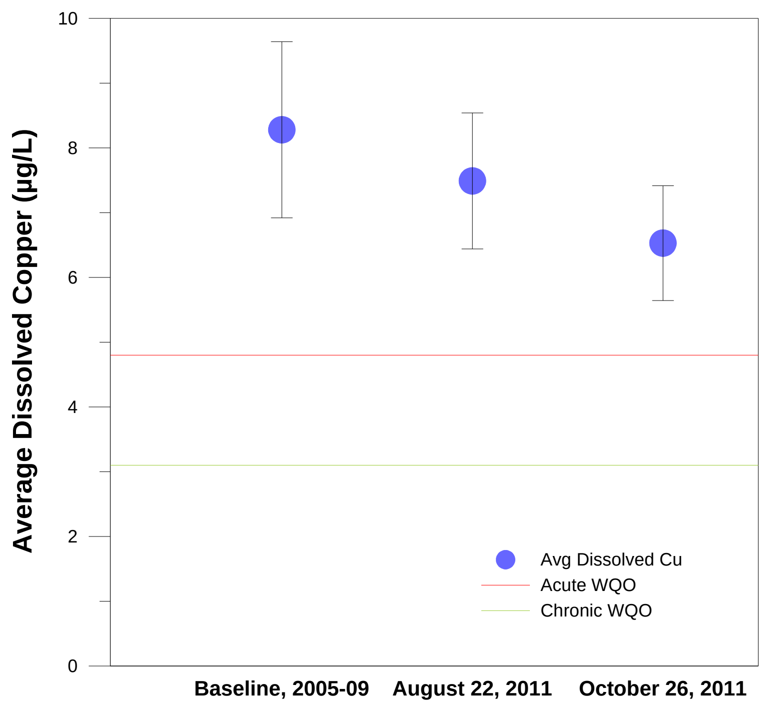

Figure 3-1. Average Dissolved Copper Concentrations in SIYB Relative to Baseline Conditions

3.3.2 Toxicity

Toxicity assessments included topsmelt 96-hour acute biossays, performed for the August survey, and mussel 48-hour chronic bioassays, performed for the August and October surveys.

3.3.2.1 Topsmelt 96-Hour Acute Bioassay

For the tests initiated on August 23 and August 24, survival of *A. affinis* in the control treatments was 95.0% and 97.5%, respectively (Table 3-4). Both survival values met the minimum acceptable control survival criterion of 90%. LC_{50}s were greater than 100% for all samples tested. Survival of topsmelt test organisms exposed to sample treatments ranged from 97.5 to 100%, and did not differ significantly from that of the controls, indicating that conditions within SIYB were nontoxic to *A. affinis*.

For the copper sulfate reference toxicant test initiated on August 23, 2011, the reference toxicant LC_{50} was 116 µg/L, which was within two standard deviations (± 107 µg/L) of the WESTON laboratory mean of 156 µg/L. For the tests initiated on August 24, 2011, the reference toxicant LC_{50} was 87.0 µg Cu^{2+}/L, which also was within two standard deviations (± 111 µg/L) of the WESTON laboratory mean of 153 µg/L. These results indicate that the sensitivity of both batches of *A. affinis* used in the assessment of SIYB surface waters fell within the normal range. Test and reference toxicant test results for *A. affinis* are summarized in Table 3-4 and are detailed in Appendix C.

Table 3-4. Results of the 96-Hour *Atherinops affinis* Bioassay, August 2011

Composite Area ID	*Atherinops affinis* Results		
	% Survival	LC_{50} for Survival (%)	NOEC / LOEC (%)
Control (Aug 23/24)	95.0 / 97.5	-	
SIYB-1	97.5	>100	>100 / >100
SIYB-2	97.5	>100	>100 / >100
SIYB-3	100	>100	>100 / >100
SIYB-4	100	>100	>100 / >100
SIYB-5	100	>100	>100 / >100
SIYB-6	97.5	>100	>100 / >100
SIYB-REF	100	>100	>100 / >100
Copper Sulfate Reference Toxicant, August 23	**Concentration (µg/L)**	**% Survival**	**LC_{50} (µg/L)**
	Control	85.0	116
	25	95.0	
	50	97.5	
	100	55.0	
	200	7.50	
	400	0.00	
Copper Sulfate Reference Toxicant, August 24	**Concentration (µg/L)**	**% Survival**	**LC_{50} (µg/L)**
	Control	100	87.0
	25	100	
	50	100	
	100	32.5	
	200	0.00	
	400	0.00	

3.3.2.2 Bivalve 48-Hour Chronic Bioassay

August 2011 Survey

For the tests initiated on August 23, 2011, survival of *M. galloprovincialis* in the control treatment was 87.6%, which met the minimum acceptable control survival criterion of 50% (Table 3-5). Normality of the surviving larvae in the control treatment was 87.1%, which was slightly below the minimum acceptable control criterion of 90%. Survival LC_{50}s and normality EC_{50}s for *M. galloprovincialis* were greater than 100% for all of the August 2011 samples. Test and reference toxicant test results for *M. galloprovincialis* are summarized in Table 3-5 and are detailed in Appendix C.

Survival of mussel larvae exposed to sample treatments collected in August 2011 ranged from 71.1 to 92.3% within SIYB and did not differ significantly from that of the controls (Table 3-5). Normality of organisms exposed to SIYB sample treatments ranged from 86.0 to 97.3%, and did not differ significantly from the control. Additionally, survival and normal development of larvae exposed to SIYB-REF waters were similar to those exposed to waters collected within SIYB. These results indicate that conditions within SIYB were nontoxic with regard to *M. galloprovincialis* survival and development.

For the copper sulfate reference toxicant test initiated on August 23, 2011, the LC_{50} was 13.5 µg/L, which was within two standard deviations (± 13.1 µg/L) of the WESTON laboratory mean of 19.6 µg/L. The EC_{50} for normality was 7.38 µg/L, which was within two standard deviations (± 3.45 µg/L) of the WESTON laboratory mean of 7.17 µg/L. These results indicate that the sensitivity of *M. galloprovincialis* used in the assessment of SIYB surface waters fell within the normal range.

Table 3-5. Results of the 48-Hour *Mytilus galloprovincialis* Bioassay, August 2011

Composite Area ID	***Mytilus galloprovincialis* Results, August 2011**				
	% Survival (in 100% concentration for test samples)	**% Normal Development (in 100% concentration for test samples)**	**LC_{50} for Survival / EC_{50} for Normality (%)**	**Survival NOEC / LOEC (%)**	**Normality NOEC / LOEC (%)**
Control	87.6	87.1	-	-	-
SIYB-1	81.9	86.0	>100 / >100	100 / >100	100 / >100
SIYB-2	80.1	97.3	>100 / >100	100 / >100	100 / >100
SIYB-3	71.1	95.0	>100 / >100	100 / >100	100 / >100
SIYB-4	91.2	95.0	>100 / >100	100 / >100	100 / >100
SIYB-5	85.7	93.0	>100 / >100	100 / >100	100 / >100
SIYB-6	92.3	89.9	>100 / >100	100 / >100	100 / >100
SIYB-REF	93.6	89.1	>100 / >100	100 / >100	100 / >100
Copper Sulfate Reference Toxicant, August 23	**Concentration (µg/L)**	**% Survival**	**% Normal Development**	**LC_{50} (µg/L)**	**Normality EC_{50} (µg/L)**
	Control	93.4	87.9	13.5	7.38
	2.5	90.8	86.7		
	5.0	90.6	83.8		
	10	80.5	0.00		
	20	7.11	0.00		
	40	2.41	0.00		

October 2011 Survey
For the tests initiated on October 27, 2011, survival of *M. galloprovincialis* in the control treatment was 92.8%, which met the minimum acceptable control survival criterion of 50%. Normality of the surviving larvae in the control treatment was 96.6%, which also met the minimum acceptable control normal development criterion of 90%. Survival LC_{50}s and normality EC_{50}s for *M. galloprovincialis* were greater than 100% for all of the October 2011 samples with the exception of SIYB-1, which was determined to be 67.0%. Test and reference toxicant test results for *M. galloprovincialis* are summarized in Table 3-6 and are detailed in Appendix C.

During the October 2011 survey, bivalve survival ranged from 86.0 to 95.0% at SIYB stations, and did not differ significantly from that of controls (Table 3-6). Normal larval development ranged from 7.12 to 96.6%in SIYB. Normal larval development results for water samples collected at SIYB-1 and SIYB-3 were significantly different from the control. The statistical difference at SIYB-3, where normal development was 91.5%, was due to extremely low variability and did not meet the biological significant reduction of $\geq$20%. Normal larval development at SIYB-1 was only 7.12%, indicating that surface waters exhibited chronic toxic effects for *M. galloprovincialis*.

For the copper sulfate reference toxicant test initiated on October 27, 2011, the LC_{50} was 13.1 µg/L, which was within two standard deviations (± 13.2 µg/L) of the WESTON laboratory mean of 19.6 µg/L. The EC_{50} for normality was 5.28 µg/L, which was within two standard deviations (± 3.63 µg/L) of the WESTON laboratory mean of 7.02 µg/L. These results indicate that the sensitivity of both batches of *M. galloprovincialis* used in the assessment of SIYB surface waters fell within the normal range.

Table 3-6. Results of the 48-Hour *Mytilus galloprovincialis* Bioassay, October 2011

Composite Area ID	*Mytilus galloprovincialis* Results, October 2011				
	% Survival (in 100% concentration for test samples)	% Normal Development (in 100% concentration for test samples)	LC_{50} for Survival / EC_{50} for Normality (%)	Survival NOEC / LOEC (%)	Normality NOEC / LOEC (%)
Control	92.8	96.6	-	-	-
SIYB-1	86.0	7.12	>100 / 67.0	100 / >100	25 / 50
SIYB-3	91.5	91.5	>100 / >100	100 / >100	50 / 100
SIYB-5	95.4	94.8	>100 / >100	100 / >100	100 / >100
Copper Sulfate Reference Toxicant, August 23	Concentration (µg/L)	% Survival	% Normal Development	LC_{50} (µg/L)	Normality EC_{50} (µg/L)
	Control	93.1	95.9	13.1	5.28
	2.5	99.8	91.7		
	5.0	93.7	64.1		
	10	85.7	0.00		
	20	1.54	0.00		
	40	0.83	0.00		

4.0 DISCUSSION

2011 SIYB TMDL monitoring findings provide evidence that trends in both copper loading and water quality are improving from baseline conditions in SIYB. Dissolved copper loading reductions were due to a combination of vessel conversions to alternative hull paints and reduced occupancy. While dissolved copper concentrations still exceeded both acute and chronic CTR thresholds in SIYB, concentrations appear to be declining from baseline conditions. Most notably, toxicity in the basin was extremely rare, since only one station was found to have surface water that inhibited normal development of mussel larvae.

4.1 Copper Loading Trends

Vessel tracking indicates that there has been a nearly 27% (i.e., 563 kg/yr) reduction in annual dissolved copper loading from vessels in SIYB when compared to the TMDL assumed baseline loading of 2,100 kg/yr. These calculations demonstrate that copper loading reductions exceed the required 2012 interim loading reduction target of 10%. This reduction was due primarily to reduced occupancy (calculated to be 408 kg/yr or 19%) and vessel conversions to non-copper (104 kg/yr or 5.0%) and low-copper (58 kg/yr or 2.8%) hull paints.

Since vessels can occupy berths up to 100% of time, conversion of vessels to non-copper paints reduced annual dissolved copper loads by up to 119 kg/yr (5.7%), assuming vessels occupied slips/moorings 100% of the time. Similarly, conversion to low-copper hull paints was calculated to reduce annual dissolved copper loads by up to 63 kg/yr (3%). Therefore, vessel conversions to non-copper and low-copper hull paints reduced copper loads by up to 8.7% in SIYB.

Two caveats must be noted for the loading reduction analysis. First, loading reduction calculations were inclusive of both unconfirmed and confirmed non-copper and low-copper hull paints. Unconfirmed transitions included vessels that were reported to have non-copper or low-copper hull paints; however, required supporting information on hull paint name, product number, name of the boatyard that applied the paint, and/or painting date was not provided. Excluding unconfirmed non-copper and low-copper hull paints, confirmed vessel transitions to non-copper and low-copper hull paints reduced annual dissolved copper loading by up to 99 kg/yr (4.7%), assuming 100% occupancy. Second, reduced occupancy was the most important contribution to loading reduction. Since occupancy has the potential to vary widely from year to year based on economic conditions and other factors, vacant slips cannot be considered a permanent loading reduction, unless commitments are made to preferentially reoccupy slips with vessels with non-copper hull paints.

4.2 Water Quality Trends

Associated with the reduction in copper loads, while not statistically significant, there has been an approximately 15% reduction in the average dissolved copper concentration measured in 2011 surveys (7.01 µg/L) from the baseline average dissolved copper concentration (8.28 µg/L). However, further progress is needed since dissolved copper concentrations at all SIYB stations still exceeded the chronic numeric WQO of 3.1 µg/L by at least three times in August and more than 1.6 times in October. In contrast, the concentration at the reference station (2.14 µg/L), which was located in the main channel of San Diego Bay just outside SIYB, was below the WQO. The high density of vessels combined with the low flow environment of the basin contributes to elevated copper concentrations in SIYB relative to adjacent areas of the Bay. Continued annual water quality monitoring will be used to compare conditions in SIYB to other areas of the Bay, while providing further evidence of improving water quality conditions over time.

Although dissolved copper concentrations in SIYB consistently exceeded the WQO, evidence of toxicity was only limited to one station. Acute toxicity was not apparent for topsmelt or mussel bioassays. Additionally, there was no chronic toxicity in the August survey, while chronic toxicity was exhibited at one station (SIYB-1) during the October survey, as measured by normal development of mussel larvae during 48-hour bioassay tests. This finding is consistent with prior SIYB toxicity surveys that have observed toxicity to mussel larvae at dissolved copper concentrations of approximately 9 µg/L in SIYB (Schiff et al., 2006), chronic toxicity near the head of SIYB at only 1 of 62 samples (Capolupo et al., 2011), or no toxicity (including a 1999-2002 San Diego Bay-wide surface water toxicity study by Rosen et al., 2005 and 2011 toxicity assessment by WESTON, 2012).

The absence of acute toxicity at dissolved copper concentrations up to 11.5 µg/L and detection of chronic toxicity at only one station with a dissolved copper concentration of 8.08 µg/L underscores the importance of considering site-specific factors that regulate copper bioavailability in the TMDL. There is an increasing body of evidence that the 3.1 µg/L WQO is overly protective of water quality beneficial uses in SIYB and San Diego Bay, as determined by water-effects ratio (WER) and biotic ligand model (BLM) studies (Rosen et al., 2005; Chadwick et al., 2008; and Capolupo et al., 2011), as well as reevaluations of more recent toxicity data. However, given that dissolved copper concentrations are still well above the existing WQO, further studies are needed to understand how site-specific factors affect copper bioavailability in SIYB.

In conclusion, the 2011 monitoring program provides evidence that vacancies and vessel hull paint conversions are resulting in reduced copper loading, reduced dissolved copper concentrations relative to baseline conditions, and water quality conditions that are largely nontoxic to indicator organisms. The Port, as the steward of San Diego Bay, is committed to continue Investigative Order-required monitoring to ensure that water quality conditions in SIYB continue to improve.

5.0 REFERENCES

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Appendix A
Vessel Tracking Data

Table A-1. Shelter Island Yacht Basin 2011 Vessel Tracking Data for Slips

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	BCM	A 1	0.99		power	28'		Cu	Pro-line	1088	Shelter Island	2/7/2011	70
	BCM	A 2	1.00					UKN					
	BCM	A 3	0.99	CF4176GZ	sail	30'	9.5'	Cu	Pro-line	1088	Shelter Island	5/18/2006	30
	BCM	A 5	1.00					UKN					
	BCM	A 6	1.00					UKN					
	BCM	A 7	1.00					UKN					
	BCM	A 8	1.00					UKN					
	BCM	A 9	1.00					UKN					
	BCM	A 10	0.99	1048410	power	36'		Cu	Pro-line	1088	Shelter Island	3/6/2007	30
	BCM	A 11	1.00					UKN					
	BCM	A 12	1.00					UKN					
	BCM	A 13	1.00					UKN					
	BCM	A 14	1.00					UKN					
	BCM	A 15	0.99		power	21'	8'	Cu	Pettit Protector		Driscoll's	4/1/2010	67
	BCM	A 16	1.00					UKN					
	BCM	B 2	1.00					UKN					
	BCM	B 3	0.98	CF 1089 RN	power	26'	8'	Cu	Interlux		Koehler Kraft	5/19/2011	
	BCM	B 4	0.96	1148921	power	32'	11'	Cu			Driscoll	2009	
	BCM	B 5	1.00					UKN					
	BCM	B 6	1.00					UKN					
	BCM	B 7	1.00					UKN					
	BCM	B 8	1.00					UKN					
	BCM	B 9	1.00					UKN					
	BCM	B 10	0.96	1225367	sail	38'	22'	Cu	Pettit Protector			Nov-11	65
	BCM	B 12	1.00					UKN					
	BCM	B 13	1.00					UKN					
	BCM	B 14	1.00					UKN					
	BCM	B 15	1.00					UKN					
	BCM	B 16	1.00					UKN					
	BCM	C 1	1.00					UKN					
	BCM	C 2	1.00		power	40'	14'1"	Cu	Pettit Trinidad Black		Vee lay Marine	2006	75
	BCM	C 3	0.97	1136010	power	48'	12'	Cu	Proline	1088	Shelter Island	2009	30
	BCM	C 4	1.00					UKN					
	BCM	C 5	1.00					UKN					
	BCM	C 6	1.00					UKN					
	BCM	C 7	1.00					UKN					
	BCM	C 8	0.92	942364	sail	44'	13.5'	Cu	Pettit Trinadad Pro		Shelter Island	5/9/2011	70
	BCM	C 9	1.00		power	42'	13'	Cu					
	BCM	C 10	1.00					UKN					
	BCM	C 11	1.00					UKN					
	BCM	C12	1.00					UKN					
	BCM	C 13	0.99		sail	30'	10'10"	Cu			Shelter Island	Apr-11	

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	BCM	C 14	1.00	1177116	sail	35'	11'4"	Cu	Interlux		Shelter Island	1-Jun	70
	BCM	C 15	1.00					UKN					
	BCM	C 16	1.00					UKN					
	BCM	C17	1.00					UKN					
	BCM	C 18	0.99		sail	32.5'	9'3"	Cu			Shelter Island	2009	
	BCM	D 1	1.00					UKN					
	BCM	D 2	1.00					UKN					
	BCM	D 3	0.76	CF 8323 EZ	sail	41'	12'6"	Cu	Pro-line	1088	Knight & Carver	4/22/2011	67
	BCM	D 4	0.99	665596	power	46'	14'6"	Cu	Interlux Ultra	3669	Driscoll's	3/25/2009	67
	BCM	D 5	1.00					UKN					
	BCM	D 6	1.00					UKN					
	BCM	D 7	1.00					UKN					
	BCM	D 8	1.00	937213	sail	40'		Cu			Shelter Island	3/22/2011	
	BCM	D 9	1.00					UKN					
	BCM	D 10	1.00					UKN					
	BCM	D 11	1.00					UKN					
	BCM	D 12	0.97	1073828	sail	30'	10'4"	Cu	Interlux Ultra		Koehler Kraft	11/11/2008	30
	BCM	D 13	1.00					UKN					
	BCM	D 14	1.00					UKN					
	BCM	D 15	1.00					UKN					
	BCM	D 16	1.00					UKN					
	BCM	D 17	1.00					UKN					
	BCM	D 18	1.00					UKN					
	BCM	D 19	1.00					UKN					
	BCM	E 1	1.00					UKN					
	BCM	E 2	1.00					UKN					
	BCM	E 3	0.96	988785	sail	37.5'	12'	Cu	Pro-line		Shelter Island	Jan-09	70
	BCM	E 4	0.99			38'		Cu			Shelter Island	2009	70
	BCM	E 5	0.99	CF 9864 JL	sail	34'	11'	Cu	Pro-line	1088	Shelter Island	Jan-09	70
	BCM	E 6	1.00					UKN					
	BCM	E 7	1.00					UKN					
	BCM	E 8	0.94	1060951	sail	35'	11.5'	Cu	Bluewater SCX		KKMI	1-Jul	67
	BCM	E 9	1.00		power			Cu			Shelter Island	2010	70
	BCM	E 10	0.97	693017	power	42'	16'	Cu	Pro-line	1088		2008	70
	BCM	E 11	1.00					UKN					
	BCM	E 12	1.00					UKN					
	BCM	E 13	1.00	679547	sail	42'		Cu			Shelter Island	1-Apr	70
	BCM	E 14	1.00					UKN					
	BCM	E 15	1.00					UKN					
	BCM	E 16	1.00					UKN					
	BCM	E 17	1.00					UKN					
	BCM	E 18	0.99	1081634	power	45'	15'	Cu	Blue-Water	8602-Blk	Knight & Carver	9/1/2009	45
	BCM	F 1	1.00					UKN					
	BCM	F 2	1.00	1160898	sail	35'		Cu	Pro-line	1088	Shelter Island	1-Sep	67

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	BCM	F 3	1.00					UKN					
	BCM	F 4	0.93	1203907	sail	36'	11'11"	Cu	Pettit Trinidad SR		Anchors Way	Dec-10	70
	BCM	F 5	0.99	626152	sail	36'	11'	Cu	International		Shelter Island	May-09	67
	BCM	F 6	1.00					UKN					
	BCM	F 7	1.00					UKN					
	BCM	F 8	1.00					UKN					
	BCM	F 9	0.95	1130743	Sail/ cat	38'	20.5'	Cu	Interlux	YBA569	Driscoll's	Mar-11	46.5
	BCM	F 10	0.84	1037301	sail	42'	13'	Cu	Sea Hawk Sharkskin	6100	Driscoll's	9/12/2011	50
	BCM	F 11	1.00					UKN					
	BCM	F 12	1.00					UKN					
	BCM	F 13	1.00					UKN					
	BCM	F 14	1.00		sail	46'	14'	Cu	Pro-line	1088	Shelter Island	2005	30
	BCM	F 15	1.00					UKN					
	BCM	F 16	1.00					UKN					
	BCM	F 17	0.99		sail	42'		Cu	Pettit Trinadad		Shelter Island	Jun-11	70
	BCM	F 18	1.00					UKN					
	BCM	G 1	1.00					UKN					
	BCM	G 2	1.00					UKN					
	BCM	G 3	0.99	989354	sail	35'	10'	Cu	Interlux	3779	Shelter Island	7/14/2010	67
	BCM	G 4	1.00					UKN					
	BCM	G 5	1.00					UKN					
	BCM	G 6	1.00					UKN					
	BCM	G 7	0.97	CF 7340 SW	sail	30'		Cu	Pro-line	1088	Shelter Island	11-Mar	
	BCM	G 8	1.00	616622	sail	33'	9.6'	UKN			Shelter Island	6/1/2011	
	BCM	G 9	1.00	613937	sail	33'4"	11'	Cu	Pettit	1088	Shelter Island	3/18/2011	70
	BCM	G 10	1.00					UKN					
	BCM	G 11	1.00					UKN					
	BCM	G 12	1.00					UKN					
	BCM	G 13	1.00					UKN					
	BCM	G 15	1.00					UKN					
	BCM	G 16	1.00					UKN					
	BCM	G 17	0.98	907488	sail	36'	11'	Cu				2006	30
	BCM	G 18	0.99	925984	sail	36'	11'9"	Cu			Shelter Island	2008	70
	BCM	G 19	1.00					UKN					
	BCM	G 20	1.00					UKN					
	BCM	G 21	1.00					UKN					
	BCM	H 1	0.83	1113607	sail	35'	11'9"	Cu			Shelter Island	Mar-11	70
	BCM	H 2	0.99		sail	30'	8.9'	Cu	Pettit	Protector	Driscoll's	3/11/2011	67
	BCM	H 4	1.00					UKN					
	BCM	H 5	1.00					UKN					
	BCM	H 7	0.96	CF 9612HF	sail	30'	10'10"	Cu	Interlux Ultra		Shelter Island	4/7/2010	67
	BCM	H 8	1.00					UKN					
	BCM	H 9	1.00		sail	29'		UKN			Koehler Kraft	2005	
	BCM	H 10	0.94	1234631	sail	34'	11'9"	Cu	Interlux	B-90	Marina del Rey	6/23/2011	70

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	BCM	H 11	1.00					UKN					
	BCM	H 12	0.99	CF 5673FV	sail	33'	11'10"	Cu	Pro-line Interlux	1088	Driscoll MB	5/16/2011	70
	BCM	H 13	1.00					UKN					
	BCM	H 14	1.00					UKN					
	BCM	H 15	1.00					UKN					
	BCM	H 16	1.00					UKN					
	BCM	H 17	1.00					UKN					
	BCM	H 18	1.00					UKN					
	BCM	H 19	1.00	MT 8828 AW	sail	24'	8'2"	Cu	Interlux Ultra	3449	Shelter Island	2/2/2011	67
	BCM	H 20	0.89	997272	sail	32'	11'9"	Cu	Pro-line		Driscoll's	Mar-11	70
	BCM	H 21	1.00					UKN					
	BCM	M 1	0.02					UKN					
	BCM	M 2	1.00					UKN					
	BCM	M 3	0.97	CF 8640 CH	power	18'		UKN			owner	Sep-10	
	BCM	M 4	0.02					UKN					
	BCM	M5	0.02					UKN					
	BCM	M 6	0.02					UKN					
	BCM	B 1	1.00		power	40'	10'	Lcu	Bottom Pro		Koehler Kraft	2/9/2007	30
	BCM	B 11	0.99	CF 9798FW	sail	24'	7'8"	Lcu-ukn			Driscoll's	2007	30
	BCM	C 19	1.00	689972	sail	43'	12'	LCu	Interlux Micron CSC	319293	Koehler Kraft	7/1/2011	37.2
	BCM	G 22	0.98	969813	sail	38'	10'3"	Lcu-ukn	Comex		Marina San Carl	Jul-08	30
	BCM	H 3	0.98	1215994	sail	34'	11'6"	Lcu-ukn				Feb-07	30
	BCM	H 6	1.00	4797		32'	12.5'	LCu	Interlux Bottomkote (	ybb669	Marty's BY	8/1/2010	35
	BCM	A 4	1.00		sail	32'	14'	Non	NA	NA	NA	NA	0
	BCM	G 14	0.99	993410	Sail	32'	11.2'	Non	E-Paint	20-301	owner	Apr-11	0
	BCM	H 22	0.00					Vacant					
	CN	1	0.03	1148953	Navigator	56'	15'	UKN					
	CN	1	0.49	1094902	Viking Spo	72'	19.08'	UKN					
	CN	2	0.43	1118933	Hatteras	55'	17.33'	UKN					
	CN	3,5	0.08	12222692	Tiara Open	30'	12.5'	UKN					
	CN	4,5,7,11,17	0.68	1125940	Tiara	35'	13.25'	UKN					
	CN	5	0.13	Inventory	Viking BCE	60'	18.75'	UKN					
	CN	5	0.05	1173952	Blackwell	61'	18'	UKN					
	CN	12	0.42		Tiara Open	43'	15.17'	UKN					
	CN	13	0.30	Inventory	Contender	31'	9.33'	UKN					
	CN	15	0.58	1087701	Bayliner	47'	15.08'	UKN					
	CN	16	0.30	1109067	Hatteras C	60'	17.33'	UKN					
	CN	5,15	0.07	Inventory	Contender	25'	8.83'	UKN					
	CN	11,13,14,20	0.72	Inventory	Tidewater	21'		UKN					
	CN	1,3,4,12	0.89	Inventory	Tiara Sovra	43'	14.75'	UKN					
	CN	3,4	0.23	Inventory	Tiara	36'	13.25'	UKN					
	CN	3,5,7,21	0.56	Inventory	Tiara Open	32'	13'	UKN					
	CN	6	0.88	Inventory	Viking Con	50'	17'	UKN					
	CN	14,20	0.31	Inventory	Contender	31'	9.33'	UKN					

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	CN	2	0.39	949662	Viking	45'	15'	Non-unconf				Dec-07	0
	CN	4	0.16	1184945	Cabo Oper	45'	15.67'	Non-unconf				Dec-07	0
	CN	5,7	0.09	1052473	Viking Spo	58'	18'	Non-unconf				Dec-07	0
	CN	5,6	0.06	DL3295AB	Viking	45'	16.33'	Non-unconf				Dec-07	0
	CN	9	1.00	1069023	Carver CM	50'	15.33'	Non-unconf				Dec-07	0
	CN	10	0.88	678325	Bertram	54'	16.92'	Non-unconf				Dec-07	0
	CN	12,14	0.32	1095497	Pursuit	30'	12'	Non-unconf				Dec-07	0
	CN	18,20	0.54		Skorgene T	26'	8.5'	Non-unconf				Dec-07	0
12/12/11	GC	21	0.98		P	46	12	Non	Pacifica Plus	YBB263	NB	04/2011	0%
12/12/11	GC	3	0.98	Broker Boat	P	36	8	UKN			DR	09/2011	
12/12/11	GC	4	0.98	CF1137877	P	42	14.5	Cu	Interlux Ultra	Y3779F	DR	09/2009	67%
12/12/11	GC	7	0.98	CF1078392	P	45	14.5	Cu	Trinidad	PET-1877C	DR	2007	70%
12/12/11	GC	10	0.98		P	46		Cu	Sharkskin	SH-6145	NB	05/2008	30.00%
12/12/11	GC	11	0.98	CF9354JZ	P	36	12.8	Cu	Sharkskin	SH-6145	NB	09/2008	30.00%
12/12/11	GC	14	0.98	CCHD678M84C	P	35	13	Cu	Trinidad	PET-1877C	DR	2010	70%
12/12/11	GC	20	0.98	CF924440	P	50	15	Cu	Interlux Ultra	Y3779F	OTH	2008	30%
12/12/11	GC	26	0.98	CF999945	S	68	15	Cu	Proline 1088	1088	OTH	02/2010	67%
12/12/11	GC	29	0.98	BERS0581G586	P	54	17	Cu	Sharkskin	SH-6145	NB	06/2006	30.00%
12/12/11	GC	33	0.98	CF1043683	P	68	20	Cu	Bluewater	BW-810	SI	11/2009	67%
12/12/11	GC	34	0.98	OSH76025A707	P	76	19.6	Cu	Pettit Z-Spar The Pro	B-94	MG	11/2011	65%
12/12/11	GC	9	0.98		P	38	13	LCu	Calif Bottomkote	YBA143	NB	10/2009	35%
12/12/11	GC	16	0.98	CF662756	P	42	14.33	LCu	Calif Bottomkote	YBA143	NB	12/2009	35%
12/12/11	GC	19	0.99	CF1098869	P	47.7	15	LCu	Bottomkote Aqua	YBA579	NB	02/2011	35%
12/12/11	GC	22	0.98	CF1073679	P	49.3	16.5	LCu	Calif Bottomkote	YBA143	NB	2008	30%
12/12/11	GC	27	0.98	VSC651101203	P	65	16.11	NON	Hempasil X3	87500	SI	11/2011	0%
12/12/11	GC	2	0.98	LYGUA127C202	P	19.5	8	UKN			OTH	01/2010	
12/12/11	GC	8	0.98	CAR2848D505	P	28.5	10	UKN					
12/12/11	GC	12	0.98	CF1224071	S	43.3	13.6	UKN					
12/12/11	GC	18	0.98	CF945678	P	45	15	UKN					
12/12/11	GC	24	0.98	XSK02757K304	P	56	15	UKN					
12/12/11	GC	25	0.97		P	65	16	UKN					
12/12/11	GC	28	0.98	CF1187744	P	65	16	UKN					
12/12/11	GC	30	0.99	Broker Boat	P	75	18.7	UKN			OTH	05/2010	
12/12/11	GC	31	1.00	CF254463	P	81	20	UKN					
12/12/11	GC	32	0.98	Broker Boat	P	80		UKN					
12/12/11	GC	1	0.00					Vacant					
12/12/11	GC	5	0.00					Vacant					
12/12/11	GC	6	0.00					Vacant					
12/12/11	GC	13	0.00					Vacant					
12/12/11	GC	15	0.00					Vacant					
12/12/11	GC	17	0.00					Vacant					
12/12/11	GC	23	0.00					Vacant					
12/12/11	GC	35	0.00					Vacant					
12/31/11	HMM	B 80	1.00					UKN					

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12/31/11	HMM	C 114	1.00					UKN					
12/31/11	HMM	M 206	1.00					UKN					
12/31/11	HMM	M 207	1.00					UKN					
12/31/11	HMM	M 211	1.00					UKN					
12/31/11	HMM	A 01	1.00	CF 4401 UH	P	23	9	UKN					
12/31/11	HMM	A 01A	1.00	CF 6863 RS	E	21	6	UKN					
12/31/11	HMM	A 02	1.00	CF 4378 UH	S	27	8	UKN					
12/31/11	HMM	A 03	1.00	CF 1411 SZ	S	25	8	UKN					
12/31/11	HMM	A 04	1.00	CF 2762 CP	P	25	8	UKN					
12/31/11	HMM	A 06	1.00	649606	S	39	12	UKN					
12/31/11	HMM	A 07	1.00	952646	P	50	15	UKN					
12/31/11	HMM	A 08	1.00	231002	S	58	13.5	UKN					
12/31/11	HMM	A 09	1.00	CF 6564 UX	P	38	14	UKN					
12/31/11	HMM	A 10	1.00	998413	P	44	15	UKN					
12/31/11	HMM	A 12	1.00	657594	P	47	14	UKN					
12/31/11	HMM	A 13	1.00	1195363	P	35	12	UKN					
12/31/11	HMM	A 14	1.00	1173101	S	54	16	UKN					
12/31/11	HMM	A 15	1.00	291037	S	44	12	UKN					
12/31/11	HMM	A 16	1.00	CF 9024 HJ	S	46	13	UKN					
12/31/11	HMM	A 17	1.00	530871	P	36	13	UKN					
12/31/11	HMM	A 18	1.00	962628	S	44.5	13.5	UKN					
12/31/11	HMM	A 18A	1.00	CF 7230 FR	S	32	9	UKN					
12/31/11	HMM	A 18B	1.00	976276	P	36	12	UKN					
12/31/11	HMM	A 18C	1.00	HIN WDSGG052E	S	35	12	UKN					
12/31/11	HMM	A 18D	1.00	1081807	S	37	12	UKN					
12/31/11	HMM	A 18E	1.00	CF 5742 EG	S	25	8	UKN					
12/31/11	HMM	A 19	1.00	692797	P	39	13	UKN					
12/31/11	HMM	A 21	1.00	1000188	P	42	15	UKN					
12/31/11	HMM	A 23	1.00	679906	S	41	13	UKN					
12/31/11	HMM	A 24	1.00	1041306	P	37.5	13.5	UKN					
12/31/11	HMM	A 25	1.00	1097123	P	42	14	UKN					
12/31/11	HMM	A 26	1.00	957849	S	38	12.5	UKN					
12/31/11	HMM	A 27	1.00	CF 8869 CG	P	41	13	UKN					
12/31/11	HMM	A 28	1.00	992358	P	42	15	UKN					
12/31/11	HMM	A 29	1.00	913764	P	36.5	13	UKN					
12/31/11	HMM	A 30	1.00	921503	P	41	12.5	UKN					
12/31/11	HMM	A 31	1.00	923742	P	38	15	UKN					
12/31/11	HMM	A 32	1.00	CF 3200 UC	P	40	12.5	UKN					
12/31/11	HMM	A 33	1.00	600392	S	36	11	UKN					
12/31/11	HMM	A 34	1.00	679095	S	35	11	UKN					
12/31/11	HMM	A 35	1.00	1135581	S	42	13	UKN					
12/31/11	HMM	A 36	1.00	CF 3671 GD	S	37	12	UKN					
12/31/11	HMM	A 37	1.00	CF 0829 GJ	S	38	11	UKN					
12/31/11	HMM	B 40	1.00	CF 3978 EP	S	34	10	UKN					

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12/31/11	HMM	B 41	1.00	1209631	S	36	12	UKN					
12/31/11	HMM	B 42	1.00	1026491	S	36	10.5	UKN					
12/31/11	HMM	B 43	1.00	980401	S	35	12	UKN					
12/31/11	HMM	B 44	1.00	CF 5775 CY	S	33	7	UKN					
12/31/11	HMM	B 45	1.00	1043306	S	37	12	UKN					
12/31/11	HMM	B 46	1.00	1127309	S	36	12	UKN					
12/31/11	HMM	B 47	1.00	1147247	S	35	10.5	UKN					
12/31/11	HMM	B 48	1.00	648236	S	33.5	11	UKN					
12/31/11	HMM	B 49	1.00	CF 6596 GD	S	37	12	UKN					
12/31/11	HMM	B 50	1.00	1025593	S	34	11	UKN					
12/31/11	HMM	B 51	1.00	CF 7137 HE	S	29	10	UKN					
12/31/11	HMM	B 52	1.00	517087	S	33	10	UKN					
12/31/11	HMM	B 54	1.00	CF 3517 TF	S	34	10	UKN					
12/31/11	HMM	B 56	1.00	CF 6432 GL	P	28	8	UKN					
12/31/11	HMM	B 57	1.00	CF 8019 TA	S	29	9.5	UKN					
12/31/11	HMM	B 58	1.00	606721	S	33	11	UKN					
12/31/11	HMM	B 59	1.00	CF 9477 KK	P	38	12	UKN					
12/31/11	HMM	B 60	1.00	514480	P	60	16	UKN					
12/31/11	HMM	B 62	1.00	1140361	P	32	12	UKN					
12/31/11	HMM	B 63	1.00	923308	S	35	11	UKN					
12/31/11	HMM	B 64	1.00	1117844	S	38	12	UKN					
12/31/11	HMM	B 65	1.00	664279	S	36	12	UKN					
12/31/11	HMM	B 66	1.00	529450	S	35	11	UKN					
12/31/11	HMM	B 67	1.00	CF 2623 GR	S	34	10	UKN					
12/31/11	HMM	B 68	1.00	CF 3782 GG	S	33	9.5	UKN					
12/31/11	HMM	B 69	1.00	695385	S	36	12	UKN					
12/31/11	HMM	B 70	1.00	912959	S	34	11	UKN					
12/31/11	HMM	B 71	1.00	641353	S	38	12	UKN					
12/31/11	HMM	B 72	1.00	CF 6870 KW	S	28	10	UKN					
12/31/11	HMM	B 73	1.00	1132290	S	36	12	UKN					
12/31/11	HMM	B 74	1.00	CF 3615 GK	S	36	10	UKN					
12/31/11	HMM	B 75	1.00	991615	S	36	13	UKN					
12/31/11	HMM	B 76	1.00	CF 8767 CT	S	32	8	UKN					
12/31/11	HMM	B 77	1.00	CF 1763 CK	P	38	13	UKN					
12/31/11	HMM	B 78	1.00	999719	S	35.5	10	UKN					
12/31/11	HMM	B 79	1.00	1069360	S	34	12	UKN					
12/31/11	HMM	C 100	1.00	1061286	S	30	11	UKN					
12/31/11	HMM	C 101	1.00	687501	S	32	9.5	UKN					
12/31/11	HMM	C 102	1.00	OR 112 ADG	P	30	9	UKN					
12/31/11	HMM	C 103	1.00	CF 9593 HF	S	30	10	UKN					
12/31/11	HMM	C 104	1.00	1070558	P	32	13	UKN					
12/31/11	HMM	C 105	1.00	CF 0661 CZ	S	25	9	UKN					
12/31/11	HMM	C 106	1.00	CF 3459 GR	S	30	10.5	UKN					
12/31/11	HMM	C 107	1.00	984845	S	30	11	UKN					

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12/31/11	HMM	C 108	1.00	CF 9376 FB	P	28	11	UKN					
12/31/11	HMM	C 109	1.00	1185675	S	30	11	UKN					
12/31/11	HMM	C 110	1.00	CF 2724 GD	P	30	12.5	UKN					
12/31/11	HMM	C 111	1.00	989678	S	27	8	UKN					
12/31/11	HMM	C 112	1.00	1055490	P	32	10	UKN					
12/31/11	HMM	C 113	1.00	CF 8923 SW	S	33	10	UKN					
12/31/11	HMM	C 81	1.00	CF 9978 KJ	P	21	8	UKN					
12/31/11	HMM	C 82	1.00	CF 3446 GG	P	30	8	UKN					
12/31/11	HMM	C 83	1.00	CF 4920 KL	S	25	8	UKN					
12/31/11	HMM	C 84	1.00	CF 8616 TK	S	34	10	UKN					
12/31/11	HMM	C 85	1.00	CF 7467 SC	S	27	9	UKN					
12/31/11	HMM	C 86	1.00	1129294	P	32	12	UKN					
12/31/11	HMM	C 87	1.00	CF 8912 FT	S	27	9	UKN					
12/31/11	HMM	C 88	1.00	CF 6650 GX	S	30	11	UKN					
12/31/11	HMM	C 90	1.00	CF 0536 HJ	S	25	8	UKN					
12/31/11	HMM	C 91	1.00	CF 4669 PW	S	30	11	UKN					
12/31/11	HMM	C 93	1.00	679745	S	31	11	UKN					
12/31/11	HMM	C 94	1.00	CF 4047 SS	S	29	9	UKN					
12/31/11	HMM	C 95	1.00	CF 4864 GH	S	27	8	UKN					
12/31/11	HMM	C 96	1.00	CF 6394 GB	S	27	12	UKN					
12/31/11	HMM	C 97	1.00	CF 2269 EU	S	27	8	UKN					
12/31/11	HMM	C 98	1.00	288514	P	53	15	UKN					
12/31/11	HMM	C 99	1.00	1114538	S	30	11	UKN					
12/31/11	HMM	D 114	1.00	CF 0020 JY	P	25	8.5	UKN					
12/31/11	HMM	D 115	1.00	CF 5908 HJ	S	28	9	UKN					
12/31/11	HMM	D 116	1.00	CF 0869 GC	S	24	9	UKN					
12/31/11	HMM	D 117	1.00	CF 4388 GB	S	26	7	UKN					
12/31/11	HMM	D 118	1.00	CF 2541 EC	S	25	8	UKN					
12/31/11	HMM	D 119	1.00	CF 1884 GA	S	30	11	UKN					
12/31/11	HMM	D 120	1.00	CF 3211 SP	S	35	12	UKN					
12/31/11	HMM	D 121	1.00	CF 5228 EM	S	28	8	UKN					
12/31/11	HMM	D 122	1.00	1044747	S	34	10	UKN					
12/31/11	HMM	D 123	1.00	CF 7348 EY	S	26	8	UKN					
12/31/11	HMM	D 124	1.00	990093	S	30	11	UKN					
12/31/11	HMM	D 125	1.00	CF 4742 EZ	S	30	10	UKN					
12/31/11	HMM	D 126	1.00	CF 9496 HJ	S	30	9	UKN					
12/31/11	HMM	D 127	1.00	CF 0099 HJ	S	30	9.6	UKN					
12/31/11	HMM	M 199	1.00	559393	S	38	13	UKN					
12/31/11	HMM	M 200	1.00	CF 0164 UE	S	38	12	UKN					
12/31/11	HMM	M 201	1.00	1070231	S	36	12	UKN					
12/31/11	HMM	M 202	1.00	1070231	S	36	12	UKN					
12/31/11	HMM	M 203	1.00	CF 8895 FM	P	24	9	UKN					
12/31/11	HMM	M 204	1.00	CF 9605 NG	S	27	10	UKN					
12/31/11	HMM	M 205	1.00	1090649	P	33	11	UKN					

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
12/31/11	HMM	M 208	1.00	CF 0426 TY	P	27	9	UKN					
12/31/11	HMM	M 209	1.00	CF 9339 FT	S	30	11	UKN					
12/31/11	HMM	M 210	1.00	1204847	P	43.3	13.8	UKN					
12/31/11	HMM	M 220	1.00	CF 8587 GL	P	22	7	UKN					
12/31/11	HMM	M 221	1.00	CF 9142 CY	S	22	8	UKN					
12/31/11	HMM	M 222	1.00	CF 1422 HJ	S	22	7	UKN					
12/31/11	HMM	M 223	1.00	CF 5456 CV	S	22	9	UKN					
12/31/11	HMM	M 224	1.00	CF 6481 HR	S	23	8	UKN					
12/31/11	HMM	M 225	1.00	WAITING FOR IN	P	22	9	UKN					
12/31/11	HMM	M 226	1.00	CF 1936 UF	S	22	8	UKN					
12/31/11	HMM	M 227	1.00	CF 8846 EJ	S	26	8	UKN					
12/31/11	HMM	M 228	1.00	CF 8149 GL	S	27	9	UKN					
12/31/11	HMM	M 229	1.00	CF 8720 TK	P	25	10	UKN					
12/31/11	HMM	M 230	1.00	CF 5180 GP	S	24	8	UKN					
12/31/11	HMM	M 231	1.00	CF 7486 FB	S	25	8	UKN					
12/31/11	HMM	M 232	1.00	CF 1618 KK	P	15	8	UKN					
12/31/11	HMM	M 233	1.00	CF 2023 NZ	P	23	8	UKN					
12/31/11	HMM	M 234	1.00	CF 1436 UV	S	29	9	UKN					
12/31/11	HMM	M 235	1.00	CF 5262 SN	P	24	9	UKN					
12/31/11	HMM	M 236	1.00	CF 3368 SA	S	33	11	UKN					
12/31/11	HMM	M 239	1.00	974358	P	34	11	UKN					
12/31/11	HMM	M 240	1.00	CF 6347 CA	S	25	8	UKN					
12/31/11	HMM	M 241	1.00	CF 8523 SZ	P	24	9	UKN					
12/31/11	HMM	M 242	1.00	CF 9009 TK	P	32	12	UKN					
12/31/11	HMM	A 20	1.00	1224405	P	35	12.5	Lcu-ukn					
12/31/11	HMM	C 92	1.00	CF 5885 EL	S	28	8	Lcu-ukn					
12/31/11	HMM	M 216	1.00	915803	P	25	8	Lcu-ukn					
12/31/11	HMM	A 05	1.00	646723	S	55	16	Non-unconf					
12/31/11	HMM	M 213	1.00	CF 8737 SW	P	10	5	Non-unconf					
12/31/11	HMM	M 214	1.00	CF 9010 SW	S	22	8	Non-unconf					
12/31/11	HMM	M 215	1.00	CF 3798 TH	P	12	6	Non-unconf					
12/31/11	HMM	M 237	1.00	NONE (TENDER)	P	10	6	Non-unconf					
12/31/11	HMM	A 11	0.00					Vacant					
12/31/11	HMM	A 18F	0.00					Vacant					
12/31/11	HMM	A 22	0.00					Vacant					
12/31/11	HMM	A 38	0.00					Vacant					
12/31/11	HMM	B 39	0.00					Vacant					
12/31/11	HMM	B 53	0.00					Vacant					
12/31/11	HMM	B 55	0.00					Vacant					
12/31/11	HMM	B 61	0.00					Vacant					
12/31/11	HMM	C 89	0.00					Vacant					
12/31/11	HMM	M 212	0.00					Vacant					
12/31/11	HMM	M 217	0.00					Vacant					
12/31/11	HMM	M 218	0.00					Vacant					

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12/31/11	HMM	M 219	0.00					Vacant					
12/31/11	HMM	M 243	0.00					Vacant					
11-Nov	KK	A4	1.00	1090001	S	35	14	Cu	Interlux Ultra (67)		OTH	9-Mar	67
11-Dec	KK	A8	0.85	1122534		34	12	Cu	Interlux Ultra (67)		OTH	10-Oct	40
11-Dec	KK	A26	0.90	951435	P	34	12	Cu	PROLINE 1088		DR	9-May	40
11-Jan	KK	B3	0.95	1154614	P	35	13	Cu	PROLINE 1088		DR	10-Mar	40
11-Oct	KK	D45	0.90	1120409	S	42	14	Cu	Interlux Ultra (67)		SI	10-May	67
11-Oct	KK	H12	0.90	1102966	P	37	13	Cu	proline 1088		DR	10-May	40
11-Oct	KK	H22	0.90	677166	P	42	14	Cu	proline 1088		DR	11-May	40
11-Oct	KK	H63	0.95	CF0310CJ	P	36	12	Cu	Interlux Ultra (67)		SI	7-May	67
11-Dec	KK	I30	0.75	914466	P	50	16	Cu	PROLINE 1088		KC	8-Aug	
11-Oct	KK	I38	0.75	972162	P	48	17	Cu	PROLINE 1088			SI	10-Apr
11-Dec	KK	I54	0.80	1185694	S	50	15.5	Cu	Interlux Ultra (67)		SI	8-Feb	67
11-Oct	KK	I68	0.90	1185391	S	47	14	Cu	trinidad vc		SI	10-Oct	70
11-Nov	KK	A5	0.75	102667	S	34	12	Cu	proline (67)		SI	8-Nov	67
11-Nov	KK	C45	0.75	198281	P	43	15	LCu	PETIT		OTH	9-Jun	25
11-Oct	KK	F27	1.00	1022910	S	55	14	LCu	seacoat		SI	9-Apr	33
11-Nov	KK	H5	0.80	NV6370KM	S	40	12	LCu	Sea Hawk Monterey		OTH	10-Mar	33
11-Dec	KK	I25	0.80	1222994	P	34	12	LCu	PETIT		DR	10-Dec	25
11-Sep	KK	G1	1.00	CF7195TK	P	31	8	Non-unconf	HYDRO HOIST				0
11-Sep	KK	G51	1.00	CF 7812 UB	P	29	9	Non-unconf	HYDRO HOIST				0
11-Oct	KK	A53	0.90	1046088	M	35	14	Non	INTERSLEEK		DR	10-May	0
	KK	A7	0.85	CF1472RG	S	30	10	UKN					
	KK	A9	1.00	1063316	S	30	12	UKN					
	KK	A10	1.00	CF3858SC	S	31	10	UKN					
	KK	A12	1.00	1026765	P	34	14	UKN					
	KK	A13	1.00	924326	S	30	14	UKN					
	KK	A15	1.00	907489	S	32	10	UKN					
	KK	A16	1.00	CF5808PS	P	30	9	UKN					
11-Jan	KK	A19	0.95	CF0552TP	M	34	15	UKN					
	KK	A22	1.00	CF9301HB	S	36	13	UKN					
	KK	A23	1.00	692959	P	39	13	UKN			SI	8-May	
	KK	A24	1.00	1068029	P	33	12	UKN					
	KK	A25	1.00		P	34	11	UKN					
11-Jan	KK	A27	0.95	1220557	S	35	12	UKN					
	KK	A28	1.00	937661	S	34	12	UKN					
	KK	A33	1.00	919750	P	33	13	UKN					
	KK	A34	1.00	CF 0257 HF	S	36	11	UKN					
11-Nov	KK	A36	0.90	1204719	S	36	11.5	UKN			KC	7-May	
	KK	A37	1.00	937661	S	32	11.5	UKN					
11-Sep	KK	A40	1.00	CF8733SZ	M	31	11	UKN		HYDRO HOIST			0
11-Jan	KK	A41	0.85	1180377	P	31	10.5	UKN					
	KK	A42	1.00	CF4008SA	P	34	12.5	UKN					
	KK	A44	1.00	107698	P	34	12	UKN					

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	KK	A45	1.00	CF1412CD	P	30	12	UKN					
11-Jan	KK	A46	0.70	980370	S	36	13	UKN					
	KK	A48	1.00	FL 8332 MJ	P	25	8	UKN					
	KK	A49	1.00	1095074	S	36	11.5	UKN					
	KK	A50	1.00	1147455	M	33	13	UKN					
	KK	A51	1.00	CF7877CR	S	34	11	UKN					
	KK	B2	1.00	951980	P	35	13	UKN					
	KK	B4	1.00	CF9374ER	P	38	13	UKN					
	KK	B5	1.00	CF8113KL	S	30	10.5	UKN					
	KK	B8	1.00		P	40	15	UKN					
	KK	B9	1.00	1012013	P	29	11	UKN					
	KK	B11	1.00		S	28	12	UKN					
11-Jan	KK	B12	0.95	1065215	P	35	14	UKN					
11-Jan	KK	B13	0.80	CF6622GD	S	30	10	UKN					
	KK	B15	1.00	CF 6757 GM	P	24	8	UKN					
	KK	B16	1.00	114263	P	43	14	UKN			KC	7-Aug	
	KK	B17	1.00	1217038	P	32	11	UKN					
	KK	B22	1.00	948523	S	40	13	UKN					
	KK	B23	1.00	CF7092JL	S	30	11	UKN					
	KK	B27	1.00	OR 613 ACS	S	25	8.5	UKN					
	KK	B30	1.00	CF 8646 CC	P	38	11	UKN					
	KK	B33	1.00	912700	P	30	10	UKN					
	KK	B36	1.00	CF 6243 HD	S	38	12.5	UKN					
	KK	B37	1.00	1215905	P	27	7	UKN					
11-Oct	KK	B40	1.00	682954	P	40	14	UKN			DR	10-Jun	
	KK	B42	1.00		P	34	13	UKN					
	KK	B43	1.00		S	32	10	UKN					
	KK	B44	1.00	1119692	S	38	14	UKN					
	KK	B45	1.00	992971	P	25	10	UKN					
	KK	B46	1.00	1164088	P	30	11	UKN					
11-Dec	KK	B51	0.95	CF7173EV	S	30	10	UKN					
	KK	B53	1.00	CF 2540 GH	S	30	11	UKN					
	KK	B55	1.00	CF1412CD	S	30	11	UKN					
11-Sep	KK	C2	1.00	925986	P	60	15.5	UKN		HYDRO HOIST			0
	KK	C3	1.00	1207194	P	42	14	UKN					
11-Jan	KK	C5	0.90	1102121	P	36	14	UKN					
	KK	C7	1.00		P	41	12	UKN					
	KK	C10	1.00	1144720	P	55	15	UKN					
	KK	C11	1.00	1129633	P	42	14.5	UKN					
11-Oct	KK	C12	0.95	1136020	P	60	15	UKN			OTH	9-May	
	KK	C13	1.00	615436	S	41	13	UKN					
	KK	C14	1.00	1177375	P	58	18	UKN					
	KK	C15	1.00	1108003	S	46	14	UKN					
	KK	C17	1.00	1113333	S	40	14	UKN					

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11-Nov	KK	C19	0.85	1204602	S	42	12.5	UKN			DR	10-Apr	
	KK	C20	1.00	7048253	S	54	16	UKN					
	KK	C21	1.00	112419	P	42	16	UKN					
	KK	C22	1.00	173375	P	53	15	UKN					
	KK	C24	1.00	1026054	P	57	15.5	UKN					
	KK	C25	1.00	519292	P	38	13	UKN					
	KK	C26	1.00		P	60	16	UKN					
11-Nov	KK	C27	1.00	CF8640SW	S	37	10.5	UKN			SI	8-May	
	KK	C28	1.00		P	50	15	UKN					
	KK	C29	1.00	592872	P	45	14	UKN					
	KK	C32	1.00	916238	P	58	18	UKN					
	KK	C33	1.00	945187	S	42	14	UKN					
	KK	C34	1.00	1212766	S	53	16	UKN					
11-Oct	KK	C36	0.90	917401	P	40	17	UKN			OTH	10-Jun	
	KK	C37	1.00	1095496	P	42	14	UKN					
	KK	C38	1.00		P	59	15	UKN					
	KK	C39	1.00	1151006	S	42	14	UKN					
11-Dec	KK	C40	0.75	106896	M	57	24	UKN			OTH	8-May	
	KK	C43	1.00	976864	P	42	13	UKN					
	KK	C47	1.00	CF9949GD	S	41	11	UKN					
	KK	D1	1.00	1195371	P	40	16	UKN					
	KK	D2	1.00		P	50	17	UKN					
	KK	D4	1.00	1052928	P	46	15	UKN					
	KK	D6	1.00	607557	P	50	14	UKN					
	KK	D8	1.00	102591	P	44	14	UKN					
	KK	D11	1.00		P	38	15	UKN					
	KK	D12	1.00	CF4199SX	H	46	16	UKN					
	KK	D13	1.00	1041396	S	43	14	UKN					
	KK	D14	1.00	972162	P	50	15	UKN					
	KK	D16	1.00	634972	P	50	15	UKN					
	KK	D18	1.00	645789	S	44	13	UKN					
11-Dec	KK	D19	0.95	1090001	S	38	12.5	UKN					
	KK	D20	1.00	1219511	P	48	15	UKN					
	KK	D21	1.00	1181668	S	40	11.5	UKN					
11-Jan	KK	D22	0.95	1034474	S	46	13	UKN					
	KK	D24	1.00		P	47	15	UKN					
	KK	D25	1.00	1091818	S	38	12	UKN					
	KK	D26	1.00	CF8768KT	P	43	15	UKN					
	KK	D28	1.00	1162899	P	42	14	UKN					
	KK	D29	1.00	1215048	P	45	14	UKN					
	KK	D30	1.00	937661	S	52	14	UKN					
	KK	D33	1.00	CF4474SA	S	42	10	UKN					
	KK	D34	1.00	1159085	S	42	13	UKN					
	KK	D35	1.00	1036078	P	43	13.5	UKN					

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	KK	D36	1.00	185405	P	47	14	UKN					
	KK	D37	1.00	1026097	S	40	13	UKN					
	KK	D38	1.00	1038697	P	47	14	UKN					
	KK	D39	1.00	1073954	S	36	11	UKN					
	KK	D40	1.00	1193032	P	50	17	UKN					
	KK	D41	1.00	CF9394EX	S	41	13	UKN					
	KK	D47	1.00	1172350	P	50	16	UKN					
	KK	E1	1.00	1183506	P	75		UKN					
	KK	E3	1.00		P	59	14.5	UKN					
	KK	E5	1.00	1216393	P	58	18	UKN					
	KK	E10	1.00	971912	P	98	23	UKN					
	KK	E11	1.00	1020228	P	57	16	UKN					
12-Jan	KK	E12	0.90	951645	S	70		UKN			OTH	9-Aug	
	KK	E13	1.00	1159705	P	60	15	UKN					
11-Nov	KK	E14	0.80	1143212	P	58	18	UKN			OTH	10-Aug	
	KK	E16	1.00	1220643	S	58	16	UKN					
	KK	E17	1.00	CF3251SN4	P	70	17	UKN					
	KK	E18	1.00	950857	P	52	15	UKN					
	KK	E19	1.00	261353	P	60	18	UKN					
	KK	E20	1.00	679765	P	44	16	UKN					
	KK	E21	1.00	1021287	P	55	17.5	UKN					
	KK	E24	1.00	1093898	S	85	20	UKN					
	KK	E25	1.00	1166859	P	55	17	UKN					
	KK	E26	1.00	950565	P	75	20	UKN					
	KK	E27	1.00	997106	P	74	18	UKN					
	KK	E28	1.00	273333	P	96	20	UKN					
	KK	E29	1.00	644393	P	60	12	UKN					
	KK	E31	1.00	1200446	P	55	13	UKN					
	KK	E34	1.00	1138828	P	80	20	UKN					
	KK	E35	1.00	674615	S	70	18	UKN					
	KK	E37	1.00	1069708	P	64	21	UKN					
	KK	F2	1.00		P	70	20	UKN					
	KK	F3	1.00	1229511	P	64	18	UKN					
	KK	F5	1.00	5822854	P	60	14	UKN					
	KK	F6	1.00	1032693	P	62	18	UKN					
	KK	F8	1.00	1215905	S	57	16.5	UKN					
	KK	F10	1.00	1076545	S	61	17	UKN					
	KK	F14	1.00	1050242	P	80	19	UKN					
	KK	F15	1.00	966881	P	48	16	UKN					
	KK	F16	1.00		P	70	19	UKN					
	KK	F20	1.00	1035689	P	57	17	UKN					
	KK	F21	1.00	1027584	S	56	15	UKN					
	KK	F22	1.00	1195570	P	57	18	UKN					
	KK	F23	1.00	1182095	P	50	14	UKN					

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	KK	F24	1.00	1187119	P	80	20	UKN					
	KK	F25	1.00	661494	S	47	13	UKN					
	KK	F26	1.00	5812	P	63	18	UKN					
	KK	F28	1.00	1021940	P	70	18.5	UKN					
	KK	F29	1.00		P	48	14	UKN					
	KK	F30	1.00	1230889	S	57	17	UKN					
	KK	F31	1.00		S	52	12	UKN					
	KK	F33	1.00	981739	P	43	14	UKN					
	KK	F35	1.00	1431	S	50	13	UKN					
	KK	F39	1.00	639448	S	49	14	UKN					
	KK	F41	1.00	CF1451KB	S	39	12	UKN					
	KK	G2	1.00	1117973	S	45	14	UKN					
	KK	G3	1.00	104765	P	35	9	UKN					
	KK	G5	1.00	CF0639FD	S	25	8	UKN					
	KK	G6	1.00	10271789	P	44	14	UKN					
	KK	G9	1.00		P	29	8	UKN					
	KK	G10	1.00	937189	P	45	15	UKN					
	KK	G13	1.00	924326	P	29	8	UKN					
	KK	G15	1.00	CF8589EX	P	30	12	UKN					
	KK	G17	1.00	1091185	P	28	9	UKN					
	KK	G21	1.00	CF1375FB	S	27	9	UKN					
	KK	G23	1.00	CF 3986 HX	P	36	11	UKN					
	KK	G25	1.00	CF1162BA	P	26	8	UKN					
	KK	G26	1.00	920199	P	44	12	UKN					
	KK	G29	1.00	1038810	P	34	12	UKN					
	KK	G30	1.00	970854	P	45	14	UKN					
	KK	G34	1.00	1035955	S	44	11	UKN					
	KK	G35	1.00	1043434	P	32	12	UKN					
	KK	G36	1.00	693931	P	45	15	UKN					
	KK	G37	1.00	CF3526SA	S	33	10	UKN					
	KK	G38	1.00	1171051	S	40	12	UKN					
	KK	G39	1.00	CF4165EF	S	25	6	UKN					
	KK	G41	1.00	CF8684PT	P	30	11	UKN					
	KK	G43	1.00	1180652	P	28	10	UKN					
	KK	G46	1.00	1227597	P	45	16	UKN					
	KK	G47	1.00	CF 3684 JA	P	28	10	UKN					
	KK	G49	1.00	1184836	P	30	10	UKN					
	KK	G52	1.00	1030322	P	45	14	UKN					
	KK	G53	1.00	CF0299PR	P	29	9.5	UKN					
	KK	G55	1.00	1169096	P	28	10	UKN					
	KK	G57	1.00	119032	P	34	11	UKN					
	KK	G58	1.00	1077029	P	40	14.5	UKN					
	KK	G61	1.00	1186984	P	31	10	UKN					
	KK	G62	1.00	655587	P	42	14	UKN					

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	KK	G65	1.00	CF4624HE	S	30	10	UKN					
	KK	G66	1.00	1073064		46	14.5	UKN					
	KK	G69	1.00	937661	P	35	13	UKN					
	KK	G70	1.00	1201411	P	44	14	UKN					
	KK	G73	1.00	980820	P	35	12	UKN					
	KK	G76	1.00	116845	P	45	14.5	UKN					
	KK	G79	1.00	1047795	S	30	11	UKN					
	KK	G80	1.00	1225979	P	45	15	UKN					
	KK	G81	1.00	677601	P	33	11	UKN					
11-Oct	KK	G85	0.95	920767	S	30	12	UKN			OTH	8-Aug	
	KK	G89	1.00	1034961	P	32	10	UKN					
	KK	G91	1.00	1147766	P	40	12	UKN					
	KK	H1	1.00	937661	M	40	15	UKN					
11-Oct	KK	H2	0.85	WN8530RB	P	34	12	UKN			OTH	9-Oct	
	KK	H4	1.00	541191	S	32	11	UKN					
	KK	H6	1.00	91073	P	41	12	UKN					
	KK	H7	1.00		S	40	12	UKN					
	KK	H10	1.00	663039	S	38	12	UKN					
	KK	H11	1.00	1133092	S	41	13.5	UKN					
	KK	H14	1.00	109772	S	36	11	UKN					
	KK	H16	1.00	982107		41		UKN					
	KK	H17	1.00		P	38	12	UKN					
	KK	H18	1.00		P	41	13	UKN					
	KK	H19	1.00	528866	P	38	14	UKN					
	KK	H23	1.00	519292	P	38	12	UKN					
	KK	H25	1.00	CF1647ST	P	38	12	UKN					
	KK	H29	1.00	1116818	S	37	13	UKN					
12-Jan	KK	H31	0.90	1192416	S	37	12	UKN			KC	10-Aug	
	KK	H33	1.00	694636	S	36	11	UKN					
	KK	H34	1.00	1192416	S	51	16	UKN					
	KK	H35	1.00		S	38	13	UKN					
	KK	H37	1.00	1103732	S	37	11.5	UKN					
	KK	H38	1.00	945453	S	49	14	UKN					
	KK	H40	1.00	CF6566GU	P	50	15	UKN					
	KK	H41	1.00	1117010	S	41	13	UKN					
	KK	H42	1.00	659832	P	51	17	UKN					
	KK	H43	1.00	1199135	P	36	14	UKN					
	KK	H44	1.00	CF7592NB	P	47	15	UKN					
	KK	H45	1.00	613899	P	38	12.5	UKN					
	KK	H46	1.00	688755	P	40	13	UKN					
	KK	H47	1.00	1179570	P	41	14	UKN					
	KK	H50	1.00	1229189	P	41	14	UKN					
	KK	H51	1.00		S	36	11.5	UKN					
	KK	H55	1.00	1032855	P	38	13	UKN					

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	KK	H56	1.00	1032855	S	42	14	UKN					
	KK	H58	1.00	1175147	S	38	13	UKN					
	KK	H61	1.00	CF0310CJ		37		UKN					
	KK	H62	1.00	903240	S	40	14	UKN					
	KK	H66	1.00	1193032	P	42	13	UKN					
	KK	H67	1.00	CF3904KT	P	39	13	UKN					
	KK	H70	1.00	1128622	P	40	14	UKN					
	KK	H72	1.00		S	38	12	UKN					
	KK	H73	1.00	1196201	P	36	13.5	UKN					
	KK	H74	1.00		S	36	12	UKN					
	KK	H76	1.00		P	40	11	UKN					
	KK	H77	1.00	CF5912HJ	S	42	13	UKN					
	KK	H80	1.00	1093852	P	45	14	UKN					
	KK	H81	1.00	1093852	S	36	12	UKN					
	KK	H83	1.00	1126098	S	35	11.5	UKN					
	KK	I4	1.00	122569	P	50	17	UKN					
	KK	I5	1.00	908258	P	48	14	UKN					
	KK	I6	1.00	1196710	P	48	16	UKN					
11-Dec	KK	I7	0.75	907651	S	49	15	UKN			DR	10-May	
	KK	I8	1.00	1223116	P	46	14	UKN					
11-Oct	KK	I10	0.75	1069798	S	49	14	UKN			DR	9-May	
	KK	I12	0.00		P	45	16	UKN					
	KK	I13	1.00	1119718	P	48	13	UKN					
	KK	I16	1.00	1177080	P	48	15	UKN					
	KK	I17	1.00	1127623	P	47	15	UKN					
	KK	I18	1.00	1152904	P	54	15	UKN					
	KK	I20	1.00	1057894	P	50	17	UKN					
	KK	I22	1.00	512706	P	50	16	UKN					
	KK	I23	1.00	1027487	S	34	12.5	UKN					
	KK	I24	1.00	694750	P	47	15	UKN					
	KK	I26	1.00	662230	P	45	14	UKN					
	KK	I27	1.00		P	34	9.5	UKN					
	KK	I28	1.00	682212	P	42	14	UKN					
	KK	I29	1.00	1133295	P	34	13	UKN					
	KK	I31	1.00	1074525	P	33	13	UKN					
	KK	I32	1.00	904645	P	40	15	UKN					
	KK	I33	1.00	1217415	S	34	12	UKN					
11-Dec	KK	I34	0.90	109059	P	45	14	UKN				DR	9-May
	KK	I35	1.00	CF2908EF	P	35	10	UKN					
	KK	I36	1.00	943572	P	44	17	UKN					
	KK	I37	1.00	937894	P	32	10	UKN					
	KK	I39	1.00	CF4506.HG	P	27	9	UKN					
	KK	I41	1.00		P	35	9	UKN					
	KK	I42	1.00	CF6992CU	P	47	13	UKN					

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	KK	I43	1.00		P	32	12	UKN					
	KK	I44	1.00	1195363	S	51	14	UKN					
	KK	I45	1.00	653489	S	35	12	UKN					
	KK	I46	1.00		P	48	15	UKN					
	KK	I47	1.00	1193032	S	34	12	UKN					
	KK	I48	1.00		S	48	15	UKN					
	KK	I49	1.00	1213226	P	26	9	UKN					
	KK	I52	1.00	1193564	S	48	15	UKN					
	KK	I56	1.00	1219517	P	44	16	UKN					
	KK	I57	1.00	1200768	P	49	15	UKN					
	KK	I58	1.00	1147460	P	52	15	UKN					
	KK	I59	1.00	1210275	P	50	13	UKN					
	KK	I61	1.00		P	46	14	UKN					
	KK	I62	1.00		P	47	15	UKN					
	KK	I63	1.00	1216619	P	50	16	UKN					
	KK	I65	1.00	1083403	P	43	17	UKN					
	KK	I66	1.00	1099886	P	50	16	UKN					
	KK	I67	1.00	1046834	P	40	15	UKN					
	KK	I70	1.00	508097	S	50	13	UKN					
11-Nov	KK	I72	0.80	955541	P	45	15	UKN			OTH	10-Dec	
11-Oct	KK	I73	0.90	1146511	P	48	15	UKN			KC	7-Oct	
	KK	I74	1.00	554241	P	40	17	UKN					
	KK	I76	1.00	933093	P	49	17	UKN					
	KK	I79	1.00	933093	P	48	15	UKN					
	KK	I81	0.00		P	41	14	UKN					
	KK	K2	1.00	982108		75	17	UKN					
	KK	K4	1.00	739127		115	21.5	UKN					
	KK	K5A	1.00			116	25	UKN					
	KK	C1	1.00			40		UKN					
	KK	H3	1.00			39		UKN					
	KK	I9	1.00			44		UKN					
	KK	A1	0.00					Vacant					
	KK	A2	0.00					Vacant					
	KK	A3	0.00					Vacant					
	KK	A6	0.00					Vacant					
	KK	A11	0.00					Vacant					
	KK	A17	0.00					Vacant					
	KK	A18	0.00					Vacant					
	KK	A20	0.00					Vacant					
	KK	A21	0.00					Vacant					
	KK	A29	0.00					Vacant					
	KK	A30	0.00					Vacant					
	KK	A31	0.00					Vacant					
	KK	A32	0.00					Vacant					

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	KK	A35	0.00					Vacant					
	KK	A38	0.00					Vacant					
	KK	A39	0.00					Vacant					
	KK	A43	0.00					Vacant					
	KK	A47	0.00					Vacant					
	KK	B6	0.00					Vacant					
	KK	B7	0.00					Vacant					
	KK	B10	0.00					Vacant					
	KK	B14	0.00					Vacant					
	KK	B18	0.00					Vacant					
	KK	B19	0.00					Vacant					
	KK	B20	0.00					Vacant					
	KK	B21	0.00					Vacant					
	KK	B24	0.00					Vacant					
	KK	B25	0.00					Vacant					
	KK	B26	0.00					Vacant					
	KK	B28	0.00					Vacant					
	KK	B29	0.00					Vacant					
	KK	B31	0.00					Vacant					
	KK	B32	0.00					Vacant					
	KK	B34	0.00					Vacant					
	KK	B35	0.00					Vacant					
	KK	B38	0.00					Vacant					
	KK	B39	0.00					Vacant					
	KK	B41	0.00					Vacant					
	KK	B47	0.00					Vacant					
	KK	B49	0.00					Vacant					
	KK	C4	0.00					Vacant					
	KK	C6	0.00					Vacant					
	KK	C8	0.00					Vacant					
	KK	C9	0.00					Vacant					
	KK	C16	0.00					Vacant					
	KK	C18	0.00					Vacant					
	KK	C23	0.00					Vacant					
	KK	C30	0.00					Vacant					
	KK	C31	0.00					Vacant					
	KK	C35	0.00					Vacant					
	KK	C41	0.00					Vacant					
	KK	D3	0.00					Vacant					
	KK	D5	0.00					Vacant					
	KK	D7	0.00					Vacant					
	KK	D9	0.00					Vacant					
	KK	D10	0.00					Vacant					
	KK	D15	0.00					Vacant					

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	KK	D17	0.00					Vacant					
	KK	D23	0.00					Vacant					
	KK	D27	0.00					Vacant					
	KK	D31	0.00					Vacant					
	KK	D32	0.00					Vacant					
	KK	D43	0.00					Vacant					
	KK	D44	0.00					Vacant					
	KK	E2	0.00					Vacant					
	KK	E4	0.00					Vacant					
	KK	E6	0.00					Vacant					
	KK	E7	0.00					Vacant					
	KK	E8	0.00					Vacant					
	KK	E9	0.00					Vacant					
	KK	E15	0.00					Vacant					
	KK	E22	0.00					Vacant					
	KK	E23	0.00					Vacant					
	KK	E30	0.00					Vacant					
	KK	E32	0.00					Vacant					
	KK	E33	0.00					Vacant					
	KK	F1	0.00					Vacant					
	KK	F4	0.00					Vacant					
	KK	F7	0.00					Vacant					
	KK	F9	0.00					Vacant					
	KK	F11	0.00					Vacant					
	KK	F12	0.00					Vacant					
	KK	F13	0.00					Vacant					
	KK	F17	0.00					Vacant					
	KK	F18	0.00					Vacant					
	KK	F19	0.00					Vacant					
	KK	F32	0.00					Vacant					
	KK	F37	0.00					Vacant					
	KK	G4	0.00					Vacant					
	KK	G7	0.00					Vacant					
	KK	G8	0.00					Vacant					
	KK	G11	0.00					Vacant					
	KK	G12	0.00					Vacant					
	KK	G14	0.00					Vacant					
	KK	G16	0.00					Vacant					
	KK	G18	0.00					Vacant					
	KK	G19	0.00					Vacant					
	KK	G20	0.00					Vacant					
	KK	G22	0.00					Vacant					
	KK	G24	0.00					Vacant					
	KK	G27	0.00					Vacant					

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	KK	G28	0.00					Vacant					
	KK	G31	0.00					Vacant					
	KK	G32	0.00					Vacant					
	KK	G33	0.00					Vacant					
	KK	G40	0.00					Vacant					
	KK	G42	0.00					Vacant					
	KK	G44	0.00					Vacant					
	KK	G45	0.00					Vacant					
	KK	G48	0.00					Vacant					
	KK	G50	0.00					Vacant					
	KK	G54	0.00					Vacant					
	KK	G56	0.00					Vacant					
	KK	G59	0.00					Vacant					
	KK	G60	0.00					Vacant					
	KK	G63	0.00					Vacant					
	KK	G64	0.00					Vacant					
	KK	G67	0.00					Vacant					
	KK	G68	0.00					Vacant					
	KK	G71	0.00					Vacant					
	KK	G72	0.00					Vacant					
	KK	G74	0.00					Vacant					
	KK	G75	0.00					Vacant					
	KK	G77	0.00					Vacant					
	KK	G78	0.00					Vacant					
	KK	G83	0.00					Vacant					
	KK	H8	0.00					Vacant					
	KK	H9	0.00					Vacant					
	KK	H13	0.00					Vacant					
	KK	H15	0.00					Vacant					
	KK	H20	0.00					Vacant					
	KK	H21	0.00					Vacant					
	KK	H24	0.00					Vacant					
	KK	H26	0.00					Vacant					
	KK	H27	0.00					Vacant					
	KK	H28	0.00					Vacant					
	KK	H30	0.00					Vacant					
	KK	H32	0.00					Vacant					
	KK	H36	0.00					Vacant					
	KK	H39	0.00					Vacant					
	KK	H48	0.00					Vacant					
	KK	H49	0.00					Vacant					
	KK	H52	0.00					Vacant					
	KK	H53	0.00					Vacant					
	KK	H54	0.00					Vacant					

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	KK	H57	0.00					Vacant					
	KK	H59	0.00					Vacant					
	KK	H60	0.00					Vacant					
	KK	H64	0.00					Vacant					
	KK	H65	0.00					Vacant					
	KK	H68	0.00					Vacant					
	KK	H69	0.00					Vacant					
	KK	H71	0.00					Vacant					
	KK	H75	0.00					Vacant					
	KK	H78	0.00					Vacant					
	KK	H79	0.00					Vacant					
	KK	I1	0.00					Vacant					
	KK	I2	0.00					Vacant					
	KK	I3	0.00					Vacant					
	KK	I11	0.00					Vacant					
	KK	I14	0.00					Vacant					
	KK	I15	0.00					Vacant					
	KK	I19	0.00					Vacant					
	KK	I21	0.00					Vacant					
	KK	I40	0.00					Vacant					
	KK	I50	0.00					Vacant					
	KK	I51	0.00					Vacant					
	KK	I53	0.00					Vacant					
	KK	I55	0.00					Vacant					
	KK	I60	0.00					Vacant					
	KK	I64	0.00					Vacant					
	KK	I69	0.00					Vacant					
	KK	I71	0.00					Vacant					
	KK	I75	0.00					Vacant					
	KK	I77	0.00					Vacant					
	KK	K I	0.00					Vacant					
	KK	K3	0.00					Vacant					
	KK	K5B	0.00					Vacant					
	KK	K6A	0.00					Vacant					
	KK	K6B	0.00					Vacant					
	KK	K7A	0.00					Vacant					
	KK	K7B	0.00					Vacant					
	KK	K8A	0.00					Vacant					
	KK	K8B	0.00					Vacant					
	KK	K13	0.00					Vacant					
	KK	K14	0.00					Vacant					
	KK	K15	0.00					Vacant					
	KK	K16	0.00					Vacant					
11-Oct	KK	A14	0.80	1110094	S	36	12	Non	Seahawk MISSIONB	4005	DR	10-May	0

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11-Jan-11	LPYC	na	1.00	CF 2818 JY	P	15	7	Cu	Interlux Super KL	UKN	DR	2005	78%
11-Jan-11	LPYC	na	1.00	CF 3326 FP	P	22	8	Cu	Ultracote	UKN	Kohlerkraft	Jun-12	67%
11-Jan-11	LPYC	na	1.00	CF 1406 pk	P	21	8	Cu	Pettit B94	UKN	DR	Feb-09	UKN
11-Jan-11	LPYC	na	1.00	CF 6560 RB	P	18	8	Non	Sea Hawk Mission Bay	UKN	DR	Mar-12	non
12/30/2011	SDYC	915	0.90	536059	Alaskan	55	17	UKN			Shelter Island Bo	May-10	
12/30/2011	SDYC	A001-A001	0.90	CF 5798 KD	Wahoo			UKN					
12/30/2011	SDYC	A002-A002	0.90	1062584	Catamaran	38	20	Cu	Sharkskin - 7			Aug-10	45
12/30/2011	SDYC	A003-A003	0.90	953048	Stephens			UKN					
12/30/2011	SDYC	A004-A004	0.90	926183	Sea Ray	22	9' 6""	Lcu-ukn	Other		SD Boat Yard	Aug-07	28
12/30/2011	SDYC	A005-A005	0.90	603396	Pacific	48	15.9	Lcu-ukn	Other		Shelter Island Bo	Mar-10	10
12/30/2011	SDYC	A006-A006	0.90	CF 7543 EG	Finistere	38	11	Cu	Proline 1088 - 6		Driscoll	Dec-06	67.6
12/30/2011	SDYC	A007-A007	0.90	CF 5370 HS	Yawl	49	11.5	Cu	Interlux Ultra		Other	Jun-04	66.5
12/30/2011	SDYC	A008-A008	0.90	910795	Sportfisher	41' 9"	13	Cu	Interlux Ultra		Shelter Island Bo	Jul-10	66.5
12/30/2011	SDYC	A009-A009	0.90	1119938	Bavaria			UKN					
12/30/2011	SDYC	A010-A010	0.90	674801	Uniflite			UKN					
12/30/2011	SDYC	A011-A011	0.90	913622	Sportfisher	40.6	14	Cu	Proline 1088 - 6		Shelter Island Bo	Apr-11	67.6
12/30/2011	SDYC	A012-A012	0.90	1175145	Grady Whit	41	12	LCu	Interlux Aqua		Driscoll	Aug-10	35
12/30/2011	SDYC	A013-A013	0.80	284244	Catamaran	46	18.5	Cu	Trinidad -6			Dec-10	65
12/30/2011	SDYC	A014-A014	1.00					UKN					
12/30/2011	SDYC	A015-A015	1.00	1122975	Offshore	30	10	UKN	0				
12/30/2011	SDYC	A016-A016	0.90	914980	Tiara Cruis	48	15	Cu	Proline 1088 - 6		Knight Carver	Jul-11	67.6
12/30/2011	SDYC	A017-A017	0.90	2417		36	13	Cu	Trinidad - 6		Driscoll	Dec-10	65
12/30/2011	SDYC	A018-A018	0.90	1149203	Cruiser	43	13	Lcu-ukn	Other		Driscoll	Jun-10	19
12/30/2011	SDYC	A019-A019	0.90	1182944	Jeanneau	40	13.8	Cu	Bluewater		Driscoll		67
12/30/2011	SDYC	A020-A020	0.90	1102280	Maxim	42	13.5	Cu	Petit Z-Spar Protector		Driscoll	Jul-11	60
12/30/2011	SDYC	A021-A021	0.90	1045344	Pacific Sea	38	22	Non-unconf	Other		Driscoll	Apr-08	0
12/30/2011	SDYC	A022-A022	0.90		Sea Ray	32'10"	9'10"	Cu	Proline 1088 - 6		Shelter Island Bo	Feb-08	67.6
12/30/2011	SDYC	A023-A023	0.90	CF 8613 SZ	Beneteau	32.8	7.5	Cu	Other		Driscoll	Jul-10	58
12/30/2011	SDYC	A024-A024	0.90	CF 6724 KS	Cheetah	34	11.4	Lcu-ukn	Other		Driscoll	Feb-11	35
12/30/2011	SDYC	A025-A025	0.90	CF 1640 UH	Kettenberg	29	8.5	UKN					
12/30/2011	SDYC	A026-A026	0.90	1207403	Flying Tige	32	6.5	Cu	Proline 1088 - 6		Driscoll	Nov-08	67.6
12/30/2011	SDYC	A027-A027	0.90	997365	Hunter	32.8	9	Cu	Interlux Ultra		Koehler	Jan-10	66.5
12/30/2011	SDYC	A028-A028	0.90	CF 0904 RS	Bayliner			UKN					
12/30/2011	SDYC	A029-A029	0.90	1135341	Grand Ban	30	10	Cu	Interlux Ultra				66.5
12/30/2011	SDYC	A030-A030	0.90	CF 1490 SZ	Choate	36	12	Cu	Proline 1088 - 6		Shelter Island Bo	Oct-10	67.6
12/30/2011	SDYC	A031-A031	0.90	CF 7880 HV	Dencho	33	11'4"	Cu	Trinidad SR - 6			Jul-07	70.8
12/30/2011	SDYC	A032-A032	0.90	1199088	Flying Tiger			UKN					
12/30/2011	SDYC	A033-A033	0.90	CF 9932 HF	Catalina			UKN					
12/30/2011	SDYC	A034-A034	0.90	CF 2457 KG	Adhara	29' 11"	10' 10"	Cu	Bluewater		Driscoll	Jul-08	45
12/30/2011	SDYC	A035-A035	0.90	593155	Grand Banks			UKN					
12/30/2011	SDYC	A036-A036	0.90	CF 4136 FJ	Cal 29	32	11	Cu	Interlux Ultra		Shelter Island Bo	Jul-10	66.5
12/30/2011	SDYC	A037-A037	0.90	1209798	Protector	29	8.5	Cu	Interlux Ultra		Driscoll	Apr-09	66.5
12/30/2011	SDYC	A038-A038	0.85	CF 0354 UP	Pearson			UKN					

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
12/30/2011	SDYC	A039-A039	0.90	CF 7193 AX	PC			UKN					
12/30/2011	SDYC	A040-A040	0.90	CF 8845 FN	Ericson	33	8	Cu	Interlux Ultra		Knight Carver	2009	66.5
12/30/2011	SDYC	A041-A041	0.90	CF 4746 FP	Columbiay	32	12	Cu	Interlux Ultra		Driscoll	Nov-04	66.5
12/30/2011	SDYC	A042-A042	0.90	CF 8692 JS	Hunter	34	10.6	Cu	Proline 1088 - 6		Koehler	Jul-02	67.6
12/30/2011	SDYC	A043-A043	0.90	CF 3225 HD		30	11	Cu	Interlux Ultra		Shelter Island Bo	Dec-10	66.5
12/30/2011	SDYC	A044-A044	0.90	CF 1717 GJ	Cal Pearson			UKN					
12/30/2011	SDYC	A045-A045	0.90	CF 6793 UE	Kirby			UKN					
12/30/2011	SDYC	A046-A046	0.90	CF9832 UR	PC	30	10.3	Cu	Interlux Ultra		Knight Carver	Mar-10	66.5
12/30/2011	SDYC	A047-A047	0.90	1172104	J100			UKN					
12/30/2011	SDYC	A048-A048	0.90	1193792	Albin	33	9.3	Cu	Proline 1088 - 6		Shelter Island Bo	Jun-11	67.6
12/30/2011	SDYC	A049-A049	0.90	CF 9651 HB	Catalina	32	10	Cu	Petit Z-Spar Protector		Shelter Island Bo	Mar-10	60
12/30/2011	SDYC	A050-A050	0.90	CF 3276 UC	Bayliner			UKN					
12/30/2011	SDYC	A051-A051	0.90	CF 2541 PV		34	10.9	UKN			Koehler	May-11	
12/30/2011	SDYC	A052-A052	0.90					UKN					
12/30/2011	SDYC	A053-A053	0.90	N/A Herreshoff	Edey & Du	28	9.5	UKN	0				Percent
12/30/2011	SDYC	A054-A054	0.90	111422	Mediterranean			UKN					
12/30/2011	SDYC	B001-B001	0.90	1089942	Ventura	38	11.5	Non-unconf	Other		Marine Group Sc	Oct-10	0
12/30/2011	SDYC	B002-B002	0.90	567975	Noel Stroll	37	13	Cu	Interlux Ultra		Koehler	Jan-10	66.5
12/30/2011	SDYC	B003-B003	0.90	1160369	Pearson	34'8"	13.5	Cu	Interlux Ultra		Koehler	Jul-09	66.5
12/30/2011	SDYC	B004-B004	0.90	515206	Grand Ban	41.5	13	UKN			Shelter Island Bo	Mar-10	
12/30/2011	SDYC	B005-B005	0.90	CF 6507 KS	Grand Ban	45	13	Cu	Proline 1088 - 6		Shelter Island Bo	Sep-11	67.6
12/30/2011	SDYC	B006-B006	0.90	116297	J105			UKN					
12/30/2011	SDYC	B007-B007	0.90	650827	Bertram	4		UKN	0				
12/30/2011	SDYC	B008-B008	0.90	CF 7375 BA	Atkins Ingri	38	13	Cu	Interlux Ultra		Koehler	Apr-10	66.5
12/30/2011	SDYC	B009-B009	0.90	637740	Valient	37.5	12.5	UKN			Koehler	Mar-09	
12/30/2011	SDYC	B010-B010	0.90	1177943	Catalina	39.8	12.3	LCu	Calif Bottomkote - 7		Driscoll	Jan-11	35
12/30/2011	SDYC	B011-B011	0.90	ETY39104J586	Fairweather			UKN					
12/30/2011	SDYC	B012-B012	0.90	1156273	Beneteau	39	11	Non	Pacifica - 5		Koehler	Feb-10	0
12/30/2011	SDYC	B013-B013	0.90	1226874	Bayliner	37	12.3	Cu	Sharkskin - 7		Driscoll	May-08	45
12/30/2011	SDYC	B014-B014	0.90	CF 4509 DA	Sciomache	38	14	Cu	Bluewater		Shelter Island Bo	Aug-09	67
12/30/2011	SDYC	B015-B015	0.90	903868	Trollycraft	38	13	Cu	Interlux Ultra		Driscoll	Apr-05	66.5
12/30/2011	SDYC	B016-B016	0.90	CF 7203 CY	Kettenburg	44'8"	14'10"	Non-unconf	Other		Shelter Island Bo	Apr-08	0
12/30/2011	SDYC	B017-B017	0.90	987656	Kettenburg			UKN					
12/30/2011	SDYC	B018-B018	0.90	CF 1910 HX	C & C	41	10	Cu	Other		Driscoll	Mar-08	67
12/30/2011	SDYC	B019-B019	0.90	1130562	Riviera			UKN					
12/30/2011	SDYC	B020-B020	0.90	1138799	Palm Beac	41.1	14.1	UKN	Other		Shelter Island Bo	Jan-09	Percent
12/30/2011	SDYC	B021-B021	0.90	1094888	Riviera			UKN					
12/30/2011	SDYC	B022-B022	0.90	1042468	J120	39	14.5	Non-unconf	Other		Shelter Island Bo	Oct-09	0
12/30/2011	SDYC	B023-B023	0.90	940055	Grand Ban	40	12	Cu	Petit Z-Spar Protector		Knight Carver	May-10	60
12/30/2011	SDYC	B024-B024	0.90	1151374	J Boat	42	13'7"	UKN	Other		Driscoll	Jun-09	
12/30/2011	SDYC	B025-B025	0.90	1186644	J-105			UKN					
12/30/2011	SDYC	B026-B026	0.90	1223545	Meridian			UKN					
12/30/2011	SDYC	B027-B027	0.90	608952	Hatteras	36	12.5	Cu	Petit Z-Spar Protector		Driscoll	Jul-11	60
12/30/2011	SDYC	B028-B028	0.90	1215900	Custom	60	18	Cu	Interlux Ultra		SD Boat Yard	Jun-10	66.5

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12/30/2011	SDYC	B029-B029	0.90	677732	Knight & Carver			UKN					
12/30/2011	SDYC	B030-B030	0.75	1172754	West Bay	75	20	Cu	Interlux Ultra		Knight Carver	Jul-10	66.5
12/30/2011	SDYC	B031-B031	0.75	1170745	West Bay			UKN					
12/30/2011	SDYC	B032-B032	0.90	971544	Riva Motor	42	14	Cu	Proline 1088 - 6		Koehler	May-06	67.6
12/30/2011	SDYC	B033-B033	0.90	1138909	Riviera	65	18	Cu	Interlux Ultra		Knight Carver	Jul-10	66.5
12/30/2011	SDYC	B034-B034	0.80	1196741	Catalina	80	20	LCu	Micron Extra - 2		Driscoll	Apr-10	39
12/30/2011	SDYC	B035-B035	0.80	1120655				UKN					
12/30/2011	SDYC	B036-B036	0.90	1116040	Beneteau	70	20	Cu	Petit Z-Spar Protector		Driscoll	May-10	60
12/30/2011	SDYC	B037-B037	0.90	1130812	Beneteau			UKN					
12/30/2011	SDYC	B038-B038	0.80	1152049	Beneteau	47	16'	Cu	Trinidad Pro - 7		Driscoll	Oct-10	70.8
12/30/2011	SDYC	B039-B039	0.90	964346	Catalina			UKN					
12/30/2011	SDYC	B040-B040	0.90	1051154	Beneteau			UKN					
12/30/2011	SDYC	B041-B041	0.90	953896	Ocean Alexander			UKN					
12/30/2011	SDYC	B042-B042	0.90	935918	Kanter	41	13	Cu	Petit Z-Spar Protector		Shelter Island Bo	Jul-11	60
12/30/2011	SDYC	B043-B043	0.90	668762	Contest			UKN					
12/30/2011	SDYC	B045-B045	0.90	983952	Californian	45	13.9	Cu	Interlux Ultra		Shelter Island Bo	Apr-09	66.5
12/30/2011	SDYC	B046-B046	0.90	547865	Columbia			UKN					
12/30/2011	SDYC	B047-B047	0.90	1122614	Beneteau	46	13'9"	Cu	Proline 1088 - 6		Marine Group Sc	Mar-09	67.6
12/30/2011	SDYC	B048-B048	0.90	640289	Kelly Peterson			UKN					
12/30/2011	SDYC	B049-B049	0.85	1053510	Catalina			UKN					
12/30/2011	SDYC	B050-B050	0.90	1064524	Bayliner			UKN					
12/30/2011	SDYC	B051-B051	0.90	502873	Cal 48	47.7	14.9	Cu	Interlux Ultra		Shelter Island Bo	Apr-10	66.5
12/30/2011	SDYC	B052-B052	0.90	CF 5798 KD	Gulfstar	43	13	Non-unconf	Other		Shelter Island Bo	Aug-09	0
12/30/2011	SDYC	B053-B053	0.90	902700	Brewer	41'10"	13'10"	Cu	Interlux Ultra		Shelter Island Bo	Apr-11	66.5
12/30/2011	SDYC	B054-B054	0.90	986604	Hershine	47	15	LCu	Calif Bottomkote - 7		Driscoll	May-09	35
12/30/2011	SDYC	B055-B055	0.90	1121977	Tiara	48	12	Cu	Sharkskin - 7		Driscoll	Sep-06	45
12/30/2011	SDYC	B056-B056	0.90	CF 0660 SS	Ranger			UKN					
12/30/2011	SDYC	B057-B057	0.90	982412	Tollycraft	48	13	Lcu-ukn	Other		Shelter Island Bo	Apr-06	4
12/30/2011	SDYC	B058-B058	0.90			48	16	NON	Pacifica - 5		Shelter Island Bo	Dec-10	0
12/30/2011	SDYC	B059-B059	0.90			31	11	Lcu-ukn	Other		Driscoll	Feb-07	37
12/30/2011	SDYC	B060-B060	0.90			25	8	Cu	Seaguard - 2		Driscoll	Sep-09	60
12/30/2011	SDYC	B061-B061	0.90			48	15	LCu	Calif Bottomkote - 7		The Boat Yard	Oct-08	35
12/30/2011	SDYC	C001-C001	1.00					UKN					
12/30/2011	SDYC	C002-C002	1.00	CF 6407 PR	Catalina			UKN					
12/30/2011	SDYC	C003-C003	1.00	CF 8687 RM	Sun Track			UKN					
12/30/2011	SDYC	C004-C004	0.99	CF 4988 PE	Capri			UKN					
12/30/2011	SDYC	C005-C005	0.99	CF 0096 HJ	Catalina	23	8	Cu	Sharkskin - 7		Shelter Island Bo	Mar-08	45
12/30/2011	SDYC	C006-C006	0.90			25	8'6"	UKN			SD Boat Yard	2009	
12/30/2011	SDYC	C007-C007	0.90	CF 4533 NB	Runabout	29	8'6"	UKN					
12/30/2011	SDYC	C008-C008	0.90			22	6	Cu	Interlux K91		Driscoll	Mar-07	70
12/30/2011	SDYC	C009-C009	0.90	CF 4523 RC	Catalina	26.83	8.83	NON	Pacifica - 5		Shelter Island Bo	Jan-10	0
12/30/2011	SDYC	C010-C010	0.90	CF 2046 JW	Grady White			UKN					
12/30/2011	SDYC	C011-C011	0.90	CF 7767 EL	Cal 29	16	7.5	Cu	Interlux Ultra		Driscoll	Aug-09	66.5
12/30/2011	SDYC	C012-C012	0.99	940780	D.B. Marine			UKN					

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12/30/2011	SDYC	C013-C013	0.90	CF 0423 TY	Corsair	29	10	Cu	Proline 1088 - 6		Shelter Island Bo	Feb-06	67.6
12/30/2011	SDYC	C014-C014	0.90	CF 8365 ER	Catalina			UKN					
12/30/2011	SDYC	C015-C015	0.90	CF 3522SC	Boston Wh	29	9	Cu	Proline 1088 - 6		Driscoll	Dec-10	67.6
12/30/2011	SDYC	C016-C016	0.90	CF 5901 TZ	Cobia	30	6.11	Cu	Interlux Ultra		Koehler	Aug-11	66.5
12/30/2011	SDYC	C017-C017	0.90	CF 2577 SV	Century			UKN					
12/30/2011	SDYC	C018-C018	0.90	CF 7884 SR	Rayglass	27	9	Cu	Proline 1088 - 6		Shelter Island Bo	Jul-07	67.6
12/30/2011	SDYC	C019-C019	0.90	CF 0471 TP	Carolina Skiff			UKN					
12/30/2011	SDYC	C020-C020	0.90		Cobia	23	8	Cu	Proline 1088-6		Shelter Island Bo	Dec-11	67.6
12/30/2011	SDYC	C021-C021	0.90	CF 5478 DA		21	8	Cu	Petit Z-Spar Protector		Applicator	Aug-09	60
12/30/2011	SDYC	C022-C022	0.90	CF 0912 SN	Parker			UKN					
12/30/2011	SDYC	C023-C023	0.90	DL04176Z	Pathfinder	17		LCu	Trilux33 - 3		SD Boat Yard	Jan-10	24
12/30/2011	SDYC	C024-C024	0.90	CF 6886 KW	Luders	18	8	Cu	Interlux Ultra		Shelter Island Bo	Jul-11	66.5
12/30/2011	SDYC	C025-C025	0.90	CF 3889 RA	Duffy	21	8	Cu	Proline 1088 - 6			Apr-09	67.6
12/30/2011	SDYC	C026-C026	0.90	1223438	Boston Wh	23	8	Cu	Interlux Ultra		Shelter Island Bo	Feb-10	66.5
12/30/2011	SDYC	C027-C027	0.90	CF 4748 JW	Sea swirl	26	6	Cu	Interlux Ultra		Koehler	Oct-07	66.5
12/30/2011	SDYC	C028-C028	0.90	CF 2035 GC		30	8.5	UKN	0		Shelter Island Bo	Jun-11	
12/30/2011	SDYC	C029-C029	0.90	CF 4133 FJ	Cal 29	22	8	LCu	Trilux / Biolux - 3		Driscoll	Mar-09	24
12/30/2011	SDYC	C030-C030	0.90	CF 2431 RI	Everglade	21	8	Cu	Interlux Ultra		Driscoll Mission I	May-10	66.5
12/30/2011	SDYC	C031-C031	0.90	CF 1474 UH	Contender	27	8	Cu	Trinidad Pro - 7		SD Boat Yard	May-08	70.8
12/30/2011	SDYC	C032-C032	0.90	CF 0582EZ	Catalina	29.3	9.3	Cu	Interlux Ultra		Driscoll	Dec-07	66.5
12/30/2011	SDYC	C033	0.90	CF 7373 NB	Grady Whit	27	8	LCu	Trilux33 - 3		Driscoll	Jun-10	24
12/30/2011	SDYC	C034-C034	0.90	1211945	Riviera	23	7.5	Cu	Interlux Ultra		Applicator	Nov-09	66.5
12/30/2011	SDYC	C035-C035	0.90	CF7700TG	Compass			UKN					
12/30/2011	SDYC	C036-C036	0.90	902828	Tillotson	22	8	Cu	ABC 3 - 2		Shelter Island Bo	Oct-06	45
12/30/2011	SDYC	C037-C037	0.90	1080461	Santa Cruz	27	9	Cu	Proline 1088 - 6		Shelter Island Bo	Jan-09	67.6
12/30/2011	SDYC	C038-C038	0.90	1080127	Tiara			UKN					
12/30/2011	SDYC	C039-C039	0.90	665405	Driscoll Au	65	18.4	Cu	Proline 1088 - 6		Knight Carver	Jun-07	67.6
12/30/2011	SDYC	C040-C040	0.90	1224149	Legacy 32			UKN					
12/30/2011	SDYC	C041-C041	0.90	CF 4008 SA	Calatina	53	14	Cu	Proline 1088 - 6		Shelter Island Bo	Jun-09	67.6
12/30/2011	SDYC	C042-C042	0.90	CF 0719 SN	Hernandez			UKN					
12/30/2011	SDYC	C043-C043	0.90	1210588	Flying Tige	47	10'6"	LCu	Micron Extra - 2		Driscoll	Jun-10	39
12/30/2011	SDYC	C044-C044	0.90	1038317	BHM Cruiser			UKN					
12/30/2011	SDYC	C045-C045	0.90	1158940	Meridian	36	8	UKN			Outside San Dieg	2010	
12/30/2011	SDYC	C046-C046	0.90	1212759	Legacy	38	11.5	Non-unconf	Other		Shelter Island Bo	Apr-08	0
12/30/2011	SDYC	C047-C047	0.90	1091221	Beneteau	33	10	LCu	Petit Vivid - 3		Driscoll	Jul-11	25
12/30/2011	SDYC	C048-C048	0.90	594605	Pacemaker	37	12	Cu	Proline 1088 - 6		Driscoll	2009	67.6
12/30/2011	SDYC	C049-C049	0.90	CF 5577 ER	Grand Ban	35	11.8	Cu	Proline 1088 - 6		Driscoll	Jan-07	67.6
12/30/2011	SDYC	C050-C050	0.90	960281	Catalina	32	12.4	Non-unconf	0		Shelter Island Bo	Jun-08	0
12/30/2011	SDYC	C051-C051	0.90	1173921	Beneteau	39	11	Cu	Micron66 - 2		Driscoll Mission I	Apr-08	45
12/30/2011	SDYC	C052-C052	0.90	677815	Blackfish	40	13.9	Cu	Proline 1088 - 6		Shelter Island Bo	Jun-10	67.6
12/30/2011	SDYC	C053-C053	0.90	622012	Morgan	32	11'6"	Cu	Jotun - 3		Driscoll	Sep-09	45
12/30/2011	SDYC	C054-C054	0.90	1032868	Cassian-Cu	36	11.5	Cu	Sharkskin - 7		Driscoll	Jun-10	45
12/30/2011	SDYC	C055-C055	0.90	CF 7573 ET	Sport Fisher			UKN					
12/30/2011	SDYC	C056-C056	0.90	1175672	Catalina			UKN					

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12/30/2011	SDYC	C057-C057	0.90	CF 0382 FN	Irwin Competition			UKN					
12/30/2011	SDYC	C058-C058	0.90	572590	Jenson			UKN					
12/30/2011	SDYC	C059-C059	0.95	CF 2405 FL	Grand Banks			UKN					
12/30/2011	SDYC	C060-C060	0.90	1136296	Grand Banks			UKN					
12/30/2011	SDYC	C061-C061	0.90	1175979	Beneteau	37	12	Cu	Interlux Ultra		Driscoll	Sep-09	66.5
12/30/2011	SDYC	C062-C062	0.90	508761	Custom			UKN					
12/30/2011	SDYC	C063-C063	0.90	572923	Kettenburg	32	7	UKN					
12/30/2011	SDYC	C064-C064	0.90	916411	Back cove	36'10"	12'8"	Cu	Interlux Ultra		Shelter Island Bo	Nov-09	66.5
12/30/2011	SDYC	C065-C065	0.90	1207993	C & C	40	13	Lcu-ukn	0		Driscoll	May-09	37
12/30/2011	SDYC	C066-C066	0.90	977064				UKN					
12/30/2011	SDYC	C067-C067	0.90			64	18	LCu	Micron Extra - 2		Shelter Island Bo	2008	39
12/30/2011	SDYC	C068-C068	0.90	922076	Golden Sta	37	10.3	Cu	Proline 1088 - 6		Shelter Island Bo	Mar-10	67.6
12/30/2011	SDYC	C069-C069	0.90	1232197	Contender	39.3	12.5	Cu	Ultrakote - 6		Shelter Island Bo	Oct-09	76
12/30/2011	SDYC	C070-C070	0.99	1041414	Offshore			UKN					
12/30/2011	SDYC	C071-C071	0.99	283405	Calkins			UKN					
12/30/2011	SDYC	D001-D001	0.90	516065	Columbia	42	15	UKN			Driscoll	Jun-10	
12/30/2011	SDYC	D002-D002	0.90	940780	D.B. Marin	47.7	14	Cu	Interlux K91		Driscoll	Apr-07	70
12/30/2011	SDYC	D003-D003	0.90	618971	Grand Ban	52	15.5	Cu	Interlux Ultra		SD Boat Yard	May-10	66.5
12/30/2011	SDYC	D004-D004	0.90	1075048	Offshore			UKN					
12/30/2011	SDYC	D005-D005	0.90	1229535	Mikelson	50	12	Cu	Interlux Ultra		Koehler	May-08	66.5
12/30/2011	SDYC	D006-D006	0.90	976270	Catalina	42	13.6	Cu	Interlux Ultra		Koehler	Aug-11	66.5
12/30/2011	SDYC	D007-D007	0.90	1141997	Beneteau	42	13'7"	Cu	Proline 1088 - 6		Driscoll	Apr-11	67.6
12/30/2011	SDYC	D008-D008	0.90	1121548	Jeanneau	48	15	Cu	Interlux Ultra		Shelter Island Bo	Jul-10	66.5
12/30/2011	SDYC	D009-D009	0.90	1063619	J120	50	16	Cu	Proline 1088 - 6		Shelter Island Bo	Jun-10	67.6
12/30/2011	SDYC	D010-D010	0.90	1077077	J120	34	11'2"	LCu	SeaHawk AF33		Driscoll	Nov-10	33
12/30/2011	SDYC	D011-D011	0.90	1187620	Chris Craft	36	12	LCu	Calif Bottomkote - 7		Driscoll	Jan-09	35
12/30/2011	SDYC	D012-D012	0.90	CF 6071 FE	CHB	46.5	14'8"	Cu	Interlux Ultra		Shelter Island Bo	May-11	66.5
12/30/2011	SDYC	D013-D013	0.90	1177732	Meridian	40	12	Cu	Proline 1088 - 6		Shelter Island Bo	Jan-09	67.6
12/30/2011	SDYC	D014-D014	0.90	941332	Albin	40	12	Cu	Proline 1088 - 6		Shelter Island Bo	Feb-11	67.6
12/30/2011	SDYC	D015-D015	0.90	1183445	Meridian			UKN					
12/30/2011	SDYC	D016-D016	0.90	674165	Silverton			UKN					
12/30/2011	SDYC	D017-D017	0.90	1073732	J120			UKN					
12/30/2011	SDYC	D018-D018	0.90	1210278	Beneteau	49	15	Cu	Proline 1088 - 6		Shelter Island Bo	Jun-07	67.6
12/30/2011	SDYC	D019-D019	0.90	1111236	McConagh	47.7	14.4	Cu	Interlux Ultra		Driscoll Mission	Jun-06	66.5
12/30/2011	SDYC	D020-D020	0.90	967973	Grand Ban	41	15	Cu	Trinidad VOC - 6		Driscoll	Jun-09	65
12/30/2011	SDYC	D021-D021	0.90	1103307	Cabo			UKN					
12/30/2011	SDYC	D022-D022	0.90	1099273	Beneteau	49	14.6	Cu	Interlux Ultra		Shelter Island Bo	May-11	66.5
12/30/2011	SDYC	D023-D023	0.90	1152753	Farr 60 Slo	50.2	14.2	NON	Petit Vivid - 3		Shelter Island Bo	Aug-09	0
12/30/2011	SDYC	D024-D024	0.90	694784	Tanton	36	11	Cu	Interlux Ultra			Feb-10	66.5
12/30/2011	SDYC	D-025.5-D-025.5	0.90	1021137	West Bay S	41	14	Cu	Interlux Ultra		Driscoll Mission	Mar-09	66.5
12/30/2011	SDYC	D025-D025	0.90	925986	Ocean Alexander			UKN					
12/30/2011	SDYC	D026-D026	0.90	1173735	Long Rang	60	16.2	NON	Petit Vivid - 3		Driscoll Mission	Sep-09	0
12/30/2011	SDYC	D027-D027	0.90	1106520	DeFever	73	15	LCu	SeaHawk AF33		SD Boat Yard	Sep-10	33

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
12/30/2011	SDYC	D028-D028	0.90	277754		30	10'8"	UKN	0		Koehler	Apr-10	Percent
12/30/2011	SDYC	D029-D029	0.90	943587	Hatteras	70	17	Cu	Proline 1088 - 6		Nielsen Beaumo	Jan-06	67.6
12/30/2011	SDYC	D030-D030	0.90	530174	Caulkins			UKN					
12/30/2011	SDYC	D031-D031	0.95	349040	Alden			UKN					
12/30/2011	SDYC	D032-D032	0.90	980106	Ocean Ale	52	14.3	Cu	Interlux Ultra		Koehler	May-10	66.5
12/30/2011	SDYC	D033-D033	0.90	501548	Kettenburg	48	16	Cu	Super KL - 6		Shelter Island Bo	Aug-08	70
12/30/2011	SDYC	D034-D034	0.90	1235856	Beneteau	50	12	Cu	Interlux Ultra		Koehler	Sep-10	66.5
12/30/2011	SDYC	D035-D035	0.90	CF 8723 KN	A & R Yawl			UKN					
12/30/2011	SDYC	D036-D036	0.90	CF 9509 OS	Transpac 4	40	14	NON	E-Paint - 10		Marine Group Sc	May-09	0
12/30/2011	SDYC	D037-D037	0.90	1042489	Baltic	43	11	Cu	Interlux Ultra		Koehler	May-10	66.5
12/30/2011	SDYC	D038-D038	0.90	1031227	Kettenburg	40	12'5"	Cu	Interlux Ultra		Shelter Island Bo	Jul-11	66.5
12/30/2011	SDYC	D039-D039	0.90	CF 7138 AX	Kettenburg	50	9	Cu	Interlux Ultra		Koehler	Jun-08	66.5
12/30/2011	SDYC	D040-D040	0.90	998164	Swan			UKN					
12/30/2011	SDYC	D041-D041	0.90	1197808	Beneteau	43	13.8	Cu	Interlux Ultra		Shelter Island Bo	Jan-11	66.5
12/30/2011	SDYC	D042-D042	0.90	1139412	Beneteau			UKN					
12/30/2011	SDYC	D043-D043	0.90	930479	Kong and Halvorsen			UKN					
12/30/2011	SDYC	D044-D044	0.90	1025915	Offshore			UKN					
12/30/2011	SDYC	D045-D045	0.90	225805	Custom - E	17	6.5	UKN	0		Shelter Island Bo	Apr-07	
12/30/2011	SDYC	D046-D046	0.90	1202534	Norseman	41	13	NON	E-Paint - 10		Driscoll	May-09	0
12/30/2011	SDYC	D047-D047	0.90	902345	Grand Ban	44	14.5	UKN	0		Applicator	Mon-09	Percent
12/30/2011	SDYC	D048-D048	0.90	1176898	Bruckmann	48' 6"	11' 7"	Cu	Proline 1088 - 6		Driscoll	May-10	67.6
12/30/2011	SDYC	D049-D049	0.90	1037354	Kettenburg	48' 6"	15' 6"	Cu	Sharkskin - 7		Other	Jun-08	45
12/30/2011	SDYC	D050-D050	0.90			48	14	Cu	Interlux Ultra		Driscoll	Nov-10	66.5
12/30/2011	SDYC	D051-D051	0.90	1137915	Tiara	42	13.67	UKN			Shelter Island Bo	Jun-10	
12/30/2011	SDYC	D052-D052	0.90	651247	Contess	42	11	Non-unconf	Other		Driscoll	Oct-10	0
12/30/2011	SDYC	D053-D053	0.90	1202546	Hunter	46	9	Cu	0		Knight Carver	Dec-09	67
12/30/2011	SDYC	E002-E002	0.90	1038590	Jeanneau	40	13.6	Cu	Interlux Ultra		Driscoll	Jun-10	66.5
12/30/2011	SDYC	E003-E003	0.90	913766	Harbor 20	39	12	LCu	Calif Bottomkote - 7		Driscoll	Sep-10	35
12/30/2011	SDYC	E004-E004	0.90	520081	Sparkman	44' 7"	14' 3"	Cu	Ultrakote - 6		Shelter Island Bo	Dec-10	76
12/30/2011	SDYC	E005-E005	0.90	975152	Skye	49	16	Cu	Micron66 - 2		Driscoll Mission	Sep-10	45
12/30/2011	SDYC	E006-E006	0.90	991919	Ericson	36	13	Cu	Interlux Ultra		Shelter Island Bo	Apr-08	66.5
12/30/2011	SDYC	E007-E007	0.90	1111185	Beneteau	51	12.5	Cu	Trinidad - 6		Koehler	Nov-08	65
12/30/2011	SDYC	E008-E008	0.90	1194140	Jeanneau	50.7	14	Cu	Proline 1088 - 6		Shelter Island Bo	Apr-09	67.6
12/30/2011	SDYC	E009-E009	0.90	944329	Nova	35	12	Cu	Petit Z-Spar Protector		Driscoll	Feb-11	60
12/30/2011	SDYC	E010-E010	0.90	631060	Peterson	47	13	NON	Mission Bay - 5		Shelter Island Bo	Mar-11	0
12/30/2011	SDYC	E011-E011	0.90	505229	Cal 48	42'5"	13'6"	Cu	Interlux Ultra		Shelter Island Bo	Jun-06	66.5
12/30/2011	SDYC	E012-E012	0.90	692078	Kelly Peterson			UKN					
12/30/2011	SDYC	E013-E013	0.90	1104563	Pearson	44	13	Cu	Sharkskin - 7		Driscoll	Apr-08	45
12/30/2011	SDYC	E014-E014	0.90	CF 2107 HT	Frers 40	48	12	UKN			Shelter Island Bo	2011	
12/30/2011	SDYC	E015-E015	0.90	923129	Kettenburg			UKN					
12/30/2011	SDYC	E016-E016	0.90	907919	Tayana	43	13.5	Cu	0		Driscoll	Oct-09	76
12/30/2011	SDYC	E017-E017	0.90	680268	Catalina	30	10	LCu	Calif Bottomkote - 7		Driscoll	-09	35
12/30/2011	SDYC	E018-E018	0.90	1158054	Mariner	41	10.33	Cu	Ultrakote - 6		Koehler	Feb-07	76
12/30/2011	SDYC	E019-E019	0.90	1078104	J125	42	12.6	Cu	Petit Z-Spar Protector		Driscoll	Jan-11	60

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
12/30/2011	SDYC	E020-E020	0.90	964346	Catalina	38	11	Cu	Proline 1088 - 6		Shelter Island Bo	Jul-08	67.6
12/30/2011	SDYC	E021-E021	0.90	1055757	Kurt Hughs			UKN					
12/30/2011	SDYC	E022-E022	0.90	973228	Denison	41	10.5	LCu	Petit Vivid - 3		SD Boat Yard	Mar-10	25
12/30/2011	SDYC	E023-E023	0.90	525755	Hatteras	42	13'10"	Cu	Proline 1088 - 6		Shelter Island Bo	Jun-10	67.6
12/30/2011	SDYC	E024-E024	0.90	1048549	Hylas			UKN					
12/30/2011	SDYC	E025-E025	0.90	548346	Custom			UKN					
12/30/2011	SDYC	E026-E026	0.90	1168598	East Bay	119	26	Cu	Interlux Ultra		Marine Group Sc	Apr-11	66.5
12/30/2011	SDYC	E027-E027	0.90	10116	Swan Aux	74	23	Cu	Proline 1088 - 6			Jul-10	67.6
12/30/2011	SDYC	E028-E028	0.90	1208125	Hatteras			UKN					
12/30/2011	SDYC	E029-E029	0.80	1123737	J160	79	15.3	Cu	Proline 1088 - 6		Nielsen Beaumo	Sep-08	67.6
12/30/2011	SDYC	E030-E030	0.90	692846	DeFever			UKN					
12/30/2011	SDYC	E031-E031	0.80	1051733	Californian	71	18	Lcu-ukn	Other		Nielsen Beaumo	Jul-08	1
12/30/2011	SDYC	E032-E032	0.80	CF 5940 AV	Stephen Bros			UKN					
12/30/2011	SDYC	E033-E033	0.90	936953	James Bett	52.8	14.5	UKN	0		Shelter Island Bo	Jul-10	
12/30/2011	SDYC	E034-E034	0.90	677539	Spindrift	64	18	Cu	Petit Z-Spar Protector		Driscoll	Apr-07	60
12/30/2011	SDYC	E035-E035	0.90	681915	Swan			UKN					
12/30/2011	SDYC	E036-E036	0.90	1146301	Catalina			UKN					
12/30/2011	SDYC	E037-E037	0.90	1086520	Formula	52	15	LCu	Trilux		Driscoll Mission I	May-10	24
12/30/2011	SDYC	E038-E038	0.80	1206973	Grady White			UKN					
12/30/2011	SDYC	E039-E039	0.90	CF 7106 GZ	Cheoy Lee	57.1	16	Cu	Proline 1088 - 6		Shelter Island Bo	Apr-10	67.6
12/30/2011	SDYC	E040-E040	0.90	971500	Catalina			UKN					
12/30/2011	SDYC	E041-E041	0.90	CF 1640 UH	Sea Ray	38	8.5	NON	Pacifica Plus		Marine Group Sc	Dec-10	0
12/30/2011	SDYC	E042-E042	0.90	1150948	J109	33'6"	11'6"	Non-unconf	Other		SD Boat Yard	Jan-11	0
12/30/2011	SDYC	E043-E043	0.90	929434	Cal 36	35	11'6	LCu	Trilux33 - 3		Driscoll	Nov-09	24
12/30/2011	SDYC	E044-E044	0.90	1070730	Hinckley	36	12	Cu	Interlux Ultra		Shelter Island Bo	Mar-09	66.5
12/30/2011	SDYC	E045-E045	0.90	1181832	Riva	33	11	Cu	Trinidad Pro - 7		Shelter Island Bo	Jul-10	70.8
12/30/2011	SDYC	E046-E046	0.90	1085029	Pursuit	36	10	Cu			SD Boat Yard	Mar-06	40
12/30/2011	SDYC	E047-E047	0.90	570436	Ranger			UKN					
12/30/2011	SDYC	E048-E048	0.90	1138277	J105	36	10	Cu	Interlux Ultra		Driscoll	Aug-10	66.5
12/30/2011	SDYC	E049-E049	0.90	1038950	J105			UKN					
12/30/2011	SDYC	E050-E050	0.90	CF 5653 JF	Catalina			UKN					
12/30/2011	SDYC	E051-E051	0.90	583277	Peterson	33'2"	9'7"	Cu	Proline 1088 - 6		Shelter Island Bo	Aug-08	67.6
12/30/2011	SDYC	E052-E052	0.90	1023306	J105	34.5	11	Cu	Proline 1088 - 6		Driscoll	Aug-11	67.6
12/30/2011	SDYC	E053-E053	0.90	CF 4855 GH	Catalina 27	34.5	11	Cu	Interlux Ultra		Shelter Island Bo	Dec-10	66.5
12/30/2011	SDYC	E054-E054	0.90	1184621	Tiara	34	11	Lcu-ukn	Other		Marine Group Sc	Jun-05	10
12/30/2011	SDYC	E055-E055	0.90	1194549	J109			UKN					
12/30/2011	SDYC	E056-E056	0.90	1101127	Ericson	34.5	11	Non-unconf	Other		Driscoll	Feb-10	0
12/30/2011	SDYC	E057-E057	0.90	1182316	Sea Ray	26	7.4	Cu	Super KL - 6		Driscoll	May-10	70
12/30/2011	SDYC	E058-E058	0.90	CF 7622 PM	Boston Wh	35	12	Cu	Petit Z-Spar Protector		Driscoll	Oct-10	60
12/30/2011	SDYC	E059-E059	0.90	CF 2642 AU	PC			UKN					
12/30/2011	SDYC	E060-E060	0.90	CF 9934 AM	Hylas	35.5	11.3	Lcu-ukn	Other		SD Boat Yard	Jun-01	10
12/30/2011	SDYC	E061-E061	0.90			33	10.4	Cu	Other		SD Boat Yard	Jan-07	100
12/30/2011	SDYC	E062-E062	0.90	CF 0111 BB	Kettenburg	21	8'4""	Cu	Proline 1088 - 6		SD Boat Yard	Sep-10	67.6
12/30/2011	SDYC	E063-E063	0.90	CF 8517 AY	Kettenburg	31' 10"	6'8"	LCu	Trilux33 - 3		Applicator	Sep-10	24

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12/30/2011	SDYC	E064-E064	0.90	CF 9653 SB	Kettenburg	36	6	Cu	Interlux Ultra		Koehler	Aug-09	66.5
12/30/2011	SDYC	E066-E066	0.90	CF 1530 AT	Kettenburg	PC		UKN					
12/30/2011	SDYC	E067-E067	0.90	1158054	Kettenburg	31	7	Cu	0			Jan-09	66
12/30/2011	SDYC	E068-E068	0.90	CF 0891 BA	Kettenburg	32	6'8"	Cu	Interlux Ultra		Koehler	Jul-07	66.5
12/30/2011	SDYC	E069-E069	0.90	CF 5088 SS	Kettenburg	31	6	Cu	Interlux Ultra			Jul-10	66.5
12/30/2011	SDYC	E070-E070	0.90	CF 5401 AV	Kettenburg	32	6' 8"	Non-unconf	Other		Koehler	Jun-08	0
12/30/2011	SDYC	E071-E071	0.90	CF 3864 BE	Kettenburg	32	6	LCu	Petit Vivid - 3		Driscoll	2008	25
12/30/2011	SDYC	E072-E072	0.90	CF 7930 AY	Kettenburg	32	7	Non-unconf	Other		The Boat Yard	May-03	0
12/30/2011	SDYC	E073-E073	0.90	CF 0577 BI	Kettenburg	PC		UKN					
12/30/2011	SDYC	E074-E074	0.90	CF 8213 AS	Kettenburg	30	6.7	Cu	Trinidad - 6		Driscoll	Dec-08	65
12/30/2011	SDYC	E075-E075	0.90		Kettenburg	32	6	Cu	Interlux Ultra			Mar-08	66.5
12/30/2011	SDYC	E076 1/2-E076 1/2	0.90	CF 8119 AH	Kettenburg	32	6	Cu	Bluewater		Driscoll	Sep-09	45
12/30/2011	SDYC	E076-E076	0.90	CF 0100 BB	Kettenburg	PC		UKN					
12/30/2011	SDYC	E077-E077	0.90	CF 4906 AN	Kettenburg	PC		UKN					
12/30/2011	SDYC	E078 1/2-E078 1/2	0.90	CF 8480 KT	Hunter	31'6"	8	UKN			SD Boat Yard		
12/30/2011	SDYC	E078-E078	0.90	906663	Californian			UKN					
12/30/2011	SDYC	E079-E079	0.90	CF 2095 GN	Catalina	40	11	Cu	Other		Shelter Island Bo	May-07	70
12/30/2011	SDYC	E080-E080	0.90	1062718	Sabre Yacht			UKN					
12/30/2011	SDYC	E081-E081	0.90	997111	Catalina	34	13	LCu	Interlux Aqua		Shelter Island Bo	Jun-08	35
12/30/2011	SDYC	E082-E082	0.90	CF 1711 UH	Alerion Exp	30	10	Cu	Proline 1088 - 6		Shelter Island Bo	Mar-07	67.6
12/30/2011	SDYC	E083-E083	0.90	CF 0131 AV	Kettenburg	36	12.5	UKN			Driscoll	Sep-10	
12/30/2011	SDYC	E084-E084	0.90	641097	DeFever	42	13	Cu	Interlux Ultra		Driscoll	Aug-10	66.5
12/30/2011	SDYC	E085-E085	0.90			33	9	Cu	Trinidad SR - 6		SD Boat Yard		70.8
12/30/2011	SDYC	E086-E086	0.90					UKN					
12/30/2011	SDYC	E087-E087	0.90					UKN					
12/30/2011	SDYC	E088-E088	1.00	687314				UKN					
12/30/2011	SDYC	E089-E089	1.00	1082735	Elite			UKN					
12/30/2011	SDYC	E090-E090	1.00	CF 5419 GF	Peterson			UKN					
12/30/2011	SDYC	E091-E091	0.90	1097724	J32			UKN					
12/30/2011	SDYC	E092-E092	0.90	CF 4207 EF	Chris Com	32	10.5	Cu	Petit Z-Spar Protector		Knight Carver	Feb-10	60
12/30/2011	SDYC	E093-E093	0.90	975012	Grand Ban	33	10.4	Non-unconf	Other		SD Boat Yard	Jan-05	0
12/30/2011	SDYC	E094-E094	0.90	CF 4674 HG	Hunter	32	11	Lcu-ukn	Other		Driscoll	Feb-11	35
12/30/2011	SDYC	E095-E095	0.90	1094890	Hunter			UKN					
12/30/2011	SDYC	E096-E096	0.90	CF 3564 GK	Santana	36	12	UKN	0		Nielsen Beaumo	2007	
12/30/2011	SDYC	E097-E097	0.90	CF 0432 TY	J105			UKN					
12/30/2011	SDYC	E098-E098	0.90	CF 1640 UH	Flying Tige	32	11	UKN					
12/30/2011	SDYC	E099-E099	0.90	1117782	J105	35	11	NON	Mission Bay - 5		Shelter Island Bo	Jun-08	0
12/30/2011	SDYC	E100-E100	0.90	1024526	Grand Banks			UKN					
12/30/2011	SDYC	E101-E101	0.90	CF 1421 OV	J34	33	8	LCu	Petit Vivid - 3		Driscoll	Mar-09	25
12/30/2011	SDYC	E102-E102	0.90	572739	Cheoy Lee			UKN					
12/30/2011	SDYC	E103-E103	0.90	1118066	Hunter	32	11.5	LCu	Micron Extra - 2		Koehler	Apr-09	39
12/30/2011	SDYC	E104-E104	0.90	1071757	J105	34	10.5	UKN	Other			Sep-11	
12/30/2011	SDYC	E105-E105	0.90	1132393	J105	35	8'10"	Cu	Proline 1088 - 6		Shelter Island Bo	Apr-10	67.6

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12/30/2011	SDYC	E106-E106	0.90	CF 8119 AH				UKN					
12/30/2011	SDYC	E107-E107	0.90	1106845	J105	34.5	11	Cu	Interlux Ultra		Driscoll	Jan-09	66.5
12/30/2011	SDYC	E108-E108	0.90		Harbor 20			UKN					
12/30/2011	SDYC	E-110.5-E-110.5	0.90	907522	Tolly Craft			UKN					
12/30/2011	SDYC	E110-E110	0.90	CF 2564 SY	Intrepid	35	11	UKN	Other		Driscoll	May-11	
12/30/2011	SDYC	F001-F001	0.90	CF 2364 GJ	Cal	30	10-12?	UKN	Other		Driscoll	May-05	Percent
12/30/2011	SDYC	F002-F002	0.90	518465S	Ranger 33			UKN					
12/30/2011	SDYC	F003-F003	0.90	653584	C&C			UKN					
12/30/2011	SDYC	F004-F004	0.90	CF 2993 GU	Aphrodite Sloop			UKN					
12/30/2011	SDYC	F005-F005	0.90					UKN					
12/30/2011	SDYC	F006-F006	0.90	1068227	Tiara			UKN					
12/30/2011	SDYC	F007-F007	0.90	CF 9485 EL	Cheoy Lee			UKN					
12/30/2011	SDYC	F008-F008	0.90	CF 7686 HR	Ranger	29	10	Cu	Proline 1088 - 6		Driscoll	Aug-06	67.6
12/30/2011	SDYC	F009-F009	0.90	1190986	Sea Ray	32	11	Non-unconf	0		SD Boat Yard	Jan-95	0
12/30/2011	SDYC	F010-F010	0.90	1211432	Pro Sport			UKN					
12/30/2011	SDYC	F011-F011	0.90	698533	Trawler	32	11	Cu	Proline 1088 - 6		Other	May-09	67.6
12/30/2011	SDYC	F012-F012	0.90	CF 6925 PW	Duffy Herre	29	9'6"	UKN					
12/30/2011	SDYC	F013-F013	0.90					UKN					
12/30/2011	SDYC	F014-F014	0.90	1204076	Beneteau	30	8.5	Non-unconf	Other		Nielsen Beaumo	Jun-02	0
12/30/2011	SDYC	F015-F015	0.90	1194152	Tartan			UKN					
12/30/2011	SDYC	F017-F017	0.90	CF 8879 FT	Ericson	34.5	11'11"	Cu	Interlux Ultra		Shelter Island Bo	May-10	66.5
12/30/2011	SDYC	F018-F018	0.90	CF 2114 EG	Cal			UKN					
12/30/2011	SDYC	F019-F019	0.90	1228727	Ericson	34	10	LCu	Calif Bottomkote - 7		SD Boat Yard	Dec-09	35
12/30/2011	SDYC	F020-F020	0.90	1147246	J boats	32	12	UKN			Shelter Island Bo	Mar-10	
12/30/2011	SDYC	F021-F021	0.90	987372	Beneteau	36	11.5	Cu	Proline 1088 - 6		Shelter Island Bo	Feb-10	67.6
12/30/2011	SDYC	F022-F022	0.90	CF 2723 GC	Ranger	29	10.5	Cu	Petit Z-Spar Protector		Driscoll	May-11	60
12/30/2011	SDYC	F023-F023	0.90	1217040	Beneteau	33	8	Cu	Proline 1088 - 6		Driscoll	Jun-11	67.6
12/30/2011	SDYC	F024-F024	0.90	CF 5620 TX	J29	35'6"	11'5"	Cu	0			Sep-08	65
12/30/2011	SDYC	F025-F025	0.90	1077930	Nordic	29	9	NON	Petit Vivid - 3		SD Boat Yard	Mon-07	0
12/30/2011	SDYC	F026-F026	0.90	CF 9759 JL	Catalina			UKN					
12/30/2011	SDYC	F027-F027	0.90	CF 5918 HJ	Catalina	34	11	Lcu-ukn	0		Shelter Island Bo	Oct-10	2
12/30/2011	SDYC	F028-F028	0.90	1097707	Catalina	30	11.5	Cu	Proline 1088 - 6		Shelter Island Bo	Mar-11	67.6
12/30/2011	SDYC	F029-F029	0.90	CF 3835 SA	Sea Ray	36	11.9	Cu	Proline 1088 - 6		Shelter Island Bo	May-08	67.6
12/30/2011	SDYC	F030-F030	0.90	CF 1659 KB	Catalina	29'8"	11	Cu	Bluewater		Shelter Island Bo	Nov-08	50
12/30/2011	SDYC	F031-F031	0.90	CF 2639 SY	Young Brot	30	10.1	Cu	Interlux Ultra		Marine Group Sc	Sep-09	66.5
12/30/2011	SDYC	F032-F032	0.90	979413	Grand Ban	30	10	LCu	Calif Bottomkote - 7		Driscoll	May-09	35
12/30/2011	SDYC	F033-F033	0.90	663868	Sabre	32	11'6"	Cu	Interlux Ultra		Shelter Island Bo	Sep-10	66.5
12/30/2011	SDYC	F034-F034	0.90	CF 4647 RI	Caribe	28'5''	9'2''	Cu	Proline 1088 - 6		Shelter Island Bo	Aug-08	67.6
12/30/2011	SDYC	F035-F035	0.90	997299	Blackfin	22	8	Cu	Proline 1088 - 6		Driscoll	May-10	67.6
12/30/2011	SDYC	F036-F036	0.90	1188034		35	12	Non-unconf	Other		Shelter Island Bo	Aug-10	0
12/30/2011	SDYC	F037-F037	0.90	CF 5252 CE	Cal 28	29	10	Lcu-ukn	Other		Shelter Island Bo	Jun-09	10
12/30/2011	SDYC	F038-F038	0.90	CF 5901 HJ	Catalina	28	11.6	Cu	Interlux Ultra			Dec-04	66.5
12/30/2011	SDYC	F039-F039	0.90	CF 8866 RC	Glacier Bay	30	11	Cu	Super KL - 6		Shelter Island Bo	Jul-08	70

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
12/30/2011	SDYC	F040-F040	0.90	CF 0255 HF	Catalina	22	8	Cu	Interlux K91		Driscoll	Dec-09	70
12/30/2011	SDYC	F041-F041	0.90	CF 8257 TK	Santana	30	10'10"	Cu	Petit Z-Spar Protector		Driscoll	Jun-10	60
12/30/2011	SDYC	F042-F042	0.90	1135896	Corsair	30		UKN	0				Percent
12/30/2011	SDYC	F043-F043	0.90	CF 8679 PT	Shamrock	31	8	UKN					
12/30/2011	SDYC	F044-F044	0.90	1111530	J105			UKN					
12/30/2011	SDYC	F045-F045	0.90	CF 7091 JL	Catalina	34.5	11	Cu	Petit Z-Spar Protector		Driscoll	Oct-10	60
12/30/2011	SDYC	F046-F046	0.90	CF 3165 FG	Grand Banks			UKN					
12/30/2011	SDYC	F047-F047	0.90	CF 0950 HZ	Hunter	32	10-6	Cu	Interlux Ultra		Driscoll Mission	Sep-09	66.5
12/30/2011	SDYC	F048-F048	0.90	1159706	Santana	21	8.4	Cu	Interlux Ultra		Driscoll Mission	May-09	66.5
12/30/2011	SDYC	F049-F049	0.90	939399	Hatteras	35	11.9	UKN	Intersleek - 8		Driscoll	Jul-11	
12/30/2011	SDYC	F050-F050	0.90	CF 7332 JB	Catalina	32	12	UKN	Other		SD Boat Yard	Mon-ar	Percent
12/30/2011	SDYC	F051-F051	0.90	CF 1235 RJ	Edgewater	29'11"	10'10"	Cu	Proline 1088 - 6		Shelter Island Bo	Feb-10	67.6
12/30/2011	SDYC	F052-F052	0.90	1082827	Grady Whit	56	15.52	UKN	Other		Driscoll	Oct-08	Percent
12/30/2011	SDYC	F053-F053	0.90	622656	Ocean	30	11	Cu	Proline 1088 - 6		Shelter Island Bo	Oct-07	67.6
12/30/2011	SDYC	F054-F054	0.90	1106745	West Bay	40	14	LCu	Calif Bottomkote - 7		Driscoll	Apr-10	35
12/30/2011	SDYC	F055-F055	0.90	1175141	Hanse	45	15	UKN	Other		Driscoll	Feb-10	Percent
12/30/2011	SDYC	F056-F056	0.90					UKN					
12/30/2011	SDYC	F058-F058	0.90	1123616	Islander			UKN					
12/30/2011	SDYC	F059-F059	0.90	1096898	Bayliner	48	7	LCu	SeaHawk AF33		Driscoll	Apr-09	33
12/30/2011	SDYC	F060-F060	0.90	CF 0973 BA	Kettenburg	38	8	UKN	0		Koehler	Aug-07	Percent
12/30/2011	SDYC	F061-F061	0.90	1077494	Ericson	40	12	Cu	Petit Z-Spar Protector		Driscoll	Aug-10	60
12/30/2011	SDYC	F062-F062	0.90	933619	Roughwate	36	11.8	Cu	Interlux K91		Koehler	Mar-09	70
12/30/2011	SDYC	F063-F063	0.90	1222872	Mikelson	59	18	Cu	Proline 1088 - 6		Shelter Island Bo	Jul-11	67.6
12/30/2011	SDYC	F064-F064	0.90	1189440	Hylas 49	49	14	Cu	Interlux Ultra			Oct-09	66.5
12/30/2011	SDYC	F065-F065	0.90	OR 812 ACF	Tiara	35'7"	11'7"	Cu	Proline 1088 - 6		Shelter Island Bo	Jul-09	67.6
12/30/2011	SDYC	F066-F066	0.90	1143089	Catalina	42	12	Cu	Petit Z-Spar Protector		Shelter Island Bo	Mar-09	60
12/30/2011	SDYC	F067-F067	0.90	1112886	San Juan			UKN					
12/30/2011	SDYC	F068-F068	0.90	994410	Grand Ban	37'	12'8"	Cu	0		Driscoll	Dec-07	65
12/30/2011	SDYC	F069-F069	0.90	508787	Cal 40	40	10'8"	Cu	Trinidad SR - 6		Driscoll	Jul-11	70.8
12/30/2011	SDYC	F070-F070	0.90	CF 7318 NA	Catalina	34	12	Cu	Proline 1088 - 6		Shelter Island Bo	Mar-09	67.6
12/30/2011	SDYC	F071-F071	0.90	1046303	Beneteau	39	12	NON	Pacifica - 5		Shelter Island Bo	2009	0
12/30/2011	SDYC	F072-F072	0.90	CF 8662 SW	Grand Ban	36	12	Cu	Trinidad SR - 6		SD Boat Yard	Jul-09	70.8
12/30/2011	SDYC	F073-F073	0.90	CF 9686 HE	Hunter			UKN					
12/30/2011	SDYC	F074-F074	0.90	697057	Newport 41	41	12'10"	Cu	Proline 1088 - 6		Shelter Island Bo	Apr-07	67.6
12/30/2011	SDYC	F075-F075	0.90	1152313	Philbrook	40	14	Cu	Interlux Ultra		Driscoll	May-09	66.5
12/30/2011	SDYC	F076-F076	0.90	1226911	Back Cove	35	11.33	Non-unconf	0		Driscoll	Mar-10	0
12/30/2011	SDYC	F077-F077	0.90	1152302	Beneteau	39.2	12	Cu	Ultrakote - 6		Driscoll	Jan-10	76
12/30/2011	SDYC	F078-F078	0.90	1120510	Beneteau	39.6	12.3	Cu	Super KL - 6		Driscoll	Feb-10	70
12/30/2011	SDYC	F079-F079	0.90	1024891	Ocean Ale	38	13	Cu	Bluewater		Driscoll	Mar-10	45
12/30/2011	SDYC	F080-F080	0.90	1102464	Beneteau	39.4	12.1	LCu	Petit Vivid - 3		Driscoll	May-08	25
12/30/2011	SDYC	F081-F081	0.90	1210284		39	12'10"	Cu	Proline 1088 - 6		Shelter Island Bo	Aug-10	67.6
12/30/2011	SDYC	F082-F082	0.90	CF 3521 GS	Charles Di	38	12	Cu	Proline 1088 - 6		Driscoll Mission	Mar-09	67.6
12/30/2011	SDYC	F083-F083	0.90	1092002	Beneteau	38	14	Cu	Proline 1088 - 6		Driscoll	Jan-11	67.6
12/30/2011	SDYC	F084-F084	0.90	CF 3349 CW	Cal 36 by J	35.5	10.33	Cu	Interlux Ultra		Driscoll	Jan-07	66.5

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12/30/2011	SDYC	F085-F085	0.90	653700	Ericson	29'10"	10	Cu	Proline 1088 - 6		Shelter Island Bo	Nov-07	67.6
12/30/2011	SDYC	F086-F086	0.90	CF 8884 SW	Chris Craft	38	11;4"	Lcu-ukn			Driscoll	Dec-11	4
12/30/2011	SDYC	F087-F087	0.90	937787	Californian			UKN					
12/30/2011	SDYC	G001-G001	0.90	CF 8308 GS	Tillitson Pearson			UKN					
12/30/2011	SDYC	G002-G002	0.90	1185859	Tillitson Pe	30	11	Cu	Sharkskin - 7		Driscoll	Apr-07	45
12/30/2011	SDYC	G003-G003	0.90	1167509	Beneteau	34'6"	11	LCu	Petit Vivid - 3		Driscoll Mission I	Jul-10	25
12/30/2011	SDYC	G004-G004	0.90	911190	Doug Peterson			UKN					
12/30/2011	SDYC	G005-G005	0.90	CF 8139 TA	Soverel			UKN					
12/30/2011	SDYC	G006-G006	0.90	1053719	Tiara	33	11	Cu	0		Driscoll	Nov-10	58
12/30/2011	SDYC	G007-G007	0.90	CF 2370 CJ	Cal 20			UKN					
12/30/2011	SDYC	G008-G008	0.90	CF 5670 NW	Boston Wh	20	7	NON	Pacifica Plus		Shelter Island Bo	Mar-10	0
12/30/2011	SDYC	G009-G009	0.90	CF 3650 K	Duffy	17	5	Non-unconf	0		Driscoll	Feb-02	0
12/30/2011	SDYC	G010-G010	0.90	CF 3377 JE	Boston Wh	18	6	Cu	Petit Z-Spar Protector		Driscoll	2011	60
12/30/2011	SDYC	G011-G011	0.90	CF 4586 NB	Beneteau	17	6.2	Cu	Interlux Ultra		Shelter Island Bo	Jul-10	66.5
12/30/2011	SDYC	G012-G012	0.90	CF 1758	Seacraft	34.3	11.5	Cu	Interlux Ultra		Shelter Island Bo	Feb-11	66.5
12/30/2011	SDYC	G013-G013	0.90	CF 4624 NB	Boston Wh	21	7	Cu			Shelter Island Bo	Sep-09	67
12/30/2011	SDYC	G014-G014	0.90	CF 7767 RJ	Chaparral			UKN					
12/30/2011	SDYC	G015-G015	0.90	CF 3730 KN	Duffy	20	8'4"	Lcu-ukn	Other		SD Boat Yard	Jan-11	20
12/30/2011	SDYC	G016-G016	0.90	CF 2773 SY	Chris Craft			UKN					
12/30/2011	SDYC	G017-G017	0.90	CF 6564 RB	Boston Wh	17	6	Cu	Trinidad SR - 6			May-09	70.8
12/30/2011	SDYC	G018-G018	0.90	CF 4142HR	Duffi (Elect	17	7.1	Cu	Interlux Ultra		Shelter Island Bo	Sep-11	66.5
12/30/2011	SDYC	G019-G019	0.90	CF 7976 BR	Cal 20	18	5	Cu	Proline 1088 - 6		SD Boat Yard	Jun-09	67.6
12/30/2011	SDYC	G020-G020	0.90	CF 1445 NY	Grady White			UKN					
12/30/2011	SDYC	G021	0.90	1021048	Mikelson	18	7	Cu	Super KL - 6		Driscoll Mission I	Jul-06	70
12/30/2011	SDYC	G022-G022	0.90	CF 2100 BB	Abeking &	50	16.5	Cu	Proline 1088 - 6		SD Boat Yard	Nov-07	67.6
12/30/2011	SDYC	G023-G023	0.90	971674	Angel	59	10	LCu	Petit Vivid - 3		Knight Carver	2009	25
12/30/2011	SDYC	G024-G024	0.90	1169431	Offshore	50	15' 5"	Cu	Proline 1088 - 6		Shelter Island Bo	Nov-10	67.6
12/30/2011	SDYC	G025-G025	0.90	1130766	Transpac 5	58	16	Cu	Super KL - 6		Shelter Island Bo	Sep-10	70
12/30/2011	SDYC	G026-G026	0.90	1117785	Nordhavn	52	13'6"	Lcu-ukn			Nielsen Beaumo	May-08	10
12/30/2011	SDYC	G027-G027	0.90	1079626	Bayliner			UKN					
12/30/2011	SDYC	G028-G028	0.90	1141235	Hylas	54	15	Cu	Proline 1088 - 6		Shelter Island Bo	Nov-10	67.6
12/30/2011	SDYC	G029-G029	0.90	928524	Transworld	54	16	Cu	Super KL - 6		Shelter Island Bo	Nov-08	70
12/30/2011	SDYC	G030-G030	0.90	1053956	Cal Yachts	38	10	LCu	SeaHawk AF33		Driscoll	Sep-08	33
12/30/2011	SDYC	G031-G031	0.90	CF 6610 AX	Kettenburg	35	11	Cu	Interlux Ultra		Shelter Island Bo	May-10	66.5
12/30/2011	SDYC	G032-G032	0.90	956166	Pacemaker	38	8	LCu	Petit Vivid - 3		Driscoll	Dec-10	25
12/30/2011	SDYC	G033-G033	0.90	CF 6396 AW	Kettenburg PC			UKN					
12/30/2011	SDYC	G034-G034	0.90	934376	Ericson			UKN					
12/30/2011	SDYC	G035-G035	0.90	CF 2594 SP	Cape Cod	35	10	LCu	SeaHawk AF33		Driscoll	Sep-08	33
12/30/2011	SDYC	G036-G036	0.90	CF 4566 TZ	Chris Craft			UKN					
12/30/2011	SDYC	G037-G037	0.90	910191	Wauquiez	28	11.5	Cu	Interlux Ultra		Koehler	Nov-09	66.5
12/30/2011	SDYC	G038-G038	0.90	1188356	Chaparral			UKN					
12/30/2011	SDYC	G039-G039	0.90	656956	Deeds	37	12	Lcu-ukn	Other		Other	Feb-09	38
12/30/2011	SDYC	G040-G040	0.90	CF 2852 GU	DeFever	39	11.9	Cu	Proline 1088 - 6		SD Boat Yard	Jul-95	67.6
12/30/2011	SDYC	G041-G041	0.90	1040355	Custom	48	15	Cu	Sharkskin - 7		Driscoll	Apr-06	45

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12/30/2011	SDYC	G042-G042	0.95					UKN					
12/30/2011	SDYC	G044-G044	0.90	1147248	Navigator	52	15	Cu	Proline 1088 - 6		Nielsen Beaumo	May-08	67.6
12/30/2011	SDYC	G045-G045	0.90	942038	Marlineer	44	16	LCu	SeaHawk AF33		Driscoll Mission	Oct-08	33
12/30/2011	SDYC	G046-G046	0.90	1217481	Transpac 5	52	13	Lcu-ukn	Other		Shelter Island Bo	Dec-10	25
12/30/2011	SDYC	G047-G047	0.90	CF 7782 ND	Offshore	48	14.6	Cu	Interlux Ultra		Shelter Island Bo	Jul-10	66.5
12/30/2011	SDYC	G048-G048	0.90	1022236	Hatteras	44	12	LCu	Interlux Aqua		Other	Apr-11	35
12/30/2011	SDYC	G049-G049	0.90	CF 1845 HZ	Morri & Pa	47	12'6"	Cu	Interlux Ultra		Shelter Island Bo	Dec-09	66.5
12/30/2011	SDYC	G050-G050	0.90	*Netherlands Doc	Bavaria	46		Lcu-ukn	Other		Driscoll	May-08	5
12/30/2011	SDYC	G051-G051	0.90	1048570	Lien HWA	47	14'11"	Cu	Bluewater		Shelter Island Bo	Feb-10	45
12/30/2011	SDYC	G052-G052	0.90	1095755	Beneteau	35	12.6	NON	Pacifica - 5		Shelter Island Bo	Sep-09	0
12/30/2011	SDYC	G053-G053	0.90	1173014	Beneteau	47	14	Cu	Interlux K91		Driscoll	Jan-10	70
12/30/2011	SDYC	G054-G054	0.90	661472	Nautor	42	13	Cu	Proline 1088 - 6		Shelter Island Bo	Sep-10	67.6
12/30/2011	SDYC	G055-G055	0.90	959578	Island Pacl	35	12	UKN	0		Shelter Island Boat Yard		Percent
12/30/2011	SDYC	G056-G056	0.90	1034965	Roughwater			UKN					
12/30/2011	SDYC	G057-G057	0.90	1217030	Sea Ray S	40	12	Cu	Proline 1088 - 6		Shelter Island Boat Yard		67.6
12/30/2011	SDYC	G058-G058	0.90	1120448	Beneteau	48	14.5	Lcu-ukn	Other		Driscoll	Jun-09	20
12/30/2011	SDYC	G059-G059	0.90	1054231	CHB	48	15	UKN	Other		Shelter Island Bo	Mar-09	Percent
12/30/2011	SDYC	G060-G060	0.90	1043147	Bertram			UKN					
12/30/2011	SDYC	H001-H001	0.90	1209638	Riviera	50	16	Cu	Interlux Ultra		Shelter Island Bo	Dec-10	66.5
12/30/2011	SDYC	H002-H002	0.90	1231971	Sea Ray S	51	14.8	LCu	Calif Bottomkote - 7		Driscoll	Apr-09	35
12/30/2011	SDYC	H003-H003	0.90	615464	DeFever	43	14	Lcu-ukn	Other		SD Boat Yard	Jan-06	10
12/30/2011	SDYC	H004-H004	0.90	1100247	J Boat			UKN					
12/30/2011	SDYC	H005-H005	0.90	972833	Nordhavn	46	15.5	UKN			Shelter Island Bo	Sep-09	
12/30/2011	SDYC	H006-H006	0.85	1024700	J120	40	12	Cu	Interlux Ultra		Driscoll	Sep-09	66.5
12/30/2011	SDYC	H007-H007	0.90	669444	Amel			UKN					
12/30/2011	SDYC	H008-H008	0.90	1091378	Catalina	36	11.9	Cu	Interlux Ultra		Shelter Island Bo	Jan-11	66.5
12/30/2011	SDYC	H009-H009	0.90	610797	Kettenburg	52	13	Cu	Interlux Ultra		Driscoll	Oct-09	66.5
12/30/2011	SDYC	H010-H010	0.90	962333	Tolly Craft	39	12.5	Cu	Sharkskin - 7		Driscoll	May-10	45
12/30/2011	SDYC	H011-H011	0.90	1080447	Hatteras	39	13.7	Cu	Interlux Ultra		Shelter Island Bo	Jul-10	66.5
12/30/2011	SDYC	H012-H012	0.90	510146	Cal	40	12	Cu	Ultrakote - 6		Shelter Island Bo	Aug-ar	76
12/30/2011	SDYC	H013-H013	0.90	962486	Bayliner	38	13.5	Cu	Other		Driscoll	Apr-03	45
12/30/2011	SDYC	H014-H014	0.90	1083073	Olympic Ac	47	14	Cu	Proline 1088 - 6		Shelter Island Bo	Jun-07	67.6
12/30/2011	SDYC	H015-H015	0.90	CF 8655 GM	Albin	38	15	Cu	Proline 1088 - 6		Shelter Island Bo	Jun-10	67.6
12/30/2011	SDYC	H016-H016	0.90	1208775	Jeanneau	36	12	Cu	Interlux Ultra		Shelter Island Bo	Jun-10	66.5
12/30/2011	SDYC	H017-H017	0.90	997332	Taswell	43	13.7	Cu	Proline 1088 - 6		Shelter Island Bo	Jan-09	67.6
12/30/2011	SDYC	H018-H018	0.90	1106522	J120	40	12	Cu	Proline 1088 - 6		Shelter Island Bo	Jan-09	67.6
12/30/2011	SDYC	H019-H019	0.90	CF 1130 JD	New York 3	36	9	UKN	Other		Shelter Island Bo	Feb-07	
12/30/2011	SDYC	H020-H020	0.90	1109702	Fleming	60'9"	16	NON	Pacifica - 5		Shelter Island Bo	Mar-09	0
12/30/2011	SDYC	H021-H021	0.90	1131732	Catalina	42	14	Cu	Super KL - 6		Outside San Dieg	Nov-07	70
12/30/2011	SDYC	H022-H022	0.90	1208872	Sabre			UKN					
12/30/2011	SDYC	H024-H024	0.90			30	10	Non-unconf	Other			Jul-04	0
12/30/2011	SDYC	H025-H025	0.90	1079060	Pilot	29	S	UKN	Other		Shelter Island Bo	2008	
12/30/2011	SDYC	H026-H026	0.90	1101126	Sea Eagle			UKN					
12/30/2011	SDYC	H027-H027	0.90	1082038	Mainship Cruiser			UKN					

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12/30/2011	SDYC	H028-H028	0.90	CF 5904 HJ	Catalina	27	9	Cu	Proline 1088 - 6		Shelter Island Bo	Oct-07	67.6
12/30/2011	SDYC	H029-H029	0.90	CF 2408 GE	Catalina	32.8	6.5	Cu	Interlux Ultra		Koehler	Jun-10	66.5
12/30/2011	SDYC	H030-H030	0.90	1096449	Kettenburg	48		Cu	Interlux Ultra		Driscoll	Jan-11	66.5
12/30/2011	SDYC	H031-H031	0.90	1096449	Trojan Cruiser			UKN					
12/30/2011	SDYC	H032-H032	0.90	1080087	Sea Ray			UKN					
12/30/2011	SDYC	H033-H033	0.90	CF 0232 EJ	Cal 29 Jensen			UKN					
12/30/2011	SDYC	H034-H034	0.90	CF 7472 HV	Freedom	36	12	LCu	Interlux Aqua		Shelter Island Bo	Feb-11	35
12/30/2011	SDYC	H035-H035	0.90	923302	Catalina	34.5	11	Cu	Interlux Ultra		Shelter Island Bo	Jul-10	66.5
12/30/2011	SDYC	H036-H036	0.90	1111938	J105			UKN					
12/30/2011	SDYC	H037-H037	0.90	1074740				UKN					
12/30/2011	SDYC	H038-H038	0.90	1065803	J120	42	13	Cu	Petit Z-Spar Protector		Driscoll	Aug-11	60
12/30/2011	SDYC	H039-H039	0.90	CF 2743 KL	Catalina	37	9	Cu	Interlux Ultra		Koehler	Apr-09	66.5
12/30/2011	SDYC	H040-H040	0.90	CF 7701 GY	Bayliner	42	14	Cu	Petit Z-Spar Protector		Driscoll	Oct-10	60
12/30/2011	SDYC	H041-H041	0.90	1116122	Catalina	39	12	Cu	Sharkskin - 7		Shelter Island Bo	Jul-09	45
12/30/2011	SDYC	H042-H042	0.90	1146194	Packet Cra	32	11.5	Cu	Interlux Ultra		Koehler	Apr-09	66.5
12/30/2011	SDYC	H043-H043	0.90	698533	Grand Ban	40	13	Cu	Interlux Ultra		Shelter Island Bo	May-09	66.5
12/30/2011	SDYC	H044-H044	0.90	1043839	Catalina	37	10'10"	Cu	Interlux Ultra		Shelter Island Bo	Apr-09	66.5
12/30/2011	SDYC	H045-H045	0.90	907329	Pacific Sea	38	13	Cu	Bluewater		Shelter Island Bo	Jan-10	45
12/30/2011	SDYC	H046-H046	0.90	1130542	Grand Banks			UKN					
12/30/2011	SDYC	H047-H047	0.90	1045777	Hunter	35	12	Non-unconf	Other		SD Boat Yard	Dec-95	0
12/30/2011	SDYC	H048-H048	0.90	1124504	J105			UKN					
12/30/2011	SDYC	H049-H049	0.90	CF 9784 NC	Sport Craft	38	12'6"	Cu	Petit Z-Spar Protector		Driscoll	May-10	60
12/30/2011	SDYC	H050-H050	0.90	1098253	Newport	44	15	Non-unconf	Other		SD Boat Yard	Apr-09	0
12/30/2011	SDYC	I001-I001	0.90	530911	Pacific	28	18	UKN			Driscoll	Aug-10	
12/30/2011	SDYC	I002-I002	0.90	1142786	Corsair Trimaran			UKN					
12/30/2011	SDYC	I003-I003	0.90	CF 3640 RH	Trophy			UKN					
12/30/2011	SDYC	I004-I004	0.90	CF 1841 PF	Bayliner			UKN					
12/30/2011	SDYC	I005-I005	0.90	CF 1693 RJ	Cuddy	22	7	Cu	Sharkskin - 7		Driscoll	Jul-10	45
12/30/2011	SDYC	I006-I006	0.90	CF 4021 RB	Sea Pro	19	6	Cu	Interlux Ultra		Marine Group Sc	Sep-10	66.5
12/30/2011	SDYC	I007-I007	0.90	CF 1184 ND	Wellcraft	22.6	8.5	Cu	Bluewater		Shelter Island Bo	Jul-09	67
12/30/2011	SDYC	I008-I008	0.90	CF 0760 SN	Crownline	18		UKN	0		Driscoll	Jan-09	Percent
12/30/2011	SDYC	I009-I009	0.90	CF 8032 SW	Stringari			UKN					
12/30/2011	SDYC	I010-I010	0.90	CF 2507 RS	Robalo	30	9"6'	LCu	Micron Extra - 2		Driscoll	Mar-10	39
12/30/2011	SDYC	I011-I011	0.80	CF 9013 TK	Hunter			UKN					
12/30/2011	SDYC	I012-I012	0.90	CF 2254 SG	Columbia			UKN					
12/30/2011	SDYC	I014-I014	0.90	CF 3479 JG	Hunter	25	8	LCu	Calif Bottomkote - 7		Driscoll	Jan-10	35
12/30/2011	SDYC	I015-I015	0.90	CF 9211 SU	Harbor 20	29	8	LCu	Interlux Aqua		Driscoll	Jan-02	35
12/30/2011	SDYC	I016-I016	0.90	CF 2086 CW	Cal Jensen	19	7	UKN			Driscoll	Feb-08	
12/30/2011	SDYC	I017-I017	0.90	9016986	Cal 2-29			UKN					
12/30/2011	SDYC	I018-I018	0.90	CF 0129 NV	Grady Whi	25	8	Cu	Trinidad - 6			Sep-05	65
12/30/2011	SDYC	I019-I019	0.90	CF 1943 PF	Bayliner	24' 7"	9' 2"	Cu	Trinidad - 6		Nielsen Beaumo	Nov-06	65
12/30/2011	SDYC	I020-I020	0.90	CF 9027 FL	Cal 25 Jen	28	9.5	LCu	Trilux33 - 3		Knight Carver	Aug-09	24
12/30/2011	SDYC	I021-I021	0.90	CF 4987 KT	Capri			UKN					
12/30/2011	SDYC	I022-I022	0.90	CF 6152 PW	Bayliner	29	9.3	Cu	Interlux K91		Outside San Dieg	Jun-09	70

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
12/30/2011	SDYC	I023-I023	0.90	CF 4206 SX	Apex			UKN					
12/30/2011	SDYC	I024-I024	0.90	CF 4736 FW	Ca 29 Jensen Marine			UKN					
12/30/2011	SDYC	I025-I025	0.90	CF 6574 ET	Ranger 26	47'7"	14'9"	LCu	VC17 - 8		SD Boat Yard	Jan-05	20.35
12/30/2011	SDYC	I026-I026	0.90	CF 0186 PG	Boston Wh	17	5	Cu	Proline 1088 - 6			Jul-09	67.6
12/30/2011	SDYC	I027-I027	0.90					UKN					
12/30/2011	SDYC	I028-I028	0.90	CF 9202 KD	Laser 28	28	9.5	UKN	Cerakote - 8			Mar-10	
12/30/2011	SDYC	I029-I029	0.90	CF 4564 SJ	Hobie	33	8	Cu	Sharkskin - 7		Driscoll	May-08	45
12/30/2011	SDYC	I030-I030	0.90	1152837	Catamaran	39	23	Cu	Trinidad SR - 6		Driscoll	Sep-09	70.8
	SGYC	A10	0.00	1173359				Vacant					
	SGYC	A18	0.00	CF1229FA				Vacant					
	SGYC	C11	0.00	983208	S			Vacant					
	SGYC	D10	0.00	900508				Vacant					
	SGYC	E11	0.00	535237	S			Vacant					
	SGYC	F04	0.00	1086743				Vacant					
	SGYC	F14	0.00	CF8668GM	S			Vacant					
	SGYC	F17	0.00	CF2030JV	P			Vacant					
	SGYC	G13	0.00	CF6857JE	S			Vacant					
	SGYC	H09	0.00	CF3106HC				Vacant					
12/9/2011	SGYC	A08	0.95	CF4535UH	S	28	11	Cu	INTERLUX	ULTRA	SI	12/2010	66
11/12/2011	SGYC	A20	0.40	CF3565HL	P	28	9.5	Cu	PROLINE	1088	KC	04/2009	67
11/11/2011	SGYC	B16	1.00	CF2821SY	S	22	8	Cu	TRINIDAD	1877	KC	08/2008	70
12/8/2011	SGYC	C03	1.00	CF3920FS	S	30	10	UKN	UKN	UKN	UKN	UKN	UKN
12/12/2011	SGYC	C08	0.95	CF2082GN	S	34	11.5	Cu	PROLINE	1033	SI	01/2011	67
11/15/2011	SGYC	C12	0.90	1086408	S	36	11.11	Cu	PROLINE	1088	SI	09/2007	30
11/14/2011	SGYC	C13	0.99	1227809	S	26.6	9.3	Cu	TRINIDAD	SR BLUE	OTH	06/2007	70
11/13/2011	SGYC	C14	0.95	1100276	S	36	12	Cu	INTERLUX	UKN	UKN	UKN	66
12/21/2011	SGYC	C18	1.00	1029959	S	34	11	Cu	PROLINE	1088	UKN	03/2009	67
11/29/2011	SGYC	D02	0.90	958348	S	33	12.6	Cu	BLUEWATER	PROCATE	SI	09/2009	67
12/14/2011	SGYC	D04	0.90	1204058	S	38.5	12.11	Cu	PROLINE	1088	SI	06/2007	30
12/3/2011	SGYC	D07	0.90	1109596	S	31	10.6	Cu	PROLINE	1088	SI	1/2009	67
12/2/2011	SGYC	D08	1.00	1191896	P	35	11.5	Cu	INTERLUX ULTRA	UKN	SI	08/2011	67
12/5/2011	SGYC	D09	0.94	CF1994HZ	S	30	10	Cu	INTERLUX	UKN	SI	06/2010	55
12/5/2011	SGYC	D11	1.00	CF210BL	S	26	9.5	UKN	PETIT	UKN	OTH	11/2010	UKN
12/14/2011	SGYC	D15	1.00	CF4986FF	S	30	10	Cu	PROLINE	1088	SI	05/2007	30
12/15/2011	SGYC	E07	0.80	CF334FL	S	40	12	Cu	PROLINE	1088	KC	06/2008	30
11/19/2011	SGYC	E10	0.85	1037051	S	45	12	Cu	PROLINE	1088	SI	06/2007	30
12/18/2011	SGYC	E13	1.00	979321	S	35	11	UKN	UKN	UKN	UKN	UKN	UKN
11/16/2011	SGYC	E14	0.80	1204753	S	42	13	Cu	INTERLUX	YBA140	DR	04/2010	45
12/14/2011	SGYC	E19	0.85	CF4731GG	S	42	12.5	Cu	PROLINE	1088	SI	06/2007	30
11/13/2011	SGYC	E20	0.95	576781	S	43	14	Cu	PROLINE	1088	UKN	UKN	67
12/14/2011	SGYC	F02	0.90	1102447	S	36	12.5	Cu	INTERLUX		SI	06/2011	66
11/12/2011	SGYC	F03	0.90	991292	S	34	11.9	Cu	PROLINE	1088	SI	07/2009	67
12/14/2011	SGYC	F05	0.90	993616	S	34	10	Cu	PROLINE	1088	SI	03/2008	30
11/15/2011	SGYC	F06	0.83	578895	S	37	10	Cu	PROLINE	1088	UKN	12/2010	67

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12/23/2011	SGYC	F09	1.00	1061589	S	43	12	UKN	PETIT VIVID	UKN	SI	01/2010	UKN
12/13/2011	SGYC	F15	1.00	CF14142BL	S	37	6	Cu	PROLINE	1088	SI	11/2010	67
12/14/2011	SGYC	F22	0.85	611232	S	35.5		Cu	TRINIDAD	UKN	SI	09/2008	70
12/7/2011	SGYC	G02	0.99	978635	S	42	15	Cu	INTERLUX	UKN	SI	11/2011	67
11/11/2011	SGYC	G03	0.95	1028449	S	42.5	12.5	Cu	PROLINE	1088	SI	04/2011	63
12/14/2011	SGYC	G04	0.95	288467	S	40		Cu	PETIT	UNK	SI	06/2011	55
11/11/2011	SGYC	G05	0.95	931776	P	42	13.7	Cu	PROLINE	1088	DR	02/2011	67
12/14/2011	SGYC	G06	0.75	641206	S	43		Cu	PROLINE	1088	SI	03/2009	67
11/22/2011	SGYC	G07	0.20	1063201	S	40	6	Cu	PROLINE	1088	SI	07/2008	30
12/14/2011	SGYC	G11	1.00	619140	S	36	11.4	Cu	PROLINE	1088	KK	06/2007	30
12/14/2011	SGYC	G15	0.95	664729	S	38	12.5	Cu	PETTE TRINIDAD	UKN	SI	05/2011	72
11/19/2011	SGYC	G17	0.95	1020713	P	42	15	Cu	PROLINE	1088	SI	09/2011	67
11/16/2011	SGYC	G18	1.00	961860	S	43	12.9	Cu	TRINIDAD	UKN	KC	02/2007	70
12/2/2011	SGYC	H01	0.85	1026666	S	36	12.5	Cu	PROLINE	1088	SI	01/2008	30
12/15/2011	SGYC	H03	1.00	1031551	P	42	14	UKN	UKN	UKN	UKN	UKN	UKN
11/12/2011	SGYC	H04	0.85	1107150	P	50	15.8	Cu	PROLINE	1088	SI	03/2010	67
11/13/2011	SGYC	H05	1.00	646273	S	39.8	12.8	Cu	INTERLUX	UKN	SI	06/2010	67
12/6/2011	SGYC	H06	0.99	CF8644NR	S	42	13.8	Cu	PROLINE	1088	SI	06/2008	30
11/14/2011	SGYC	H15	0.90	595942	S	33	11	Cu	PROLINE	1088	UKN	UKN	67
12/1/2011	SGYC	H18	1.00	CF3142CN	S	37	10.1	Cu	PROLINE	1088	SI	11/2011	67
12/14/2011	SGYC	F11	0.95	297422	S	43	10.5	Cu	PROLINE	1088	UKN	03/2006	30
11/14/2011	SGYC	A02	0.95	CF3288SM	S	32	9	Lcu-ukn	UKN	UKN	UKN	06/2006	30
11/26/2011	SGYC	A04	0.90	CF0719SN	S	32	10.5	Lcu-ukn	UKN	UKN	SI	05/2008	30
12/2/2011	SGYC	A12	0.90	CF6415PR	S	28	9	Lcu-ukn	UKN	UKN	DR	09/2008	30
11/16/2011	SGYC	A22	1.00	AZ6418AH	S	28.7	9.3	Lcu-ukn	UKN	UKN	DR	08/2008	30
12/2/2011	SGYC	B02	0.70	CF3541KA	S	25	9	Lcu-ukn	UKN	UKN	SI	05/2007	30
11/19/2011	SGYC	B06	0.90	9369GF	S	30	10.1	LCu	CERAKOTE	M99	SI	12/2008	30
11/27/2011	SGYC	B18	0.85	6807JG	S	30	10.1	Lcu-ukn	UKN	UKN	SI	06/2008	30
12/14/2011	SGYC	C02	0.99	CF1470FX	S	35	9	Lcu-ukn	UKN	UKN	SI	11/2007	30
12/16/2011	SGYC	C04	1.00	1150454	S	38	12	Lcu-ukn	UNK	UKN	SI	03/2008	30
11/19/2011	SGYC	C06	1.00	1034601	S	36	11.2	Lcu-ukn	UKN	UKN	DR	10/2004	30
11/15/2011	SGYC	C07	0.80	CF4200GX	S	30	10.6	Lcu-ukn	UKN	UKN	SI	06/2007	30
11/11/2011	SGYC	C09	0.95	CF9328RK	S	32	12	Lcu-ukn	UKN	UKN	UKN	5/2008	30
11/23/2011	SGYC	C10	0.99	CF0558GM	S	30	10	LCu	INTERLUX	CSC	SI	UKN	37
11/15/2011	SGYC	C20	0.99	CF9760JL	S	34		Lcu-ukn	UKN	UKN	UKN	06/2005	30
12/14/2011	SGYC	C21	1.00	651978	S	30	9	LCu	INTERLUX	UNK	SI	01/2007	30
12/14/2011	SGYC	D01	1.00	CF2716ST	P	28	10	Lcu-ukn	UKN	UKN	UKN	02/2008	30
12/17/2011	SGYC	D03	0.95	CF5429HR	S	30	10	LCu	INTERLUX	UKN	SI	05/2006	30
12/14/2011	SGYC	D13	1.00	CF7856CG	S	25		Lcu-ukn	UKN	UNK	SI	11/2007	30
11/19/2011	SGYC	D16	1.00	CF3192ER	S	34	10	Lcu-ukn	UKN	UKN	SI	06/2003	30
11/11/2011	SGYC	D17	0.85	8323611	P	30	10	Lcu-ukn	UKN	UKN	UKN	UKN	0
12/14/2011	SGYC	D20	0.90	667195	S	34		Lcu-ukn	UNK	UNK	SI	05/2008	30
11/22/2011	SGYC	D21	0.99	CF1154GN	S	34	10	LCu	BLUEWATER	PROCATE	KC	12/2008	30

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12/4/2011	SGYC	E03	0.90	950902	S	44	14	LCu	CAL BOTTOM KOTE	UKN	SI	10/2010	33
12/14/2011	SGYC	E06	0.99	923010	S	43	15	LCu	PETIT	UKN	SI	03/2006	30
12/2/2011	SGYC	E08	0.80	1125745	S	42	13.1	Lcu-ukn	UKN	U	UKN	01/2008	30
11/11/2011	SGYC	E09	0.70	100974	S	46	14	Lcu-ukn	UKN	UKN	UKN	05/2008	30
12/15/2011	SGYC	E12	0.90	903011	S	35.7	11.5	Lcu-ukn	UKN	UKN	KC	10/2008	30
11/25/2011	SGYC	E15	0.90	CF7066HJ	S	36	12	LCu	INTERLUX	UKN	KK	01/2007	30
12/14/2011	SGYC	E15	0.50	654291	S	44	12.6	LCu	SEA HAWK	UKN	OTH	06/2008	30
12/13/2011	SGYC	E17	1.00	1091723	P	42	15	LCu	RED HAWK	UNK	OTH	06/2010	33
12/14/2011	SGYC	F01	1.00	933839	P	40		Lcu-ukn	UKN	UNK	SI	05/2007	30
11/25/2011	SGYC	F07	1.00	624104	S	38	12.5	Lcu-ukn	UKN	UKN	SI	12/2007	30
11/13/2011	SGYC	F08	0.99	1105978	S	42	10.3	LCu	INTERLUX	SUPER KL	SI	11/2008	30
11/14/2011	SGYC	F10	0.83	1042260	S	44	13.6	LCu	CAL BOTTOM KOTE	UKN	SI	05/2011	35
11/18/2011	SGYC	G09	0.99	CF2884HW	S	40	12	LCu	INTERLUX	UKN	BAJA	02/2007	30
11/11/2011	SGYC	G10	0.95	900619	S	52	15	Lcu-ukn	UKN	UKN	UKN	05/2006	30
12/5/2011	SGYC	G12	0.95	1033835	S	49	13	LCu	INTERLUX	UKN	SI	11/2006	30
11/5/2011	SGYC	G14	1.00	7558P	P	44	14.5	Lcu-ukn	UKN	UKN	UKN	03/2007	30
12/14/2011	SGYC	H02	1.00	536182	P	30	10	Lcu-ukn	UKN	UKN	SI	01/2008	30
12/14/2011	SGYC	H13	0.85	1065080	S	41		Lcu-ukn	UKN	UKN	SI	03/2011	32
11/15/2011	SGYC	H14	0.90	653810	S	46	14.8	Lcu-ukn	UKN	UKN	UKN	05/2008	30
12/14/2011	SGYC	H16	1.00	DON'T HAVE	P	57	14.6	LCU	PETIT	UKN	SI	07/2006	30
12/9/2011	SGYC	A06	1.00	CF1641UN	S	32.6	9.15	Non	NON	N/A	N/A	N/A	0
11/11/2011	SGYC	F13	1.00	6821JG	S	34	12	Non	N/A	N/A	N/A	N/A	0
11/25/2011	SGYC	G16	1.00	1133651	S	41	12	Non	No Paint	N/A	N/A	N/A	0
12/12/2011	SGYC	B22	0.95	CF6627GX	S	29.1	10.1	NON	INTERSLEEK	900	SI	10/2009	0
12/14/2011	SGYC	C19	0.95	1909591	S	33		Non-unconf	N/A	N/A	N/A	N/A	0
11/9/2011	SGYC	E16	0.75	DON'T HAVE	S	40	11.8	NON	VC	UKN	SELF	01/2008	0
12/14/2011	SGYC	A16	0.85	CF4650FR	S	30	8.5	UKN	UKN	UKN	OTH	UKN	UKN
12/3/2011	SGYC	A24	0.90	CF0384GN	S	27		UKN	UKN	U	SI	06/2010	UKN
12/11/2011	SGYC	A26	1.00	CF9174EE			UKN	UKN	UKN	UKN	UKN	UKN	UKN
11/12/2011	SGYC	A28	0.90	964572	P	34	11.5	UKN	UKN	UKN	SI	UKN	UKN
11/22/2011	SGYC	B-04	0.90	1098705	S	31	11.5	UKN	UKN	UKN	UKN	UKN	UKN
12/7/2011	SGYC	B08	1.00	1183140				UKN	UKN	UKN	UKN	UKN	UKN
11/19/2011	SGYC	B10	0.50	CF0275UW	UKN	25	8.5	UKN	UKN	UKN	SI	06/2011	UKN
12/12/2011	SGYC	B12	0.99	CF0850DJ	S	28	6.5	UKN	UKN	UKN	SI	10/2011	UKN
11/25/2011	SGYC	B14	1.00	NM5164BC	S	30	10	UKN	UKN	UKN	UKN	UKN	UKN
11/14/2011	SGYC	B20	0.90	1101523	S	32	10.4	UKN	UKN	UKN	UKN	UKN	UKN
11/11/2011	SGYC	C01	1.00	CF2174UH	S	35	10	UKN	UKN	UKN	UKN	09/2009	UKN
12/14/2011	SGYC	C04	1.00	1150454	S	31	10.5	UKN	UKN	UKN	UKN	UKN	UKN
11/20/2011	SGYC	C-05	0.97	1031950	S	32	11.9	UKN	UKN	UKN	UKN	UKN	UKN
11/12/2011	SGYC	C15	0.92	CF6572FZ	S	30	11	UKN	UKN	UKN	KK	UKN	UKN
11/11/2011	SGYC	C16	0.85	DON'T HAVE	S	41	11.4	UKN	UKN	UKN	SI	05/2010	UKN
12/2/2011	SGYC	D05	0.80	CF6642GX	S	27	8.1	UKN	UKN	UKN	SI	01/2009	UKN

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11/13/2011	SGYC	D06	0.82	1107977	S	41.8	13	UKN	UKN	UKN	UKN	UKN	UKN
11/14/2011	SGYC	D12	0.85	1226818	S	36	11.11	UKN	UKN	UKN	UKN	05/2010	UKN
12/8/2011	SGYC	D14	0.99	1081522	S	36	12	UKN	TRINIDAD	UKN	SI	05/2010	72
11/21/2011	SGYC	D18	0.95	0200VE	S	32	6	UKN	INTERLUX	ULTRA	KK	07/2011	66
11/19/2011	SGYC	D19	0.99	927205	S	32.6	11	UKN	CAL BOTTOM KOTE	UKN	DR	03/2010	UKN
11/13/2011	SGYC	E01	0.95	615841	S	37	12	UKN	UKN	UKN	DR	03/2010	UKN
11/19/2011	SGYC	E02	0.95	1128494	P	36	14	UKN	PETIT	UKN	DR	09/2010	72
12/14/2011	SGYC	E04	0.90	930939	P	42	14.6	UKN	UNK	UKN	SI	03/2011	UKN
11/14/2011	SGYC	E05	0.92	1058850	S	40	12.11	UKN	UKN	UKN	UKN	UKN	UKN
12/2/2011	SGYC	E18	0.90	625808	P	35	12	UKN	PETIT	UKN	DR	06/2011	UKN
11/21/2011	SGYC	F12	0.80	599094	S	40	12	UKN	PETIT	UKN	KC	08/2011	72
11/18/2011	SGYC	F16	0.96	900408	S	36	12.5	UKN	UKN	UKN	UKN	UKN	UKN
12/5/2011	SGYC	F18	1.00	1109768	P			UKN	UKN	UKN	UKN	UKN	UKN
12/14/2011	SGYC	F19	1.00	AZ6194BN	P	47		UKN	UKN	UKN	DR	03/2010	UKN
11/14/2011	SGYC	F20	0.95	CF9843SH	P	30	12	UKN	UKN	UKN	UKN	06/2010	UKN
12/14/2011	SGYC	G01	1.00	461660	P	36	13	UKN	UKN	UKN	SI	09/2010	UKN
11/17/2011	SGYC	H07	0.95	1127697	P	31	12	UKN	UKN	UKN	UKN	04/2011	UKN
12/14/2011	SGYC	H08	0.95	CF7503FS	P	38		UKN	INTERLUX	UNK	KC	08/2011	UNK
11/16/2011	SGYC	H10	1.00	672657	S	48	15	UKN	UKN	UKN	SI	06/2011	UKN
12/3/2011	SGYC	H11	0.90	681563	S	39	14.5	UKN	UKN	UKN	SI	06/10	UKN
11/18/2011	SGYC	H12	0.99	CF4574NW	S	42	13	UKN	UKN	UKN	UKN	UKN	UKN
12/7/2011	SGYC	H17	1.00	539568	S	34.11	34.11	UKN	UKN	UKN	KK	09/2011	UKN
12/14/2011	SGYC	F-21	0.95	966464	S	34		UKN	UKN	UNK	SI	09/2010	UNK
12/24/09	SIM	002	1.00	CF 0373 UE	P	21.0	8.6	Cu	INTERLUX ULTRA		SI	12/24/09	59
08/06/11	SIM	005	0.93	CF 7403 PB	P	14.1	6.0	Cu	PETIT PROTECTOR	ZSPAR B9	DR	06/04/10	
11/23/11	SIM	113	0.91	1221423	S	46.0	13.0	Cu	Proline 1088			10/20/11	67
11/20/11	SIM	126B	1.00	901967	S	49.0	12.7	Cu	Proline 1088			02/01/10	67
12/20/11	SIM	210	0.99	CF 5499 EG	P	32.0	9.8	Cu	Interlux Ultra with Bio	y3559F		12/15/09	67
12/22/11	SIM	212	0.99	CF 7694 FG	S	27.0	9.0	Cu	Interlux ultra				
11/21/11	SIM	214	1.00	1157280	S	33.0	10.8	Cu	UNKNOWN			05/01/11	67
11/22/11	SIM	228	0.83	1162903	S	32.7	6.3	Cu	PRO-LINE 1088			11/13/09	67
12/01/11	SIM	304	0.86	AZ 4189 BF	P	38.0	10.0	Cu	INTERLUX ULTRA			02/01/11	66
11/10/11	SIM	306	0.81	IL 507 JN	S	39.3	12.3	Cu	UNKNOWN			11/01/11	
09/21/11	SIM	312	0.95	980990	P	38.3	13.2	Cu	PETTIT PROTECTO	ZSPAR B91			
11/26/11	SIM	408	1.00	919804	S	29.9	10.9	Cu	8 year old paint		SI	06/01/03	
12/16/11	SIM	419	0.80	1186984	P	25.0	9.5	Cu	INTERLUX ULTRA W	3779		12/12/11	67
11/23/11	SIM	501	1.00	982814	S	41.0	13.1	Cu	INTERLUX ULTRA W/BIOLUX			10/01/11	67
12/09/11	SIM	507	0.94	930574	S	39.0	11.1	Cu	VOC TRINIDAD RED	PET 1678		06/17/11	65
11/28/11	SIM	510	1.00	1196712	S	35.9	12.1	Cu	PROLINE 1088 W/ORGANIC BIOCIDE			01/01/10	67
11/28/11	SIM	600 B	1.00	CF 8700 HV	P	30.0	11.3	Cu	6 year old paint			12/31/05	
06/30/10	SIM	003	0.99	CF 8406 RT	P	19.0	1.0	LCu	PETIT VIVID WHITE		SI	01/16/07	25
11/11/11	SIM	101	1.00	545417	P	37.4	6.3	LCu	ULTRA FAST W/BIO	Y3669FG			
11/14/11	SIM	207	0.99	1077114	S	40.0	13.6	LCu	PETTIT HYDROCOA	PET-124OG		11/01/09	40

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
11/14/11	SIM	209	0.99	1041963	S	40.6	13.5	LCu	PETTIT HYDROCOA	PET-124OG		03/01/10	40
08/01/11	SIM	415	0.97	CF 6434 EU	S	26.0	8.0	LCu	INTERLUX MICRON VOC ULTR		KC	07/01/11	37
08/22/10	SIM	427	0.99	1236015	S	30.0	10.1	LCu	INTERLUX MICROS CSC		OTH	08/22/10	37
10/08/10	SIM	432	0.93	1070415	P	30.2	11.0	LCu	INTERLUX CA BOTT	94-YBB263	OTH	10/08/10	35
11/14/11	SIM	009	0.84	CF 3154 PU	P	16.0	6.5	Non	NO PAINT				0
12/06/11	SIM	117	0.94	1155230	S	38.3	12.0	NON	INTERSLEEK 900			06/01/11	
12/06/11	SIM	220	0.94	CF 1034 JT	S	32.0	11.0	NON	INTERSLEEK 900			06/01/11	
07/14/10	SIM	600 A	1.00	999448	S	55.1	15.3	NON	INTERLUX PERFORMANCE EP		OTH	07/14/10	0
11/22/11	SIM	618 C	1.00	662836	P	70.0	23.6	Non-unconf				01/25/09	0
06/30/10	SIM	001	1.00	CF 3286 TF	P	23.0	0.0	UKN					
12/17/10	SIM	004	1.00	CF 0581 HJ	P	15.0	6.0	UKN					
08/04/11	SIM	006	0.80	CF 6646 RM	E	18.0	6.0	UKN					
06/30/10	SIM	007	0.98	595405	S	24.0	8.1	UKN					
06/30/10	SIM	008	1.00	CF 1165 GH	S	24.0	8.1	UKN					
06/30/10	SIM	011	1.00	CF 8810 RC	P	16.0	6.6	UKN					
06/12/11	SIM	011	0.98	CF 6654 RS	P	14.0	6.0	UKN					
06/30/10	SIM	012	0.80	CF 2439 JU	P	16.0	6.5	UKN					
	SIM	013	0.86					UKN					
06/30/10	SIM	014	0.97	CF 2564 NX	P	22.0	8.0	UKN					
06/30/10	SIM	015	1.00	CF 1930 UN	P	29.0	8.0	UKN					
06/30/10	SIM	016	0.99	CF 9560 RL	P	24.0	9.0	UKN					
06/30/10	SIM	017	0.95	CF 6794 TH	P	28.0	9.2	UKN					
06/30/10	SIM	018	1.00	CF 1498 UV	P	24.0	8.6	UKN					
07/01/11	SIM	019	0.99	CF 0416 UP	P	26.0	8.0	UKN					
12/06/11	SIM	020	0.93	CF 1838 UN	P	21.0	8.0	UKN			SI	08/24/10	
06/30/10	SIM	021	1.00	AZ 5673 AH	P	28.0	11.0	UKN					
06/30/10	SIM	100	1.00	1188611	P	44.0	13.0	UKN					
10/07/11	SIM	102	0.66	33768	P	47.0	13.9	UKN					
02/28/11	SIM	103	1.00	942584	P	42.2	15.0	UKN					
06/30/10	SIM	104	1.00	1197732	S	49.5	14.8	UKN					
06/30/10	SIM	105	0.96	909331	P	41.9	13.0	UKN					
11/06/11	SIM	106	1.00	993274	S	44.8	13.1	UKN				12/01/08	
	SIM	107	0.62					UKN					
05/03/10	SIM	108	0.96	902618	P	53.0	15.3	UKN					
06/30/10	SIM	109	0.99	1122003	S	37.8	12.5	UKN					
06/30/10	SIM	110	0.98	680355	S	52.0	12.5	UKN					
01/11/11	SIM	111	1.00	1150461	S	46.0	14.0	UKN					
02/28/11	SIM	112	0.67	1127638	P	43.4	15.7	UKN					
06/30/10	SIM	114	0.97	1114571	S	48.6	14.2	UKN					
12/09/11	SIM	115	0.66	931889	S	44.0	13.5	UKN					
05/03/11	SIM	116	0.99	1141781	S	45.5	14.7	UKN					
12/18/11	SIM	118	0.59					UKN					
11/01/11	SIM	119	0.48	new build	S	46.0	15.0	UKN					
06/30/10	SIM	120	0.99	978492	S	42.1	14.3	UKN					

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12/05/11	SIM	121	0.99	1131036	S	46.3	13.8	UKN			SI	04/01/11	
11/20/11	SIM	122	0.88	1202905	P	48.0	15.0	UKN	UNKNOWN				
06/30/10	SIM	123	1.00	CF 5329 JC	S	41.0	12.1	UKN					
06/30/10	SIM	124	1.00	665239	P	45.0	15.0	UKN					
06/30/10	SIM	125	0.96	1108628	S	46.4	14.7	UKN					
06/30/10	SIM	126A	0.99	1021619	P	45.9	14.9	UKN					
08/01/11	SIM	200	0.94	1226290	P	29.7	10.4	UKN					
	SIM	201	0.83					UKN					
	SIM	202	0.68					UKN					
	SIM	203	0.66					UKN					
06/30/10	SIM	204	0.96	CF 2777 GC	S	33.0	9.7	UKN					
11/14/11	SIM	205	1.00	1122860	S	40.0	13.0	UKN	ABLATIVE				
06/30/10	SIM	208	1.00	CF 4467 GC	S	30.0	11.0	UKN					
06/30/10	SIM	211	0.99	544986	S	39.0	13.3	UKN					
06/30/10	SIM	213	0.90	693583	P	38.1	13.4	UKN					
09/20/11	SIM	215	0.99	690358	P	38.0	11.4	UKN					
06/11/11	SIM	216	0.90	CF 0854 ST	P	30.0	11.1	UKN					
06/30/10	SIM	217	1.00	1036303	S	39.7	12.1	UKN					
	SIM	218	0.66					UKN					
06/30/10	SIM	219	1.00	944526	S	41.0	13.8	UKN					
06/30/10	SIM	221	0.99	661497	S	36.6	11.5	UKN					
04/01/11	SIM	222	0.95	CF 8655 TK	S	30.0	11.0	UKN					
06/30/10	SIM	223	0.99	967050	S	39.5	12.6	UKN					
06/30/10	SIM	224	0.99	968888	S	29.9	10.9	UKN					
06/30/10	SIM	225	1.00	940781	S	39.6	12.7	UKN					
	SIM	226	0.51					UKN					
06/30/10	SIM	230	0.95	1104412	S	30.9	4.7	UKN					
06/30/10	SIM	232	1.00	CF 9886 FW	S	27.0	9.0	UKN					
	SIM	233	0.55					UKN					
06/30/10	SIM	300	0.96	1092569	P	34.5	13.0	UKN					
06/30/10	SIM	301	1.00	912629	P	37.4	12.3	UKN					
06/30/10	SIM	302	0.87	1214310	P	34.5	12.0	UKN					
	SIM	303	0.60					UKN					
06/30/10	SIM	305	0.99	665299	P	34.9	12.9	UKN					
	SIM	307	0.23					UKN					
11/22/11	SIM	308	0.83	CF 0549 JS	P	38.0	12.3	UKN	UNKNOWN				
06/30/10	SIM	309	0.81	1065387	P	43.0	13.0	UKN					
11/12/11	SIM	310	0.83	1160373	S	43.0	12.9	UKN	UNKNOWN				
11/08/11	SIM	311	0.95	GUEST	S	40.0	12.8	UKN					
06/30/10	SIM	313	0.98	944820	P	38.8	13.9	UKN					
12/27/10	SIM	314	0.99	728692	P	36.0	12.6	UKN					
06/30/10	SIM	315	0.97	1086620	P	35.5	6.2	UKN					
06/30/10	SIM	316	0.99	905565	P	36.2	12.5	UKN					
02/28/11	SIM	317	1.00	1080127	P	35.2	13.2	UKN					

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11/14/11	SIM	318	0.76	1163851	P	37.0	12.0	UKN					
07/06/11	SIM	319	0.87	939675	S	41.9	12.5	UKN					
06/30/10	SIM	320	0.99	590059	S	43.8	9.5	UKN					
11/22/11	SIM	321	1.00	918781	S	36.4	12.5	UKN			SI	05/01/09	
05/07/11	SIM	322	0.87	1025476	P	41.4	12.8	UKN					
11/27/11	SIM	323	0.55	1073732	P	40.0	12.0	UKN					
12/12/10	SIM	324	0.83	947856	P	40.3	14.4	UKN					
09/30/10	SIM	325	0.99	CF 3624 HG	S	37.0	12.0	UKN					
01/15/11	SIM	326	0.98	1143085	S	42.0	12.0	UKN					
06/30/10	SIM	327	0.97	1094489	P	44.0	15.0	UKN					
11/15/11	SIM	400	0.99	996797	P	27.8	10.0	UKN	UNKNOWN				
06/30/10	SIM	401	1.00	599092	S	29.9	10.9	UKN					
06/30/10	SIM	402	0.82	CF 0655 TP	P	34.5	11.0	UKN					
	SIM	403	0.54					UKN					
06/15/10	SIM	404	0.83	CF 2586 FN	S	28.0	7.7	UKN					
06/30/10	SIM	405	0.97	1195366	S	33.1	11.5	UKN					
06/30/10	SIM	406	0.86	1183335	P	28.3	9.3	UKN					
06/30/10	SIM	407	0.91	1223484	P	24.6	8.5	UKN					
06/30/10	SIM	409	1.00	CF 4854 GH	S	30.0	10.0	UKN					
	SIM	410	0.62					UKN					
01/31/11	SIM	411	0.84	CF 5854 TZ	P	28.0	9.5	UKN					
04/01/11	SIM	412	0.99	CF 7957 TG	P	25.0	9.5	UKN					
06/30/10	SIM	413	0.99	CF 6109 GZ	P	30.0	11.0	UKN					
12/01/11	SIM	416	0.99	CF 8166 EM	S	29.1	9.1	UKN					
06/30/10	SIM	417	0.98	122648	S	30.0	10.0	UKN					
06/30/10	SIM	418	0.99	CF 8674 SH	S	30.0	11.0	UKN					
10/22/10	SIM	420	0.99	1182676	P	31.0	10.5	UKN					
06/30/10	SIM	421	0.88	CF 7779 FG	S	29.0	9.6	UKN					
05/03/11	SIM	422	0.97	CF 0031 UW	P	30.0	10.0	UKN					
06/30/10	SIM	423	0.99	1202539	P	28.3	9.3	UKN					
06/30/10	SIM	424	0.99	CF 6754 RS	P	23.0	7.6	UKN					
01/03/11	SIM	425	1.00	CF 8024 PJ	P	26.0		UKN					
11/17/10	SIM	428	1.00	CF 8783 KP	S	30.0	9.6	UKN					
01/07/11	SIM	429	1.00	CF 0407 SG	P	33.0	10.5	UKN					
06/30/10	SIM	430	1.00	664278	P	27.2	9.8	UKN					
06/10/11	SIM	431	1.00	CF 3653 JZ	P	28.0	8.5	UKN					
06/30/10	SIM	433	1.00	CF 2527 SS	S	30.0	7.0	UKN					
09/01/11	SIM	434	0.88	1025672	P	60.0	16.0	UKN					
06/30/10	SIM	500	1.00	CF 0394 GJ	P	50.0	15.0	UKN					
11/15/11	SIM	502	0.99	1086407	P	29.9	11.5	UKN					
06/30/10	SIM	503	0.99	1228244	S	35.0	10.0	UKN					
12/20/11	SIM	504	1.00	1136766	P	33.0	12.0	UKN			DR	09/25/09	
	SIM	505	0.72					UKN					
06/30/10	SIM	506	1.00	1206686	P	33.2	10.4	UKN					

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06/30/10	SIM	508	1.00	CF 5319 JA	S	36.0	12.5	UKN					
12/22/11	SIM	509	1.00	1220560	S	38.7	13.3	UKN					
09/01/11	SIM	511	0.76	YW75837	S	39.0	12.7	UKN					
10/18/10	SIM	512	0.99	1118512	P	34.0	13.3	UKN					
03/12/10	SIM	513	0.97	1226671	S	42.5	13.6	UKN					
06/30/10	SIM	514	0.94	1090576	S	34.5	11.0	UKN					
10/14/11	SIM	515	0.94	1099191	P	41.0	13.8	UKN					
06/30/10	SIM	516	0.98	813499	S	34.0	11.3	UKN					
06/30/10	SIM	517	1.00	656960	S	39.7	12.2	UKN					
01/19/07	SIM	518	1.00	1118878	S	34.5	11.0	UKN					
06/30/10	SIM	519	0.97	1049769	S	40.2	13.2	UKN					
02/28/11	SIM	520	0.85	1130755	S	35.1	11.4	UKN					
06/30/10	SIM	521	0.97	693116	S	43.7	12.4	UKN					
06/30/10	SIM	522	0.99	942540	S	35.9	13.0	UKN					
09/01/11	SIM	523	0.68	1167984	S	36.0	12.0	UKN					
06/30/10	SIM	524	1.00	1045230	P	34.0	11.7	UKN					
06/26/10	SIM	525	0.98	1180878	S	37.0	12.1	UKN					
06/30/10	SIM	526	0.99	954794	P	63.5	17.0	UKN					
	SIM	600	0.70					UKN					
06/30/10	SIM	600 C	1.00	1140191	P	44.1	13.8	UKN					
	SIM	600 D	1.00					UKN					
09/12/11	SIM	600 E	1.00	1200466	P	55.0	17.3	UKN					
	SIM	600 F	1.00					UKN					
08/31/11	SIM	601	0.71	Guest	S	109.0	24.0	UKN					
08/31/11	SIM	602	0.64	Guest	S	85.0	24.0	UKN					
10/03/11	SIM	603	0.75	Guest	S	106.0	28.0	UKN					
06/30/10	SIM	604	0.74	941448	P	85.1	21.1	UKN					
	SIM	605	0.57					UKN					
05/31/11	SIM	606	0.74	1207179	P	115.0	26.0	UKN					
12/05/11	SIM	607	0.76	1063394	P	84.8	21.2	UKN					
08/31/11	SIM	608	0.39	Guest	M	140.0	30.0	UKN					
08/31/11	SIM	609	0.42	Guest	M	210.0	30.0	UKN					
06/30/10	SIM	609 A	1.00	360231	P	50.5	15.4	UKN					
06/30/10	SIM	610	0.77	912165	P	84.1	20.0	UKN					
10/31/11	SIM	611	0.74	GUEST	P	102.0	28.0	UKN					
09/18/11	SIM	612	0.63	Guest	P	92.0	21.6	UKN					
09/29/11	SIM	613	0.65	Guest	P	110.6	23.8	UKN					
	SIM	614	0.53					UKN					
	SIM	615	0.51		P			UKN					
	SIM	615	0.57					UKN					
	SIM	617	0.46					UKN					
	SIM	618	0.65					UKN					
	SIM	618 A	0.00					Vacant					

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	SIM	618 B	0.00					Vacant					
	SIM	618 D	0.00					Vacant					
	SIM	618 E	0.00					Vacant					
	SIM	618 F	0.00					Vacant					
08/29/11	SIM	010	0.96	CF 3423 EU	P	22.0	8.6	NON	INTERLUX PACIFICA		SI	08/29/11	0
08/11/09	SIM	206	1.00	CF 8685 JS	S	31.0	10.1	NON	INTERLUX PACIFICA		SI	08/11/09	
01/29/08	SIM	414	0.95	971746	S	30.0	9.0	NON	SEAHAWK MISSION BAY BLUE		SI	01/29/08	
08/02/10	SIM	426	1.00	NV 9722 KV	P	30.0	90.0	NON	INTERLUX PACIFIC	94-YBB263	OTH	04/06/10	
	SWYC	A1	1.00	CG 1124266	Sail	47'	12'	Cu	Pro Line 1800	1800		Mar-11	67%
	SWYC	A2	1.00	984899	Power	42'	13'	Cu	Blue Water ABZ 45	8801	Driscoll	Feb-09	45%
	SWYC	A3	0.98	CG 942555	Power	44'	13'11"	Cu	proline	1088	Marine Group	Jun-10	67%
	SWYC	A4	1.00	1065434	Power	45'	14'	Cu	Proline	1088	Shelter Island	May-09	58%
	SWYC	A5	0.10	1077877	Sail			Cu					50+
	SWYC	A6	1.00	1181715	Sail	47'	13'	Cu					50+
	SWYC	A7	1.00	CG 512010	Sail	49'	9'	Cu					50+
	SWYC	A8	0.90	CG 946222	Sail	46'	13'	Cu			Driscoll		50+
	SWYC	A9	0.89	CF 5880 GP	Sail	47'	13'	UKN			Koehler Kraft	Sep-09	
	SWYC	A11	0.85	1206414	Power	47'	14'	Cu	Interlux		shelter island	Mar-10	39%
	SWYC	A13	1.00	CG 937057	Power	44'	14'	Cu					50+
	SWYC	A14	0.95	CG 652880	Sail	42'	12'10"	Cu	Proline	1088	Shelter Island	Apr-06	67%
	SWYC	A15	0.95	695659	Power	44'	15'	Cu	Proline	1088	Shelter Island	May-10	67
	SWYC	A16	1.00	CG1154575	Power	46'	13'	Cu					50+
	SWYC	A17	0.95	CF 279880	Sail	49'	11'	Cu	Trinidad		Self	Jul-07	70%
	SWYC	A19	0.90	697064	Sail	34'	12'	Cu	Interlux Ultra	3669G	Koehler Kraft	Sep-11	60%
	SWYC	A20	0.98	CG 996248	Power	39'	13'7"	Cu	Interlux Ultra		shelter island	Feb-10	57%
	SWYC	A21	1.00	1152268	Power	30'	10'	Cu					50+
	SWYC	A22	0.98	CG 1135679	Sail	30'	29'	Cu	Proline	1088	shelter island	Mar-08	67%
	SWYC	A23	0.95	CF 0253 GH	Sail	35"	10'	Cu					50+
	SWYC	A25	1.00	CG 588713	Sail	30'	11'	Cu					50+
	SWYC	A26	1.00	CF 2444 JM	Sail	30'	11'	Cu					50+
	SWYC	A27	1.00	CF 5556 ER	Power	32'	11'6"	Cu			Shelter Island	May-09	67%
	SWYC	A28	0.95	558187	Sail	33'	9'6'	Cu			Driscoll	Nov-11	50+
	SWYC	A29	0.90	CG 1150621	Sail	34'5"	11"	Cu			Driscoll	Nov-09	50+
	SWYC	A30	1.00	CG1108873	Sail	28'	10'	Cu					50+
	SWYC	A31	1.00	CF 629095	Sail	32'	8'	Cu					50+
	SWYC	A32	1.00	CF 0678 JS	Sail	29'11"	10'10"	Cu	Proline	1088	Shelter Island	Mar-08	67%
	SWYC	A33	1.00	CG 1087119	Sail	30'	11'	UKN					
	SWYC	A34	0.95	CF 9264 HJ	Sail	28'4"	9'4"	Cu	Pettit		Shelter Island	Jan-11	65%
	SWYC	A36	1.00	CF 5900 HJ	Sail	31'	10'	Cu					50+
	SWYC	A37	1.00	CF 7142 AV	Power	26'	10'5"	Cu	Proline	1088	Koehler Kraft	1-Oct	67%
	SWYC	A38	1.00	CF 4465 CV	Power	28'	9'	Cu					50+
	SWYC	A39	1.00	1029112	Power	30'	10'5"	Cu	Pettit		Koehler Kraft	Sep-09	67%
	SWYC	A40	1.00	CF4757 HJ	Sail	33'	11'	Cu					50+
	SWYC	A41	1.00	CF3419 GL	Sail	29'	10'	Cu					50+

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	SWYC	A42	1.00	CF8934 SW	Sail	30'	11'	Cu					50+
	SWYC	A43	1.00	1037287	Sail	33'	11'	Cu	Interlux	Ultra	Shelter Island	Oct-11	67%
	SWYC	A45	1.00		Sail	35'	11'	UKN					
	SWYC	A46	0.93	CG581984	Sail	32'	10'6"	Cu	Proline	1088	Driscolls	Jul-10	67%
	SWYC	A49	0.90	CF8545KH	Sail	28'	9'6"	Cu	Interlux Ultra	3669	Driscoll	Feb-11	67%
	SWYC	A50	1.00	1050588	Sail	24'	10'	Cu					50+
	SWYC	A51	0.20	125941	Power	31'	10'	Cu					50+
	SWYC	A53	0.10	1092755	Sail	28'	10'	Cu					50+
	SWYC	A54	0.50	CF 5904 NM	Sail	24'	8'	Cu					50+
	SWYC	A56	1.00	CG1100932	Sail	30'8"	10'5"	Cu	Interlux	Ultra	shelter island	Nov-10	67%
	SWYC	A57	1.00		Sail	26'	7'	Cu					50+
	SWYC	A58	1.00	CF0845 GJ	Sail	28[	8'	Cu	Interlux	Ultra			67%
	SWYC	A61	1.00	CF7040 FY	Sail	30'	9'	Cu					50+
	SWYC	A62	1.00	CF8954 TK	Sail	30'	10'10"	Cu			Shelter Island	Aug-09	50+
	SWYC	A63	0.95	CF7147 RH	Power	26	8	UKN			Himself	Apr-09	
	SWYC	A65	1.00	CF6837 TH	Power	31'	8'	Cu					50+
	SWYC	A67	1.00	CF5092 VC	Power	32'	11'	Cu					50+
	SWYC	A68	1.00	CG 684658	Power			UKN					
	SWYC	A70	0.98	916726	Sail	32'	10'11"	Cu	Z Spar Pettit	B-91	Driscolls	Jun-10	65%
	SWYC	A71	1.00	CF7453 JW	Sail	30'	9'	Cu	Interlux Ultra		Koehler Kraft	Feb-11	50%
	SWYC	A72	1.00	CF2086 TX	Sail	30'	10'	Cu					50+
	SWYC	A73	1.00		Power	35'	10'	Cu					50+
	SWYC	A75	1.00	CF6181TK	Sail	31'	10'	Cu					50+
	SWYC	A76	1.00	CF4197SX	Sail	30'	11'	Cu					50+
	SWYC	A77	1.00	CG1031221	Sail	34'	12'	Cu					50+
	SWYC	A78	0.98	1111052	Sail	34'5"	11'	Cu	Interlux Ultra w/ Biolu	3779G Bla	Shelter Island	Mar-11	67%
	SWYC	A86	0.90	CF8718 TK	Power	31'	10'4"	Cu				Jan-11	50+
	SWYC	A88	1.00	CF5034 HN	Sail	30'6"	10'8"	Cu				Jul-10	50+
	SWYC	A90	0.99	4307FY	Sail	26'9"	9'	Cu	Interlux	Ultra	Shelter Island	Jan-10	67%
	SWYC	A92	1.00		Sail	31'	10'	Cu					50+
	SWYC	A94	1.00	1123344	Sail	38'2"	11'2"	Cu			Newport Beach	Mar-08	50+
	SWYC	A95	1.00	CF8136 EM	Sail	36'	12'	Cu					50+
	SWYC	B1	1.00	CG936537	Power	40'	14'	Cu					50+
	SWYC	B2	1.00	CG909278	Power	47'	14'	Cu					50+
	SWYC	B3	1.00	CG1117786	Power	37'	12'	Cu					50+
	SWYC	B4	1.00		Power	41'	13'	Cu					50+
	SWYC	B5	0.90	CG1167923	Power	44'	13'8"	Cu	Interlux Ultra		Shelter Island	Sep-10	67%
	SWYC	B6	1.00	10866	Sail	42'	13'	Cu			Driscoll	Aug-07	50+
	SWYC	B7	1.00	CG106065	Power	44'	14'	Cu	Pro Gold Anti06/Expary				50+
	SWYC	B8	0.98	683455	Sail	40'	12'	Cu	Proline Vinyl	1088	Shelter Island	Nov-09	56%
	SWYC	B10	0.85	CG684720	Sail	41'	11'10'	Cu	Interlux Ultra		Koehler Kraft	Sep-11	67%
	SWYC	B11	0.96	959661	Sail	45'	14'	Cu	Proline	1088	Shelter Island	Aug-06	67%
	SWYC	B12	1.00	SD105DZ	Power	36'	12'	Cu					50+
	SWYC	B13	0.98	CG926942	Sail	39'	12'	Cu	Proline	1088	Shelter Island	Jun-10	67%

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	SWYC	B14	0.98	512123	Sail	38'6"	11'9"	Cu			Shelter Island	Aug-10	50+
	SWYC	B16	0.98	CG1113568	Sail	36'	11'	Cu			Koehler Kraft	Nov-07	50+
	SWYC	B17	1.00	CG1034612	Sail	40'	13'	Cu	Proline	1088	Shelter Island	Feb-11	67%
	SWYC	B18	1.00	CG 909675	Sail	42'	13'	Cu					50+
	SWYC	B19	0.88	1172036	Sail	43'	14'6"	Cu			Shelter Island	Mar-11	50+
	SWYC	B20	1.00	CF1058 KC	Sail	38'	12'	UKN					
	SWYC	B21	0.95	CG1061438	Sail	37'6"	12'6"	Cu	Proline	1088	Shelter Island	Oct-09	67%
	SWYC	B22	0.80	CG 915080	Sail	40'	12'2"	UKN			Ventura	Aug-09	
	SWYC	B23	0.95	CF382055	Power	40'	12'6"	Cu	Interlux	3559	Shelter Island	Mar-10	67%
	SWYC	B24	1.00	CF3820SS	Sail	37'	12'	Cu					50+
	SWYC	B25	0.96	1220152	Sail	40'	13'10"	Cu	Proline	1088	Shelter Island	Jun-10	67%
	SWYC	B26	0.95	CG1060852	Sail	37'1"	12'4"	Cu	Interlux	1088	shelter island	May-07	68%
	SWYC	C2	1.00	CF3841HK	Power	40'	13'	Cu	Interlux w/ biolux				67%
	SWYC	C3	1.00	CF5444HT	Power	38'	13'	Cu					50+
	SWYC	C4	0.95	CG 600070	Power	33'	13'3"	Cu	Proline	1088	Shelter Island	Dec-11	67%
	SWYC	C5	1.00	STNAA2401102	Power	39'	13'6"'	Cu	Proline	1088	Shelter Island	Oct-09	67%
	SWYC	C6	1.00	CG1091296	Power			Cu					50+
	SWYC	C7	1.00	689650	Power			Cu					50+
	SWYC	C8	0.90	974065	Power	39'4"	13'	Cu	Proline	1088	Shelter Island	Apr-09	67%
	SWYC	C9	1.00	CG919608	Sail			Cu					50+
	SWYC	C10	1.00	CG1132779	Power			Cu					50+
	SWYC	C11	0.95	CG 665625	Power	50'	15'	Cu	Interlux w/ Biolux		Koehler Kraft	Jun-08	67%
	SWYC	C12	0.99	919132	Power	47'	16'	Cu	Interlux w/ Biolux		Balboa Boatyard	Oct-09	67%
	SWYC	C13	1.00	1213425	Sail	53'	16'	Cu	Pettit	1661	Shelter Island	Mar-11	13.10%
	SWYC	C14	0.88	1156703	Sail	40'	13'6"	Cu	Proline	1088C	Shelter Island	Oct-11	56%
	SWYC	C15	1.00	1163852	Sail	43'10"	14'2"	Cu	Proline	1088	Shelter Island	Jun-08	67%
	SWYC	C16	0.95	1070791	Sail	45'	15'	Cu	Proline	1088	Shelter Island	Oct-11	67%
	SWYC	C17	1.00	982110	Power	48'	14'	Cu					50+
	SWYC	C18	1.00					Cu					50+
	SWYC	C21	1.00	5181JE	Sail	34'	9'	Cu	Interlux	Ultra Plus	Driscoll	Apr-10	67%
	SWYC	C23	1.00	1057797	Sail	33'	11'6"	Cu					50+
	SWYC	C24	0.98	1139746	Sail	37'3"	12'9"	Cu			Shelter Island	Aug-09	
	SWYC	C25	0.95	680805	Sail	38'	12'6"	Cu	Interlux Ultra	3669	driscoll	Mar-10	>40
	SWYC	C26	0.98	CF8883GY				Cu					50+
	SWYC	C27	1.00	1202317	Power	38'	12'	Cu					50+
	SWYC	C28	0.90	1181355	Sail	33'3"	10'8"	Cu	Proline	1088	Driscoll	Jun-11	67%
	SWYC	C29	0.95	119675	Sail	34'	10'8"	Cu			Driscoll	2010	50+
	SWYC	C30	1.00	CF2773HL	Sail	30'	10'	Cu					50+
	SWYC	C32	1.00	1086325	Power	33'	10'6"	Cu	Pettit Trinidad SR	1088	Shelter Island	Jan-11	70%
	SWYC	C33	0.97	623343	Power	36'	12'4"	Cu	Proline	1088	Driscoll	May-10	67%
	SWYC	C34	0.77	1200281	Sail	37'1"	12'	Cu	Proline	1088	Shelter Island	Oct-11	67%
	SWYC	C35	1.00	CG992670	Sail	34'	12'	Cu					50+
	SWYC	C36	1.00	1168844	Sail	40'	12'	Cu					50+
	SWYC	C37	1.00	1117010	Power	34'	12'	Cu					50+

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	SWYC	D3	1.00	1103323	Sail	32'	11'	Cu					50+
	SWYC	D5	0.95		sail	34'	11'9"	Cu			Driscoll	Jun-11	50+
	SWYC	D6	1.00	1021087	Sail	40'	11'8"	Cu					50+
	SWYC	D7	0.98	1031909	Power	40'	13'	Cu	Interlux	Ultra	Shelter Island	Nov-11	67%
	SWYC	D8	1.00	CF0278FG	Sail	38'	13'	Cu					50+
	SWYC	D9	0.85	118022	Power	40'	13'	Cu	Interlux Ultra Kote		Driscoll	Jun-10	78%
	SWYC	D10	0.90	1121778	Sail	39'3"	12'	Cu					50+
	SWYC	D11	0.95	1166584	Sail	36'	11'4"	Cu	Proline	1088	Shelter Island	May-10	67%
	SWYC	D12	0.90	CF3478	Sail	32'	12'	Cu			Driscoll	Mar-08	50+
	SWYC	D13	0.92	1080149	Sail	33'9"	11'8"	Cu	Pettit Z Spar		Driscoll		65%
	SWYC	D14	0.90	974779	Sail	35'	11'4"	Cu	Interlux Ultra w/ Biolux		Koehler Kraft	Oct-10	67%
	SWYC	D15	1.00	CF7366JB	Sail	34'	12'	Cu	Proline	1088		2007	67%
	SWYC	D16	1.00	CF9770JL	Sail	36'	12'	Cu					50+
	SWYC	D18	1.00	1076969	Sail	36'1"	12'5"	Cu	Pettit		Driscoll	Jun-11	67%
	SWYC	D19	1.00	1084367	Power	34'	11'	Cu					50+
	SWYC	D20	1.00	952160	Power	32'	12'	Cu					50+
	SWYC	D21	1.00	1030197	Power	31'	10'	Cu					50+
	SWYC	D22	1.00	1060603	Sail	38'5"	12'	UKN			Shelter Island	Mar-09	
	SWYC	D23	0.95	1072764	Sail	36'	9'	Cu	Interlux		Driscoll	Nov-09	67%
	SWYC	D25	1.00	922977	Sail	35'	11'	Cu					50+
%	SWYC	D27	0.85	922803	Sail	38'	34'	Cu	Proline	1088	Shelter Island	Aug-07	50+
	SWYC	D28	1.00	976008	Sail	33'	11'	Cu					50+
	SWYC	D29	0.89	CF9634HB	Sail	36'	11'8"	Cu			Knight & Carver	Jun-11	30%
	SWYC	D30	1.00	592923	Power	42'	15'	Cu					50+
	SWYC	D31	1.00	CF4667JB	Power	40'	13'	Cu					50+
	SWYC	D32	1.00	978575	Sail	36'	12'	Cu					50+
	SWYC	D33	1.00	CF3684HL	Sail	41'	13'	Cu	Proline	1088		2008	67%
	SWYC	D34	0.95	907988	Power	42'	13'	Cu	Interlux Ultra w/ Biolu	3669	Shelter Island	Jun-10	67%
	SWYC	D35	1.00	1231443	Sail	37'	12'8"	Cu	Proline	1088C	Shelter Island	2009	59%
	SWYC	D36	0.98	289-465	Power	38'	13'	Cu	Interlux		Koehler	Oct-09	45%
	SWYC	D37	1.00	CG1094657	Sail	41'	9'	Cu			Shelter Island	Feb-09	50+
	SWYC	D38	1.00	1162928	Sail	42'	13'	Cu					50+
	SWYC	D39	0.92	947542	Power	38'	12'5"	Cu	West Marine CPP	5436936	Latitude 48	Aug-09	27%
	SWYC	D40	0.85	1195102	Sail	42'	13'	Cu			Driscoll	Nov-06	50+
	SWYC	D41	1.00	CF0612HJ	Sail	40'	15'	Cu					50+
	SWYC	D42	1.00	591563	Sail	40'		Cu	Proline 1088			Jun-07	67%
	SWYC	D44	1.00	1080336	Sail	48'	14'	Cu					50+
	SWYC	D45	0.98	CG645341	Sail	41'	12'	Cu	Trinidad	u/k	Koehler Kraft	Jun-08	60%
	SWYC	D46	0.98	1120492	sail	47'	14'8"	Cu	Interlux Ultra Blue	3669	Shelter Island	Nov-09	67%
	SWYC	D47	1.00	945537	Sail	49'	15'	Cu	Interlux			Feb-06	50+
	SWYC	D48	0.90	1109050	Sail	45'	14'	Cu	International Paint w/ Biolux		Shelter Island	May-11	67%
	SWYC	D49	1.00	705498	Power	45'	13'6"	Cu			Shelter Island	May-09	50+
	SWYC	D50	1.00	CF2064FH	Sail			Cu					50+
	SWYC	D52	1.00	1050044	Power	43'	14'	Cu					50+

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	SWYC	D53	1.00	635392	Sail	58'	20'	Cu					50+
	SWYC	D54	1.00	1165523	Sail	51'	14'	Cu					50+
	SWYC	D55	1.00	CF8600EX	sail	49'	15'	Cu					50+
	SWYC	D56	0.97	616345	Power	44'	14'5"	Cu	Pettit	Protector	Driscolls	Mar-11	67%
	SWYC	D57	1.00	1140929	Sail	50'	13'	Cu					50+
	SWYC	D58	0.95	654645	Power	51'7"	17'	Cu	Pettit Trinidad		Shelter Island	May-10	70%
	SWYC	D59	0.90	CG905101	Power	57'	46'	Cu	Pettit		Shelter Island	Jun-09	
	SWYC	D60	1.00	977464	Sail	55'	15'	Cu					50+
	SWYC	D61	1.00		Power	55'	16'	Cu					50+
	SWYC	D62	1.00	1100698	Power	64'	16'	Cu					50+
	SWYC	D63	0.50	505534	Power	60'	17'	Cu	Tropikote	2145	Baja Naval	Oct-11	75%
	SWYC	D64	0.95	69336C	Sail	70'	13'	Cu	Proline	1088	Koehler Kraft	Mar-10	67%
	SWYC	D66	1.00	981661	Power	67'	17'	Cu					50+
	SWYC	D67	0.95	CG 925539	Power	63'	15'5"	Cu	Pettit		Koehler Kraft		67%
	SWYC	D68	1.00	1113164	Power	58'	11'	Cu					50+
	SWYC	D69	0.85	906692	Power	57'	15'6"	Cu	Pettit Protector		Driscoll	Aug-11	67%
	SWYC	D70	0.90	639824	Sail	35'2'	12'4"	Cu	Proline	1088	Shelter Island	Feb-07	67%
	SWYC	D72	1.00	CF2709GC	Sail	33'	11'	Cu					50+
	SWYC	D73	1.00	1054321	Sail	34'	11'	Cu					50+
	SWYC	D74	1.00	CF6499TH	Sail	32'	10'	Cu					50+
	SWYC	D75	1.00		Sail	33'	11'	Cu					50+
	SWYC	D77	1.00	987098	Sail	35'	11'	Cu					50+
	SWYC	D78	0.90	CF4568HR	Sail	38'3"	12'6"	Cu	Proline		Shelter Island	Apr-10	67%
	SWYC	D79	0.95	904887	Sail	36'6"	12'	Cu	Proline	1088	Shelter Island	May-10	67%
	SWYC	D80	1.00	1092282	Sail	37'	12'	Cu					50+
	SWYC	D81	1.00		Sail	31'	10'	Cu					50+
	SWYC	D83	1.00		Sail	47'	15'	Cu					50+
	SWYC	D84	1.00		Sail	41'	13'	Cu					50+
	SWYC	D85	0.95	CG931306	Power	36'	13'5"	Cu			Shelter Island		50+
	SWYC	D86	0.90	1053865	Power	41'	14'11"	Cu	Interlux	CA Bottom	Driscoll	Sep-08	35%
	SWYC	D87	0.97	1069486	Power	36'	12'	Cu	Pro-Line		Shelter Island	Mar-11	67%
	SWYC	D88	1.00					Cu					50+
	SWYC	D89	1.00	CF9793SF	Sail	28'	6'	Cu					50+
	SWYC	D90	0.97		Power	24'	6'	Cu					50+
	SWYC	D91	0.90	1231129	Sail	28'	10'	Cu			Driscolls	Nov-10	40%
	SWYC	D93	1.00	CF3035KH	Sail	34'	13'	Cu	Pettit	1245	Marine Group	Aug-13	45.70%
	SWYC	D94	0.90	CF8505FK	Power	29'	10'	Cu			Shelter Island	Jul-09	50+
	SWYC	E2	0.98	970496	sail	35'2"	28'6"	Cu	Pettit Z Spar	B-91 Blue	Driscoll	Sep-09	65%
	SWYC	E3	1.00	CF2671SY	Sail	35'	11'	Cu					50+
	SWYC	E4	1.00	1168850	Sail	34'	11'	Cu	Interlux Ultra Blue	3669	Shelter Island	Dec-09	67%
	SWYC	E5	0.85	1095110	Sail	38'	12'	Cu	White Label Sea-Coa	45 ABL 86	Shelter Island	Feb-11	39.97%
	SWYC	E6	1.00	CF6100KB	Power	34'	11'11'	Cu	Seahawk Sharkskin		Driscoll	May-07	45%
	SWYC	E7	0.98	1034547	Power	37'	13'	Cu	Interlux	Ultra	shelter island	Jun-11	67%
	SWYC	E8	1.00	118725	Sail	38'	11'	Cu					50+

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
	SWYC	E9	1.00	947591	Sail	37'	12'	Cu					50+
	SWYC	E10	1.00	1045658	Sail	38'	12'	Cu					50+
	SWYC	E12	1.00	CF6403JA	Sail	30'	10'	Cu					50+
	SWYC	E13	1.00	CF8851AR	Sail	32'	9'	Cu	Proline	1088			67%
	SWYC	E14	1.00	CG9651125	Sail	36'	12'	Cu	Proline	1088	Shelter Island	Jan-11	67%
	SWYC	E15	0.95	CF7228SX	Sail	33'	11'	Cu	Interlux	ultra	Shelter Island	Jun-09	67%
	SWYC	E16	0.90	908708	Power	36'	13'	Cu	Pettit		shelter island	Apr-09	67%
	SWYC	E18	1.00	1135431	Sail	41'	12'	Cu					50+
	SWYC	E19	1.00	CF6373CY	Sail	44'	12'	Cu					50+
	SWYC	E20	0.88	679695	Sail	38'	12'6"	Cu			Shelter Island	Jul-10	50+
	SWYC	E21	1.00		Sail	42'	13'	Cu					50+
	SWYC	E22	1.00	1049467	Sail	39'	11'	Cu					50+
	SWYC	E23	0.95	1197802	Sail	35'2"	12'9'	Cu	Interlux		Shelter Island	Apr-10	100%
	SWYC	E24	1.00	1030948	Sail	39'	11'	Cu					50+
	SWYC	E25	0.95	CF0461SN	Power	44'	30'	Cu	ProLine	Y1088 C	Driscoll MB	Jul-09	59.40%
	SWYC	E27	0.85	954080	Sail	38'	12'	Cu	Interlux		Shelter Island	Jun-11	20%
	SWYC	E28	1.00	941443	Power	41'	14'	Cu					50+
	SWYC	E29	1.00	1022028	Sail	41'	12'	Cu					50+
	SWYC	E30	0.90	1222479	Sail	45'	14'	Cu	ProLine	1088		Aug-09	67%
	SWYC	E31	1.00	1049886	Sail	40'	13'	Cu					50+
	SWYC	E32	1.00	1047379	Sail	34'	12'	Cu					50+
	SWYC	E33	0.85	976415	Power	48'	14'6"	Cu	Proline	1088	Shelter Island	Oct-10	67%
	SWYC	E35	1.00	947145	Sail	39'	12'	Cu					50+
	SWYC	E36	1.00		Sail	36'	12'	Cu					50+
	SWYC	E37	1.00					Cu					50+
	SWYC	E38	0.98	CF1855UN	Sail	35'	11'9"	Cu			shelter island	Dec-10	50+
	SWYC	E39	0.95		sail	35'8"	11'9"	Cu	Intenational		shelter island	Jan-11	67%
	SWYC	E41	0.95	CG1039978	Sail	36'	12'	Cu	Interlux		Driscoll	Jan-10	41%
	SWYC	E42	0.98	987114	Sail	34'4"	11'	Cu	Interlux	3779	Shelter Island	Oct-11	67%
	SWYC	E43	0.98	CF8746HR	Sail	30'	10'8"	Cu	Proline	1088			57%
	SWYC	E44	1.00	1227991	Sail	32'	11'	Cu			Catalina Yachts	2010	50+
	SWYC	E46	1.00	690846	Sail	34'	11'	Cu					50+
	SWYC	E47	0.98	1055545	Power	36'	10'6"	Cu			Shelter Island	Aug-09	50+
	SWYC	E48	1.00	1096120	Sail	34'	12'	Cu					50+
	SWYC	E49	1.00	CF1591GH	Sail	34'	11'	Cu					50+
	SWYC	E50	0.98	CG928770	sail	28'	10'	Cu	Biolux	928770	Koehler Kraft	Jul-10	65%
	SWYC	E52	1.00	3449G2	sail	27'5"	10'	Cu	Proline	1088C	Shelter Island	Aug-11	66%
	SWYC	E53	0.98	VF9536JZ	Power	25'	10'	Cu	Interlux	YBA143	Marine Group	Apr-10	35%
	SWYC	E54	1.00	CF18589PY	Power	21'	8'	Cu					50+
	SWYC	E55	0.98	CF6216PW	Power	24'	8'	UKN				Aug-09	
	SWYC	E57	1.00	CF6602CL	Sail	24'	7'	Cu					50+
	SWYC	E58	1.00	CF1311SZ	Power	27'	6'	Cu					50+
	SWYC	E60	0.90	CF1024BC	Sail	21'	8'	UKN			Shelter Island	2010	
	SWYC	E61	0.95	CF8659GK	Power	23'	7'9"	Cu	Proline	1088	Driscolls	Sep-09	38%

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	SWYC	E63	1.00	CF8975RC	Power	25'	8'	Cu					50+
	SWYC	E65	1.00	CF7296SD	Power	22'4"	8'	Cu			Hipp Marine	Oct-05	50+
	SWYC	E68	1.00	1160783	Power	25'	8'	Cu			Shelter Island		50+
	SWYC	E69	1.00	1147766	Power	39'	15'	Cu					50+
	SWYC	E70	1.00		Sail	28'	10'	Cu					50+
	SWYC	F1	1.00	CF5475EG	Sail	35'	12'	Cu					50+
	SWYC	F2	0.85	1134526	Sail	35'4"	11'8"	Cu	Interlux Ultra	3779	Driscolls	Jun-10	67%
	SWYC	F4	1.00	99740				Cu					50+
	SWYC	F5	0.95	CG1104410	Sail	38'	13'	Cu	Interlux Ultra	3669	Shelter Island	Jan-11	67%
	SWYC	F6	1.00	985912				Cu					50+
	SWYC	F8	1.00	1031121	Sail	38'	13'	Cu					50+
	SWYC	F9	1.00	1052458		35'	12'	Cu					50+
	SWYC	F10	1.00		Power	35'	11'	Cu					50+
	SWYC	F11	1.00	1036888	Sail	39'	14'	Cu					50+
	SWYC	F12	0.95	1125399	sail	34'	11'	Cu	Interlux		Driscoll	Mar-11	67%
	SWYC	F13	1.00	CF9866HB	Sail	39'	12'	Cu					50+
	SWYC	F14	1.00					Cu					50+
	SWYC	F15	1.00	911291	sail	36'	12'	Cu	Interlux Ultra w/ Biolu	Ultra	Kohler Krafts	Jun-08	67%
	SWYC	F16	1.00	1151468	sail	35'	11'6"	Cu	Interlux		shelter island	Nov-11	67%
	SWYC	F17	1.00	912885	Sail	36'	12'	Cu					50+
	SWYC	F19	1.00	CF8683JS	Sail	34'	11'	Cu					50+
	SWYC	F20	0.98	CF6994HC	Sail	41'	12'	Cu	Proline	1099	Shelter Island	Oct-10	67%
	SWYC	F21	0.99	661977	Sail	39'5"	12'8"	Cu	Bottom Pro Gold		South Bay CA M	Jul-06	
	SWYC	F22	0.98	1166236	Sail	32'	10'9'	Cu	Interlux	Ulra (black)	Shelter Island	Jul-11	67%
	SWYC	F23	1.00	CF7989GB	Power	36'	11'	Cu					50+
	SWYC	F24	1.00	CF2413HW	Sail	41'	12'	Cu					50+
	SWYC	F25	0.95	1039324	sail	36'	11'	Cu			Shelter Island	Aug-09	50+
	SWYC	F27	0.95	1081682	Power	42'	14'	Cu	Interlux Ultra	3779	Shelter Island	Mar-10	67%
	SWYC	F28	1.00	CF4406PX	Power	24'6"	8'5"	Cu	Pettit	1881	Driscoll	Dec-09	40%
	SWYC	F29	1.00	CF9314HN	Sail	34'	10'	Cu					50+
	SWYC	F30	0.95	648745	Power	41'	13'11"	Cu	Interlux		shelter island	Aug-11	67%
	SWYC	F32	0.95	CF4751 SB	sail	28'6"	9'5"	Cu			shelter island	Jan-08	50+
	SWYC	F35	1.00	676964	sail	25'	9'	Cu			shelter island	Jun-10	50+
	SWYC	F36	1.00	CF0269HF	sail	27'	8'	Cu	Proline	1088	Shelter Island	Feb-08	67%
	SWYC	F38	1.00	CF77594B	Sail	26'	7'	Cu					50+
	SWYC	F39	1.00	CF2944KL	Power	20'	7'	Cu	Pettit	B91 Blue	Driscoll	Jul-10	65%
	SWYC	F40	1.00					Cu					50+
	SWYC	F41	1.00		Sail	24'	7'	Cu					50+
	SWYC	F42	1.00	CF7395NB	Power	21'	8'	Cu	Proline		Shelter Island	Jan-07	67%
	SWYC	F45	0.97	44825A	Power	24'	8'	Cu	Interlux Ultra		Shelter Island	Mar-10	67%
	SWYC	F48	1.00		sail	24'	6'	Cu					50+
	SWYC	F49	1.00	CF5339GZ	Sail	24'	6'	Cu					50+
	SWYC	F50	1.00	CF6661	sail	27'	6'	Cu					75%
	SWYC	F51	1.00	CF5014SS	Sail	24'	6'	Cu	Interlux Ultra			Jul-11	50%

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	SWYC	F52	1.00	CF2602GR	Sail	27'	8'	UKN					
	SWYC	F53	1.00	CF7886HV	Sail	25'	8'	Cu	Pettit Trinidad SR	1277	CA Marine Servi	Jan-07	70%
	SWYC	F54	1.00					Cu					50+
	SWYC	F55	1.00	CF5333PN	Power	22'	5'	Cu					50+
	SWYC	F56	1.00		Power	24'	8'	Cu					50+
	SWYC	F57	1.00	CF5014SS	sail	19'	7'	Cu	Interlux Ultra	Ultra	Shelter Island	Feb-11	67%
	SWYC	F58	1.00					Cu					50+
	SWYC	F59	1.00	CF9327	sail	21'	6"	Cu					50+
	SWYC	F61	0.98	CF3136	Power	22'	8'	Cu	Zspar B-90	60061-49	Aquarius		65%
	SWYC	F62	1.00					UKN					
	SWYC	A80	1.00		Sail	33'	10'	CU					50+
	SWYC	A82	1.00	CF4200 HE	Sail	30'	11'	Cu					50+
	SWYC	A24	0.87	CF1972AV	Sail	33'	6'7"	LCu	Interlux Trilux 33	3734316	Koehler Kraft	Jun-11	24%
	SWYC	A55	0.88	1088393	Sail	30'	10'3"	LCu	Pettit Vivid	1161	Driscoll	Dec-10	25%
	SWYC	D4	0.95	1123615	Sail	35	9'8"	LCu	Seahawk	af-33	Knight + Barver	Jul-07	33%
	SWYC	A10	1.00	CF 1585 GP	Power	48'	15'	Non-unconf			Koehler Kraft	Apr-10	0
	SWYC	A12	1.00	CG 1059878	Power	50'	16'	Non-unconf					0
	SWYC	A18	0.95	CF 0547 TP	Sail	44'	13'	Non-unconf					0
	SWYC	B9	1.00	CG958030	Power	38'	14'	Non-unconf					0
	SWYC	C22	1.00	CG1125756	Power	36	13	Non-unconf			koehler	2008	0
	SWYC	C31	1.00	CF42133SS	35'	11'		Non-unconf					0
	SWYC	D1	1.00	CF1237GH	Sail	30'	12'	Non-unconf					0
	SWYC	D17	0.90	1083695	Sail	33'4"	12'3"	Non-unconf				2008	0
	SWYC	D71	1.00		Sail	36'	13'	Non-unconf					0
	SWYC	D76	1.00	CG925991	Power	37'	13'	Non-unconf			Baumont	Feb-10	0
	SWYC	E11	1.00	967216		38'	13'	Non-unconf					0
	SWYC	E34	0.95	688067	Sail	34'	11'	Non-unconf					0
	SWYC	E40	1.00	744268	Sail	30'	10'8"	Non-unconf					0%
	SWYC	E51	0.95	1210094	Power	28'	8'5"	Non-unconf			P & K Marine	Mar-10	0
	SWYC	F3	1.00	CF2086HR	Sail	33'	11'	Non-unconf					0
	SWYC	F7	1.00	CG908254	Sail	36'	11'	Non-unconf			Shelter Island	Feb-07	0
	SWYC	F33	1.00	CF1193NJ	Sail	36'3"	8'3"	NON	EP 2000		Shelter Island	Aug-08	0
	SWYC	F43	0.95	8988GT	Sail	27'	5'4"	Non-unconf			Driscoll	2009	0
	SWYC	A44	0.00					Vacant					
	SWYC	A47	0.00					Vacant					
	SWYC	A52	0.00					Vacant					
	SWYC	A60	0.00					Vacant					
	SWYC	A84	0.00					Vacant					
	SWYC	A85	0.00					Vacant					
	SWYC	A87	0.00					Vacant					
	SWYC	A89	0.00					Vacant					
	SWYC	A91	0.00					Vacant					
	SWYC	A93	0.00					Vacant					
	SWYC	A96	0.00					Vacant					

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	SWYC	D2	0.00					Vacant					
	SWYC	D92	0.00					Vacant					
	SWYC	E1	0.00					Vacant					
	SWYC	E56	0.00					Vacant					
	SWYC	E59	0.00					Vacant					
	SWYC	E66	0.00					Vacant					
	SWYC	F18	0.00					Vacant					
	SWYC	F31	0.00					Vacant					
	SWYC	F37	0.00					Vacant					
	SWYC	F46	0.00					Vacant					
	SWYC	F47	0.00					Vacant					
	SWYC	F60	0.00					Vacant					
	SWYC	A35	0.95	CF 8947 HB	Sail	30'	10'10"	NON	Interlux Pacifica			2008	0
	SWYC	A48	0.98	1209167	Power	30'1"	9'6"	NON	Interlux Pacifica	Ultra-Black	Shelter Island Bo	Oct-10	0
	SWYC	A59	1.00	CF7776 FX	Power	29'	8'6"	NON	Interlux Pacifica		Koehler Kraft	Feb-10	0
	SWYC	A64	1.00	CF2353 GJ	Sail	30'	11'	NON	Interlux Pacifica				0
	SWYC	A69	1.00	1232431	Sail	28'	10'	NON	Interlux Pacifica			Jun-07	0
	SWYC	A74	1.00	5222	Power	26'	3'	NON-unconf	I				0
	SWYC	A79	1.00	CF0138 HY	Sail	32'	6'5"	NON	Interlux Pacifica		Driscolls		0
	SWYC	A81	0.90	CG1027487	Sail	24'	8'	NON	Interlux Pacifica		Shelter Island	2010	0
	SWYC	A83	0.95	1186905	Sail	30'6"	11'4"	NON	Interlux Pacifica		Shelter Island	Oct-10	0
	SWYC	B15	0.95	CG969802	Sail	41'5"	12'	NON	Interlux Pacifica		Shelter Island	Mar-10	0
	SWYC	C1	1.00	1193337	Power	34'5"	13'	NON	Interlux Pacifica		Driscoll	Oct-09	0
	SWYC	C19	1.00	1190038	Power	45'	15'	NON	Interlux Pacifica			Dec-10	0
	SWYC	C20	1.00	1151268	Power	36'	11'11"	NON	Interlux Pacifica		Koehler Kraft	Jul-09	0
	SWYC	D24	0.99	1142416	Power	33'	10'5'	NON	Interlux Pacifica	YBA163	Shelter Island	Jun-08	0
	SWYC	D26	1.00		Sail	34'	11'9"	NON	Interlux Pacifica		Ventra Marina	Sep-09	0%
	SWYC	D43	0.95	1093696	Power	51'	15'	NON	Interlux Pacifica		Shelter Island	Apr-11	0
	SWYC	D51	1.00	1020736	Power	42'	15'6"	NON	Interlux Pacifica		shelter island		0
	SWYC	D65	0.90	546129	Power	54'	17'	NON	Interlux Pacifica		Shelter Island	May-10	0
	SWYC	D82	0.95	CG1226672	Sail	36'9"	11'10"	NON	Interlux Pacifica		Shelter Island	Apr-10	0
	SWYC	E17	1.00	688885	Power	39'	13'8"	NON	Interlux Pacifica		Koehler Kraft	Jun-07	0
	SWYC	E26	0.95	1143453	Sail	43'	14'2"	NON	Interlux Pacifica		shelter island	Feb-10	0
	SWYC	E45	0.95	CF8755JA	Sail	34'	13'	NON	Interlux Pacifica		Koehler Kraft	May-11	0
	SWYC	E62	0.98	CF9001TK	Power	22'	6'	NON	Interlux Pacifica		Shelter Island	Jan-10	0
	SWYC	E64	1.00	CF5324JA	Sail	25'	8'	NON	Interlux Pacifica		Driscoll	2006	0
	SWYC	E67	1.00	NV6617-KY	Power	19'	8'	NON	Interlux Pacifica		Shelter Island	Jan-11	0
	SWYC	F26	1.00	1086107	Power	36'	12'6"	NON	Interlux Pacifica		shelter island	Feb-11	0
	SWYC	F34	1.00	4545	sail	27'	8'	NON	Interlux Pacifica		shelter island		0
	SWYC	F44	0.90	CF2139UH	Power	23'	7'6"	NON	Interlux Pacifica		Nexus Marine	Jun-09	0
12/20/11	TON	1	0.99	Broker Boat	P	34	13	LCu	Hydrocoat		OTH		40%
12/20/11	TON	2	0.98	Broker Boat	P	34	13	LCu	Hydrocoat		OTH		40%
12/20/11	TON	3	0.99	Broker Boat	P	35	9.75	LCu	Hydrocoat		OTH		40%

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12/20/11	TON	4	0.98	Broker Boat	P	33	11	LCu	Hydrocoat		OTH		40%
12/20/11	TON	5	0.98	Broker Boat	P	42	14.5	LCu	Hydrocoat		OTH		40%
12/20/11	TON	6	0.99	Broker Boat	P	68	19	LCu	Hydrocoat		OTH		40%
12/20/11	TON	7	0.99	Broker Boat	P	34	13	LCu	Hydrocoat		OTH		40%
12/20/11	TON	8	0.00					Vacant					
12/20/11	TON	9	0.00					Vacant					
12/20/11	TON	10	0.00					Vacant					
12/20/11	TON	11	0.00					Vacant					
	Trans	1	0.42					UKN					
	Trans	2	0.42					UKN					
	Trans	3	0.68					UKN					
	Trans	4	0.78					UKN					
	Trans	5	0.71					UKN					
	Trans	6	0.65					UKN					
	Trans	7	0.70					UKN					
	Trans	8	0.62					UKN					
	Trans	9	0.75					UKN					
	Trans	10	0.48					UKN					
	Trans	11	0.59					UKN					
	Trans	12	0.59					UKN					
	Trans	13	0.42					UKN					
	Trans	14	0.59					UKN					
	Trans	15	0.58					UKN					
	Trans	16	0.74					UKN					
	Trans	18	0.29					UKN					
	Trans	19	0.76					UKN					
	Trans	20	0.85					UKN					
	Trans	21	0.69					UKN					
	Trans	22	0.66					UKN					
	Trans	23	0.86					UKN					
	Trans	24	0.70					UKN					
	Trans	25	0.47					UKN					
	Trans	26	0.27					UKN					
	Trans	27	0.37					UKN					
	Trans	28	0.75					UKN					
	Trans	29	0.42					UKN					
	Trans	30	0.04					UKN					
	Trans	33	0.55					UKN					
	Trans	?	0.27					UKN					
	Trans	0-2	0.04					UKN					
	Trans	29X	0.05					UKN					
	Trans	3X	0.12					UKN					
1/31/12	HPD	N/A	0.30	Port ID #7716	P	32	12	Cu	UKN	UKN		2006	UKN
1/31/12	HPD	N/A	0.50	Port ID #7717	P	32	12	Non	HEMPEL	Hempasil X	Shelter Island	Jun-11	0

Date	Facility	Slip/ Mooring Number	Percent of Time Occupied	Vessel Document # or Registration #	Vessel Type	Vessel Length	Vessel Beam	Paint Type	Paint Name	Product Number	Boatyard	Painting Date	% Copper
1/31/12	HPD	N/A	0.50	Port ID #7718	P	32	12	Non	International	Intersleek 9	Shelter Island	Jun-11	0
1/31/12	HPD	N/A	0.50	Port ID #7719	P	32	12	Non	International	Intersleek 9	Shelter Island	Dec-10	0
1/31/12	HPD	N/A	0.50	Port ID #7762	P	31	10	Non	Epaint	SN-1	UKN	2008	0
1/31/12	HPD	N/A	0.50	Port ID #7763	P	31	10	Non	Epaint	SN-1	UKN	2009	0
1/31/12	HPD	N/A	0.85	Port ID #9066	P	36	10	Non	Epaint	SN-1	UKN	2009	0
1/31/12	HPD	N/A	0.30	Port ID #9138	P	39.1	13	Non	Epaint	Sunwave	Manufacturer	2010	0
1/31/12	HPD	N/A	0.30	Port ID #9139	P	39.1	13	Non	Epaint	Sunwave	Manufacturer	2010	0
1/31/12	HPD	N/A	0.60	Port ID #7708	P	40	14	Non	International	Intersleek 9	Shelter Island	Jun-11	0
1/31/12	HPD	N/A	0.60	Port ID #7730	P	34	8	Non	International	Intersleek 9	Shelter Island	Jun-11	0
1/31/12	HPD	N/A	0.80	Port ID #7750	P	23	8	Non	International	Intersleek 9	Shelter Island	Jun-11	0
1/31/12	GST	03-01	0.90	Port ID #7720	P	20	7	Non	International	Intersleek 9	Shelter Island	Jun-11	0
1/31/12	GST	03-02	0.60	Port ID #9144	M	20	8	Non	International	Intersleek 9	Manufacturer	2011	0

Table A-2. Shelter Island Yacht Basin 2011 Vessel Tracking Data for Port-Operated Anchorage

Date	Vessels	% Occupancy of 40 Moorings	# of Moored Days per 3-day Permit
1/7/2011	8	20	2
1/14/2011	32	80	2
1/21/2011	6	15	2
1/28/2011	17	43	2
2/4/2011	12	30	2
2/11/2011	22	55	2
2/18/2011	27	68	2
2/25/2011	4	10	2
3/4/2011	13	33	2
3/11/2011	11	28	2
3/18/2011	7	18	2
3/25/2011	19	48	2
4/1/2011	23	58	2
4/8/2011	9	23	2
4/15/2011	22	55	2
4/22/2011	19	48	2
4/29/2011	21	53	2
5/6/2011	24	60	2
5/13/2011	15	38	2
5/20/2011	26	65	2
5/27/2011	41	103	2
6/3/2011	13	33	2
6/10/2011	38	95	2
6/17/2011	19	48	2
6/24/2011	37	93	2
7/1/2011	55	138	2
7/8/2011	21	53	2
7/15/2011	38	95	2
7/22/2011	17	43	2
7/29/2011	41	103	2
8/5/2011	31	78	2
8/12/2011	27	68	2
8/19/2011	27	68	2
8/26/2011	38	95	2
9/2/2011	38	95	2
9/9/2011	16	40	2
9/16/2011	24	60	2
9/23/2011	18	45	2
9/30/2011	17	43	2
10/7/2011	44	110	2
10/14/2011	40	100	2
10/21/2011	38	95	2
10/28/2011	40	100	2
11/4/2011	18	45	2
11/11/2011	27	68	2
11/18/2011	12	30	2
11/24/2011	18	45	2
12/2/2011	13	33	2
12/9/2011	15	38	2
12/16/2011	10	25	2
12/23/2011	10	25	2
12/30/2011	44	110	2

Shelter Island Yacht Basin Master Leaseholders, Hull Coating Data Compiled Jan15, 2012

	Average Yearly Occupancy Percentage	Number of Slips	Number of Vacant Slips	Number of Non-copper Painted Hulls	Number of Hulls not loading copper into basin	Number of Low Copper Hulls
Bay Club Marina	96	156	6	2	8	14
Kona Kai	61	526	206	2	208	16
Shelter Isl Marina	86	135	19	9	28	9
Half Moon Marina	92	178	14	5	19	3
Crow's Nest	41	26	15	0	15	8
Gold Coast	76	35	8	2	10	9
SDYC	90	572	57	37	94	138
SGYC	83	141	24	3	27	58
SWYC	90	383	38	48	86	42
Tonga Landing	73	11	3	0	3	7
La Playa YC	100	4	0	1	1	1
TOTALS				109	500	305
Loading Reduction						**30%**

Appendix B
Best Management Practice Plans

Shelter Island Master Leaseholders
TMDL Group

BMP Plan
And
TMDL Compliance

Table of Contents

Overview of Our Commitment

It is the intention of the Shelter Island Master Leaseholders TMDL Group to be committed in doing its part, to the fullest extent possible, to comply with TMDL requirements, loading allocations, and schedules for achieving required copper loading reductions. The following BMP plan is intended to help us achieve these goals.

Compliance Items in Place

- Formation of the Shelter Island Master Leaseholders (SIML) TMDL Group
  - Unanimous and voluntary participation by all SIML's

- SIML's began attendance of TMDL stakeholder meetings in 2005.

- All SIML's are certified Clean Marinas or in the process of becoming certified.

- All SIML's are collecting vessel hull paint information and tracking as required by the Port of San Diego and the TMDL.

- Hull Cleaner Compliance

  - Check to ensure all divers have valid Port of San Diego Hull Cleaning Permits prior to entry of leasehold.

  - Report hull cleaners who arrive via boat and do not check in with the Dockmaster's Office to the Port of San Diego.

  - Report hull cleaners to the port of San Diego that do not use proper BMP's or who create visible paint plumes during hull cleaning.

  - Posted diver BMP signs on leasehold.

- Boater Education
  - Committed to ongoing TMDL education using the following tools:

    - Newsletters
    - Workshops
    - Readily available literature

- Require boaters to use only Port permitted hull cleaner's

- Regular BMP Assessments
- Ongoing Staff Training
- Alternative Paint Incentive Programs planned to include:
  - Wait List Priority
  - Financial Incentives
  - Regular BMP Assessments

Table B-1. Best Management Practices and Other Actions Implemented by the Port to Reduce Dissolved Copper Loads

BMP TYPE	DESCRIPTION	LOCATION	PURPOSE(S)	TARGETED OUTCOME(S)	ASSESSMENT MECHANISM	SCHEDULE / STATUS	PARTNER
Defined Projects for Stage 2 (2007-2012)							
Policy/ Regulation	In-water Hull Cleaning Permit: An ordinance was developed to reduce or eliminate copper loading from in-water hull cleaning activities. The ordinance requires that all in-water hull cleaning be conducted in a manner that does not produce a visible paint plume or cloud, and that all hull cleaning businesses operating on Port tidelands obtain a Port permit.	SIYB Bay-wide	The objective of the In-Water Hull Cleaning regulation is to reduce or eliminate copper pollution caused by hull cleaning activities in San Diego Bay.	Load reduction: All hull cleaning businesses operating on Port Tidelands have obtained permits and follow industry standard BMPs.	# of permitted in-water hull cleaning businesses/ total in-water hull cleaning businesses	Start Date: Fiscal Year (FY) 10 Completion Date: Ongoing. Permits are to be reissued two years following initial date of issuance. Status: Implementation of the two-year permit is complete. The Port conducted a thorough public outreach process to gather input and hear concerns about the proposed hull cleaning regulations. The Port conducted three public workshops during this reporting period to seek input from the boating community, professional divers, marinas, and others in order to better understand the in-water hull cleaning industry and identify environmental impacts and solutions to minimize those impacts. The Port issued press releases and used other media sources to advertise workshops and communicate key project milestones. The Board of Port Commissioners approved the Permit and Code Amendment during this reporting period and the permit became effective on November 1, 2011. As of December 31, 2011, 50 in-water hull cleaning companies obtained permits.	
Policy/ Regulation	Copper Hull Paint Legislation Senate Bill (SB) 623 (Kehoe): The Port is involved in the development of state legislation that will phase out the use of copper paints on most recreational vessels in California Port staff began working as a co-sponsor of SB 623 regarding regulation of copper hull paints with Senator Kehoe's office, San Diego Coastkeeper, and Sacramento	SIYB Bay-wide Statewide	This bill supports the Port's efforts to reduce copper pollution in San Diego Bay marinas by controlling copper loading throughout the state.	Load reduction: Approval of SB 623		Start Date: FY11 Completion Date: FY11 Status: Port staff traveled to Sacramento to testify at the Senate Environmental Quality Policy Committee on May 2, 2011, and participated in a stakeholder forum on May 19, 2011. In August 2011, SB 623 became a two-year bill. Since then it has passed out of the Senate and currently is being held in Assembly Appropriations. This committee will not discuss SB 623 until July or August 2012. Port is continuing outreach efforts to stakeholders.	Senator Christine Kehoe, San Diego Coastkeeper

BMP TYPE	DESCRIPTION	LOCATION	PURPOSE(S)	TARGETED OUTCOME(S)	ASSESSMENT MECHANISM	SCHEDULE / STATUS	PARTNER
	legislative consultants.						
Policy/ Regulation	Brake Pad Legislation: The project involves providing support for SB 346 (Kehoe) which requires for brake pads sold in California to contain no more than 0.5% copper by 2025. In addition, the bill will: 1) creates limits for other brake pad materials; 2) establishes a certification process by a third party testing agency and requires Department of Toxic Substances Control to charge a fee to cover the costs; 3) establishes civil penalties for violations; and 4) creates a Brake Friction Materials Water Pollution Fund.	Bay-wide Statewide	The Port supported Sustainable Conservation's Brake Pad Partnership technical efforts legislatively this reporting period by providing letters of support. The Port's support was critical in obtaining Senator Kristine Kehoe's sponsorship of SB 346 (Kehoe).	Load reduction: reduction of copper in brake pad materials.	Support of Sustainable Conservation; Approval of Senate Bill 346 (Kehoe)	Start Date: FY09 Completion Date: FY11 Status: Complete. The bill was signed by Governor Schwarzenager in September 2010.	
Alternative Hull Paint Studies	USEPA-funded "Safer Alternatives to Copper Antifouling Paints" Project: The grant presented a platform to test the effectiveness of several types of alternative non-copper paints and allow comparisons between emerging paint products. Testing occurred in two phases: panel and boat testing.	SIYB Bay-wide Statewide	The objective of the project was to identify and promote the use of effective non-copper antifouling paints.	Completeness: Development of a standardized protocol for testing the effectiveness of new coatings and a viable alternatives list.	Completed study and final report was prepared by the Port and Dr. Katy Wolf (Institute for Research and Technical Assistance).	Start Date: FY07 Completion Date: FY11 Status: Complete Final report was submitted January 31, 2011. The project was determined to be successful in achieving its goal of identifying viable alternative hull paints to copper hull paint.	
Alternative Hull Paint Studies: Long-term Hull Paint Testing Program	Development: Development of a panel testing program to evaluate new and emerging coatings and technologies	SIYB Bay-wide Statewide	The objective of the project was to identify effective non-copper antifouling paints through panel testing.	Completeness/Change in Awareness	A standardized protocol for testing the effectiveness of new coatings has been developed.	Start Date: FY09 Completion Date: On-going Status: Tested 22 new alternative hull paints from August 2009 – August 2010. Tested 18 new alternative hull paints from August	Paint manufacturers, Boatyards, Marinas/yacht clubs

BMP TYPE	DESCRIPTION	LOCATION	PURPOSE(S)	TARGETED OUTCOME(S)	ASSESSMENT MECHANISM	SCHEDULE / STATUS	PARTNER
						2010 – August 2011. No testing occurred during FY 12, but additional testing will occur in the future.	
Alternative Hull Paint Studies: Long-term Hull Paint Testing Program	Hornblower Cruises Paint Testing Partnership	SIYB Bay-wide Statewide	The objective of the project was to test alternative hull paints and spread awareness of the alternative hull paint options. The project is proving to be extremely beneficial in educating the public and spreading the Port's message on hull paint transition	Change in Awareness	Completed Study/ Boater surveys	Start Date: FY09 Completion Date: On-going Status: Tested 10 alternative hull paints from 2009-2011. Continued partnership by testing 10 alternative hull paints from 2011-2013.	Hornblower Cruises
Alternative Hull Paint Studies: Long-term Hull Paint Testing Program	Alternative Product Development Financial support for this research was provided by the Port's Environmental Fund.	SIYB Bay-wide Statewide	The Port continued to support new product development by funding research projects to develop alternative hull paints and/or associated technologies.	Completeness: Development of new viable alternative hull paints	Completed study and final report	Start Date: FY11 Completion Date: FY13 Status: There are three funded projects that are designed to be completed within two years.	Paint manufacturers, Academia
Alternative Hull Paint Studies: Long-term Hull Paint Testing Program	San Diego State University MBA Consulting Program's Antifouling Paint Contacts Project	Bay-wide	Identify alternative hull paint products available world-wide and develop a contact list	Completeness: Database of contacts and an understanding of global efforts	Completed study and final report	Start Date: FY09 Completion Date: FY09 Status: Complete	
Hull Paint Transition	Transition of Port Fleet to Non-copper Hull Paints by 2012	SIYB	To facilitate the reduction of copper loading to SIYB in compliance with interim and final loading reduction targets	Load reduction: 100% of fleet transitioned to non-copper hull paints	# converted/ total	Start Date: FY09 Completion Date: FY11 Status: Complete. All Port boats have been converted.	
Hull Paint Transition/ Grant Funding/ Incentives	319(h) Hull Paint Conversion Project: The project is designed to reduce the levels of copper in SIYB by encouraging boaters to switch from copper to non-biocide hull paint. The project consists of three primary components: 1) education and outreach, 2) load reduction via hull paint conversion, and 3) long-term tracking of vessel conversion using a web-based system.	SIYB	The purpose of the project is to convert SIYB boats to non-copper hull paints. This is consistent with the implementation strategy identified in the SIYB TMDL Technical Report.	Load reduction: ~200 vessels converted to non-toxic hull paints	# of vessels converted and tracking size of vessels to determine loading reduction	Start Date: FY11 Completion Date: FY14 Status: • 43 Boat Owner Interest Forms have been submitted to date • Five boat owners have submitted signed agreements and slip location verification documentation • One task authorization form was sent to boatyard • Completed consultant selection, contracting and initiated the development of the conceptual design of vessel tracking database • Developed an outreach approach for the SIYB Copper Hull Paint Conversion Project and drafted associated outreach materials by working with stakeholders and consultants. Meetings	Paint manufacturers, Boatyards

BMP TYPE	DESCRIPTION	LOCATION	PURPOSE(S)	TARGETED OUTCOME(S)	ASSESSMENT MECHANISM	SCHEDULE / STATUS	PARTNER
	The Port initiated work on the SIYB Copper Hull Paint Conversion Project on February 15, 2011.					were held with project stakeholders to discuss appropriate outreach approaches to effectively reach the boating community. During these meetings, each party's role in the outreach efforts was identified. • Developed the process and procedures for implementing the hull paint conversion project • Met with participating boatyards • Met with project stakeholders five times to discuss appropriate outreach approaches that will effectively reach the boating community • Established a new web domain dedicated for the Port's Copper Reduction Program web page to make it easier for boat owners to reach grant-related information, as well as general copper pollution information	
Education/ Outreach	San Diego State University MBA Consulting Program's Copper Reduction Program Marketing Strategy	Bay-wide	The Port partnered with the San Diego State University's MBA Business Consulting Program to develop a marketing strategy that identified the most effective approaches to reach boaters and change hull paint behaviors.	Completeness/Change in Awareness	Completed study and final report	Start and Completion Date: FY11 Status: Project completed in May 2011. The Port began to coordinate internally to initiate some of the approaches identified in the strategy during this reporting period.	San Diego State University
Education/ Outreach	Booths at major events	SIYB Bay-wide	Distribution of brochures and other educational materials for the public of the copper pollution issue, available non-biocide hull paint options, or of the Grant funds available to assist in transitioning to non-biocide hull paints.	Change in Awareness/Change in Behavior	# of posted advertisements or pamphlets distributed; # of people applying for 319h Hull Paint Conversion Project funds at the events; Results from public opinion/awareness or applicant surveys (as applicable)	On-going Status: Booths at six events • Sun Road Boat Show on 1/27/10 – 1/30/11. Estimated 13,300 in attendance over the timeframe of the event. No surveys distributed. • Day at the Docks on April 17, 2011. Estimated 1,000 in attendance. No survey distributed. • Boater Safety Day at Shelter Island Marina – May 21, 2011. Approx. 20 people in attendance. No survey distributed. • 319h Hull Paint Conversion Project Public Workshop / Media Event on August 6, 2011. More information on this event below. • World Trade Center Peace and Prosperity event on September 10, 2011. No survey distributed. • America's Cup World Series (AC World Series) event on November 12-20, 2011. No survey distributed.	
Education/ Outreach	Workshops/seminars for Boaters	SIYB Bay-wide	Conduct educational workshops for the public to provide information on non-	Change in Awareness/Change in	# of people attending; # of	On-going	All Named Parties

BMP TYPE	DESCRIPTION	LOCATION	PURPOSE(S)	TARGETED OUTCOME(S)	ASSESSMENT MECHANISM	SCHEDULE / STATUS	PARTNER
			copper hull paints.	Behavior	people applying for 319h Hull Paint Conversion Project funds as a result of the event; results from applicant surveys; pre/post-tests; sign-in sheets from workshops	Status: 319h Hull Paint Conversion Project Public Workshop / Media Event (August 6, 2011): • Approximately 150 people attended. • Announcement published in three local boating publications (Latitude 38, Bluesky News and The Log) • Five boatyards, five paint manufacturers, UC Coastal Resources Program, and the Port were present and had booths	
Education/ Outreach	Education brochures/outreach materials/press releases	SIYB Baywide	Development of brochures and other educational materials for the public of the copper pollution issue, available non-biocide hull paint options, or of the grant funds available to assist in transitioning to non-biocide hull paints. The Port worked with stakeholders and consultants to finalize outreach materials.	Change in awareness	# of brochures, pamphlets, or press releases distributed; # of people applying for 319h Hull Paint Conversion Project funds; results from applicant surveys; pre/post-tests	On-going Status: Completed several outreach materials: • "How to Select an Alternative Hull Paint brochure • 319h Hull Paint Conversion Project advertisement flier • 319h Hull Paint Conversion Project's Frequently Asked Questions flier • Posters, postcards, ecards for 319h Hull Paint Conversion Project Public Workshop / Media Event and remind boaters following media event • Eleven press releases over the reporting period on different projects within the Copper Reduction Program	All Named Parties
Education/ Outreach	Presentations at Conferences	Bay-wide State-wide	Presented information on the Copper Reduction Program and on non-copper hull paint alternative hull paints.	Change in awareness	# of brochures or pamphlets distributed/people attending	On-going Status: Presented at two conferences • California Stormwater Quality Association (September 26-28, 2011) • Marine Recreation Association Conference (November 2 – 4, 2011)	
Education/ Outreach	Participation in state-wide copper sub-workgroup	Bay-wide State-wide	The Port participates in a state-wide copper sub-workgroup, led by the Department of Pesticide Regulation (DPR), to increase overall understanding of copper impacts statewide	Change in Awareness/Change in Behavior	# of meetings/people participating	On-going Status: The workgroup met four times: March 9, 2011, June 8, 2011, August 7, 2011, and December 7, 2011.	All Named Parties, Paint Manufacturers, Boatyards, Hull Cleaners
Agency Wide Activities	Construction Site Inspections	SIYB Bay-wide	All construction projects on Port tidelands that meet certain criteria are required to submit a storm water pollution prevention plan (SWPPP) for the Port's approval. If the project is	Change in Behavior	Total # Inspections; # of follow up inspections	On-going Status: Three construction projects required inspections in SIYB in 2011	

BMP TYPE	DESCRIPTION	LOCATION	PURPOSE(S)	TARGETED OUTCOME(S)	ASSESSMENT MECHANISM	SCHEDULE / STATUS	PARTNER
			subject to the General Stormwater Construction Permit, then the SWPPP is prepared in accordance with the conditions stated within that permit. If the project is not subject to the General Construction Stormwater Permit, but will disturb either 100 square feet or more of soil or will occur over or within a waterbody, a mini-SWPPP is required. The mini-SWPPP includes a project description and site maps, identifies responsible parties for SWPPP implementation, BMPs, employee training and inspection. Corrective actions may be taken if these requirements are not followed.			One of the construction projects required follow-up inspections	
Agency Wide Activities	Commercial Business Inspections	SIYB Bay-wide	The Port inspects prioritized commercial facilities per the Municipal Permit in the SIYB and bay-wide. One particular component, the Port's marina inspection program, has been an effort to educate boat owners about pollution prevention, focusing on visual observations designed to identify sources of pollution, both actual and potential, and to identify the pollution prevention practices being implemented at the marinas.	Change in Behavior	Total # Inspections; # of follow up inspections	On-going Status: 14 inspections occurred in SIYB in 2011. • 2 municipal • 12 commercial facilities (including marinas/yacht clubs) Landside BMPs were determined to be properly implemented. No follow-up inspections were required for these facilities	
Structural and Mechanical BMP Implementatio n	SUSMP and Development Regulations	SIYB Bay-wide	The Port incorporates standard urban storm water mitigation plan (SUSMP) requirements on applicable development and redevelopment projects bay-wide. Depending on the type and size of the projects, SUSMP requirements could include site design, source controls, and treatment controls such as low-impact development.	Change in Behavior: Compliance	# of projects submitted subject to SUSMP	On-going Status: Two construction projects in SIYB submitted in 2011 were subject to SUSMP requirements.	
Monitoring	Regional Harbor Monitoring Program (RHMP): Core Monitoring Program	SIYB Bay-wide RHMP Harbors	Assesses conditions found in San Diego Bay based on comparisons to historical data and comparisons to contaminant concentrations to known surface water and sediment thresholds.	Completeness	Report on findings of the study results completed by Weston for RHMP	Start Date: FY08 Completion Date: FY10 Status: Complete	City of San Diego, City of Oceanside, County of Orange
Monitoring/	RHMP Special Study #1	Bay-wide	Provide a review of the existing data	Completeness	Report on	Start Date: FY10	City of San Diego,

BMP TYPE	DESCRIPTION	LOCATION	PURPOSE(S)	TARGETED OUTCOME(S)	ASSESSMENT MECHANISM	SCHEDULE / STATUS	PARTNER
Reporting	Copper Literature Review	RHMP Harbors	and literature on the extent and magnitude of copper contamination in RHMP harbors; identify and determine the relative importance of copper sources; and use the BLM to predict SSOs based on site-specific water quality data.		findings of the study results completed by WESTON for RHMP	Completion Date: FY12 Status: Complete	City of Oceanside, County of Orange
Monitoring/ Reporting	RHMP Special Study #2 Toxicity Assessments	Bay-wide RHMP Harbors	Toxicity assessments were performed at stations previously shown to have sediment toxicity, with the intention of performing toxicity identification evaluations.	Completeness	Report on findings of the study results by WESTON for RHMP	Start Date: FY11 Completion Date: FY13 Status:	City of San Diego, City of Oceanside, County of Orange
Monitoring/ Reporting	RHMP Special Study #3 Copper Flux Study	SIYB RHMP Harbors	Laboratory assessment will be used to test flux of dissolved copper between sediments and the water column under static and mixing conditions at marina locations in RHMP harbors.	Completeness	Report on findings of the study results by Weston for RHMP	Start Date: FY11 Completion Date: FY13 Status:	City of San Diego, City of Oceanside, County of Orange

Appendix C
Water Quality Results

PHYSIS
TERRA FAUNA FLORA AQUA AURA
ENVIRONMENTAL LABORATORIES, INC.
Innovative Solutions for Nature

September 19, 2011

Matt Wartian
Weston Solutions, Inc.
2433 Impala Dr.
Carlsbad, CA 92010-

Project Name: Shelter Island Yacht Basin
Physis Project ID: 1108003-001

Dear Matt,

Enclosed are the analytical results for samples submitted to PHYSIS Environmental Laboratories, Inc. (PHYSIS) on 08/22/2011. A total of 7 samples were received for analysis in accordance with the attached chain of custody (COC). Per the COC, the samples were analyzed for:

Elements
Total & Dissolved Trace Metals by EPA 1640
Subcontract
Total Organic Carbon by SM 5310 B
Dissolved Organic Carbon by SM 5310 B

Analytical results in this report apply only to samples submitted to PHYSIS in accordance with the COC and areintended to be considered in their entirety.

Please feel free to contact me at any time with any questions. PHYSIS appreciates the opportunity to provideyou with our analytical and support services.

Regards,

Misty Mercier
Extension 202
714-335-5918 cell
mistymercier@physislabs.com

ABBREVIATIONS and ACRONYMS

QM	Quality Manual
QA	Quality Assurance
QC	Quality Control
MDL	method detection limit
RL	reporting limit
R1	project sample
R2	project sample replicate
MS1	matrix spike
MS2	matrix spike replicate
B1	procedural blank
B2	procedural blank replicate
BS1	blank spike
BS2	blank spike replicate
LCS1	laboratory control spike
LCS2	laboratory control spike replicate
LCM1	laboratory control material
LCM2	laboratory control material replicate
CRM1	certified reference material
CRM2	certified reference material replicate
RPD	relative percent difference
LMW	low molecular weight
HMW	high molecular weight

QUALITY ASSURANCE SUMMARY

LABORATORY BATCH: Physis' QM defines a laboratory batch as a group of 20 or fewer project samples of similar matrix, processed together under the same conditions and with the same reagents. QC samples are associated with each batch and are used to assess the validity of the sample analyses.

PROCEDURAL BLANK: Laboratory contamination introduced during method use was assessed through the analysis of procedural blanks at a minimum frequency of one per batch. Physis' QM requires that all procedural blanks be below 10 times the MDL and all detectable constituents in the procedural blanks be flagged in the project sample results with a B qualifier.

ACCURACY: Accuracy of analytical measurements is the degree of closeness based on percent recovery calculations between measured values and the actual or true value and includes a combination of reproducibility error and systematic bias due to sampling and analytical operations. Accuracy of the project data was indicated by analysis of MS, BS, LCS, LCM, CRM, and/or surrogate spikes on a minimum frequency of one per batch. Physis' QM requires that 95% of the target compounds greater than 10 times the MDL be within the specified acceptance limits.

PRECISION: Precision is the agreement among a set of replicate measurements without assumption of knowledge of the true value and is based on RPD calculations between repeated values. Precision of the project data was determined by analysis of replicate MS1/MS2, BS1/BS2, LCS1/LCS2, LCM1/LCM2, CRM1/CRM2, surrogate spikes and/or replicate project sample analysis (R1/R2) on a minimum frequency of one per batch. Physis' QM requires that for 95% of the compounds greater than 10 times the MDL, the percent RPD should be within the specified acceptance range.

MATRIX SPIKES: MS samples were employed to assess the effect a particular project sample matrix has on the accuracy of a measurement. It is prepared by adding a known amount of the target analyte(s) to an aliquot of the project sample. Matrix spikes indicate the bias of analytical measurements due to chemical interferences inherent in the sample matrix. If the matrix spike recovery does not fall within the specified acceptance limits, it may be an indication of sample matrix interference in the specific project sample used for the MS. Intrinsic target analyte concentration in the specific project sample can also significantly impact MS recovery.

BLANK SPIKES: BS demonstrates performance of the preparation and analytical methods on a clean matrix void of potential matrix related interferences. The BS is performed in laboratory deionized water, making these recoveries a better indicator of the efficiency of the laboratory method per se.

CERTIFIED REFERENCE MATERIALS: CRMs are pre-homogenized materials of various matrices for which analytical information has been determined and certified by a recognized authority. These are used to provide a quantitative assessment of the accuracy of a preparation and analytical method. CRMs are analyzed to provide evidence that the laboratory method produces results that are comparable to those obtained by an independent organization.

SURROGATES: Where CRMs are unavailable, target analyte recovery can be assessed by monitoring added surrogate compounds/elements. A surrogate is a pure analyte unlikely to be found in any project sample and most often used with organic analytical procedures. Percent recovery is calculated for each surrogate and is used to monitor method performance within each discrete sample and is indicative of the procedure's ability to recover the actual analytes of interest.

HOLDING TIME: Method recommended holding times are the length of time a project sample can be stored under specific conditions after collection and prior to analysis without significantly affecting the analyte's concentration. Holding times can be extended if preservation techniques are employed to reduce biodegradation, volatilization, oxidation, sorption, precipitation, and other physical and chemical processes. Physis' QM requires that all samples analyzed beyond the method recommended holding time be flagged in the sample results with an H qualifier.

TOTAL/DISSOLVED FRACTION: In some instances, the results for the dissolved fraction may be higher than the total fraction for a particular analyte (e.g. trace metals). This is typically caused by the analytical variation for each result and indicates that the target analyte is primarily in the dissolved phase, within the sample.

PHYSIS QUALIFIER CODES

CODE	DEFINITION
*	see Case Narrative
ND	analyte not detected at or above the MDL
B	analyte was detected in the procedural blank greater than 10 times the MDL
E	analyte concentration exceeds the upper limit of the linear calibration range, reported value is estimated
H	sample received and/or analyzed past the recommended holding time
J	analyte was detected at a concentration below the RL and above the MDL, reported value is estimated
N	insufficient sample, analysis could not be performed
M	analyte was outside the specified recovery and/or RPD acceptance limits due to matrix interference. The associated B/BS were within limits, therefore the sample data was reported without further clarification
SH	analyte concentration in the project sample exceeded the spike concentration, therefore MS recovery and/or RPD acceptance limits do not apply
SL	analyte results for R1 and/or R2 were lower than 10 times the MDL, therefore RPD acceptance limits do not apply
NH	project sample was heterogeneous and sample homogeneity could not be readily achieved using routine laboratory practices, therefore RPD was outside the specified acceptance limits
R	Physis' QM allows for 5% of the target compounds greater than 10 times the MDL to be outside the specified acceptance limits for precision and/or accuracy. This is often due to random error and does not indicate any significant problems with the analysis of these project samples

ANALYTICAL REPORT

PHYSIS
TERRA AQUA AURA
ENVIRONMENTAL LABORATORIES, INC.
Innovative Solutions for Nature

PHYSIS ENVIRONMENTAL LABORATORIES, INC.
Innovative Solutions for Nature
1904 E. Wright Circle, Anaheim CA 92806 main: (714) 602-5320 fax: (714) 602-5321 www.physislabs.com info@physislabs.com CA ELAP #2769

Trace Metals ANALYTICAL REPORT

ANALYTE	FRACTION	RESULT	MDL	RL	UNITS	BATCH ID	PREPARED	ANALYZED	METHOD	QA CODE
Physis Sample ID: 8443-R1	**SIYB-1**					**Seawater**	**Sampled: 22-Aug-11**	**16:35**	**Received: 23-Aug-11**	
Copper (Cu)	Total	14.36	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Copper (Cu)	Dissolved	11.32	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Total	35.968	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Dissolved	33.126	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Physis Sample ID: 8444-R1	**SIYB-2**					**Seawater**	**Sampled: 22-Aug-11**	**16:25**	**Received: 23-Aug-11**	
Copper (Cu)	Total	10.53	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Copper (Cu)	Dissolved	7.22	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Total	25.455	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Dissolved	22.743	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Physis Sample ID: 8445-R1	**SIYB-3**					**Seawater**	**Sampled: 22-Aug-11**	**16:15**	**Received: 23-Aug-11**	
Copper (Cu)	Total	10.37	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Copper (Cu)	Dissolved	7.55	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Total	24.377	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Dissolved	22.684	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Physis Sample ID: 8446-R1	**SIYB-4**					**Seawater**	**Sampled: 22-Aug-11**	**16:10**	**Received: 23-Aug-11**	
Copper (Cu)	Total	10.7	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Copper (Cu)	Dissolved	7.81	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Total	25.028	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Dissolved	23.842	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Physis Sample ID: 8447-R1	**SIYB-5**					**Seawater**	**Sampled: 22-Aug-11**	**16:00**	**Received: 23-Aug-11**	
Copper (Cu)	Total	11.19	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Copper (Cu)	Dissolved	8.72	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Total	30.252	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Dissolved	29.392	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Physis Sample ID: 8448-R1	**SIYB-6**					**Seawater**	**Sampled: 22-Aug-11**	**15:40**	**Received: 23-Aug-11**	

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Trace Metals ANALYTICAL REPORT

ANALYTE	FRACTION	RESULT	MDL	RL	UNITS	BATCH ID	PREPARED	ANALYZED	METHOD	QA CODE
Copper (Cu)	Total	9.51	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Copper (Cu)	Dissolved	7.48	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Total	24.895	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Dissolved	23.896	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Physis Sample ID: 8449-R1	**SIYB-REF**					**Seawater**	**Sampled: 22-Aug-11**	**15:25**	**Received: 23-Aug-11**	
Copper (Cu)	Total	3.05	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Copper (Cu)	Dissolved	2.14	0.01	0.02	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Total	8.37	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	
Zinc (Zn)	Dissolved	7.458	0.005	0.01	µg/L	E-2137	8/29/2011	9/3/2011	EPA 1640	

QUALITY CONTROL REPORT

PHYSIS
TERRA FAUNA FLORA AQUA AURA
ENVIRONMENTAL LABORATORIES, INC.
Innovative Solutions for Nature

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Trace Metals QUALITY CONTROL REPORT

Analyte	Fraction	Batch ID	Result	MDL	RL	Units	Spike Level	Source Result	% Recovery	Acceptance Limits	Limit Pass/Fail	RPD	RPD LIMIT	Limit Pass/Fail	QA Code
Lab Blank	**8442-B1**		**QAQC**	**Procedural Blank DI Water**					**Prepared 8/29/2011**			**Analyzed 03-Sep-11**			
Copper (Cu)	Total	E-2137	ND	0.01	0.02	µg/L									
Copper (Cu)	Dissolved	E-2137	ND	0.01	0.02	µg/L									
Zinc (Zn)	Total	E-2137	ND	0.005	0.01	µg/L									
Zinc (Zn)	Dissolved	E-2137	ND	0.005	0.01	µg/L									
Lab Dup	**8443-R2**		**SIYB-1**	**Seawater**					**Prepared 8/29/2011**			**Analyzed 03-Sep-11**			
Copper (Cu)	Total	E-2137	13.8	0.01	0.02	µg/L						4	30	PASS	
Copper (Cu)	Dissolved	E-2137	11.48	0.01	0.02	µg/L						1	30	PASS	
Zinc (Zn)	Total	E-2137	33.51	0.005	0.01	µg/L						7	30	PASS	
Zinc (Zn)	Dissolved	E-2137	33.566	0.005	0.01	µg/L						1	30	PASS	
Lab Control Mate	**8450-LCM1**		**QAQC**	**LCM - Physis Seawater Seawater**					**Prepared 8/29/2011**			**Analyzed 03-Sep-11**			
Copper (Cu)	Total	E-2137	0.12	0.01	0.02	µg/L									
Zinc (Zn)	Total	E-2137	0.566	0.005	0.01	µg/L									
Lab Control Spik	**8450-LCS1**		**QAQC**	**LCM - Physis Seawater Seawater**					**Prepared 8/29/2011**			**Analyzed 03-Sep-11**			
Copper (Cu)	Total	E-2137	16.89	0.01	0.02	µg/L	20	0.12	84	75 - 125%	PASS				
Zinc (Zn)	Total	E-2137	23.166	0.005	0.01	µg/L	20	0.566	113	75 - 125%	PASS				
Lab Control Spik	**8450-LCS2**		**QAQC**	**LCM - Physis Seawater Seawater**					**Prepared 8/29/2011**			**Analyzed 03-Sep-11**			
Copper (Cu)	Total	E-2137	16.28	0.01	0.02	µg/L	20	0.12	81	75 - 125%	PASS	4	30	PASS	
Zinc (Zn)	Total	E-2137	22.928	0.005	0.01	µg/L	20	0.566	112	75 - 125%	PASS	1	30	PASS	

SUBCONTRACT REPORT

PHYSIS
TERRA AQUA AURA
ENVIRONMENTAL LABORATORIES, INC.
Innovative Solutions for Nature

SunStar Laboratories, Inc.
Providing Quality Analytical Services Nationwide

25712 Commercentre Drive
Lake Forest, California 92630
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949.297.5027 Fax

29 August 2011

Misty Mercier
PHYSIS Environmental Laboratories, Inc.
1904 E. Wright Circle
Anaheim, CA 92806

RE: 1108003-001

Enclosed are the results of analyses for samples received by the laboratory on 08/23/11 16:00. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Daniel J Chavez

Daniel Chavez
Project Manager

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

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949.297.5027 Fax

PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
SIYB-1	T111152-01	Water	08/22/11 16:35	08/23/11 16:00
SIYB-2	T111152-02	Water	08/22/11 16:25	08/23/11 16:00
SIYB-3	T111152-03	Water	08/22/11 16:15	08/23/11 16:00
SIYB-4	T111152-04	Water	08/22/11 16:10	08/23/11 16:00
SIYB-5	T111152-05	Water	08/22/11 16:00	08/23/11 16:00
SIYB-6	T111152-06	Water	08/22/11 15:40	08/23/11 16:00
SIYB-REF	T111152-07	Water	08/22/11 15:25	08/23/11 16:00

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

SIYB-1
T111152-01(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.81**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	
Total Organic Carbon	**0.22**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	J

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

SIYB-2
T111152-02(Water)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.78**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	
Total Organic Carbon	**0.23**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	J

SunStar Laboratories, Inc.

Daniel J Chávez

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

SIYB-3
T111152-03(Water)

SunStar Laboratories, Inc.

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Conventional Chemistry Parameters by APHA/EPA/ASTM Methods										
Dissolved Organic Carbon	**0.75**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	
Total Organic Carbon	**0.22**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	J

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

SIYB-4
T111152-04(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.74**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	
Total Organic Carbon	**0.21**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	J

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

SIYB-5
T111152-05(Water)

SunStar Laboratories, Inc.

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Conventional Chemistry Parameters by APHA/EPA/ASTM Methods										
Dissolved Organic Carbon	**0.65**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	
Total Organic Carbon	**0.21**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	J

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

SIYB-6
T111152-06(Water)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
				SunStar Laboratories, Inc.						
Conventional Chemistry Parameters by APHA/EPA/ASTM Methods										
Dissolved Organic Carbon	**0.66**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	
Total Organic Carbon	**0.22**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	J

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

SIYB-REF
T111152-07(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.65**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	
Total Organic Carbon	**0.23**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	J

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods - Quality Control

SunStar Laboratories, Inc.

Analyte	Result	MDL	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1081914 - General Preparation											
Blank (1081914-BLK1)					Prepared: 08/19/11 Analyzed: 08/25/11						
Total Organic Carbon	0.209	0.062	0.50	mg/l							J
Duplicate (1081914-DUP1)		**Source: T111159-10**			Prepared: 08/19/11 Analyzed: 08/26/11						
Total Organic Carbon	7.72	0.062	0.50	mg/l		7.38			4.60	20	
Batch 1082412 - General Preparation											
Blank (1082412-BLK1)					Prepared: 08/24/11 Analyzed: 08/25/11						
Dissolved Organic Carbon	ND	0.062	0.50	mg/l							
Duplicate (1082412-DUP1)		**Source: T111152-01**			Prepared: 08/24/11 Analyzed: 08/25/11						
Dissolved Organic Carbon	0.686	0.062	0.50	mg/l		0.814			17.1	20	

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	08/29/11 14:50

Notes and Definitions

J	Detected but below the Standard Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

PHYSIS ENVIRONMENTAL LABORATORIES, INC.

CHAIN of CUSTODY

SEND TO: SunStar

COMPANY NAME: PHYSIS Environmental Laboratories, Inc.	E-MAIL: sc@physislabs.com	PROJECT NAME / NUMBER: 1108003-001	COC PAGE 1 of 1
PROJECT MANAGER: Misty Mercier	FAX: 714 602-5321	PO #: / PHYSIS SOS #: 1108003	TYPE OF ICE USED: ☑ WET ☐ BLUE ☐ DRY
COMPANY ADDRESS: 1904 E. Wright Circle, Anaheim, CA 92806	PHONE: 714 602-5320 x202 office; 714 335-5918 cell	SAMPLED BY:	SHIPPED VIA: ☐ FEDEX ☐ UPS ☐ USPS ☐ Client ☐ Physis ☑ other

TURNAROUND TIME: ☐ NORMAL ☐ RUSH business days

REPORT FORMAT: ☑ PDF/EDD ☐ SWAMP EDD ☐ other

SPECIAL INSTRUCTIONS:

please report down to MDL

T111152

3.6°

PHYSIS MATRIX CODES

SW = seawater FW = freshwater RW = rainwater
WW = wastewater DW = drinking water
S = sediment T = tissue E = extract O = other (specify)

REQUESTED ANALYSES

PLEASE SEE PHYSIS SOS

lab use		SAMPLE ID	SAMPLE DESCRIPTION	SAMPLE date	SAMPLE time	physis matrix code	no. of bottles	Total Organic Carbon	Dissolved Organic Carbon
	1	SIYB-1		8/22/11	16:35	SW	~~1~~ 4	X	X
	2	SIYB-2		8/22/11	16:25	SW		X	X
	3	SIYB-3		8/22/11	16:15	SW		X	X
	4	SIYB-4		8/22/11	16:10	SW		X	X
	5	SIYB-5		8/22/11	16:00	SW	1	X	X
	6	SIYB-6		8/22/11	15:40	SW		X	X
	7	SIYB-REF		8/22/11	15:25	SW	~~1~~	X	X
	8						3		
	9								
	10								

HOLD

RELINQUISHED BY print	signature	company	date & time	RECEIVED BY print	signature	company	date & time
Kevin Laurd	[signature]	PHYSIS	8/23/11 1600	Dan Marteski	[signature]	SunStar Labs	8/23/11 1600

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

SAMPLE RECEIVING REVIEW SHEET

BATCH # T111152

Client Name: PHYSIS   Project: 1108003-001

Received by: DAN   Date/Time Received: 8/23/11 1600

Delivered by : ☐ Client ☒ SunStar Courier ☐ GSO ☐ FedEx ☐ Other ______

Total number of coolers received 0   **Temp criteria = 6°C > 0°C (no <u>frozen</u> containers)**

Temperature: cooler #1 3.8 °C +/- the CF (- 0.2°C) = 3.6 °C corrected temperature

cooler #2 ______°C +/- the CF (- 0.2°C) = ______°C corrected temperature

cooler #3 ______°C +/- the CF (- 0.2°C) = ______°C corrected temperature

Samples outside temp. but received on ice, w/in 6 hours of final sampling.	☒ Yes	☐ No*	☐ N/A
Custody Seals Intact on Cooler/Sample	☐ Yes	☐ No*	☒ N/A
Sample Containers Intact	☒ Yes	☐ No*	
Sample labels match COC ID's	☒ Yes	☐ No*	
Total number of containers received match COC	☒ Yes	☐ No*	
Proper containers received for analyses requested on COC	☒ Yes	☐ No*	
Proper preservative indicated on COC/containers for analyses requested	☒ Yes	☐ No*	☐ N/A

Complete shipment received in good condition with correct temperatures, containers, labels, volumes preservatives and within method specified holding times. ☒ **Yes** ☐ **No***

* Complete Non-Conformance Receiving Sheet if checked   Cooler/Sample Review - Initials and date BC 8/23/11

Comments:

CHAIN OF CUSTODY

1108003-001

WESTON SOLUTIONS

☒ 2433 Impala Drive • Carlsbad, CA 92010 • (760) 795-6900, FAX 931-1580
☐ 1440 Broadway, Ste. 910 • Oakland, CA 94612 • (510) 808-0302, FAX 891-9710

CHAIN OF CUSTODY

32228

DATE 8/23/11 PAGE 1 OF 1

PROJECT NAME / SURVEY / PROJECT NUMBER: Shelter Island Yacht Basin

PROJECT MANAGER / CONTACT: Matt Wartian (760) 809-1959

COMPANY / CLIENT: Weston

ADDRESS: See above

PHONE / FAX / EMAIL: " "

ANALYSIS/TEST REQUESTED — FOR WESTON USE ONLY

SITE ID (Location)	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE / VOLUME	TOTAL NUMBER OF CONTAINER	TOC/DOC	Total/Dissolved Cu	Total/Dissolved Zn	PRESERVED HOW	SAMPLE TEMP. (°C) UPON RECEIPT	WESTON LAB ID
SIYB	SIYB-1	8/22/11	1635	SLT	P 1L	1		X	X	Ice 4°C		
	SIYB-1		1635		G 100mL	4	X					
	SIYB-2		1625		P 1L	1		X	X			
	SIYB-2		1625		G 100mL	4	X					
	SIYB-3		1615		P 1L	1		X	X			
	SIYB-3		1615		G 100mL	4	X					
	SIYB-4		1610		P 1L	1		X	X			
	SIYB-4		1610		G 100mL	4	X					
	SIYB-5		1600		P 1L	1		X	X			
	SIYB-5		1600		G 100mL	4	X					
	SIYB-6		1540		P 1L	1		X	X			
	SIYB-6		1540		G 100mL	4	X					
	SIYB-REF		1525		P 1L	1		X	X			
	SIYB-REF		1525		G 100mL	4	X					

Sample Matrix Codes: FW=fresh water GW=ground water SLT=salt water SW=storm water WW=waste water SED=sediment A=air BIO=biologic SB=soil T=tissue O=other (specify) ______

Container Code: G=glass P=plastic B=bags ☐ O=other ______

Shipped By: ☐ Courier ☐ UPS ☐ FedEx ☐ USPS ☐ Client drop off ☐ Other ______

Turnaround Time: ☐ 2-day ☐ 5-day ☐ 7-day ☐ 10-day ☐ 14-day ☐ Standard ☐ Other ______

Reporting Requirements: ☐ PDF ☐ EDD ☐ Hard Copy ☐ Email ☐ Other ______

SAMPLED BY: PRINT Chris Clark SIGNATURE [signature]

COMMENTS / SPECIAL INSTRUCTIONS: See attached analyte list

	RELINQUISHED BY: Print Name	Signature	Firm	Date/Time	RECEIVED BY: Print Name	Signature	Firm	Date/Time
1.	Chris Clark	[signature]	Weston	8/23/11 1155	Kevin Lauro	[signature]	Physis	8/23/11 1155
2.								
3.								
4.								
5.								
6.								

WHITE – return to originator • YELLOW – lab • PINK – retained by originator

Analyte	Method	Method Detection Limit	Reporting Limit	Units
Chemistry Laboratory Measurements				
Total Organic Carbon	USEPA 9060	0.1	0.2	mg/L
Dissolved Organic Carbon	USEPA 9060	0.1	0.2	mg/L
Total Copper	USEPA 1640	0.01	0.02	ug/L
Dissolved Copper	USEPA 1640	0.01	0.02	ug/L
Total Zinc	USEPA 1640	0.005	0.01	ug/L
Dissolved Zinc	USEPA 1640	0.005	0.01	ug/L

PHYSIS
TERRA FAUNA FLORA AQUA AURA
ENVIRONMENTAL LABORATORIES, INC.

PHYSIS PROJECT ID
1108003-001

SAMPLE RECEIPT SUMMARY

CLIENT: Weston   Date Received: 8/23/11   Received By: kl   Inspected By: kl

COURIER

☐ PHYSIS ☑ CLIENT ☐ FEDEX ☐ UPS
☐ OTHER: ______

COOLER

☑ COOLER ☐ BOX total # 1
☐ OTHER: ______

TEMPERATURE

8 °C
☐ WET ICE ☑ BLUE ICE
☐ DRY ICE ☐ NONE

SAMPLE INTEGRITY UPON RECEIPT

1. COC(s) included and completely filled out.......... *YES*
2. All sample containers arrived intact.......... *YES*
3. All samples listed on COC(s) are present.......... *YES*
4. Information on containers consistent with information on COC(s).......... *YES*
5. Correct containers and volume for all analyses indicated.......... *YES*
6. All samples received within method holding time.......... *YES*
7. Correct preservation used for all analyses indicated.......... *YES*

NOTES

Reset Form

Print Form

PHYSIS
TERRA FAUNA FLORA AQUA AURA
ENVIRONMENTAL LABORATORIES, INC.
Innovative Solutions for Nature

November 23, 2011

Matt Wartian
Weston Solutions, Inc.
2433 Impala Dr.
Carlsbad, CA 92010-

Project Name: Shelter Island Yacht Basin
Physis Project ID: 1108003-002

Dear Matt,

Enclosed are the analytical results for samples submitted to PHYSIS Environmental Laboratories, Inc. (PHYSIS) on 10/27/2011. A total of 3 samples were received for analysis in accordance with the attached chain of custody (COC). Per the COC, the samples were analyzed for:

Elements
Dissolved Copper by EPA 1640
Subcontract
Total Organic Carbon by SM 5310 B
Dissolved Organic Carbon by SM 5310 B

Analytical results in this report apply only to samples submitted to PHYSIS in accordance with the COC and are intended to be considered in their entirety.

Please feel free to contact me at any time with any questions. PHYSIS appreciates the opportunity to provide you with our analytical and support services.

Regards,

Misty Mercier
Extension 202
714-335-5918 cell
mistymercier@physislabs.com

ABBREVIATIONS and ACRONYMS

QM	Quality Manual
QA	Quality Assurance
QC	Quality Control
MDL	method detection limit
RL	reporting limit
R1	project sample
R2	project sample replicate
MS1	matrix spike
MS2	matrix spike replicate
B1	procedural blank
B2	procedural blank replicate
BS1	blank spike
BS2	blank spike replicate
LCS1	laboratory control spike
LCS2	laboratory control spike replicate
LCM1	laboratory control material
LCM2	laboratory control material replicate
CRM1	certified reference material
CRM2	certified reference material replicate
RPD	relative percent difference
LMW	low molecular weight
HMW	high molecular weight

QUALITY ASSURANCE SUMMARY

LABORATORY BATCH: Physis' QM defines a laboratory batch as a group of 20 or fewer project samples of similar matrix, processed together under the same conditions and with the same reagents. QC samples are associated with each batch and are used to assess the validity of the sample analyses.

PROCEDURAL BLANK: Laboratory contamination introduced during method use was assessed through the analysis of procedural blanks at a minimum frequency of one per batch. Physis' QM requires that all procedural blanks be below 10 times the MDL and all detectable constituents in the procedural blanks be flagged in the project sample results with a B qualifier.

ACCURACY: Accuracy of analytical measurements is the degree of closeness based on percent recovery calculations between measured values and the actual or true value and includes a combination of reproducibility error and systematic bias due to sampling and analytical operations. Accuracy of the project data was indicated by analysis of MS, BS, LCS, LCM, CRM, and/or surrogate spikes on a minimum frequency of one per batch. Physis' QM requires that 95% of the target compounds greater than 10 times the MDL be within the specified acceptance limits.

PRECISION: Precision is the agreement among a set of replicate measurements without assumption of knowledge of the true value and is based on RPD calculations between repeated values. Precision of the project data was determined by analysis of replicate MS1/MS2, BS1/BS2, LCS1/LCS2, LCM1/LCM2, CRM1/CRM2, surrogate spikes and/or replicate project sample analysis (R1/R2) on a minimum frequency of one per batch. Physis' QM requires that for 95% of the compounds greater than 10 times the MDL, the percent RPD should be within the specified acceptance range.

MATRIX SPIKES: MS samples were employed to assess the effect a particular project sample matrix has on the accuracy of a measurement. It is prepared by adding a known amount of the target analyte(s) to an aliquot of the project sample. Matrix spikes indicate the bias of analytical measurements due to chemical interferences inherent in the sample matrix. If the matrix spike recovery does not fall within the specified acceptance limits, it may be an indication of sample matrix interference in the specific project sample used for the MS. Intrinsic target analyte concentration in the specific project sample can also significantly impact MS recovery.

BLANK SPIKES: BS demonstrates performance of the preparation and analytical methods on a clean matrix void of potential matrix related interferences. The BS is performed in laboratory deionized water, making these recoveries a better indicator of the efficiency of the laboratory method per se.

CERTIFIED REFERENCE MATERIALS: CRMs are pre-homogenized materials of various matrices for which analytical information has been determined and certified by a recognized authority. These are used to provide a quantitative assessment of the accuracy of a preparation and analytical method. CRMs are analyzed to provide evidence that the laboratory method produces results that are comparable to those obtained by an independent organization.

SURROGATES: Where CRMs are unavailable, target analyte recovery can be assessed by monitoring added surrogate compounds/elements. A surrogate is a pure analyte unlikely to be found in any project sample and most often used with organic analytical procedures. Percent recovery is calculated for each surrogate and is used to monitor method performance within each discrete sample and is indicative of the procedure's ability to recover the actual analytes of interest.

HOLDING TIME: Method recommended holding times are the length of time a project sample can be stored under specific conditions after collection and prior to analysis without significantly affecting the analyte's concentration. Holding times can be extended if preservation techniques are employed to reduce biodegradation, volatilization, oxidation, sorption, precipitation, and other physical and chemical processes. Physis' QM requires that all samples analyzed beyond the method recommended holding time be flagged in the sample results with an H qualifier.

TOTAL/DISSOLVED FRACTION: In some instances, the results for the dissolved fraction may be higher than the total fraction for a particular analyte (e.g. trace metals). This is typically caused by the analytical variation for each result and indicates that the target analyte is primarily in the dissolved phase, within the sample.

PHYSIS QUALIFIER CODES

CODE	DEFINITION
*	see Case Narrative
ND	analyte not detected at or above the MDL
B	analyte was detected in the procedural blank greater than 10 times the MDL
E	analyte concentration exceeds the upper limit of the linear calibration range, reported value is estimated
H	sample received and/or analyzed past the recommended holding time
J	analyte was detected at a concentration below the RL and above the MDL, reported value is estimated
N	insufficient sample, analysis could not be performed
M	analyte was outside the specified recovery and/or RPD acceptance limits due to matrix interference. The associated B/BS were within limits, therefore the sample data was reported without further clarification
SH	analyte concentration in the project sample exceeded the spike concentration, therefore MS recovery and/or RPD acceptance limits do not apply
SL	analyte results for R1 and/or R2 were lower than 10 times the MDL, therefore RPD acceptance limits do not apply
NH	project sample was heterogeneous and sample homogeneity could not be readily achieved using routine laboratory practices, therefore RPD was outside the specified acceptance limits
R	Physis' QM allows for 5% of the target compounds greater than 10 times the MDL to be outside the specified acceptance limits for precision and/or accuracy. This is often due to random error and does not indicate any significant problems with the analysis of these project samples

ANALYTICAL REPORT

PHYSIS

TERRA AQUA AURA

ENVIRONMENTAL LABORATORIES, INC.

Innovative Solutions for Nature

Trace Metals ANALYTICAL REPORT

ANALYTE	FRACTION	RESULT	MDL	RL	UNITS	BATCH ID	PREPARED	ANALYZED	METHOD	QA CODE
Physis Sample ID: 9665-R1	**SIYB-1**					**Seawater**	**Sampled: 26-Oct-11**	**8:50**	**Received: 27-Oct-11**	
copper (Cu)	Dissolved	8.08	0.01	0.02	µg/L	E-3030	11/15/2011	11/18/2011	EPA 1640	
Physis Sample ID: 9666-R1	**SIYB-3**					**Seawater**	**Sampled: 26-Oct-11**	**9:05**	**Received: 27-Oct-11**	
copper (Cu)	Dissolved	6.51	0.01	0.02	µg/L	E-3030	11/15/2011	11/18/2011	EPA 1640	
Physis Sample ID: 9667-R1	**SIYB-5**					**Seawater**	**Sampled: 26-Oct-11**	**9:20**	**Received: 27-Oct-11**	
copper (Cu)	Dissolved	5.01	0.01	0.02	µg/L	E-3030	11/15/2011	11/18/2011	EPA 1640	

QUALITY CONTROL REPORT

PHYSIS ENVIRONMENTAL LABORATORIES, INC.
Innovative Solutions for Nature
1904 E. Wright Circle, Anaheim CA 92806 main: (714) 602-5320 fax: (714) 602-5321 www.physislabs.com info@physislabs.com CA ELAP #2769

Trace Metals QUALITY CONTROL REPORT

Analyte	Fraction	Batch ID	Result	MDL	RL	Units	Spike Level	Source Result	% Recovery	Acceptance Limits	Limit Pass/Fail	RPD	RPD LIMIT	Limit Pass/Fail	QA Code
Lab Blank 9664-B1			**QAQC**	**Procedural Blank DI Water**				**Prepared 11/15/2011**			**Analyzed 18-Nov-11**				
copper (Cu)	Dissolved	E-3030	ND	0.01	0.02	µg/L									
Lab Dup 9665-R2			**SIYB-1**	**Seawater**				**Prepared 11/15/2011**			**Analyzed 18-Nov-11**				
copper (Cu)	Dissolved	E-3030	7.05	0.01	0.02	µg/L						14	30	PASS	
Lab Control Mate 9668-LCM1			**QAQC**	**LCM - Physis Seawater Seawater**				**Prepared 11/15/2011**			**Analyzed 18-Nov-11**				
copper (Cu)	Dissolved	E-3030	0.75	0.01	0.02	µg/L									
Lab Control Spik 9668-LCS1			**QAQC**	**LCM - Physis Seawater Seawater**				**Prepared 11/15/2011**			**Analyzed 18-Nov-11**				
copper (Cu)	Dissolved	E-3030	18.66	0.01	0.02	µg/L	20	0.75	90	75 - 125%	PASS				
Lab Control Spik 9668-LCS2			**QAQC**	**LCM - Physis Seawater Seawater**				**Prepared 11/15/2011**			**Analyzed 18-Nov-11**				
copper (Cu)	Dissolved	E-3030	19	0.01	0.02	µg/L	20	0.75	91	75 - 125%	PASS	1	30	PASS	

SUBCONTRACT REPORT

PHYSIS
TERRA AURA
ENVIRONMENTAL LABORATORIES, INC.
Innovative Solutions for Nature

SunStar Laboratories, Inc.
Providing Quality Analytical Services Nationwide

25712 Commercentre Drive
Lake Forest, California 92630
949.297.5020 Phone
949.297.5027 Fax

04 November 2011

Misty Mercier
PHYSIS Environmental Laboratories, Inc.
1904 E. Wright Circle
Anaheim, CA 92806
RE: 1108003-002

Enclosed are the results of analyses for samples received by the laboratory on 10/28/11 08:30. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Daniel J Chavez

Daniel Chavez
Project Manager

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

25712 Commercentre Drive
Lake Forest, California 92630
949.297.5020 Phone
949.297.5027 Fax

PHYSIS Environmental Laboratories, Inc.	Project: 1108003-002	
1904 E. Wright Circle	Project Number: 1108003-002	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	11/04/11 15:47

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
SIYB-1	T111590-01	Water	10/26/11 08:50	10/28/11 08:30
SIYB-3	T111590-02	Water	10/26/11 09:05	10/28/11 08:30
SIYB-5	T111590-03	Water	10/26/11 09:20	10/28/11 08:30

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

25712 Commercentre Drive
Lake Forest, California 92630
949.297.5020 Phone
949.297.5027 Fax

PHYSIS Environmental Laboratories, Inc.	Project: 1108003-002	
1904 E. Wright Circle	Project Number: 1108003-002	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	11/04/11 15:47

SIYB-1
T111590-01(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.55**	0.062	0.50	mg/l	1	1102818	10/28/11	10/31/11	SM 5310 B	
Total Organic Carbon	**0.41**	0.062	0.50	"	"	1102819	10/28/11	10/29/11	"	J

Daniel J Chávez

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

25712 Commercentre Drive
Lake Forest, California 92630
949.297.5020 Phone
949.297.5027 Fax

PHYSIS Environmental Laboratories, Inc.	Project: 1108003-002	
1904 E. Wright Circle	Project Number: 1108003-002	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	11/04/11 15:47

SIYB-3
T111590-02(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.45**	0.062	0.50	mg/l	1	1102818	10/28/11	10/31/11	SM 5310 B	J
Total Organic Carbon	**0.34**	0.062	0.50	"	"	1102819	10/28/11	10/29/11	"	J

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Daniel J Chávez

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

25712 Commercentre Drive
Lake Forest, California 92630
949.297.5020 Phone
949.297.5027 Fax

PHYSIS Environmental Laboratories, Inc.	Project: 1108003-002	
1904 E. Wright Circle	Project Number: 1108003-002	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	11/04/11 15:47

SIYB-5
T111590-03(Water)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
				SunStar Laboratories, Inc.						
Conventional Chemistry Parameters by APHA/EPA/ASTM Methods										
Dissolved Organic Carbon	**0.38**	0.062	0.50	mg/l	1	1102818	10/28/11	10/31/11	SM 5310 B	J
Total Organic Carbon	**0.35**	0.062	0.50	"	"	1102819	10/28/11	10/29/11	"	J

SunStar Laboratories, Inc.

Daniel J Chávez

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SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

25712 Commercentre Drive
Lake Forest, California 92630
949.297.5020 Phone
949.297.5027 Fax

PHYSIS Environmental Laboratories, Inc.	Project: 1108003-002	
1904 E. Wright Circle	Project Number: 1108003-002	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	11/04/11 15:47

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods - Quality Control

SunStar Laboratories, Inc.

Analyte	Result	MDL	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1102818 - General Preparation											
Blank (1102818-BLK1)					Prepared & Analyzed: 10/28/11						
Dissolved Organic Carbon	ND	0.062	0.50	mg/l							
Duplicate (1102818-DUP1)		**Source: T111565-14**			Prepared & Analyzed: 10/28/11						
Dissolved Organic Carbon	9.52	0.062	0.50	mg/l		8.76			8.31	20	
Batch 1102819 - General Preparation											
Blank (1102819-BLK1)					Prepared: 10/28/11 Analyzed: 10/29/11						
Total Organic Carbon	ND	0.062	0.50	mg/l							
Duplicate (1102819-DUP1)		**Source: T111591-07**			Prepared: 10/28/11 Analyzed: 10/29/11						
Total Organic Carbon	13.8	0.062	0.50	mg/l		14.0			1.64	20	

SunStar Laboratories, Inc.

Daniel J Chávez

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

25712 Commercentre Drive
Lake Forest, California 92630
949.297.5020 Phone
949.297.5027 Fax

PHYSIS Environmental Laboratories, Inc.	Project: 1108003-002	
1904 E. Wright Circle	Project Number: 1108003-002	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	11/04/11 15:47

Notes and Definitions

J	Detected but below the Standard Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

Daniel J Chávez

PHYSIS ENVIRONMENTAL LABORATORIES, INC.

CHAIN of CUSTODY

SEND TO: SunStar

COMPANY NAME: PHYSIS Environmental Laboratories, Inc.
E-MAIL: sc@physislabs.com
PROJECT MANAGER: Misty Mercier
FAX: 714 602-5321
COMPANY ADDRESS: 1904 E. Wright Circle, Anaheim, CA 92806
PHONE: 714 602-5320 x202 office; 714 335-5918 cell
PROJECT NAME / NUMBER: 1108003-002
COC PAGE: 1 of 1
PO #:
PHYSIS SOS #: 1108003
TYPE OF ICE USED: ☐ WET ☐ BLUE ☐ DRY
SAMPLED BY:
SHIPPED VIA: ☐ FEDEX ☐ UPS ☐ USPS ☐ Client ☐ Physis ☑ other
TURNAROUND TIME: ☐ NORMAL ☐ RUSH ___ business days
REPORT FORMAT: ☑ PDF/EDD ☐ SWAMP EDD ☐ other

SPECIAL INSTRUCTIONS:

please report down to MDL

T111590

Temp. 3.2°

PHYSIS MATRIX CODES

SW = seawater FW = freshwater RW = rainwater
WW = wastewater DW = drinking water
S = sediment T = tissue E = extract O = other (specify)

REQUESTED ANALYSES

PLEASE SEE PHYSIS SOS

lab use		SAMPLE ID	SAMPLE DESCRIPTION	SAMPLE date	SAMPLE time	physis matrix code	no. of bottles	TOC	DOC
01	1	SIYB-1		10/26/11	8:50	SW	4	X	X
02	2	SIYB-3		10/26/11	9:05	SW	4	X	X
03	3	SIYB-5		10/26/11	9:20	SW	4	X	X

print	signature	company	date & time
Richard Hanken	[signature]	PHYSIS	10/28/11 8:30

RECEIVED BY

print	signature	company	date & time
Dan Marteski	[signature]	SunStar Labs	10/28/11 830

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

SAMPLE RECEIVING REVIEW SHEET

BATCH # T111590

Client Name: PHYSIS   Project: 1108003-002

Received by: DAN   Date/Time Received: 10-28-11 8:30

Delivered by: ☐ Client ☒ SunStar Courier ☐ GSO ☐ FedEx ☐ Other ______

Total number of coolers received 0   **Temp criteria = 6°C > 0°C (no frozen containers)**

Temperature: cooler #1 3.4 °C +/- the CF (- 0.2°C) = 3.2 °C corrected temperature

cooler #2 ______ °C +/- the CF (- 0.2°C) = ______ °C corrected temperature

cooler #3 ______ °C +/- the CF (- 0.2°C) = ______ °C corrected temperature

Samples outside temp. but received on ice, w/in 6 hours of final sampling.	☒ Yes	☐ No*	☐ N/A
Custody Seals Intact on Cooler/Sample	☐ Yes	☐ No*	☒ N/A
Sample Containers Intact	☒ Yes	☐ No*	
Sample labels match COC ID's	☒ Yes	☐ No*	
Total number of containers received match COC	☒ Yes	☐ No*	
Proper containers received for analyses requested on COC	☒ Yes	☐ No*	
Proper preservative indicated on COC/containers for analyses requested	☒ Yes	☐ No*	☐ N/A

Complete shipment received in good condition with correct temperatures, containers, labels, volumes preservatives and within method specified holding times. ☒ **Yes** ☐ **No***

* Complete Non-Conformance Receiving Sheet if checked   Cooler/Sample Review - Initials and date BC 10-28-11

Comments:

CHAIN OF CUSTODY

1108003-002

WESTON SOLUTIONS

☒ 2433 Impala Drive • Carlsbad, CA 92010 • (760) 795-6900, FAX 931-1580
☐ 1440 Broadway, Ste. 910 • Oakland, CA 94612 • (510) 808-0302, FAX 891-9710

CHAIN OF CUSTODY

30193

DATE 10/27/11 PAGE 1 OF 1

PROJECT NAME / SURVEY / PROJECT NUMBER: Shelter Island Yacht Basin
PROJECT MANAGER / CONTACT: Matt Wartian
COMPANY / CLIENT: Weston
ADDRESS: see above
PHONE / FAX / EMAIL: " "

SITE ID (Location)	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE / VOLUME	TOTAL NUMBER OF CONTAINER	TOC	DOC	Dissolved Copper	PRESERVED HOW	SAMPLE TEMP. (°C) UPON RECEIPT	WESTON LAB ID
Shelter Island	SIYB-1	10/26/11	0850	SLT	100mL G	4	X			Ice 4°C		
↓	↓	↓	↓	↓	250mL G	2		X		↓		
↓	↓	↓	↓	↓	1L P	1			X	↓		
↓	SIYB-3	10/26/11	0905	SLT	100mL G	4	X			↓		
↓	↓	↓	↓	↓	250mL G	2		X		↓		
↓	↓	↓	↓	↓	1L P	1			X	↓		
↓	SIYB-5	10/26/11	0920	SLT	100mL G	4	X			↓		
↓	↓	↓	↓	↓	250mL G	2		X		↓		
↓	↓	↓	↓	↓	1L P	1			X	↓		

FOR WESTON USE ONLY

Sample Matrix Codes: FW= fresh water GW=ground water SLT=salt water SW=storm water WW=waste water SED=sediment A=air BIO=biologic SS=soil T=tissue O=other (specify) ____

Container Code: G=glass P=plastic B=bags ☐ O=other ____

Shipped By: ☐ Courier ☐ UPS ☐ FedEx ☐ USPS ☒ Client drop off ☐ Other ____

Turnaround Time: ☐ 2-day ☐ 5-day ☐ 7-day ☐ 10-day ☐ 14-day ☐ Standard ☐ Other ____

Reporting Requirements: ☐ PDF ☐ EDD ☐ Hard Copy ☐ Email ☐ Other ____

SAMPLED BY: PRINT Chris Clark SIGNATURE [signature]

COMMENTS / SPECIAL INSTRUCTIONS: see attached analyte list

	RELINQUISHED BY				RECEIVED BY			
	Print Name	Signature	Firm	Date/Time	Print Name	Signature	Firm	Date/Time
1.	Chris Clark	[signature]	Weston	10/27/11	Etugte Vaki	[signature]	PHMDS	10/27/11 12:50
2.								
3.								
4.								
5.								
6.								

WHITE – return to originator • YELLOW – lab • PINK – retained by originator

Clark, Christopher

From: Clark, Christopher
Sent: Tuesday, October 18, 2011 1:03 PM
To: 'Misty Mercier'
Cc: Wartian, Matthew
Subject: Shelter Island Yacht Basin Copper Study: Event 2

Hi Misty,

I hope you are doing well. We are heading back out to Shelter island Yacht Basin to complete a second event. This event will not be as in depth as the previous. Instead of 7 stations there will only be 3 station and the analyte list has been reduced. Listed below are the chemical analytes for our work at Shelter Island Yacht Basin. Sampling will take place on Wednesday October 26th and the samples will be dropped off on Thursday October 27th. Could you please provide us with the sample containers by Monday October 24th including a few spares? Please let me know if you will need any additional information.

*3 sample stations

Analyte	Method	Method Detection Limit	Reportin g Limit	Units
Chemistry Laboratory Measurements				
Total Organic Carbon	USEPA 9060	0.1	0.2	mg/L
Dissolved Organic Carbon	USEPA 9060	0.1	0.2	mg/L
Dissolved Copper	USEPA 1640	0.01	0.02	ug/L

Thanks,

Chris

Chris Clark
Field Ops Manager/Project Scientist/H&S Officer
Weston Solutions Inc.
2433 Impala Dr. Carlsbad, Ca. 92010
Office: 760-795-6994
Cell: 760-908-5753
Fax: 760-931-1580
Welcome to Weston Solutions, Inc.
><((((º>`·.¸¸.·´¯`·.¸.·´¯`·...¸><((((º>¸.
.·´¯`·.¸.·,..·´¯`·.. ><((((º>`·.¸¸.·´¯`·.¸.·´¯`·...¸><((((º>

PHYSIS
TERRA FAUNA FLORA AQUA AURA
ENVIRONMENTAL LABORATORIES, INC.

PHYSIS PROJECT ID: 1108003-002

SAMPLE RECEIPT SUMMARY

CLIENT: WESTON   Date Received: 10/27/11   Received By: EV   Inspected By: EV

COURIER
☐ PHYSIS ☑ CLIENT ☐ FEDEX ☐ UPS
☐ OTHER: ______

COOLER
☑ COOLER ☐ BOX total # 1
☐ OTHER: ______

TEMPERATURE
3.9 °C
☑ WET ICE ☐ BLUE ICE
☐ DRY ICE ☐ NONE

SAMPLE INTEGRITY UPON RECEIPT

1. COC(s) included and completely filled out........ *YES*
2. All sample containers arrived intact........ *YES*
3. All samples listed on COC(s) are present........ *NO; see notes below*
4. Information on containers consistent with information on COC(s)........ *YES*
5. Correct containers and volume for all analyses indicated........ *YES*
6. All samples received within method holding time........ *YES*
7. Correct preservation used for all analyses indicated........ *YES*

NOTES

for sample SIYB-1, received no TOC bottle (amber glass w/H2S04)
instead, received 2 DOC bottles (amber glass unpreserved)
used extra DOC bottle for TOC (added H2S04)

Reset Form

1904 E. Wright Circle, Anaheim CA 92806   (714) 602-5320 main / (714) 602-5321 fax

Print Form

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	23 Aug 11
Client Sample ID:	SIYB-1	Date Test Ended:	27 Aug 11
Weston Test ID:	C110823.0162	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No. BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***
Age: 12 days old

Concentration (%)	Number of Test Organisms at Start of Test	Number of Test Organisms at End of Test	Percent Survival
Control	40	38	95.0
6.25	40	40	100
12.5	40	37	92.5
25	40	39	97.5
50	40	40	100
100	40	39	97.5

Acute Toxicity Statement for Sample SIYB-1

Distribution Method	Result	Variance Method	Result
Shapiro-Wilk's Test	Normal; p > 0.01	N/A	Could Not Be Confirmed

Hypothesis Method	NOEC	LOEC	TUa	Point Estimation Method	EC_{50}
Steel's Many-One Rank Test	100%	>100%	0.23	Linear Interpolation	>100%

EC_{15}	EC_{25}	EC_{40}	Mean Mortality in 100%
>100%	>100%	>100%	2.50%

Acute Toxicity Statement: Test substance SIYB-1 produced 97.5 percent survival in the 100 percent test concentration at 96 hours. The LC_{50} at 96 hours was estimated to be >100 percent test substance.

Toxicity, expressed as toxic units acute (TUa), was 0.23.

Protocol Deviations: none

QA Officer 1/3/12 Date

Approved 1/5/12 Date

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	23 Aug 11
Client Sample ID:	SIYB-1	Date Test Ended:	27 Aug 11
Weston Test ID:	C110823.0162	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No.: BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***

Test Solution Physical and Chemical Data

Total Chlorine (mg/L)			
Concentration (%)	Initial	Renewal	Final
Control	0.00	*	*
100	0.00	*	*

*Chlorine not detected in initial measurement of sample

Concentration (%)	Statistic	D.O. (mg/L)	Temp.(°C)	Salinity (ppt)	pH
Control	Mean	6.3	21.6	32.9	7.8
	Minimum	5.6	20.9	32.8	7.6
	Maximum	7.2	22.4	33.1	8.0
6.25	Mean	5.7	21.4	32.9	7.8
	Minimum	5.7	21.1	32.8	7.6
	Maximum	7.2	22.0	33.1	8.0
12.5	Mean	6.5	21.6	33.0	7.8
	Minimum	5.6	21.1	32.8	7.6
	Maximum	7.3	22.4	33.5	8.0
25	Mean	6.6	21.5	33.0	7.8
	Minimum	5.7	21.0	32.8	7.6
	Maximum	7.3	22.1	33.1	8.0
50	Mean	6.7	21.6	33.0	7.8
	Minimum	5.3	21.0	32.8	7.6
	Maximum	7.6	22.4	33.2	8.0
100	Mean	6.9	21.6	33.0	7.8
	Minimum	5.4	21.1	32.9	7.6
	Maximum	8.5	22.4	33.1	8.0

Weston Solutions, Inc.

Analytical Report

Client:	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	23 Aug 11
Client Sample ID:	SIYB-1	Date Test Ended:	27 Aug 11
Weston Test ID:	C110823.0162	Matrix:	Liquid

TEST: 96 Hour Acute Effluent Toxicity Bioassay, Weston Protocol No. BIO 062, EPA-821-R-02-012

LAB CONTROL WATER: Seawater collected from Scripps Institution of Oceanography.

Dissolved Oxygen	6.5 mg/L
Temperature	21.5 °C
pH	8.0

TEST ORGANISM: Topsmelt, *Atherinops affinis* Age: 12 days old
Supplier: Aquatic BioSystems
Feeding: Fed *Artemia* nauplii *ad libitum* daily prior to testing.

TEST CHAMBER: Half liter containers, 4 replicate samples, 5 concentrations, and 4 replicate controls, brought to a 250mL final volume.

EXPERIMENTAL DESIGN:

1. Sample was collected by Weston Solutions personnel on August 22, 2011 at 1635 hours. The sample arrived at the Weston Solutions laboratory on the following day at 0920 hours in one 10L container. Temperature upon arival was 5.8°C.
2. The temperature of the effluent was adjusted to 21±1°C.
3. 10 test organisms were placed in each test container.
4. Test chambers were held at 21±1°C for 96 hours with a photoperiod of 16 hours light: 8 hours darkness.
5. Test chambers were renewed daily.
6. Each test chamber was fed 1000 freshly hatched *Artemia* nauplii daily for the duration of the test.

MORTALITY CRITERIA: Lack of respiratory movement and lack of reaction to gentle prodding

ACCEPTIBILITY CRITERIA: $\geq$ 90% survival in controls. Evaluation of the concentration-response relationship indicated that the data presented in this report are reliable.

REFERENCE TOXICITY: (Control Chart Included)

Toxicant: CuSO4, Lot No.: 2008506, Received: 7/13/11, Opened: 7/28/11, Expires: 8/31/12.

96 Hour LC_{50}:	116.12 ppb	NOEC:	100 ppb
96 Hour LC_{25}:	91.74 ppb	LOEC:	200 ppb
Laboratory Mean:	155.99 ppb		
Test Date:	8/23/2011	Within 95 % Confidence Limits	

STUDY DIRECTOR: S. Hasan

INVESTIGATORS: K. Curry, B. Griffith, J. Hansen, S. Hasan

Acute Fish Test-96 Hr Survival

Start Date:	8/23/2011 16:30	Test ID:	C110823.0162	Sample ID:	SIYB-1
End Date:	8/27/2011 16:05	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:35	Protocol:	EPAA 02-EPA Acute	Test Species:	AA-Atherinops affinis

Comments:

Conc-%	1	2	3	4
Control	0.9000	0.9000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	0.8000	0.9000	1.0000
25	1.0000	1.0000	0.9000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	0.9000

			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.9500	1.0000	0.9500	0.9000	1.0000	6.077	4			0.9750	1.0000
6.25	1.0000	1.0526	1.0000	1.0000	1.0000	0.000	4	22.00	10.00	0.9750	1.0000
12.5	0.9250	0.9737	0.9250	0.8000	1.0000	10.351	4	17.00	10.00	0.9688	0.9936
25	0.9750	1.0263	0.9750	0.9000	1.0000	5.128	4	20.00	10.00	0.9688	0.9936
50	1.0000	1.0526	1.0000	1.0000	1.0000	0.000	4	22.00	10.00	0.9688	0.9936
100	0.9750	1.0263	0.9750	0.9000	1.0000	5.128	4	20.00	10.00	0.9688	0.9936

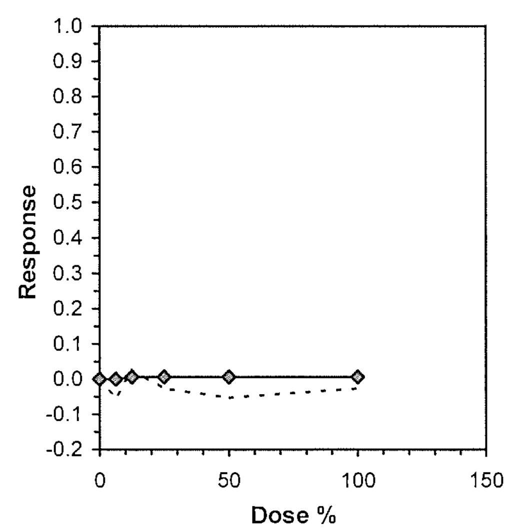
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.91922	0.884	-0.8155	0.8829
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			

TUa = 0.23



Test: AC-Acute Fish Test	Test ID: C110823.01 62
Species: AA-Atherinops affinis	Protocol: EPAA 02-EPA Acute
Sample ID: SIYB-1	Sample Type: AMB1-Ambient water
Start Date: 8/23/2011 16:30 End Date: 8/27/2011 16:05	Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				9	
	2	2	Control	10				9	
	3	3	Control	10				10	
	4	4	Control	10				10	
	5	1	6.250	10				10	
	6	2	6.250	10				10	
	7	3	6.250	10				10	
	8	4	6.250	10				10	
	9	1	12.500	10				10	
	10	2	12.500	10				8	
	11	3	12.500	10				9	
	12	4	12.500	10				10	
	13	1	25.000	10				10	
	14	2	25.000	10				10	
	15	3	25.000	10				9	
	16	4	25.000	10				10	
	17	1	50.000	10				10	
	18	2	50.000	10				10	
	19	3	50.000	10				10	
	20	4	50.000	10				10	
	21	1	100.000	10				10	
	22	2	100.000	10				10	
	23	3	100.000	10				10	
	24	4	100.000	10				9	

Comments:

 ToxCalc 5.0 Reviewed by: YS

WESTON SOLUTIONS

Topsmelt 96-Hour Acute Toxicity Test

KC ③

Client	~~Weston~~ Port of San Diego
Project:	Shelter Island Yacht Basin
Client Sample ID:	SIYB-1
Weston Test ID:	C110823.0162
Species	*Atherinops affinis*

Date Received:	8/23/11
Date Test Started:	8/23/11
Date Test Ended:	8/27/11
Study Director:	S. Hasan
Organisms/Chamber:	10

	Conc.	Meter #	D.O. (mg/L)	Meter #	Temp (°C)	Meter #	Salinity (ppt)	Meter #	pH	Total Chlorine (mg/L)
Day 0 (0 Hours)	Control	3	6.5	3	21.5	5	33.0	4	8.0	0.00
Date: 8/23/11	6.25		6.7		21.4		33.0		8.0	
Sample ID: C110823.01	12.5		6.8		21.5		33.0		8.0	
Dilutions (Tech): KC	25		6.9		21.8		33.0		8.0	
WQ Time: 1415 Rep: Stock	50		7.3		21.5		32.9		8.0	
Technician: BG	100		7.9		21.7		32.9		8.0	0.00
24 Hours (OLD)	Control 1	2	5.9	2	22.4	6	33.0	4	7.6	
Date: 8/24/11	6.25		5.7		21.9		33.1		7.6	
WQ Time: 1055 Rep: 1	12.5		5.6		21.6		32.9		7.6	
Technician: BG	25		5.7		22.1		33.1		7.6	
	50		5.3		22.4		33.2		7.6	
	100		5.4		22.0		33.0		7.6	
24 Hours (Renewal Water)	Control 1	3	7.2	3	21.0	5	32.8	3	7.9	
Date: 8/24/11	6.25		7.2		21.1		32.8		7.9	
Sample ID: C110823.01	12.5		7.3		21.2		32.8		8.0	
Dilutions (Tech): KC	25		7.3		21.1		32.8		8.0	
WQ Time: 1710 Rep: Stock	50		7.4		21.1		32.9		8.0	
Technician: BG	100		7.6		21.2		33.0		8.0	
48 Hours (OLD)	Control	3	5.6	3	20.9	5	32.8	3	7.7	
Date: 8/25/11	6.25		5.7		21.1		32.9		7.7	
WQ Time: 1005 Rep: 2	12.5		5.8		21.2		33.5		7.7	
Technician: BG	25		5.9		21.1		32.9		7.8	
	50		5.9		21.2		32.8		7.8	
	100		5.6		22.4		33.0		7.8	
48 Hours (Renewal Water)	Control	3	6.8	3	21.5	5	32.8	3	7.9	②JH
Date: 8/25/11	6.25		6.9		21.3		32.8		7.9	
Sample ID: C110823.01	12.5		7.1		21.3		32.8		7.9	
Dilutions (Tech): KC	25		7.2		21.3		32.8		7.9	
WQ Time: 0955 Rep: Stock	50		7.6		21.3		32.8		7.9	
Technician: BG	100		8.5		21.3		32.9		7.9	②JH
72 Hours (OLD)	Control	2	6.0	2	22.4	6	33.1	3	7.7	
Date: 8/26/11	6.25		6.3		21.1		33.1		7.6	
WQ Time: 1000 Rep: 3	12.5		6.1		22.4		33.0		7.7	
Technician: BG	25		6.3		22.0		33.1		7.7	
	50		6.2		22.2		33.1		7.7	
	100		6.2		21.5		33.1		7.7	
72 Hours (Renewal Water)	Control	3	6.6	3	21.1	5	32.8	4	7.9	
Date: 8/26/11	6.25		6.6		21.1		32.8		7.9	
Sample ID: C110823.01	12.5		6.8		21.1		32.8		7.9	
Dilutions (Tech): BG	25		7.0		21.0		32.8		7.9	
WQ Time: 1045 Rep: Stock	50		7.2		21.0		32.8		8.0	
Technician: JH	100		8.0		21.1		32.9		8.0	
96 Hours KC①	Control	3	~~6.3~~ 5.8	3	~~22.0~~ 21.9	5	~~32.9~~ 32.9	4	~~7.7~~ 7.7	②JH
Date: 8/27/11	6.25		6.3		22.0		32.9		7.7	
WQ Time: 1555 Rep: 4	12.5		6.2		22.1		33.0		7.7	
Technician: KC	25		6.2		21.8		33.1		7.6	
	50		6.3		22.3		33.1		7.7	
	100		6.3		21.9		33.1		7.7	②JH

① WC 8/27/11 KC
② Chlorine not detected at test initiation 8/29/11 JH
③ IE 8/30/11 KC

WESTON SOLUTIONS

Topsmelt 96-Hour Acute Toxicity Test

Weston Test ID:	Client:	Client Sample ID:
C110823.0162	Port of San Diego ~~Weston~~ ③	SIYB-1

Survival Data

Conc.	Rep	24 Hours # Alive	24 Hours #Dead	48 Hours # Alive	48 Hours #Dead	72 Hours # Alive	72 Hours #Dead	96 Hours # Alive	96 Hours #Dead
		Date: 8/24/11		Date: 8/25/11		Date: 8/26/11		Date: 8/27/11	
		Renewal Time: 1730		Renewal Time: 1020		Renewal Time: 1450		End Time: 1605	
		Technician: BG		Technician: BG		Technician: BG		Technician: KC	
Control	1	9	1	9	0	9	0	9	0
	2	9	1	9	0	9	0	9	0
	3	10	0	10	0	10	0	10	0
	4	10	0	10	0	10	0	10	0
6.25	1	10	0	10	0	10	0	10	0
	2	10	0	10	0	10	0	10	0
	3	10	0	10	0	10	0	10	0
	4	10	0	10	0	10	0	10	0
12.5	1	10	0	10	0	10	0	10	0
	2	8	2	8	0	8	0	8	0
	3	9	1	9	0	9	0	9	0
	4	10	① ~~10~~ 0	10	0	10	0	10	0
25	1	10	0	10	0	10	0	10	0
	2	10	0	10	0	10	0	10	0
	3	9	1	9	0	9	0	9	0
	4	10	0	10	0	10	0	10	0
50	1	10	0	10	0	10	0	10	0
	2	10	0	10	0	10	0	10	0
	3	10	0	10	0	10	0	10	0
	4	10	0	10	0	10	0	10	0
100	1	10	0	10	0	10	0	10	0
	2	10	0	10	0	10	0	10	0
	3	10	0	10	0	10	0	② ~~9~~ 10	0
	4	9	1	9	0	9	0	9	0
	1	X ④ BG							
	2								
	3								
	4								

Feeding Information	Day 0	24 Hours	48 Hours	72 Hours
Feed Time*:	1650	0830	0830	0845
Technician:	KC	KC	KC	KC

*Topsmelt should be fed at test initiation and approximately 2 hours before renewal at 24, 48, and 72 hours.

Start Time:	1630 KC/BG	
End Time:	1605 KC	
Supplier:	Aquatic Bio Systems	
Organism Batch:	ABS 8683	Age: 12 days

Dilution Water Batch:	SI0072511
Hobo Temp. No.:	71637
Test Location:	Room 3
Test Acceptablility: ✓ ≥ 90% Survival in Control	

① IE 8/24/11 BG
② WC 8/27/11 KC
③ IE 8/30/11 KC
④ WC 9/27/11 BG

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	23 Aug 11
Client Sample ID:	SIYB-2	Date Test Ended:	27 Aug 11
Weston Test ID:	C110823.0262	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No. BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***
Age: 12 days old

Concentration (%)	Number of Test Organisms at Start of Test	Number of Test Organisms at End of Test	Percent Survival
Control	40	38	95.0
6.25	40	39	97.5
12.5	40	38	95.0
25	40	39	97.5
50	40	40	100
100	40	39	97.5

Acute Toxicity Statement for Sample SIYB-2

Distribution Method	Result	Variance Method	Result
Shapiro-Wilk's Test	Non-normal; $p \leq 0.01$	N/A	Could Not Be Confirmed

Hypothesis Method	NOEC	LOEC	TUa	Point Estimation Method	EC_{50}
Steel's Many-One Rank Test	100%	>100%	0.23	Linear Interpolation	>100%

EC_{15}	EC_{25}	EC_{40}	Mean Mortality in 100%
>100%	>100%	>100%	2.50%

Acute Toxicity Statement: Test substance SIYB-2 produced 97.5 percent survival in the 100 percent test concentration at 96 hours. The LC_{50} at 96 hours was estimated to be >100 percent test substance.

Toxicity, expressed as toxic units acute (TUa), was 0.23.

Protocol Deviations: Sample arrived at 9.9°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity.

[signature]	1/3/12	[signature]	1/5/12
QA Officer	Date	Approved	Date

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	23 Aug 11
Client Sample ID:	SIYB-2	Date Test Ended:	27 Aug 11
Weston Test ID:	C110823.0262	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No.: BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***

Test Solution Physical and Chemical Data

Total Chlorine (mg/L)			
Concentration (%)	Initial	Renewal	Final
Control	0.00	*	*
100	0.02	*	*

*Chlorine not detected in initial measurement of sample

Concentration (%)	Statistic	D.O. (mg/L)	Temp.(°C)	Salinity (ppt)	pH
Control	Mean	6.3	21.6	32.9	7.8
	Minimum	5.6	20.9	32.8	7.6
	Maximum	7.2	22.4	33.1	8.0
6.25	Mean	5.7	21.5	33.0	7.9
	Minimum	5.6	21.1	32.8	7.6
	Maximum	7.2	22.1	33.3	8.0
12.5	Mean	6.4	21.5	32.9	7.9
	Minimum	5.5	21.1	32.8	7.6
	Maximum	7.4	22.0	33.2	8.0
25	Mean	6.5	21.6	33.0	7.9
	Minimum	5.5	21.1	32.8	7.7
	Maximum	7.4	22.4	33.4	8.0
50	Mean	6.6	21.5	33.0	7.9
	Minimum	5.8	21.0	32.8	7.7
	Maximum	7.6	22.4	33.2	8.0
100	Mean	6.9	21.6	33.0	7.9
	Minimum	5.4	21.1	32.8	7.7
	Maximum	8.3	22.4	33.2	8.1

Weston Solutions, Inc.

Analytical Report

Client:	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	23 Aug 11
Client Sample ID:	SIYB-2	Date Test Ended:	27 Aug 11
Weston Test ID:	C110823.0262	Matrix:	Liquid

TEST: 96 Hour Acute Effluent Toxicity Bioassay, Weston Protocol No. BIO 062, EPA-821-R-02-012

LAB CONTROL WATER: Seawater collected from Scripps Institution of Oceanography.

Dissolved Oxygen	6.5 mg/L
Temperature	21.5 °C
pH	8.0

TEST ORGANISM: Topsmelt, *Atherinops affinis* Age: 12 days old
Supplier: Aquatic BioSystems
Feeding: Fed *Artemia* nauplii *ad libitum* daily prior to testing.

TEST CHAMBER: Half liter containers, 4 replicate samples, 5 concentrations, and 4 replicate controls, brought to a 250mL final volume.

EXPERIMENTAL DESIGN:

1. Sample was collected by Weston Solutions personnel on August 22, 2011 at 1625 hours. The sample arrived at the Weston Solutions laboratory on the following day at 0920 hours in one 10L container. Temperature upon arival was 9.9°C.
2. The temperature of the effluent was adjusted to 21±1°C.
3. 10 test organisms were placed in each test container.
4. Test chambers were held at 21±1°C for 96 hours with a photoperiod of 16 hours light: 8 hours darkness.
5. Test chambers were renewed daily.
6. Each test chamber was fed 1000 freshly hatched *Artemia* nauplii daily for the duration of the test.

MORTALITY CRITERIA: Lack of respiratory movement and lack of reaction to gentle prodding

ACCEPTIBILITY CRITERIA: $\geq$ 90% survival in controls. Evaluation of the concentration-response relationship indicated that the data presented in this report are reliable.

REFERENCE TOXICITY: (Control Chart Included)

Toxicant: $CuSO_4$, Lot No.: 2008506, Received: 7/13/11, Opened: 7/28/11, Expires: 8/31/12.

96 Hour LC_{50}:	116.12 ppb	NOEC:	100 ppb
96 Hour LC_{25}:	91.74 ppb	LOEC:	200 ppb
Laboratory Mean:	155.99 ppb		
Test Date:	8/23/2011	Within 95 % Confidence Limits	

STUDY DIRECTOR: S. Hasan
INVESTIGATORS: K. Curry, B. Griffith, J. Hansen, S. Hasan

Acute Fish Test-96 Hr Survival

Start Date:	8/23/2011 16:30	Test ID:	C110823.0262	Sample ID:	SIYB-2
End Date:	8/27/2011 16:40	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:25	Protocol:	EPAA 02-EPA Acute	Test Species:	AA-Atherinops affinis

Comments:

Conc-%	1	2	3	4
Control	0.9000	0.9000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	0.9000
12.5	1.0000	1.0000	0.8000	1.0000
25	1.0000	0.9000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	0.9000	1.0000	1.0000

			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.9500	1.0000	0.9500	0.9000	1.0000	6.077	4			0.9708	1.0000
6.25	0.9750	1.0263	0.9750	0.9000	1.0000	5.128	4	20.00	10.00	0.9708	1.0000
12.5	0.9500	1.0000	0.9500	0.8000	1.0000	10.526	4	19.00	10.00	0.9708	1.0000
25	0.9750	1.0263	0.9750	0.9000	1.0000	5.128	4	20.00	10.00	0.9708	1.0000
50	1.0000	1.0526	1.0000	1.0000	1.0000	0.000	4	22.00	10.00	0.9708	1.0000
100	0.9750	1.0263	0.9750	0.9000	1.0000	5.128	4	20.00	10.00	0.9708	1.0000

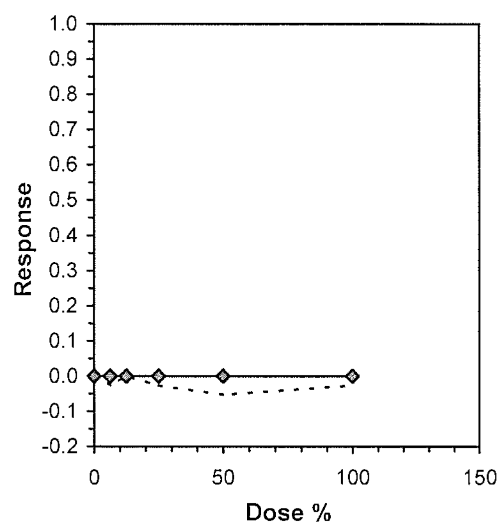
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.81429	0.884	-1.3812	1.52338
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			

TUa = 0.23



Test: AC-Acute Fish Test		Test ID: C110823.0262
Species: AA-Atherinops affinis		Protocol: EPAA 02-EPA Acute
Sample ID: SIYB-2		Sample Type: AMB1-Ambient water
Start Date: 8/23/2011 16:30	End Date: 8/27/2011 16:40	Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				9	
	2	2	Control	10				9	
	3	3	Control	10				10	
	4	4	Control	10				10	
	5	1	6.250	10				10	
	6	2	6.250	10				10	
	7	3	6.250	10				10	
	8	4	6.250	10				9	
	9	1	12.500	10				10	
	10	2	12.500	10				10	
	11	3	12.500	10				8	
	12	4	12.500	10				10	
	13	1	25.000	10				10	
	14	2	25.000	10				9	
	15	3	25.000	10				10	
	16	4	25.000	10				10	
	17	1	50.000	10				10	
	18	2	50.000	10				10	
	19	3	50.000	10				10	
	20	4	50.000	10				10	
	21	1	100.000	10				10	
	22	2	100.000	10				9	
	23	3	100.000	10				10	
	24	4	100.000	10				10	

Comments:

WESTON SOLUTIONS

Topsmelt 96-Hour Acute Toxicity Test

BIO062

KC ⑤ ⑦

Client	~~Weston~~ Port of San Diego
Project:	Shelter Island Yacht Basin
Client Sample ID:	SIYB-2
Weston Test ID:	C110823.02 62
Species	*Atherinops affinis*

Date Received:	8/23/11
Date Test Started:	8/23/11
Date Test Ended:	8/27/11
Study Director:	S. Hasan
Organisms/Chamber:	10

	Conc.	Meter #	D.O. (mg/L)	Meter #	Temp (°C)	Meter #	Salinity (ppt)	Meter #	pH	Total Chlorine (mg/L)
Day 0 (0 Hours)	Control 1	3	6.5	3	21.5	5	33.0	4	8.0	0.0D
Date: 8/23/11	6.25		6.8		21.1		33.0		8.0	
Sample ID: C110823.02	12.5		6.8		21.3		33.0		8.0	
Dilutions (Tech): KC	25		6.8		21.5		33.0		8.0	
WQ Time: 1435 Rep: Stock	50		7.1		21.3		32.9		8.0	
Technician: BG	100		7.9		21.4		32.9		8.1	0.002 ⑤JH
24 Hours (OLD)	Control 1	2	5.9 5.6	2	22.4 21.9	6	33.0 33.3	4	7.6 7.6	
Date: 8/24/11	6.25		5.6 5.5 ① BG		21.9 21.9		33.3 33.2		7.6 7.6	
WQ Time: 1110 Rep: 1	12.5		5.5 5.6		21.9 21.9		33.2 33.4		7.6 7.7	
Technician: BG	25		5.8 5.9		21.9 21.6		33.4 33.2		7.7 7.7	
	50		5.9		21.6		33.2		7.7	
	100		5.4		21.8		33.1		7.7	
24 Hours (Renewal Water)	Control 1	3	7.2	3	21.0	5	32.8	3	7.9	
Date: 8/24/11	6.25		7.2		21.3		32.8		8.0	
Sample ID: C110823.02	12.5		7.4		21.2		32.8		8.0	
Dilutions (Tech): KC	25		7.4		21.2		32.8		8.0	
WQ Time: 1745 Rep: Stock	50		7.3		21.2		32.9		8.0	
Technician: BG	100		7.7		21.1		33.0		8.0	
48 Hours (OLD)	Control	3	5.6 ~~5.8~~ ②BG	3	20.9	5	32.8	3	7.7	
Date: 8/25/11	6.25		5.8		21.7		32.9		7.8	
WQ Time: 1010 Rep: 2	12.5		5.9		21.2		32.9		7.8	
Technician: BG	25		5.5		22.4		32.9		7.8	
	50		5.8		21.6		32.9		7.8	
	100		5.5		22.4		32.9		7.8	
48 Hours (Renewal Water)	Control	3	6.8	3	21.5	5	32.8	3	7.9	⑥JH
Date: 8/25/11	6.25		7.0		21.3		32.8		7.9	
Sample ID: C110823.02	12.5		7.1		21.3		32.8		7.9	
Dilutions (Tech): BG	25		7.2		21.3		32.8		7.9	
WQ Time: 1000 Rep: Stock	50		7.6		21.1		32.8		8.0	
Technician: BG	100		8.3		21.1		32.8		8.0	⑥JH
72 Hours (OLD)	Control	2	6.0	2	22.4	6	33.1	3	7.7	
Date: 8/26/11	6.25		6.0		21.7		33.0		7.7	
WQ Time: 1010 Rep: 3	12.5		6.1		21.4		33.1		7.8	
Technician: BG	25		6.2		21.3		33.1		7.8	
	50		5.8		22.4		33.2		7.8	
	100		6.0		22.3		33.2		7.8	
72 Hours (Renewal Water)	Control	3	6.6	3	21.1	5	32.8	4	7.9	
Date: 8/26/11	6.25		6.6		21.1		33.0		8.0	
Sample ID: C110823.02	12.5		6.8		21.1		32.8		8.0	
Dilutions (Tech): BG	25		6.9		21.1		32.8		8.0	
WQ Time: 1050 Rep: Stock	50		7.5		21.0		32.8		8.0	
Technician: JH	100		8.2		21.3		32.8		8.0	
96 Hours	Control	3	~~6.5~~ 5.8	3	~~22.2~~ 21.8	5	32.9	4	7.7	⑥JH
Date: 8/27/11	6.25	KC ③	~~6.8~~ 5.9		22.1 ~~22.0~~	KC ⑤	33.0		7.8	
WQ Time: 1525 Rep: 4	12.5		~~6.9~~ 5.9		22.0 ~~21.4~~		32.9		7.8	
Technician: KC	25		~~6.9~~ 5.9		21.9 ~~21.7~~		32.9		7.8	
	50		~~7.2~~ 5.8		22.0 ~~21.9~~		33.1		7.9	
	100		~~7.4~~ 5.9		21.6 ~~22.0~~		33.2		7.8	⑥JH

① WC, 8/24/11 BG
② IE ~~KC~~ ④ 8/25/11 BG
③ ~~WP~~ 8/27/11 KC
④ IE ~~IE~~ 8/27/11 KC
↳ WQ done on wrong test. KC

⑤ WP 8/29/11 JH
⑥ Chlorine not detected at test initiation 8/29/11 JH
⑦ IE 8/30/11 KC

WESTON SOLUTIONS

Topsmelt 96-Hour Acute Toxicity Test

BIO062

Weston Test ID: C110823.0262	Client: Port of San Diego ~~Weston~~ KC ②	Client Sample ID: SIYB-2

Survival Data

Conc.	Rep	24 Hours Date: 8/24/11 Renewal Time: 1750 Technician: BG/KC # Alive	#Dead	48 Hours Date: 8/25/11 Renewal Time: 1055 Technician: BG # Alive	#Dead	72 Hours Date: 8/26/11 Renewal Time: 1510 Technician: BG # Alive	#Dead	96 Hours Date: 8/27/11 End Time: 1640 Technician: KC # Alive	#Dead
Control	1	9 ~~10~~ ①BG	1	9	Ø	9	Ø	9	Ø
	2	9	1	9	Ø	9	Ø	9	Ø
	3	10	10	10	Ø	10	Ø	10	Ø
	4	10	10	10	Ø	10	Ø	10	Ø
6.25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	9	1	9	Ø	9	Ø	9	Ø
12.5	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	8	2	8	Ø	8	Ø	8	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	9	1	9	Ø	9	Ø	9	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
50	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
100	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	9	1	9	Ø	9	Ø	9	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
	1								
	2								
	3								
	4								

Feeding Information	Day 0	24 Hours	48 Hours	72 Hours
Feed Time*:	1650	0830	0830	0845
Technician:	KC	KC	KC	KC

*Topsmelt should be fed at test initiation and approximately 2 hours before renewal at 24, 48, and 72 hours.

Start Time:	1630 KC/BG
End Time:	1640 KC
Supplier:	Aquatic Bio Systems
Organism Batch:	ABS 8683 Age: 12 days

Dilution Water Batch:	SI0072511
Hobo Temp. No.:	71437
Test Location:	Room 3
Test Acceptability:	X ≥ 90% Survival in Control

①IE 8/24/11 BG
②IE 8/30/11 KC

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-3	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0362	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No. BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***
Age: 13 days old

Concentration (%)	Number of Test Organisms at Start of Test	Number of Test Organisms at End of Test	Percent Survival
Control	40	39	97.5
6.25	40	39	97.5
12.5	40	40	100
25	40	39	97.5
50	40	40	100
100	40	40	100

Acute Toxicity Statement for Sample SIYB-3

Distribution Method	Result	Variance Method	Result
Shapiro-Wilk's Test	Non-normal; $p \leq 0.01$	N/A	Could Not Be Confirmed

Hypothesis Method	NOEC	LOEC	TUa	Point Estimation Method	EC_{50}
Steel's Many-One Rank Test	100%	>100%	0	Linear Interpolation	>100%

EC_{15}	EC_{25}	EC_{40}	Mean Mortality in 100%
>100%	>100%	>100%	0.00%

Acute Toxicity Statement: Test substance SIYB-3 produced 100 percent survival in the 100 percent test concentration at 96 hours. The LC_{50} at 96 hours was estimated to be >100 percent test substance.

Toxicity, expressed as toxic units acute (TUa), was 0.

Protocol Deviations: Due to a shortage of organisms available on 8/23/11 the test was started within 48 Hrs of sampling rather than 36 Hrs. Sample arrived at 10.3°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity.

[signature]	1/3/12	[signature]	1/5/12
QA Officer	Date	Approved	Date

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-3	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0362	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No.: BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***

Test Solution Physical and Chemical Data

Total Chlorine (mg/L)			
Concentration (%)	Initial	Renewal	Final
Control	0.02	*	*
100	0.00	*	*

*Chlorine not detected in initial measurement of sample

Concentration (%)	Statistic	D.O. (mg/L)	Temp.(°C)	Salinity (ppt)	pH
Control	Mean	6.5	21.9	32.6	7.8
	Minimum	6.0	21.3	31.3	7.5
	Maximum	7.2	22.4	33.0	8.0
6.25	Mean	5.9	21.8	32.8	7.6
	Minimum	5.6	21.3	32.6	6.0
	Maximum	7.4	22.3	33.0	8.0
12.5	Mean	6.8	21.6	32.9	7.8
	Minimum	6.0	21.1	32.7	7.6
	Maximum	7.5	22.0	33.1	8.0
25	Mean	6.8	21.6	33.0	7.8
	Minimum	5.8	21.3	32.7	7.5
	Maximum	7.6	22.1	33.1	8.0
50	Mean	7.1	21.4	33.1	7.8
	Minimum	6.0	20.6	32.9	7.6
	Maximum	7.6	21.9	33.2	8.0
100	Mean	7.3	21.7	33.0	7.8
	Minimum	5.8	21.2	32.8	7.6
	Maximum	8.2	22.2	33.2	8.0

Weston Solutions, Inc.

Analytical Report

Client:	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-3	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0362	Matrix:	Liquid

TEST: 96 Hour Acute Effluent Toxicity Bioassay, Weston Protocol No. BIO 062, EPA-821-R-02-012

LAB CONTROL WATER: Seawater collected from Scripps Institution of Oceanography.

Dissolved Oxygen	7.2 mg/L
Temperature	21.9 °C
pH	8.0

TEST ORGANISM: Topsmelt, *Atherinops affinis* Age: 13 days old
Supplier: Aquatic BioSystems
Feeding: Fed *Artemia* nauplii *ad libitum* daily prior to testing.

TEST CHAMBER: Half liter containers, 4 replicate samples, 5 concentrations, and 4 replicate controls, brought to a 250mL final volume.

EXPERIMENTAL DESIGN:

1. Sample was collected by Weston Solutions personnel on August 22, 2011 at 1615 hours. The sample arrived at the Weston Solutions laboratory on the following day at 0920 hours in one 10L container. Temperature upon arival was 10.3°C.
2. The temperature of the effluent was adjusted to 21±1°C.
3. 10 test organisms were placed in each test container.
4. Test chambers were held at 21±1°C for 96 hours with a photoperiod of 16 hours light: 8 hours darkness.
5. Test chambers were renewed daily.
6. Each test chamber was fed 1000 freshly hatched *Artemia* nauplii daily for the duration of the test.

MORTALITY CRITERIA: Lack of respiratory movement and lack of reaction to gentle prodding

ACCEPTIBILITY CRITERIA: $\geq$ 90% survival in controls. Evaluation of the concentration-response relationship indicated that the data presented in this report are reliable.

REFERENCE TOXICITY: (Control Chart Included)

Toxicant: CuSO4, Lot No.: 2008506, Received: 7/13/11, Opened: 7/28/11, Expires: 8/31/12.

96 Hour LC_{50}:	87.04 ppb		NOEC:	50 ppb
96 Hour LC_{25}:	68.52 ppb		LOEC:	100 ppb
Laboratory Mean:	153.08 ppb			
Test Date:	8/24/2011		Within 95 % Confidence Limits	

STUDY DIRECTOR: S. Hasan
INVESTIGATORS: K. Curry, B. Griffith, J. Hansen, S. Hasan

Acute Fish Test-96 Hr Survival

Start Date:	8/24/2011 15:50	Test ID:	C110823.0362	Sample ID:	SIYB-3
End Date:	8/28/2011 14:30	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:15	Protocol:	EPAA 02-EPA Acute	Test Species:	AA-Atherinops affinis

Comments:

Conc-%	1	2	3	4
Control	0.9000	1.0000	1.0000	1.0000
6.25	1.0000	0.9000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	0.9000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4			0.9875	1.0000
6.25	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4	18.00	10.00	0.9875	1.0000
12.5	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9875	1.0000
25	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4	18.00	10.00	0.9875	1.0000
50	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9875	1.0000
100	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9875	1.0000

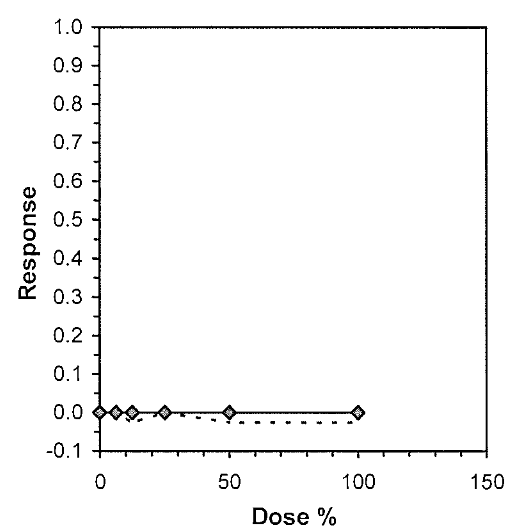
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.66831	0.884	-1.7439	2.37302
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			

TUa = ϕ



 ToxCalc v5.0.23 Reviewed by: YB

Test: AC-Acute Fish Test								Test ID: C110823.03u2	
Species: AA-Atherinops affinis								Protocol: EPAA 02-EPA Acute	
Sample ID: SIYB-3								Sample Type: AMB1-Ambient water	
Start Date: 8/24/2011 15:50				End Date: 8/28/2011 14:30				Lab ID: CCA-Weston, Carlsbad	
Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				9	
	2	2	Control	10				10	
	3	3	Control	10				10	
	4	4	Control	10				10	
	5	1	6.250	10				10	
	6	2	6.250	10				9	
	7	3	6.250	10				10	
	8	4	6.250	10				10	
	9	1	12.500	10				10	
	10	2	12.500	10				10	
	11	3	12.500	10				10	
	12	4	12.500	10				10	
	13	1	25.000	10				10	
	14	2	25.000	10				10	
	15	3	25.000	10				9	
	16	4	25.000	10				10	
	17	1	50.000	10				10	
	18	2	50.000	10				10	
	19	3	50.000	10				10	
	20	4	50.000	10				10	
	21	1	100.000	10				10	
	22	2	100.000	10				10	
	23	3	100.000	10				10	
	24	4	100.000	10				10	

Comments:

ToxCalc 5.0

Reviewed by: YJ

WESTON SOLUTIONS

Topsmelt 96-Hour Acute Toxicity Test

BIO062

KC ③

Client	~~Weston~~ Port of San Diego
Project:	Shelter Island and Yacht Basin
Client Sample ID:	SIYB-3
Weston Test ID:	C110823.0362
Species	*Atherinops affinis*

Date Received:	8/23/11
Date Test Started:	8/24/11
Date Test Ended:	8/28/11
Study Director:	S. Hasan
Organisms/Chamber:	10

	Conc.	Meter #	D.O. (mg/L)	Meter #	Temp (°C)	Meter #	Salinity (ppt)	Meter #	pH	Total Chlorine (mg/L)
Day 0 (0 Hours)	Control 2	3	7.2	3	21.9	5	32.8	3	8.0	0.02
Date: 8/24/11	6.25		7.4		22.0		32.7		8.0	
Sample ID: C110823.03	12.5		7.5		21.8		32.7		8.0	
Dilutions (Tech): KC	25		7.6		21.7		32.8		8.0	
WQ Time: 1505 Rep: Stock	50		7.6		21.2		33.1		8.0	
Technician: JH	100		7.9		21.2		32.8		8.0	0.00
24 Hours (OLD)	Control 2	2	6.0	2	22.4	6	31.3	4	7.8	
Date: 8/25/11	6.25		5.7		22.1		32.6		6.0	
WQ Time: 0935 Rep: 1	12.5		6.0		21.7		32.7		7.6	
Technician: SH	25		6.0		21.7		32.7		7.5	
	50		6.0		20.6		33.2		7.6	
	100		5.8		21.5		32.8		7.6	
24 Hours (Renewal Water)	Control 2	2	6.7	2	21.3	6	33.0	4	8.0	
Date: 8/25/11	6.25		6.9		21.3		33.0		8.0	
Sample ID: C110823.03	12.5		6.9		21.5		33.0		8.0	
Dilutions (Tech): KC/BG	25		7.1		21.4		33.0		8.0	
WQ Time: 1115 Rep: Stock	50		7.3		21.4		32.9		8.0	
Technician: SH	100		8.0		21.4		33.1		8.0	
48 Hours (OLD)	Control 2	2	6.1	2	22.3	6	32.8	3	7.7	
Date: 8/26/11	6.25		5.6		21.9		32.9		7.7	
WQ Time: 1030 Rep: 2	12.5		6.5		21.1		32.9		7.8	
Technician: BG	25		5.8		21.8		33.0		7.8	
	50		6.2		21.7		33.1		7.8	
	100		6.1		22.2		33.1		7.8	
48 Hours (Renewal Water)	Control 2	2	6.6	2	21.5	6	32.9	3	7.5	②JH
Date: 8/26/11	6.25		6.9		21.4		33.0		7.5	
Sample ID: C110823.03	12.5		6.9		21.3		33.0		7.6	
Dilutions (Tech): BG	25		7.1		21.3		33.0		7.7	
WQ Time: 1110 Rep: Stock	50		7.5		21.3		33.1		7.7	
Technician: BG	100		8.2		21.4		33.1		7.7	②JH
72 Hours (OLD)	Control 2	3	~~5.8~~ 6.5	3	22.2	5	32.6	4	7.7	
Date: 8/27/11	6.25	KC	~~5.8~~ 6.8		22.0		32.7		7.8	
WQ Time: 1055 Rep: 3	12.5	①	~~5.4~~ 6.9		21.4		32.9		7.7	
Technician: KC	25		6.9		21.7		33.1		7.7	
	50		7.2		21.9		33.1		7.8	
	100		7.1		22.0		33.2		7.7	
72 Hours (Renewal Water)	Control 2	3	6.6	3	21.3	5	33.0	4	7.8	
Date: 8/27/11	6.25		6.8		21.5		33.0		7.9	
Sample ID: C110823.03	12.5		6.9		21.8		33.1		7.7	
Dilutions (Tech): KC	25		7.0		21.4		33.0		7.8	
WQ Time: 1200 Rep: Stock	50		7.6		21.3		33.1		7.9	
Technician: KC	100		8.1		21.6		33.1		7.9	
96 Hours	Control 2	3	6.4	3	21.9	5	32.7	4	7.6	②JH
Date: 8/28/11	6.25		6.8		22.3		32.7		7.7	
WQ Time: 1210 Rep: 4	12.5		6.8		22.0		32.8		7.8	
Technician: KC	25		6.8		22.1		33.0		7.8	
	50		7.0		21.6		32.9		7.8	
	100		6.9		22.2		33.1		7.9	②JH

① IE 8/27/11 KC

② Chlorine not detected at test initiation 8/29/11 JH

③ IE 8/30/11 KC

WESTON SOLUTIONS

Topsmelt 96-Hour Acute Toxicity Test

Weston Test ID:	Client:	Client Sample ID:
C110823.0362	Port of San Diego ~~Weston~~ ①	SIYB-3

Survival Data

Conc.	Rep	24 Hours # Alive	24 Hours #Dead	48 Hours # Alive	48 Hours #Dead	72 Hours # Alive	72 Hours #Dead	96 Hours # Alive	96 Hours #Dead
		Date: 8/25/11		Date: 8/26/11		Date: 8/27/11		Date: 8/28/11	
		Renewal Time: 1240		Renewal Time: 1420		Renewal Time: 1310		End Time: 1430	
		Technician: BG		Technician: SH		Technician: KC		Technician: KC	
Control	1	9	1	9	Ø	9	Ø	9	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
6.25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	9	1NB	9	Ø	9	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
12.5	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	9	1	9	Ø	9	Ø	9	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
50	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
100	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
	1								
	2								
	3								
	4								

Feeding Information	Day 0	24 Hours	48 Hours	72 Hours
Feed Time*:	1545	~~0900~~ KC 0845	0900	0830
Technician:	SH	KC	KC	KC

*Topsmelt should be fed at test initiation and approximately 2 hours before renewal at 24, 48, and 72 hours.

① WC 8/25/11 SH

Start Time:	1530 JH / KC		
End Time:	1430 KC		
Supplier:	Aquatic Bio Systems		
Organism Batch:	ABS 8915	Age:	13 days

Dilution Water Batch:	S10082411
Hobo Temp. No.:	778891
Test Location:	Rm 3
Test Acceptablility: ✓ ≥ 90% Survival in Control	

① IE 8/30/11 KC

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-4	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0462	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No. BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***
Age: 13 days old

Concentration (%)	Number of Test Organisms at Start of Test	Number of Test Organisms at End of Test	Percent Survival
Control	40	39	97.5
6.25	40	40	100
12.5	40	40	100
25	40	40	100
50	40	40	100
100	40	40	100

Acute Toxicity Statement for Sample SIYB-4

Distribution Method	Result	Variance Method	Result
Shapiro-Wilk's Test	Non-normal; $p \leq 0.01$	N/A	Could Not Be Confirmed

Hypothesis Method	NOEC	LOEC	TUa	Point Estimation Method	EC_{50}
Steel's Many-One Rank Test	100%	>100%	0	Linear Interpolation	>100%

EC_{15}	EC_{25}	EC_{40}	Mean Mortality in 100%
>100%	>100%	>100%	0.00%

Acute Toxicity Statement: Test substance SIYB-4 produced 100 percent survival in the 100 percent test concentration at 96 hours. The LC_{50} at 96 hours was estimated to be >100 percent test substance.

Toxicity, expressed as toxic units acute (TUa), was 0.

Protocol Deviations: Due to a shortage of organisms available on 8/23/11 the test was started within 48 Hrs of sampling rather than 36 Hrs. Sample arrived at 8.4°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity.

[signature]	12/22/11	[signature]	1/5/12
QA Officer	Date	Approved	Date

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-4	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0462	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No.: BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***

Test Solution Physical and Chemical Data

Total Chlorine (mg/L)			
Concentration (%)	Initial	Renewal	Final
Control	0.02	*	*
100	0.01	*	*

*Chlorine not detected in initial measurement of sample

Concentration (%)	Statistic	D.O. (mg/L)	Temp.(°C)	Salinity (ppt)	pH
Control	Mean	6.5	21.9	32.6	7.8
	Minimum	6.0	21.3	31.3	7.5
	Maximum	7.2	22.4	33.0	8.0
6.25	Mean	5.8	21.5	32.9	7.9
	Minimum	5.6	21.1	32.7	7.7
	Maximum	7.4	21.9	33.0	8.0
12.5	Mean	6.6	21.7	32.8	7.9
	Minimum	5.9	21.2	32.6	7.8
	Maximum	7.5	22.2	33.0	8.0
25	Mean	6.8	21.5	32.9	7.9
	Minimum	6.2	21.2	32.7	7.8
	Maximum	7.5	22.0	33.0	8.0
50	Mean	6.8	21.6	32.9	7.9
	Minimum	5.6	20.8	32.6	7.8
	Maximum	8.0	22.3	33.1	8.0
100	Mean	7.1	21.6	33.0	7.9
	Minimum	5.7	20.9	32.8	7.3
	Maximum	8.4	22.1	33.1	8.1

Weston Solutions, Inc.

Analytical Report

Client:	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-4	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0462	Matrix:	Liquid

TEST: 96 Hour Acute Effluent Toxicity Bioassay, Weston Protocol No. BIO 062, EPA-821-R-02-012

LAB CONTROL WATER: Seawater collected from Scripps Institution of Oceanography.

Dissolved Oxygen	7.2	mg/L
Temperature	21.9	°C
pH	8.0	

TEST ORGANISM: Topsmelt, *Atherinops affinis* Age: 13 days old
Supplier: Aquatic BioSystems
Feeding: Fed *Artemia* nauplii *ad libitum* daily prior to testing.

TEST CHAMBER: Half liter containers, 4 replicate samples, 5 concentrations, and 4 replicate controls, brought to a 250mL final volume.

EXPERIMENTAL DESIGN:

1. Sample was collected by Weston Solutions personnel on August 22, 2011 at 1610 hours. The sample arrived at the Weston Solutions laboratory on the following day at 0920 hours in one 10L container. Temperature upon arival was 8.4°C.
2. The temperature of the effluent was adjusted to 21±1°C.
3. 10 test organisms were placed in each test container.
4. Test chambers were held at 21±1°C for 96 hours with a photoperiod of 16 hours light: 8 hours darkness.
5. Test chambers were renewed daily.
6. Each test chamber was fed 1000 freshly hatched *Artemia* nauplii daily for the duration of the test.

MORTALITY CRITERIA: Lack of respiratory movement and lack of reaction to gentle prodding

ACCEPTIBILITY CRITERIA: $\geq$ 90% survival in controls. Evaluation of the concentration-response relationship indicated that the data presented in this report are reliable.

REFERENCE TOXICITY: (Control Chart Included)

Toxicant: $CuSO_4$, Lot No.: 2008506, Received: 7/13/11, Opened: 7/28/11, Expires: 8/31/12.

96 Hour LC_{50}:	87.04	ppb	NOEC:	50	ppb
96 Hour LC_{25}:	68.52	ppb	LOEC:	100	ppb
Laboratory Mean:	153.08	ppb			
Test Date:	8/24/2011		Within 95 % Confidence Limits		

STUDY DIRECTOR: S. Hasan
INVESTIGATORS: K. Curry, B. Griffith, J. Hansen, S. Hasan

Acute Fish Test-96 Hr Survival

Start Date:	8/24/2011 15:50	Test ID:	C110823.0462	Sample ID:	SIYB-4
End Date:	8/28/2011 14:50	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:10	Protocol:	EPAA 02-EPA Acute	Test Species:	AA-Atherinops affinis

Comments:

Conc-%	1	2	3	4
Control	0.9000	1.0000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

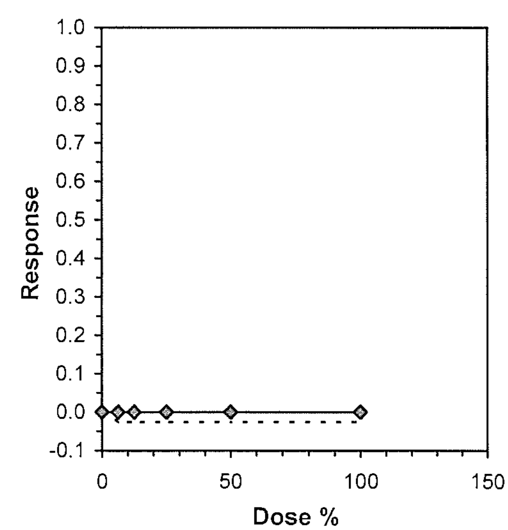
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4			0.9958	1.0000
6.25	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9958	1.0000
12.5	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9958	1.0000
25	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9958	1.0000
50	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9958	1.0000
100	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9958	1.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.46508	0.884	-3.0206	13.9892
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



TUa = ϕ

ToxCalc v5.0.23

Reviewed by: KJ

Test: AC-Acute Fish Test		Test ID: C110823.04 62
Species: AA-Atherinops affinis		Protocol: EPAA 02-EPA Acute
Sample ID: SIYB-4		Sample Type: AMB1-Ambient water
Start Date: 8/24/2011 15:50	End Date: 8/28/2011 14:50	Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				9	
	2	2	Control	10				10	
	3	3	Control	10				10	
	4	4	Control	10				10	
	5	1	6.250	10				10	
	6	2	6.250	10				10	
	7	3	6.250	10				10	
	8	4	6.250	10				10	
	9	1	12.500	10				10	
	10	2	12.500	10				10	
	11	3	12.500	10				10	
	12	4	12.500	10				10	
	13	1	25.000	10				10	
	14	2	25.000	10				10	
	15	3	25.000	10				10	
	16	4	25.000	10				10	
	17	1	50.000	10				10	
	18	2	50.000	10				10	
	19	3	50.000	10				10	
	20	4	50.000	10				10	
	21	1	100.000	10				10	
	22	2	100.000	10				10	
	23	3	100.000	10				10	
	24	4	100.000	10				10	

Comments:

 ToxCalc 5.0 Reviewed by: VB

Topsmelt 96-Hour Acute Toxicity Test

KC ③

Client	~~Weston~~ Port of San Diego
Project:	Shelter Island Yacht Basin
Client Sample ID:	SIYB-4
Weston Test ID:	C110823.04
Species	*Atherinops affinis*

Date Received:	8/23/11
Date Test Started:	8/24/11
Date Test Ended:	8/28/11
Study Director:	S. Hasan
Organisms/Chamber:	10

	Conc.	Meter #	D.O. (mg/L)	Meter #	Temp (°C)	Meter #	Salinity (ppt)	Meter #	pH	Total Chlorine (mg/L)
Day 0 (0 Hours)	Control	3	7.2	3	21.4	5	32.8	3 ①JH	8.0	0.02
Date: 8/24/11	6.25		7.4		21.6		33.0		8.0	
Sample ID: C110823.04	12.5		7.5		21.6		32.8		8.0	
Dilutions (Tech): KC	25		7.5		21.3		32.7		8.0	
WQ Time: 1610 Rep: Stock	50		8.0		20.8		32.7		8.0	
Technician: JH	100		8.4		20.9		32.8		8.0	0.01
24 Hours (OLD)	Control	2	6.0	2	22.4	6	31.3	4	7.8	
Date: 8/25/11	6.25		5.6		21.8		32.8		7.7	
WQ Time: 0935 Rep: 1	12.5		5.9		22.2		32.6		7.8	
Technician: SH	25		6.2		21.5		32.7		7.8	
	50		5.6		21.9		32.6		7.8	
	100		5.7		21.9		32.8		7.3	
24 Hours (Renewal Water)	Control	2	6.7	2	21.3	6	33.0	4	8.0	
Date: 8/25/11	6.25		6.7		21.3		32.8		8.0	
Sample ID: C110823.04	12.5		6.9		21.3		32.8		8.0	
Dilutions (Tech): KC/BG	25		7.1		21.3		33.0		8.0	
WQ Time: 1045 Rep: Stock	50		7.4		21.3		33.1		8.0	
Technician: SH	100		8.1		21.4		33.1		8.1	
48 Hours (OLD)	Control	2	6.1	2	22.3	6	32.8	3	7.7	
Date: 8/26/11	6.25		6.1		21.9		32.9		7.8	
WQ Time: 1045 Rep: 2	12.5		6.1		21.8		32.9		7.8	
Technician: BG	25		6.2		21.7		33.0		7.8	
	50		6.2		21.7		32.8		7.8	
	100		6.1		22.1		32.9		7.8	
48 Hours (Renewal Water)	Control	2	6.6	2	21.5	6	32.9	3	7.5	②JH
Date: 8/26/11	6.25		7.0		21.2		33.0		7.8	
Sample ID: C110823.04	12.5		6.9		21.2		33.0		7.9	
Dilutions (Tech): KC	25		7.1		21.2		33.0		7.9	
WQ Time: 1115 Rep: Stock	50		7.5		21.2		33.0		7.9	
Technician: BG	100		8.2		21.2		33.1		8.0	②JH
72 Hours (OLD)	Control	3	6.5	3	22.2	5	32.6	4	7.7	
Date: 8/27/11	6.25		6.2		21.6		32.7		7.8	
WQ Time: 1110 Rep: 3	12.5		6.4		21.9		32.7		7.8	
Technician: KC	25		6.4		22.0		32.9		7.9	
	50		5.9		22.1		33.0		7.9	
	100		5.8		21.9		33.0		7.9	
72 Hours (Renewal Water)	Control	3	6.6	3	21.3	5	33.0	4	7.8	
Date: 8/27/11	6.25		7.0		21.1		33.0		7.9	
Sample ID: C110823.04	12.5		6.9		21.3		33.0		7.9	
Dilutions (Tech): KC	25		7.0		21.2		33.0		8.0	
WQ Time: 1210 Rep: Stock	50		7.3		21.2		33.1		7.9	
Technician: KC	100		8.0		21.4		33.1		8.0	
96 Hours	Control	3	6.4	3	21.9	5	32.7	4	7.6	②JH
Date: 8/28/11	6.25		6.2		21.6		32.7		7.8	
WQ Time: 1220 Rep: 4	12.5		6.4		22.0		32.9		7.9	
Technician: KC	25		6.5		22.0		32.8		7.8	
	50		6.1		22.3		32.8		7.9	
	100		6.2		21.9		32.9		7.9	②JH

① IW 8/29/11 JH
② Chlorine not detected at test initiation 8/29/11 JH
③ IE 8/30/11 KC

Topsmelt 96-Hour Acute Toxicity Test

Weston Test ID:	Client:	Client Sample ID:
C110823.0462	Port of San Diego KC ① ~~Weston~~	SIYB-4

Survival Data

Conc.	Rep	24 Hours Date: 8/25/11 Renewal Time: 1315 Technician: BG		48 Hours Date: 8/26/11 Renewal Time: 1430 Technician: BG		72 Hours Date: 8/27/11 Renewal Time: 1330 Technician: KC		96 Hours Date: 8/28/11 End Time: 1450 Technician: KC	
		# Alive	#Dead	# Alive	#Dead	# Alive	#Dead	# Alive	#Dead
Control	1	9	1	9	Ø	9	Ø	9	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
6.25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
12.5	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
50	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
100	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
	1								
	2								
	3								
	4								

Feeding Information	Day 0	24 Hours	48 Hours	72 Hours
Feed Time*:	1545	0845	0900	0830
Technician:	SH	KC	KC	KC

*Topsmelt should be fed at test initiation and approximately 2 hours before renewal at 24, 48, and 72 hours.

Start Time:	1530 SH / KC		
End Time:	1450 KC		
Supplier:	Aquatic BioSystems		
Organism Batch:	ABS 8915	Age:	13 days

Dilution Water Batch:	SI082411
Hobo Temp. No.:	778891
Test Location:	Rm 3
Test Acceptablility: ✓ ≥ 90% Survival in Control	

① IE 8/30/11 KC

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-5	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0562	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No. BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***
Age: 13 days old

Concentration (%)	Number of Test Organisms at Start of Test	Number of Test Organisms at End of Test	Percent Survival
Control	40	39	97.5
6.25	40	40	100
12.5	40	38	95.0
25	40	40	100
50	40	39	97.5
100	40	40	100

Acute Toxicity Statement for Sample SIYB-5

Distribution Method	Result	Variance Method	Result
Shapiro-Wilk's Test	Non-normal; p ≤ 0.01	N/A	Could Not Be Confirmed

Hypothesis Method	NOEC	LOEC	TUa	Point Estimation Method	EC_{50}
Steel's Many-One Rank Test	100%	>100%	0	Linear Interpolation	>100%

EC_{15}	EC_{25}	EC_{40}	Mean Mortality in 100%
>100%	>100%	>100%	0.00%

Acute Toxicity Statement: Test substance SIYB-5 produced 100 percent survival in the 100 percent test concentration at 96 hours. The LC_{50} at 96 hours was estimated to be >100 percent test substance.

Toxicity, expressed as toxic units acute (TUa), was 0.

Protocol Deviations: Due to a shortage of organisms available on 8/23/11 the test was started within 48 Hrs of sampling rather than 36 Hrs. Sample arrived at 10.1°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity. Chlorine not re-checked at 48 or 72 Hours due to technician error.

QA Officer	1/5/12 Date	Approved	1/5/12 Date

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-5	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0562	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No.: BIO 062
EPA-821-R-02-012

Test Organism: *Atherinops affinis*

Test Solution Physical and Chemical Data

Total Chlorine (mg/L)			
Concentration (%)	Initial	Renewal	Final
Control	0.02	*	*
100	0.03	**	**

* Chlorine not detected in initial measurement of sample.
** Chlorine not taken due to technician error.

Concentration (%)	Statistic	D.O. (mg/L)	Temp.(°C)	Salinity (ppt)	pH
Control	Mean	6.5	21.9	32.6	7.8
	Minimum	6.0	21.3	31.3	7.5
	Maximum	7.2	22.4	33.0	8.0
6.25	Mean	5.8	21.7	32.8	7.9
	Minimum	5.9	21.1	32.7	7.7
	Maximum	7.3	22.1	33.1	8.2
12.5	Mean	6.8	21.7	32.9	8.0
	Minimum	6.0	21.0	32.6	7.8
	Maximum	7.7	22.4	33.2	8.2
25	Mean	6.9	21.5	32.9	8.0
	Minimum	6.0	21.2	32.7	7.8
	Maximum	8.2	22.1	33.2	8.2
50	Mean	7.0	21.5	32.9	8.0
	Minimum	6.1	21.0	32.7	7.8
	Maximum	7.9	22.4	33.2	8.2
100	Mean	7.1	21.5	32.9	8.0
	Minimum	5.8	20.8	32.1	7.8
	Maximum	8.3	22.0	33.2	8.2

Weston Solutions, Inc.

Analytical Report

Client:	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-5	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0562	Matrix:	Liquid

TEST: 96 Hour Acute Effluent Toxicity Bioassay, Weston Protocol No. BIO 062, EPA-821-R-02-012

LAB CONTROL WATER: Seawater collected from Scripps Institution of Oceanography.

Dissolved Oxygen	7.2 mg/L
Temperature	21.9 °C
pH	8.0

TEST ORGANISM: Topsmelt, *Atherinops affinis* Age: 13 days old
Supplier: Aquatic BioSystems
Feeding: Fed *Artemia* nauplii *ad libitum* daily prior to testing.

TEST CHAMBER: Half liter containers, 4 replicate samples, 5 concentrations, and 4 replicate controls, brought to a 250mL final volume.

EXPERIMENTAL DESIGN:

1. Sample was collected by Weston Solutions personnel on August 22, 2011 at 1600 hours. The sample arrived at the Weston Solutions laboratory on the following day at 0920 hours in one 10L container. Temperature upon arival was 10.1°C.
2. The temperature of the effluent was adjusted to 21±1°C.
3. 10 test organisms were placed in each test container.
4. Test chambers were held at 21±1°C for 96 hours with a photoperiod of 16 hours light: 8 hours darkness.
5. Test chambers were renewed daily.
6. Each test chamber was fed 1000 freshly hatched *Artemia* nauplii daily for the duration of the test.

MORTALITY CRITERIA: Lack of respiratory movement and lack of reaction to gentle prodding

ACCEPTIBILITY CRITERIA: $\geq$ 90% survival in controls. Evaluation of the concentration-response relationship indicated that the data presented in this report are reliable.

REFERENCE TOXICITY: (Control Chart Included)
Toxicant: $CuSO_4$, Lot No.: 2008506, Received: 7/13/11, Opened: 7/28/11, Expires: 8/31/12.

96 Hour LC_{50}:	87.04 ppb		NOEC:	50 ppb
96 Hour LC_{25}:	68.52 ppb		LOEC:	100 ppb
Laboratory Mean:	153.08 ppb			
Test Date:	8/24/2011		Within 95 % Confidence Limits	

STUDY DIRECTOR: S. Hasan
INVESTIGATORS: K. Curry, B. Griffith, J. Hansen, S. Hasan

Acute Fish Test-96 Hr Survival

Start Date:	8/24/2011 15:50	Test ID:	C110823.0562	Sample ID:	SIYB-5
End Date:	8/28/2011 15:05	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:00	Protocol:	EPAA 02-EPA Acute	Test Species:	AA-Atherinops affinis

Comments:

Conc-%	1	2	3	4
Control	0.9000	1.0000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	0.8000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	0.9000
100	1.0000	1.0000	1.0000	1.0000

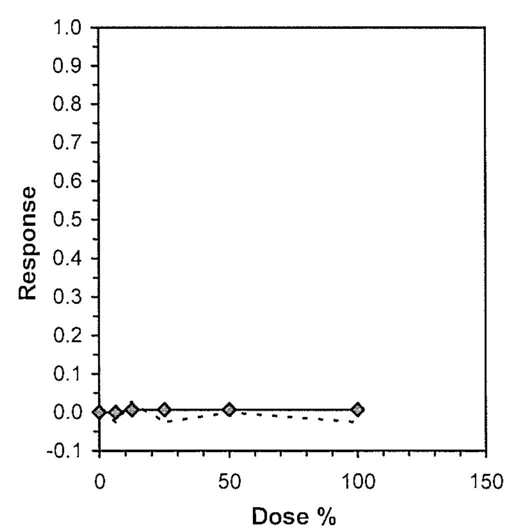
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4			0.9875	1.0000
6.25	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9875	1.0000
12.5	0.9500	0.9744	0.9500	0.8000	1.0000	10.526	4	17.50	10.00	0.9813	0.9937
25	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9813	0.9937
50	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4	18.00	10.00	0.9813	0.9937
100	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9813	0.9937

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.73354	0.884	-2.0553	5.27706
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



TUa = ϕ

 ToxCalc v5.0.23 Reviewed by: VA

Test: AC-Acute Fish Test | Test ID: C110823.05 62
Species: AA-Atherinops affinis | Protocol: EPAA 02-EPA Acute
Sample ID: SIYB-5 | Sample Type: AMB1-Ambient water
Start Date: 8/24/2011 15:50 | End Date: 8/28/2011 15:05 | Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				9	
	2	2	Control	10				10	
	3	3	Control	10				10	
	4	4	Control	10				10	
	5	1	6.250	10				10	
	6	2	6.250	10				10	
	7	3	6.250	10				10	
	8	4	6.250	10				10	
	9	1	12.500	10				10	
	10	2	12.500	10				10	
	11	3	12.500	10				10	
	12	4	12.500	10				8	
	13	1	25.000	10				10	
	14	2	25.000	10				10	
	15	3	25.000	10				10	
	16	4	25.000	10				10	
	17	1	50.000	10				10	
	18	2	50.000	10				10	
	19	3	50.000	10				10	
	20	4	50.000	10				9	
	21	1	100.000	10				10	
	22	2	100.000	10				10	
	23	3	100.000	10				10	
	24	4	100.000	10				10	

Comments:

Topsmelt 96-Hour Acute Toxicity Test

BIO062

Ke ③

Client	~~Weston~~ Port of San Diego
Project:	Shelter Island Yacht Basin
Client Sample ID:	SIYB-5
Weston Test ID:	C110823.0562
Species	*Atherinops affinis*

Date Received:	8/23/11
Date Test Started:	8/24/11
Date Test Ended:	8/28/11
Study Director:	S. Hansen
Organisms/Chamber:	10

	Conc.	Meter #	D.O. (mg/L)	Meter #	Temp (°C)	Meter #	Salinity (ppt)	Meter #	pH	Total Chlorine (mg/L)
Day 0 (0 Hours)	Control	3	7.2	3	21.4	5	32.8	3	8.0	0.02
Date: 8/24/11	6.25		7.3		22.0		32.8		8.0	
Sample ID: C110823.05	12.5		7.4		21.5		32.8		8.0	
Dilutions (Tech): KC	25		7.4		21.3		32.7		8.0	
WQ Time: 1515 Rep: Stock	50		7.8		21.0		32.7		8.0	
Technician: JH	100		8.0		20.8		32.4		8.0	0.03
24 Hours (OLD)	Control	2	6.0	2	22.4	6	31.3	4	7.8	
	6.25		6.0		22.1		32.7		7.8	
Date: 8/25/11	12.5		6.0		22.4		33.1		7.9	
WQ Time: 0935 Rep: 1	25		6.0		21.4		32.7		7.8	
Technician: SH	50		6.1		22.4		32.7		7.9	
	100		5.8		21.8		32.1		7.8	
24 Hours (Renewal Water)	Control	2	6.7	2	21.3	6	33.0	4	8.0	
Date: 8/25/11	6.25		7.0		21.4		32.9		7.7	
Sample ID: C110823.05	12.5		6.9		21.4		33.0		8.0	
Dilutions (Tech): KC/BG	25		7.1		21.5		33.0		8.0	
WQ Time: 1051 Rep: Stock	50		7.4		21.5		33.1		8.0	
Technician: SH	100		8.0		21.5		33.2		8.0	
48 Hours (OLD)	Control	2	6.1	2	22.3	6	32.8	3	7.7	
	6.25		5.9		21.8		32.8		7.8	
Date: 8/26/11	12.5		6.1		21.8		32.8		7.8	
WQ Time: 1040 Rep: 2	25		6.2		21.7		32.9		7.8	
Technician: BG	50		6.2		21.0		32.8		7.8	
	100		6.1		21.6		33.1		7.8	
48 Hours (Renewal Water)	Control	2	6.6	2	21.5	6	32.9	3	7.5	①JH
Date: 8/26/11	6.25		6.9		21.3		33.0		8.0	
Sample ID: C110823.05	12.5		7.7		21.3		33.1		8.1	
Dilutions (Tech): KC	25		8.2		21.3		33.1		8.1	
WQ Time: 1120 Rep: Stock	50		7.6		21.4		33.1		8.1	
Technician: BG	100		8.3		21.4		33.1		8.2	②JH
72 Hours (OLD)	Control	3	6.5	3	22.2	5	32.6	4	7.7	
	6.25		6.1		22.1		32.7		7.9	
Date: 8/27/11	12.5		6.3		22.1		32.7		7.8	
WQ Time: 1120 Rep: 3	25		6.3		21.8		32.9		7.9	
Technician: KC	50		6.3		22.0		32.9		7.9	
	100		6.3		21.7		33.0		7.9	
72 Hours (Renewal Water)	Control	3	6.6	3	21.3	5	33.0	4	7.8	
Date: 8/27/11	6.25		6.8		21.1		33.1		8.2	
Sample ID: C110823.05	12.5		7.4		21.0		33.2		8.2	
Dilutions (Tech): KC	25		8.0		21.2		33.2		8.2	
WQ Time: 1220 Rep: Stock	50		7.9		21.2		33.2		8.2	
Technician: KC	100		8.1		21.1		33.2		8.2	
96 Hours	Control	3	6.4	3	21.9	5	32.7	4	7.6	①JH
	6.25		6.3		21.8		32.7		7.8	
Date: 8/28/11	12.5		6.3		22.4		32.6		7.8	
WQ Time: 1230 Rep: 4	25		6.2		22.1		32.7		7.8	
Technician: KC	50		6.3		21.8		32.9		7.8	
	100		6.3		22.0		32.9		7.8	②JH

① chlorine not detected at test initiation 8/24/11 JH

② Due to tech error, chlorine not taken 8/29/11 JH

③ IE 8/30/11 KC

WESTON SOLUTIONS

Topsmelt 96-Hour Acute Toxicity Test

BIO062

Weston Test ID:	Client:	Client Sample ID:
C110823.0562	Port of San Diego ③ ~~Weston~~	SIYB-5

Survival Data

Conc.	Rep	24 Hours # Alive	24 Hours #Dead	48 Hours # Alive	48 Hours #Dead	72 Hours # Alive	72 Hours #Dead	96 Hours # Alive	96 Hours #Dead
		Date: 8/25/11		Date: 8/26/11		Date: 8/27/11		Date: 8/28/11	
		Renewal Time: 1330		Renewal Time: 1450		Renewal Time: 1345		End Time: 1505	
		Technician: BG		Technician: BG		Technician: KC		Technician: KC	
Control	1	9	1 ① BG	9	Ø	9	Ø	9	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
6.25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
12.5	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	9	1	9	Ø	9	Ø	~~8(+)~~ KC ②	1
25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
50	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	9	1	9	Ø	9	Ø
100	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
	1								
	2								
	3								
	4								

Feeding Information	Day 0	24 Hours	48 Hours	72 Hours
Feed Time*:	1545	0845	0900	0830
Technician:	SH	KC	KC	KC

*Topsmelt should be fed at test initiation and approximately 2 hours before renewal at 24, 48, and 72 hours.

Start Time:	1550 SH / KC
End Time:	1505 KC
Supplier:	Aquatic Bio Systems
Organism Batch:	ABS 8915 — Age: 13 days

Dilution Water Batch:	SI082411
Hobo Temp. No.:	778891
Test Location:	Rm 3
Test Acceptablility:	✓ ≥ 90% Survival in Control

① IE 8/25/11 BG
② IE 8/28/11 KC
③ IE 8/30/11 KC

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-6	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0662	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No. BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***
Age: 13 days old

Concentration (%)	Number of Test Organisms at Start of Test	Number of Test Organisms at End of Test	Percent Survival
Control	40	39	97.5
6.25	40	40	100
12.5	40	40	100
25	40	40	100
50	40	39	97.5
100	40	39	97.5

Acute Toxicity Statement for Sample SIYB-6

Distribution Method	Result	Variance Method	Result
Shapiro-Wilk's Test	Non-normal; $p \leq 0.01$	N/A	Could Not Be Confirmed

Hypothesis Method	NOEC	LOEC	TUa	Point Estimation Method	EC_{50}
Steel's Many-One Rank Test	100%	>100%	0.23	Linear Interpolation	>100%

EC_{15}	EC_{25}	EC_{40}	Mean Mortality in 100%
>100%	>100%	>100%	2.50%

Acute Toxicity Statement: Test substance SIYB-6 produced 97.5 percent survival in the 100 percent test concentration at 96 hours. The LC_{50} at 96 hours was estimated to be >100 percent test substance.

Toxicity, expressed as toxic units acute (TUa), was 0.23.

Protocol Deviations: Due to a shortage of organisms available on 8/23/11 the test was started just outside 48 Hrs of sampling rather than within 36 Hrs. Sample arrived at 7.3°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity.

QA Officer	12/22/11 Date	Approved	1/5/12 Date

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-6	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0662	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No.: BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***

Test Solution Physical and Chemical Data

Total Chlorine (mg/L)			
Concentration (%)	Initial	Renewal	Final
Control	0.02	*	*
100	0.00	*	*

*Chlorine not detected in initial measurement of sample

Concentration (%)	Statistic	D.O. (mg/L)	Temp.(°C)	Salinity (ppt)	pH
Control	Mean	6.5	21.9	32.6	7.8
	Minimum	6.0	21.3	31.3	7.5
	Maximum	7.2	22.4	33.0	8.0
6.25	Mean	5.7	21.7	32.8	7.9
	Minimum	5.7	21.2	32.6	7.7
	Maximum	7.2	22.3	33.0	8.3
12.5	Mean	6.5	21.7	32.9	8.0
	Minimum	5.6	21.2	32.7	7.8
	Maximum	7.4	22.3	33.1	8.3
25	Mean	6.6	21.5	32.8	8.0
	Minimum	5.7	21.1	32.6	7.8
	Maximum	7.4	21.8	33.0	8.3
50	Mean	6.7	21.7	32.9	8.0
	Minimum	5.5	20.9	32.7	7.8
	Maximum	7.6	22.2	33.1	8.3
100	Mean	7.1	21.6	32.9	8.0
	Minimum	5.9	20.6	32.7	7.8
	Maximum	8.3	22.3	33.1	8.4

Weston Solutions, Inc.

Analytical Report

Client:	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-6	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0662	Matrix:	Liquid

TEST: 96 Hour Acute Effluent Toxicity Bioassay, Weston Protocol No. BIO 062, EPA-821-R-02-012

LAB CONTROL WATER: Seawater collected from Scripps Institution of Oceanography.

Dissolved Oxygen	7.2 mg/L
Temperature	21.9 °C
pH	8.0

TEST ORGANISM: Topsmelt, *Atherinops affinis* Age: 13 days old
Supplier: Aquatic BioSystems
Feeding: Fed *Artemia* nauplii *ad libitum* daily prior to testing.

TEST CHAMBER: Half liter containers, 4 replicate samples, 5 concentrations, and 4 replicate controls, brought to a 250mL final volume.

EXPERIMENTAL DESIGN:

1. Sample was collected by Weston Solutions personnel on August 22, 2011 at 1540 hours. The sample arrived at the Weston Solutions laboratory on the following day at 0920 hours in one 10L container. Temperature upon arival was 7.3°C.
2. The temperature of the effluent was adjusted to 21±1°C.
3. 10 test organisms were placed in each test container.
4. Test chambers were held at 21±1°C for 96 hours with a photoperiod of 16 hours light: 8 hours darkness.
5. Test chambers were renewed daily.
6. Each test chamber was fed 1000 freshly hatched *Artemia* nauplii daily for the duration of the test.

MORTALITY CRITERIA: Lack of respiratory movement and lack of reaction to gentle prodding

ACCEPTIBILITY CRITERIA: $\geq$ 90% survival in controls. Evaluation of the concentration-response relationship indicated that the data presented in this report are reliable.

REFERENCE TOXICITY:
(Control Chart Included)

Toxicant: $CuSO4$, Lot No.: 2008506, Received: 7/13/11, Opened: 7/28/11, Expires: 8/31/12.

96 Hour LC_{50}:	87.04 ppb		NOEC:	50	ppb
96 Hour LC_{25}:	68.52 ppb		LOEC:	100	ppb
Laboratory Mean:	153.08 ppb				
Test Date:	8/24/2011		Within 95 % Confidence Limits		

STUDY DIRECTOR: S. Hasan
INVESTIGATORS: K. Curry, B. Griffith, J. Hansen, S. Hasan

Acute Fish Test-96 Hr Survival

Start Date:	8/24/2011 15:50	Test ID:	C110823.0662	Sample ID:	SIYB-6
End Date:	8/28/2011 15:20	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 15:40	Protocol:	EPAA 02-EPA Acute	Test Species:	AA-Atherinops affinis

Comments:

Conc-%	1	2	3	4
Control	0.9000	1.0000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	0.9000
100	1.0000	1.0000	0.9000	1.0000

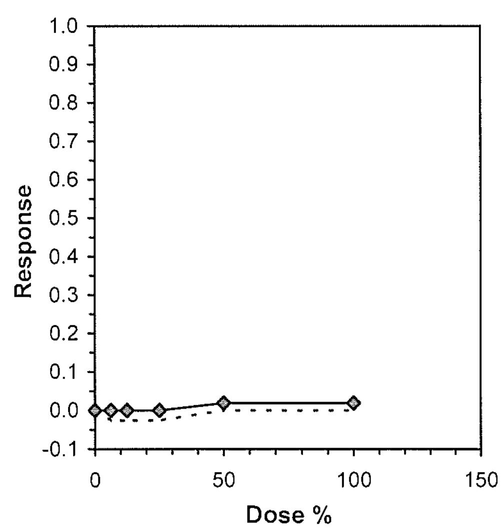
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4			0.9938	1.0000
6.25	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9938	1.0000
12.5	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9938	1.0000
25	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9938	1.0000
50	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4	18.00	10.00	0.9750	0.9811
100	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4	18.00	10.00	0.9750	0.9811

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.66831	0.884	-1.7439	2.37302
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



TUa = 0.23

 ToxCalc v5.0.23 Reviewed by: YB

Test: AC-Acute Fish Test		Test ID: C110823.0662
Species: AA-Atherinops affinis		Protocol: EPAA 02-EPA Acute
Sample ID: SIYB-6		Sample Type: AMB1-Ambient water
Start Date: 8/24/2011 15:50	End Date: 8/28/2011 15:20	Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				9	
	2	2	Control	10				10	
	3	3	Control	10				10	
	4	4	Control	10				10	
	5	1	6.250	10				10	
	6	2	6.250	10				10	
	7	3	6.250	10				10	
	8	4	6.250	10				10	
	9	1	12.500	10				10	
	10	2	12.500	10				10	
	11	3	12.500	10				10	
	12	4	12.500	10				10	
	13	1	25.000	10				10	
	14	2	25.000	10				10	
	15	3	25.000	10				10	
	16	4	25.000	10				10	
	17	1	50.000	10				10	
	18	2	50.000	10				10	
	19	3	50.000	10				10	
	20	4	50.000	10				9	
	21	1	100.000	10				10	
	22	2	100.000	10				10	
	23	3	100.000	10				9	
	24	4	100.000	10				10	

Comments:

 ToxCalc 5.0 Reviewed by: YB

WESTON SOLUTIONS

Topsmelt 96-Hour Acute Toxicity Test

BIO062

~~Weston~~ ③

Client	~~Weston~~ Port of San Diego
Project:	Shelter Island Yacht Basin
Client Sample ID:	SIYB-6
Weston Test ID:	C110823.0662
Species	*Atherinops affinis*

Date Received:	8/23/11
Date Test Started:	8/24/11
Date Test Ended:	8/28/11
Study Director:	S. Hasan
Organisms/Chamber:	10

	Conc.	Meter #	D.O. (mg/L)	Meter #	Temp (°C)	Meter #	Salinity (ppt)	Meter #	pH	Total Chlorine (mg/L)
Day 0 (0 Hours)	Control	3	7.2	3	21.9	5	32.8	3	8.0	0.02
Date: 8/24/11	6.25		7.2		21.5		32.7		8.0	
Sample ID: C110823.06	12.5		7.4		21.4		32.7		8.0	
Dilutions (Tech): KC	25		7.4		21.3		32.7		8.0	
WQ Time: 1520 Rep: stock	50		7.6		20.9		32.7		8.0	
Technician: JH	100		8.3		20.6		32.8		8.0	0.00
24 Hours (OLD)	Control	2	6.0	2	22.4	6	31.3	4	7.8	
Date: 8/25/11	6.25		6.0		21.2		32.8		7.7	
WQ Time: 0935 Rep: ~~1~~ 4	12.5		5.6		21.4		32.9		7.8	
Technician: SH	25		5.7		21.8		32.7		7.8	
	50		5.5		22.0		32.9		7.8	
	100		6.0		22.3		32.8		7.8	
24 Hours (Renewal Water)	Control	2	6.7	2	21.3	6	33.0	4	8.0	
Date: 8/25/11	6.25		6.9		21.6		32.9		8.0	
Sample ID: C110823.06	12.5		7.0		21.6		33.0		8.0	
Dilutions (Tech): KC/BG	25		7.1		21.6		33.0		8.0	
WQ Time: 1057 Rep: stock	50		7.4		21.6		33.0		8.0	
Technician: SH	100		8.1		21.6		33.1		8.0	
48 Hours (OLD)	Control	2	6.1	2	22.3	6	32.8	3	7.7	
Date: 8/26/11	6.25		5.7		21.8		32.8		7.7	
WQ Time: 1050 Rep: 2	12.5		5.9		22.3		32.8		7.8	
Technician: BG	25		6.2		21.1		32.8		7.8	
	50		5.9		22.2		33.0		7.8	
	100		5.9		21.4		33.0		7.8	
48 Hours (Renewal Water)	Control	2	6.6	2	21.5	6	32.9	3	7.5	② JH
Date: 8/26/11	6.25		6.9		21.4		32.9		8.2	
Sample ID: C110823.06	12.5		6.9		21.4		33.0		8.2	
Dilutions (Tech): KC	25		7.1		21.5		33.0		8.2	
WQ Time: 1125 Rep: Stock	50		7.5		21.5		33.1		8.3	
Technician: BG	100		8.2		21.6		33.1		8.3	② JH
72 Hours (OLD)	Control	3	6.5	3	22.2	5	32.6	4	7.7	
Date: 8/27/11	6.25		6.1		22.3		32.6		7.7	
WQ Time: 1130 Rep: 3	12.5		6.2		21.8		32.7		7.8	
Technician: KC	25		6.4		21.7		32.6		7.8	
	50		6.1		22.0		32.8		7.8	
	100		6.1		22.1		32.8		7.9	
72 Hours (Renewal Water)	Control	3	6.6	3	21.3	5	33.0	4	7.8	
Date: 8/27/11	6.25		6.8		21.2		33.0		8.3	
Sample ID: C110823.06	12.5		6.9		21.2		33.1		8.3	
Dilutions (Tech): KC	25		7.0		21.3		33.0		8.3	
WQ Time: 1230 Rep: Stock	50		7.5		21.2		33.1		8.3	
Technician: KC	100		8.3		21.3		33.1		8.4	
96 Hours	Control	3	6.4	3	21.9	5	32.7	4	7.6	② JH
Date: 8/28/11	6.25		6.0		22.2		32.6		7.8	
WQ Time: 1240 Rep: 4	12.5		5.9		22.1		32.7		7.8	
Technician: KC	25		6.0		21.7		32.7		7.9	
	50		6.1		22.1		32.7		7.9	
	100		6.0		22.0		32.7		7.9	② JH

OJE 8/25/11 SH

② Chlorine not detected at test initiation 8/29/11 JH

③ IE 8/30/11 KC

Topsmelt 96-Hour Acute Toxicity Test

Weston Test ID:	Client:	Client Sample ID:
C110823.0662	Port of San Diego ① ~~Weston~~	SIYB-6

Survival Data

Conc.	Rep	24 Hours Date: 8/25/11 Renewal Time: 1345 Technician: BG		48 Hours Date: 8/26/11 Renewal Time: 1445 Technician: SH		72 Hours Date: 8/27/11 Renewal Time: 1400 Technician: KC		96 Hours Date: 8/28/11 End Time: 1520 Technician: KC	
		# Alive	#Dead	# Alive	#Dead	# Alive	#Dead	# Alive	#Dead
Control	1	9	1	9	Ø	9	Ø	9	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
6.25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
12.5	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
50	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	9	1
100	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	9	1	9	Ø	9	Ø	9	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
	1								
	2								
	3								
	4								

Feeding Information	Day 0	24 Hours	48 Hours	72 Hours
Feed Time*:	1745	0845	0900	0830
Technician:	SH	KC	KC	KC

*Topsmelt should be fed at test initiation and approximately 2 hours before renewal at 24, 48, and 72 hours.

Start Time:	1550 SH / KC		
End Time:	1520 KC		
Supplier:	Aquatic Bio Systems		
Organism Batch:	ABS 8915	Age:	13 days

① IE 8/30/11 KC

Dilution Water Batch:	SI082411
Hobo Temp. No.:	778891
Test Location:	Rm 3
Test Acceptablility: ✓ ≥ 90% Survival in Control	

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-REF	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0762	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No. BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***
Age: 13 days old

Concentration (%)	Number of Test Organisms at Start of Test	Number of Test Organisms at End of Test	Percent Survival
Control	40	39	97.5
6.25	40	39	97.5
12.5	40	40	100
25	40	40	100
50	40	40	100
100	40	40	100

Acute Toxicity Statement for Sample SIYB-REF

Distribution Method	Result	Variance Method	Result
Shapiro-Wilk's Test	Non-normal; $p \leq 0.01$	N/A	Could Not Be Confirmed

Hypothesis Method	NOEC	LOEC	TUa	Point Estimation Method	EC_{50}
Steel's Many-One Rank Test	100%	>100%	0	Linear Interpolation	>100%

EC_{15}	EC_{25}	EC_{40}	Mean Mortality in 100%
>100%	>100%	>100%	0.00%

Acute Toxicity Statement: Test substance SIYB-REF produced 100 percent survival in the 100 percent test concentration at 96 hours. The LC_{50} at 96 hours was estimated to be >100 percent test substance.

Toxicity, expressed as toxic units acute (TUa), was 0.

Protocol Deviations: Due to a shortage of organisms available on 8/23/11 the test was started just outside 48 Hrs of sampling rather than within 36 Hrs. Sample arrived at 6.7°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity.

QA Officer	12/22/11 Date	Approved	1/5/12 Date

Weston Solutions, Inc.

Analytical Report

Client	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-REF	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0762	Matrix:	Liquid

96 Hour Acute Effluent Toxicity Bioassay
Weston Testing Protocol No.: BIO 062
EPA-821-R-02-012

Test Organism: ***Atherinops affinis***

Test Solution Physical and Chemical Data

Total Chlorine (mg/L)			
Concentration (%)	Initial	Renewal	Final
Control	0.02	*	*
100	0.00	*	*

*Chlorine not detected in initial measurement of sample

Concentration (%)	Statistic	D.O. (mg/L)	Temp.(°C)	Salinity (ppt)	pH
Control	Mean	6.5	21.9	32.6	7.8
	Minimum	6.0	21.3	31.3	7.5
	Maximum	7.2	22.4	33.0	8.0
6.25	Mean	5.7	21.7	32.9	8.0
	Minimum	5.6	21.3	32.8	7.7
	Maximum	7.2	22.2	33.0	8.5
12.5	Mean	6.4	21.7	32.9	8.0
	Minimum	5.7	21.1	32.8	7.8
	Maximum	7.2	22.3	33.0	8.5
25	Mean	6.5	21.7	32.9	8.0
	Minimum	5.7	21.4	32.5	7.7
	Maximum	7.3	22.0	33.1	8.5
50	Mean	6.9	21.5	32.9	8.0
	Minimum	5.8	21.0	32.6	7.8
	Maximum	8.1	21.9	33.1	8.4
100	Mean	7.1	21.6	33.1	8.0
	Minimum	5.9	20.8	32.9	7.5
	Maximum	8.3	22.3	33.2	8.5

Weston Solutions, Inc.

Analytical Report

Client:	Port of San Diego	Date Received:	23 Aug 11
Project:	Shelter Island Yacht Basin	Date Test Started:	24 Aug 11
Client Sample ID:	SIYB-REF	Date Test Ended:	28 Aug 11
Weston Test ID:	C110823.0762	Matrix:	Liquid

TEST: 96 Hour Acute Effluent Toxicity Bioassay, Weston Protocol No. BIO 062, EPA-821-R-02-012

LAB CONTROL WATER: Seawater collected from Scripps Institution of Oceanography.

Dissolved Oxygen	7.2 mg/L
Temperature	21.9 °C
pH	8.0

TEST ORGANISM: Topsmelt, *Atherinops affinis* Age: 13 days old
Supplier: Aquatic BioSystems
Feeding: Fed *Artemia* nauplii *ad libitum* daily prior to testing.

TEST CHAMBER: Half liter containers, 4 replicate samples, 5 concentrations, and 4 replicate controls, brought to a 250mL final volume.

EXPERIMENTAL DESIGN:

1. Sample was collected by Weston Solutions personnel on August 22, 2011 at 1525 hours. The sample arrived at the Weston Solutions laboratory on the following day at 0920 hours in one 10L container. Temperature upon arival was 6.7°C.
2. The temperature of the effluent was adjusted to 21±1°C.
3. 10 test organisms were placed in each test container.
4. Test chambers were held at 21±1°C for 96 hours with a photoperiod of 16 hours light: 8 hours darkness.
5. Test chambers were renewed daily.
6. Each test chamber was fed 1000 freshly hatched *Artemia* nauplii daily for the duration of the test.

MORTALITY CRITERIA: Lack of respiratory movement and lack of reaction to gentle prodding

ACCEPTIBILITY CRITERIA: $\geq$ 90% survival in controls. Evaluation of the concentration-response relationship indicated that the data presented in this report are reliable.

REFERENCE TOXICITY: Toxicant: $CuSO_4$, Lot No.: 2008506, Received: 7/13/11, Opened: 7/28/11, Expires: 8/31/12.
(Control Chart Included)

96 Hour LC_{50}:	87.04 ppb	NOEC:	50	ppb
96 Hour LC_{25}:	68.52 ppb	LOEC:	100	ppb
Laboratory Mean:	153.08 ppb			
Test Date:	8/24/2011	Within 95 % Confidence Limits		

STUDY DIRECTOR: S. Hasan
INVESTIGATORS: K. Curry, B. Griffith, J. Hansen, S. Hasan

Acute Fish Test-96 Hr Survival					
Start Date:	8/24/2011 15:50	Test ID:	C110823.0762	Sample ID:	SIYB-REF
End Date:	8/28/2011 15:35	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 15:25	Protocol:	EPAA 02-EPA Acute	Test Species:	AA-Atherinops affinis
Comments:					

Conc-%	1	2	3	4
Control	0.9000	1.0000	1.0000	1.0000
6.25	0.9000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4			0.9917	1.0000
6.25	0.9750	1.0000	0.9750	0.9000	1.0000	5.128	4	18.00	10.00	0.9917	1.0000
12.5	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9917	1.0000
25	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9917	1.0000
50	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9917	1.0000
100	1.0000	1.0256	1.0000	1.0000	1.0000	0.000	4	20.00	10.00	0.9917	1.0000

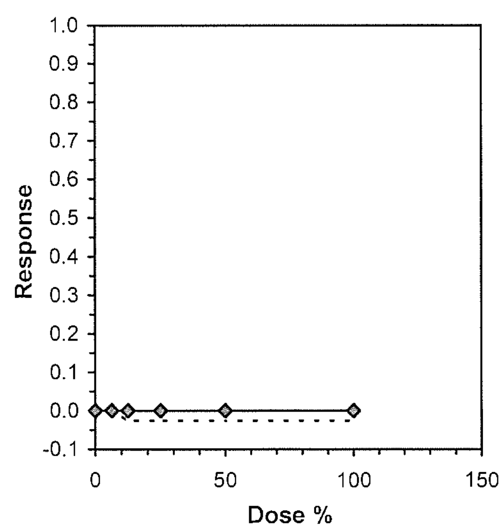
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.61382	0.884	-2.1359	5.27706
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			

TUa = ϕ



 ToxCalc v5.0.23 Reviewed by: vb

Test: AC-Acute Fish Test				Test ID: C110823.0702
Species: AA-Atherinops affinis				Protocol: EPAA 02-EPA Acute
Sample ID: SIYB-REF				Sample Type: AMB1-Ambient water
Start Date: 8/24/2011 15:50		End Date: 8/28/2011 15:35		Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				9	
	2	2	Control	10				10	
	3	3	Control	10				10	
	4	4	Control	10				10	
	5	1	6.250	10				9	
	6	2	6.250	10				10	
	7	3	6.250	10				10	
	8	4	6.250	10				10	
	9	1	12.500	10				10	
	10	2	12.500	10				10	
	11	3	12.500	10				10	
	12	4	12.500	10				10	
	13	1	25.000	10				10	
	14	2	25.000	10				10	
	15	3	25.000	10				10	
	16	4	25.000	10				10	
	17	1	50.000	10				10	
	18	2	50.000	10				10	
	19	3	50.000	10				10	
	20	4	50.000	10				10	
	21	1	100.000	10				10	
	22	2	100.000	10				10	
	23	3	100.000	10				10	
	24	4	100.000	10				10	

Comments:

ToxCalc 5.0

Reviewed by: VB

Weston Solutions

Topsmelt 96-Hour Acute Toxicity Test

KC ③

Client	~~Weston~~ Port of San Diego
Project:	Shelter Island Yacht Basin
Client Sample ID:	SIYB - Ref
Weston Test ID:	C110823.0762
Species	*Atherinops affinis*

Date Received:	8/23/11
Date Test Started:	8/24/11
Date Test Ended:	8/28/11
Study Director:	S. Hasan
Organisms/Chamber:	10

	Conc.	Meter #	D.O. (mg/L)	Meter #	Temp (°C)	Meter #	Salinity (ppt)	Meter #	pH	Total Chlorine (mg/L)
Day 0 (0 Hours)	Control	3	7.2	3	21.9	5	32.8	3	8.0	0.02
Date: 8/24/11	6.25		7.2		21.6		32.8		8.0	
Sample ID: C11082307	12.5		7.2		21.5		32.8		8.0	
Dilutions (Tech): KC	25		7.3		21.4		32.7		8.0	
WQ Time: 1525 Rep: Stock	50		7.4		21.0		32.7		8.0	
Technician: JH	100		8.3		20.8		32.9		8.1	0.00
24 Hours (OLD)	Control	2	6.0	2	22.4	6	31.3	4	7.8	
	6.25		5.9		21.3		32.9		7.8	
Date: 8/25/11	12.5		5.8		21.1		32.8		7.8	
WQ Time: 0935 Rep: 1	25		5.7		22.0		32.5		7.8	
Technician: SH	50		6.2		21.3		32.6		7.9	
	100		5.9		21.4		32.9		7.8	
24 Hours (Renewal Water)	Control	2	6.7	2	21.3	6	33.0	4	8.0	
Date: 8/25/11	6.25		6.9		21.6		32.9		8.0	
Sample ID: C110823.07	12.5		7.6		21.6		33.0		8.0	
Dilutions (Tech): KC/BG	25		7.2		21.6		33.0		8.0	
WQ Time: 1103 Rep: Stock	50		8.1		21.6		33.0		8.0	
Technician: SH	100		8.1		21.6		33.1		7.5	
48 Hours (OLD)	Control	2	6.1	2	22.3	6	32.8	3	7.7	
	6.25		5.6 ~~6.0~~ ① BG		21.9		32.9		7.8	
Date: 8/26/11	12.5		5.7 ~~6.1~~		21.8		32.9		7.8	
WQ Time: 1030 Rep: 2	25		5.8 ~~6.2~~		21.7		33.0		7.8	
Technician: BG	50		5.8		21.6		33.0		7.8	
	100		5.9		21.4		33.0		7.8	
48 Hours (Renewal Water)	Control	2	6.6	2	21.5	6	32.9	3	7.5	② JH
Date: 8/26/11	6.25		6.8		21.6		33.0		8.3	
Sample ID: C110823.07	12.5		6.9		21.6		33.0		8.3	
Dilutions (Tech): BG	25		7.1		21.6		33.0		8.4	
WQ Time: 1130 Rep: Stock	50		7.5		21.6		33.0		8.4	
Technician: BG	100		8.2		21.7		33.1		8.4	② JH
72 Hours (OLD)	Control	3	6.5	3	22.2	5	32.6	4	7.7	
	6.25		6.0		21.6		32.8		7.8	
Date: 8/27/11	12.5		5.9		22.1		32.8		7.8	
WQ Time: 1145 Rep: 3	25		6.0		22.0		33.1		7.9	
Technician: KC	50		6.1		21.9		33.1		7.9	
	100		6.1		22.3		33.2		7.9	
72 Hours (Renewal Water)	Control	3	6.6	3	21.3	5	33.0	4	7.8	
Date: 8/27/11	6.25		6.7		21.5		33.0		8.5	
Sample ID: C11082307	12.5		6.8		21.6		33.0		8.5	
Dilutions (Tech): KC	25		6.9		21.4		33.0		8.5	
WQ Time: 1240 Rep: Stock	50		7.4		21.4		32.9		8.4	
Technician: KC	100		7.9		21.5		33.0		8.5	
96 Hours	Control	3	6.4	3	21.9	5	32.7	4	7.6	② JH
	6.25		5.9		22.2		32.9		7.7	
Date: 8/28/11	12.5		5.9		22.3		32.8		7.8	
WQ Time: 1250 Rep: 4	25		5.9		22.0		33.0		7.7	
Technician: KC	50		6.2		21.7		33.0		7.8	
	100		6.1		22.0		33.2		7.9	② JH

① IE 8/26/11 BG

② Chlorine not detected at test initiation 8/24/11 JH

③ IE 8/30/11 KC

Weston Test ID: C110823.0762	Client: Port of San Diego ~~Weston~~ ke ①	Client Sample ID: SIYB-Ref

Survival Data

Conc.	Rep	24 Hours Date: 8/25/11 Renewal Time: 1400 Technician: BG # Alive	#Dead	48 Hours Date: 8/26/11 Renewal Time: 1445 Technician: BGZ # Alive	#Dead	72 Hours Date: 8/27/11 Renewal Time: 1415 Technician: ke # Alive	#Dead	96 Hours Date: 8/28/11 End Time: 1535 Technician: ke # Alive	#Dead
Control	1	9	1	9	Ø	9	Ø	9	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
6.25	1	9	1	9	Ø	9	Ø	9	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
12.5	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
25	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
50	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
100	1	10	Ø	10	Ø	10	Ø	10	Ø
	2	10	Ø	10	Ø	10	Ø	10	Ø
	3	10	Ø	10	Ø	10	Ø	10	Ø
	4	10	Ø	10	Ø	10	Ø	10	Ø
	1								
	2								
	3								
	4								

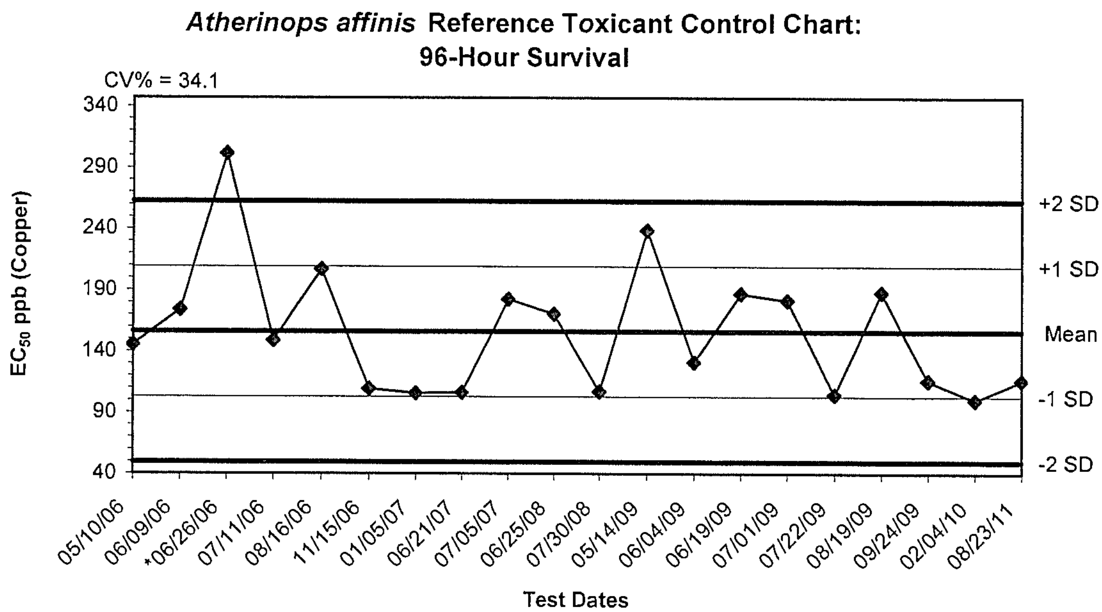
Feeding Information	Day 0	24 Hours	48 Hours	72 Hours
Feed Time*:	1745	0845	0900	0830
Technician:	ke / JH	KC	ke	ke

*Topsmelt should be fed at test initiation and approximately 2 hours before renewal at 24, 48, and 72 hours.

Start Time:	1530 JH		
End Time:	1535 ke		
Supplier:	Aquatic Bio Systems		
Organism Batch:	ABS 8915	Age:	13 days

① IE 8/30/11 ke

Dilution Water Batch:	SI0082411
Hobo Temp. No.:	778891
Test Location:	Room 3
Test Acceptablility:	X ≥ 90% Survival in Control



Dates	Values	Mean	-1 SD	-2 SD	+1 SD	+2 SD
05/10/06	145.3200	155.9936	102.7388	49.4841	209.2484	262.5031
06/09/06	174.0000	155.9936	102.7388	49.4841	209.2484	262.5031
*06/26/06	301.4970	155.9936	102.7388	49.4841	209.2484	262.5031
07/11/06	148.8500	155.9936	102.7388	49.4841	209.2484	262.5031
08/16/06	206.7660	155.9936	102.7388	49.4841	209.2484	262.5031
11/15/06	109.2980	155.9936	102.7388	49.4841	209.2484	262.5031
01/05/07	105.6200	155.9936	102.7388	49.4841	209.2484	262.5031
06/21/07	106.0580	155.9936	102.7388	49.4841	209.2484	262.5031
07/05/07	182.6330	155.9936	102.7388	49.4841	209.2484	262.5031
06/25/08	170.5600	155.9936	102.7388	49.4841	209.2484	262.5031
07/30/08	106.9980	155.9936	102.7388	49.4841	209.2484	262.5031
05/14/09	238.8521	155.9936	102.7388	49.4841	209.2484	262.5031
06/04/09	130.8960	155.9936	102.7388	49.4841	209.2484	262.5031
06/19/09	186.8720	155.9936	102.7388	49.4841	209.2484	262.5031
07/01/09	181.3600	155.9936	102.7388	49.4841	209.2484	262.5031
07/22/09	104.3930	155.9936	102.7388	49.4841	209.2484	262.5031
08/19/09	187.9400	155.9936	102.7388	49.4841	209.2484	262.5031
09/24/09	115.8400	155.9936	102.7388	49.4841	209.2484	262.5031
02/04/10	100.0000	155.9936	102.7388	49.4841	209.2484	262.5031
08/23/11	116.1190	155.9936	102.7388	49.4841	209.2484	262.5031

*Value was out of 95% CI range at time of testing.
Updated 9/26/11 KC

Acute Fish Test-96 Hr Survival

Start Date:	8/23/2011 16:35	Test ID: C110713.09		Sample ID:	REF-Ref Toxicant
End Date:	8/27/2011 17:15	Lab ID: CCA-Weston, Carlsbad		Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol: EPAA 02-EPA Acute		Test Species:	AA-Atherinops affinis
Comments:					

Conc-ppb	1	2	3	4
Control	0.8000	0.8000	0.9000	0.9000
25	1.0000	1.0000	1.0000	0.8000
50	1.0000	0.9000	1.0000	1.0000
100	0.4000	0.4000	0.8000	0.6000
200	0.0000	0.1000	0.1000	0.1000
400	0.0000	0.0000	0.0000	0.0000

			Transform: Untransformed					Rank	1-Tailed		
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.8500	1.0000	0.8500	0.8000	0.9000	6.792	4			0.8500	0.0000
25	0.9500	1.1176	0.9500	0.8000	1.0000	10.526	4	23.00	10.00	0.9500	-0.1176
50	0.9750	1.1471	0.9750	0.9000	1.0000	5.128	4	25.00	10.00	0.9750	-0.1471
100	0.5500	0.6471	0.5500	0.4000	0.8000	34.816	4	11.00	10.00	0.5500	0.3529
*200	0.0750	0.0882	0.0750	0.0000	0.1000	66.667	4	10.00	10.00	0.0750	0.9118
400	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	4			0.0000	1.0000

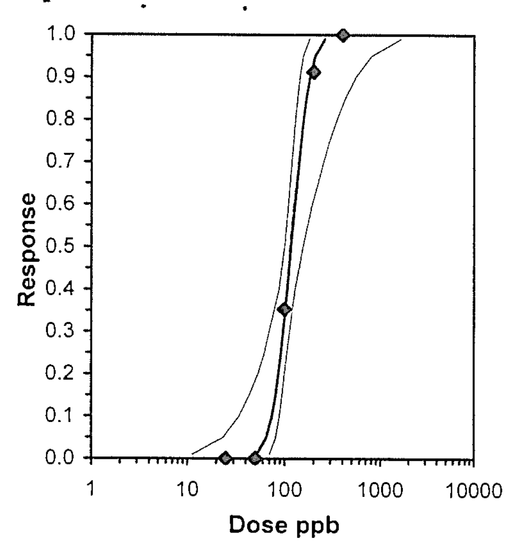
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.85449	0.868	0.37937	1.76807
Bartlett's Test indicates equal variances (p = 0.09)	8.06948	13.2767		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	200	141.421	

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	6.59074	2.25373	2.17342	11.0081	0	6.36558	7.81473	0.1	2.0649	0.15173	12
Intercept	-8.6092	4.57491	-17.576	0.35757							
TSCR											

Point	Probits	ppb	95% Fiducial Limits	
EC01	2.674	51.5147	11.5118	70.3604
EC05	3.355	65.3632	23.479	81.8949
EC10	3.718	74.2089	34.1767	89.2002
EC15	3.964	80.8439	43.8461	94.8881
EC20	4.158	86.5378	53.1946	100.14
EC25	4.326	91.7412	62.4035	105.522
EC40	4.747	106.283	87.7966	127.969
EC50	5.000	116.119	100.395	154.329
EC60	5.253	126.865	110.133	194.011
EC75	5.674	146.975	123.774	294.537
EC80	5.842	155.812	128.962	349.452
EC85	6.036	166.786	135.038	427.292
EC90	6.282	181.698	142.836	551.302
EC95	6.645	206.288	154.887	806.072
EC99	7.326	261.743	179.634	1649.93



ToxCalc v5.0.23

Reviewed by:

Test: AC-Acute Fish Test	Test ID: C110713.09
Species: AA-Atherinops affinis	Protocol: EPAA 02-EPA Acute
Sample ID: REF-Ref Toxicant	Sample Type: CUSO-Copper sulfate
Start Date: 8/23/2011 16:35 End Date: 8/27/2011 17:15	Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				8	
	2	2	Control	10				8	
	3	3	Control	10				9	
	4	4	Control	10				9	
	5	1	25.000	10				10	
	6	2	25.000	10				10	
	7	3	25.000	10				10	
	8	4	25.000	10				8	
	9	1	50.000	10				10	
	10	2	50.000	10				9	
	11	3	50.000	10				10	
	12	4	50.000	10				10	
	13	1	100.000	10				4	
	14	2	100.000	10				4	
	15	3	100.000	10				8	
	16	4	100.000	10				6	
	17	1	200.000	10				0	
	18	2	200.000	10				1	
	19	3	200.000	10				1	
	20	4	200.000	10				1	
	21	1	400.000	10				0	
	22	2	400.000	10				0	
	23	3	400.000	10				0	
	24	4	400.000	10				0	

Comments:

Reviewed by: [signature]

WESTON SOLUTIONS

96 Hour Topsmelt
Reference Toxicant Test

Test ID: C110713.09	Replicates: 4	Study Director: K. Curry	Location: Rm. 3
Dilution Water Batch: S10072511	Organism Batch: ABS8683	Associated Test(s): SIYB	No. of Organisms: 10

Toxicant: Copper Sulfate (0.509gCu/LCuSO4	Lot #: 2008506	Date Prepared: 7/13/11	Initials: KC
Target Concentrations: 400 ppb		Quantity of Stock: Target: 1.572 mL	Quantity of Diluent: Target: 2000 mL
400 ppb		Actual: 1.5724 ml	Actual: 2000.0ml

Serial Dilute by ½ to obtain concentrations of 200, 100, 50, and 25 ppb.

0 Hours Date: 8/23/11 WQ Time: 1500 Start Time: 1635 KC Initials: BG

STOCK

	Control	25	50	100	200	400
D.O. (mg/L)	6.5	6.4	6.3	6.4	6.4	6.3
Temperature	22.0	22.3	22.4	21.9	22.1	21.9
Salinity	33.0	33.0	33.0	32.9	33.0	32.9
pH	8.0	8.0	8.0	8.0	8.0	8.0

24 Hours Date: 8/24/11 Time: 1235 Initials: KC

Renewal Information Toxicant Amount: 1.5722 Diluent Amount: 2000.0 Initials: BG

	Control	25	50	100	200	400
No. Alive Rep 1	9(1)	10	10	7(3)	10	10
No. Alive Rep 2	8(2)	10	9(1)	9(1)	10	9(1)
No. Alive Rep 3	9(1)	10	10	10	10	8(2)
No. Alive Rep 4	9(1)	8(2)	10	10	9(1)	10

48 Hours Date: 8/25/11 Time: 1110 Initials: KC

Renewal Information Toxicant Amount: 0.7864 Diluent Amount: 1000.0 Initials: KC

	Control	25	50	100	200	400
No. Alive Rep 1	9	10	10	7	1(9)	1(9)
No. Alive Rep 2	8	10	9	8(1)	3(7)	Ø(9)
No. Alive Rep 3	9	10	10	8(2)	6(4)	1(7)
No. Alive Rep 4	9	8	10	9(1)	4(5)	1(9)

WESTON SOLUTIONS

96 Hour Topsmelt
Reference Toxicant Test

72 Hours Date: 8/26/11 Time: 1340 Initials: SH

Renewal Information Toxicant Amount: 0.7865 Diluent Amount: 1000.0 Initials: KC

	Control	25	50	100	200	400
No. Alive Rep 1	9	10	10	4 (3)	1	1
No. Alive Rep 2	8	10	9	4 (4)	1 (2)	–
No. Alive Rep 3	9	10	10	8	2 (4)	Ø (1)
No. Alive Rep 4	9	8	10	6 (3)	2 (2)	1

96 Hours Date: 8/27/11 WQ Time: 1650 Replicate: 4 Initials: KC

STOCK

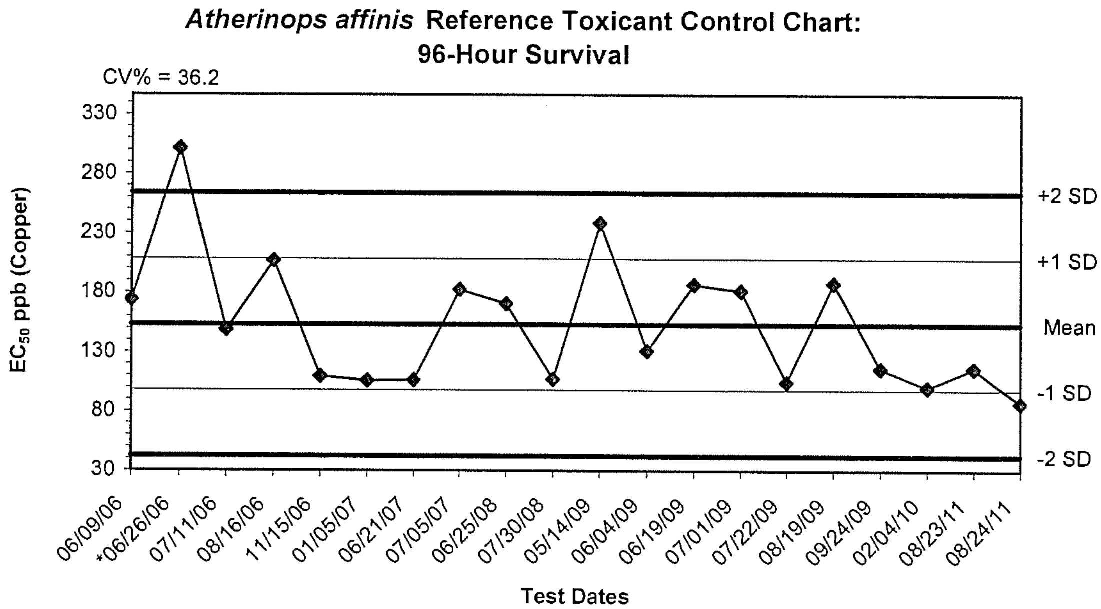
	Control	25	50	100	200	400
D.O. (mg/L)	6.7	6.4	6.4	6.4	6.4	6.4
Temperature	21.8	22.0	21.6	21.6	21.7	21.9
Salinity	32.8	32.7	32.7	32.8	32.7	32.6
pH	8.0	8.0	8.0	8.0	8.0	7.9

96 Hour Survival Data End Time: 1715 Initials: KC

	Control	25	50	100	200	400
No. Alive Rep 1	8 (1)	10	10	4	Ø (1)	Ø (1)
No. Alive Rep 2	8	10	9	4	1	–
No. Alive Rep 3	9	10	10	8	1 (1)	–
No. Alive Rep 4	9	8	10	6	1 (1)	Ø (1)

☐ Pass ☐ Fail

Notes:



Dates	Values	Mean	-1 SD	-2 SD	+1 SD	+2 SD
06/09/06	174.0000	153.0795	97.6593	42.2390	208.4997	263.9199
*06/26/06	301.4970	153.0795	97.6593	42.2390	208.4997	263.9199
07/11/06	148.8500	153.0795	97.6593	42.2390	208.4997	263.9199
08/16/06	206.7660	153.0795	97.6593	42.2390	208.4997	263.9199
11/15/06	109.2980	153.0795	97.6593	42.2390	208.4997	263.9199
01/05/07	105.6200	153.0795	97.6593	42.2390	208.4997	263.9199
06/21/07	106.0580	153.0795	97.6593	42.2390	208.4997	263.9199
07/05/07	182.6330	153.0795	97.6593	42.2390	208.4997	263.9199
06/25/08	170.5600	153.0795	97.6593	42.2390	208.4997	263.9199
07/30/08	106.9980	153.0795	97.6593	42.2390	208.4997	263.9199
05/14/09	238.8521	153.0795	97.6593	42.2390	208.4997	263.9199
06/04/09	130.8960	153.0795	97.6593	42.2390	208.4997	263.9199
06/19/09	186.8720	153.0795	97.6593	42.2390	208.4997	263.9199
07/01/09	181.3600	153.0795	97.6593	42.2390	208.4997	263.9199
07/22/09	104.3930	153.0795	97.6593	42.2390	208.4997	263.9199
08/19/09	187.9400	153.0795	97.6593	42.2390	208.4997	263.9199
09/24/09	115.8400	153.0795	97.6593	42.2390	208.4997	263.9199
02/04/10	100.0000	153.0795	97.6593	42.2390	208.4997	263.9199
08/23/11	116.1190	153.0795	97.6593	42.2390	208.4997	263.9199
08/24/11	87.0370	153.0795	97.6593	42.2390	208.4997	263.9199

*Value was out of 95% CI range at time of testing.
Updated 9/26/11 KC

Acute Fish Test-96 Hr Survival

Start Date:	8/24/2011 17:18	Test ID:	C110713.12	Sample ID:	REF-Ref Toxicant
End Date:	8/28/2011 15:55	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol:	EPAA 02-EPA Acute	Test Species:	AA-Atherinops affinis
Comments:					

Conc-ppb	1	2	3	4
Control	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	0.3000	0.4000	0.2000	0.4000
200	0.0000	0.0000	0.0000	0.0000
400	0.0000	0.0000	0.0000	0.0000

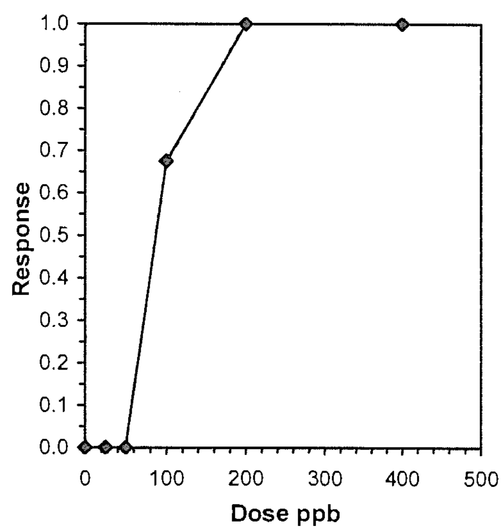
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	1.0000	1.0000	1.0000	1.0000	1.0000	0.000	4			1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	0.000	4	18.00	10.00	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	0.000	4	18.00	10.00	1.0000	1.0000
*100	0.3250	0.3250	0.3250	0.2000	0.4000	29.459	4	10.00	10.00	0.3250	0.3250
200	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	4			0.0000	0.0000
400	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.65314	0.844	-1.0919	5.41572
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	50	100	70.7107	

Linear Interpolation (200 Resamples)

Point	ppb	SD	95% CL(Exp)		Skew
IC05	53.704	0.212	53.107	54.444	0.0412
IC10	57.407	0.423	56.214	58.889	0.0412
IC15	61.111	0.635	59.320	63.333	0.0412
IC20	64.815	0.846	62.427	67.778	0.0412
IC25	68.519	1.058	65.534	72.222	0.0412
IC40	79.630	1.693	74.854	85.556	0.0412
IC50	87.037	2.116	81.068	94.444	0.0412



 ToxCalc v5.0.23 Reviewed by:

Test: AC-Acute Fish Test	Test ID: C110713.12
Species: AA-Atherinops affinis	Protocol: EPAA 02-EPA Acute
Sample ID: REF-Ref Toxicant	Sample Type: CUSO-Copper sulfate
Start Date: 8/24/2011 17:18 End Date: 8/28/2011 15:55	Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Start	24 Hr	48 Hr	72 Hr	96 Hr	Notes
	1	1	Control	10				10	
	2	2	Control	10				10	
	3	3	Control	10				10	
	4	4	Control	10				10	
	5	1	25.000	10				10	
	6	2	25.000	10				10	
	7	3	25.000	10				10	
	8	4	25.000	10				10	
	9	1	50.000	10				10	
	10	2	50.000	10				10	
	11	3	50.000	10				10	
	12	4	50.000	10				10	
	13	1	100.000	10				3	
	14	2	100.000	10				4	
	15	3	100.000	10				2	
	16	4	100.000	10				4	
	17	1	200.000	10				0	
	18	2	200.000	10				0	
	19	3	200.000	10				0	
	20	4	200.000	10				0	
	21	1	400.000	10				0	
	22	2	400.000	10				0	
	23	3	400.000	10				0	
	24	4	400.000	10				0	

Comments:

Reviewed by:

WESTON SOLUTIONS.

96 Hour Topsmelt
Reference Toxicant Test

Test ID: C110713.12	Replicates: 4	Study Director: K. Curry	Location: Rm. 3
Dilution Water Batch: S10082411	Organism Batch: ABS 8915	Associated Test(s): S143	No. of Organisms: 10

Toxicant: Copper Sulfate (0.509gCu/LCuSO4	Lot #: 2008506	Date Prepared: 8/24/11	Initials: BG
Target Concentrations: **400 ppb**		Quantity of Stock: Target: 1.572 mL	Quantity of Diluent: Target: 2000 mL
400 ppb		Actual: 1.5722	Actual: 2000.0 mL

Serial Dilute by ½ to obtain concentrations of 200, 100, 50, and 25 ppb.

0 Hours Date: 8/24/11 WQ Time: 1645 Start Time: 1718 Initials: SH

STOCK

	Control	25	50	100	200	400
D.O. (mg/L)	7.1	6.9	7.0	6.9	7.1	7.0
Temperature	21.6	21.3	21.4	21.4	21.4	21.4
Salinity	32.7	32.8	32.8	32.8	32.7	32.7
pH	8.0	8.0	8.0	8.0	8.0	8.0

24 Hours Date: 8/25/11 Time: 12/15 Initials: BG

Renewal Information Toxicant Amount: 0.7860 mL Diluent Amount: 1000 mL Initials: BG

	Control	25	50	100	200	400
No. Alive Rep 1	10	10	10	9(1)	3(7)	Ø (10)
No. Alive Rep 2	10	10	10	10	7(3)	Ø (10)
No. Alive Rep 3	10	10	10	10	7(3)	Ø (10)
No. Alive Rep 4	10	10	10	8(2)	2(8)	Ø (10)

48 Hours Date: 8/26/11 Time: 1400 Initials: SH

Renewal Information Toxicant Amount: 0.3930 mL Diluent Amount: 1000 mL Initials: JH

	Control	25	50	100	200	400
No. Alive Rep 1	10	10	10	6(3)	1(2)	
No. Alive Rep 2	10	10	10	4(6)	0(7)	
No. Alive Rep 3	10	10	10	2(8)	3(4)	
No. Alive Rep 4	10	10	10	4(4)	0(2)	

WESTON SOLUTIONS

96 Hour Topsmelt
Reference Toxicant Test

72 Hours	Date: 8/27/11		Time: 1440		Initials: KC	
Renewal Information	Toxicant Amount: 0.3931		Diluent Amount: ~~0.3931~~ 1000.0 KC ①		Initials: KC	
	Control	25	50	100	200	400
No. Alive Rep 1	10	10	10	6	Ø (1)	
No. Alive Rep 2	10	10	10	4	—	
No. Alive Rep 3	10	10	10	2	1 (2)	
No. Alive Rep 4	10	10	10	4	—	

96 Hours	Date: 8/28/11	WQ Time: 1400		Replicate: 3		Initials: KC
			STOCK			
	Control	25	50	100	200	400
D.O. (mg/L)	6.8	6.6	6.7	6.6	6.8	6.8
Temperature	22.4	22.1	22.1	22.2	22.3	22.2
Salinity	32.6	32.6	32.7	32.7	32.6	32.5
pH	8.1	8.0	8.0	8.0	8.0	8.1

96 Hour Survival Data		End Time: 1555			Initials: KC	
	Control	25	50	100	200	400
No. Alive Rep 1	10	10	10	3 (3)	—	
No. Alive Rep 2	10	10	10	4	—	
No. Alive Rep 3	10	10	10	2	Ø (1)	
No. Alive Rep 4	10	10	10	4	—	

① IE 8/27/11 KC

☐ Pass ☐ Fail

Notes:

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-1	**Test ID No.:**	C110823.0142

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	87.1	87.6
6.25%	87.6	91.4
12.5%	93.8	90.3
25%	94.5	86.6
50%	95.8	83.4
100%	86.0	81.9

QA Unit — Date: 1/3/12

Approved — Date: 1/5/12

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-1	**Test ID No.:**	C110823.0142

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.36$). Dunnett's Multiple-Comparison Test provided a NOEC (No Observed Effect Concentration) of 100 percent and a LOEC (Lowest Observed Effect Concentration) of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.70$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	100%	>100%	100%	>100%	SIYB-1

Protocol Deviations: Control normality was slightly below the protocol limit of ≥90 percent for the test and the associated Reference Toxicant test. The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-1	**Test ID No.:**	C110823.0142

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*.

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	16.0	30.0	8.0
6.25	7.6	15.9	30.2	8.0
12.5	7.5	15.8	30.5	8.0
25	7.6	16.1	30.9	8.0
50	7.7	16.3	31.6	8.0
100	8.0	16.4	33.1	8.0
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.5		
6.25		14.5		
12.5		14.5		
25		14.5		
50		14.5		
100		14.4		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.8	15.3	30.1	7.9
6.25	7.7	14.9	30.6	7.9
12.5	7.9	14.9	30.7	7.9
25	8.0	14.9	31.4	8.0
50	8.0	15.0	31.8	8.0
100	8.0	14.8	33.7	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-1	**Test ID No.:**	C110823.0142

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	30.0 ppt
pH	8.0
Dissolved Oxygen	7.5 mg/L
Temperature	16.0°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis*. Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on August 22, 2011, at 1635 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0920 hours. The temperature of the sample upon receipt was 5.8°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 218 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.42 ppb survival, 6.07 ppb proportion normal
	48 hr EC_{50}:	13.47 ppb survival, 7.38 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.65 ppb survival, 7.17 ppb proportion normal
	Test Date:	8/23/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith, J. Hansen

Bivalve Larval Survival and Development Test-Proportion Normal					
Start Date:	8/23/2011 18:45	Test ID:	C110823.0142	Sample ID:	SIYB -1
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:35	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

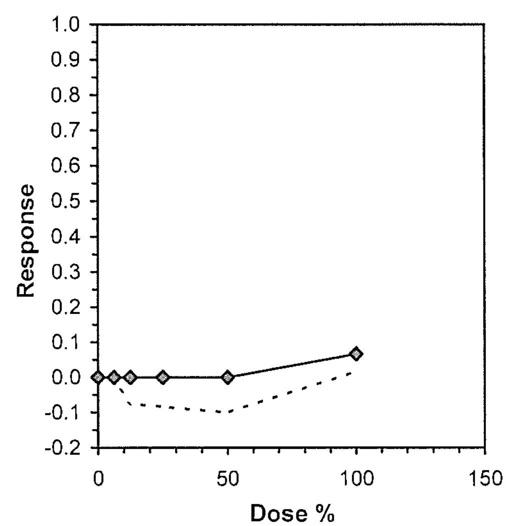
Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.8600	0.9029	0.8889	0.8533
12.5	0.9126	0.9436	0.9465	0.9497
25	0.9326	0.9231	0.9519	0.9709
50	0.9660	0.9357	0.9593	0.9719
100	0.8021	0.8606	0.8686	0.9097

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4				0.9179	1.0000
6.25	0.8763	1.0057	1.2125	1.1777	1.2539	2.975	4	-0.286	2.410	0.0714	0.9179	1.0000
12.5	0.9381	1.0767	1.3210	1.2707	1.3447	2.571	4	-3.947	2.410	0.0714	0.9179	1.0000
25	0.9446	1.0842	1.3368	1.2898	1.3995	3.645	4	-4.482	2.410	0.0714	0.9179	1.0000
50	0.9582	1.0998	1.3675	1.3144	1.4024	2.788	4	-5.516	2.410	0.0714	0.9179	1.0000
100	0.8603	0.9873	1.1908	1.1098	1.2656	5.364	4	0.443	2.410	0.0714	0.8571	0.9338

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.97704		0.884		-0.1708	0.05185
Bartlett's Test indicates equal variances (p = 0.36)					5.47937		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.05144	0.05904	0.02437	0.00176	1.2E-05	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	87.756			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Bivalve Larval Survival and Development Test-Proportion Alive					
Start Date:	8/23/2011 18:45	Test ID:	C110823.0142	Sample ID:	SIYB -1
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:35	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
Control	0.9266	0.7661	0.9587	0.8532
6.25	0.9174	0.9450	0.9495	0.8440
12.5	0.9450	0.8945	0.8578	0.9128
25	0.8853	0.8349	0.9541	0.7890
50	0.9450	0.7844	0.7890	0.8165
100	0.8578	0.9541	0.8028	0.6606

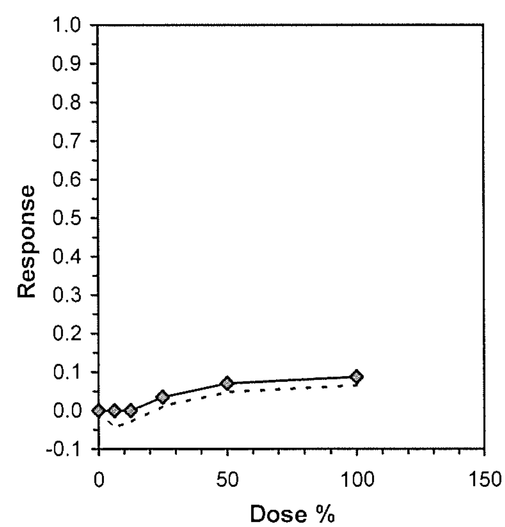
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8761	1.0000	1.2265	1.0659	1.3662	10.793	4				0.8976	1.0000
6.25	0.9140	1.0432	1.2806	1.1648	1.3442	6.424	4	-0.650	2.410	0.2003	0.8976	1.0000
12.5	0.9025	1.0301	1.2573	1.1841	1.3340	4.972	4	-0.370	2.410	0.2003	0.8976	1.0000
25	0.8658	0.9882	1.2065	1.0935	1.3549	9.339	4	0.241	2.410	0.2003	0.8658	0.9647
50	0.8337	0.9516	1.1609	1.0879	1.3340	10.057	4	0.790	2.410	0.2003	0.8337	0.9289
100	0.8188	0.9346	1.1496	0.9488	1.3549	14.658	4	0.925	2.410	0.2003	0.8188	0.9123

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.98248	0.884	0.18513	-0.3685
Bartlett's Test indicates equal variances (p = 0.70)	2.96989	15.0863		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	0.15449	0.17435	0.01079	0.01382	0.57659	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	35.238			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



ToxCalc v5.0.23

Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test					Test ID: C110823.0142			
Species: MG-Mytilus galloprovincialis					Protocol: EPAW 95-EPA West Coast			
Sample ID: SIYB -1					Sample Type: AMB1-Ambient water			
Start Date: 8/23/2011 18:45				End Date: 8/25/2011 17	Lab ID: CCA-Weston, Carlsbad			
Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	202	202	177	
	2	2	Control	218	167	167	145	
	3	3	Control	218	209	209	184	
	4	4	Control	218	186	186	160	
	5	1	6.250	218	200	200	172	
	6	2	6.250	218	206	206	186	
	7	3	6.250	218	207	207	184	
	8	4	6.250	218	184	184	157	
	9	1	12.500	218	206	206	188	
	10	2	12.500	218	195	195	184	
	11	3	12.500	218	187	187	177	
	12	4	12.500	218	199	199	189	
	13	1	25.000	218	193	193	180	
	14	2	25.000	218	182	182	168	
	15	3	25.000	218	208	208	198	
	16	4	25.000	218	172	172	167	
	17	1	50.000	218	206	206	199	
	18	2	50.000	218	171	171	160	
	19	3	50.000	218	172	172	165	
	20	4	50.000	218	178	178	173	
	21	1	100.000	218	187	187	150	
	22	2	100.000	218	208	208	179	
	23	3	100.000	218	175	175	152	
	24	4	100.000	218	144	144	131	

Comments:

Reviewed by:

Bivalve Counts Worksheet

Test ID: C110823.01 SIYB - 1

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	177	25	202
	2	145	22	167
	3	184	25	209
	4	160	26	186
6.25	1	172	28	200
	2	186	20	206
	3	184	23	207
	4	157	27	184
12.5	1	188	18	206
	2	184	11	195
	3	177	10	187
	4	189	10	199
25	1	180	13	193
	2	168	14	182
	3	198	10	208
	4	167	5	172
50	1	199	7	206
	2	160	11	171
	3	165	7	172
	4	173	5	178
100	1	150	37	187
	2	179	29	208
	3	152	23	175
	4	131	13	144
	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0

JA

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT:	Port of San Diego
PROJECT:	Shelter Island Yacht Basin
CLIENT SAMPLE ID:	SIYB-1
WESTON TEST ID:	C110823.0142
SPECIES:	M. galloprovincialis

DATE RECEIVED:	8/23/11
DATE TEST STARTED:	8/23/11
DATE TEST ENDED:	8/25/11
WESTON SOP NO.:	BIO 042
STUDY DIRECTOR:	K. Skrivseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours)	Control	2	7.5	2	16.0	6	30.0	3	8.0
Date: 8/23/11	~~Brine Control~~		—		—		—		—
Sample ID: C110823.01	6.25		7.6		15.9		30.2		8.0
Dilutions (Tech): KC	12.5		7.5		15.8		30.5		8.0
WQ Time: 1800	25		7.6		16.1		30.9		8.0
Technician: BG	50		7.7		16.3		31.6		8.0
	100		8.0		16.4		33.1 ① ks		8.0
24 Hours	Control			6B	14.5				
	~~Brine Control~~				—				
Date: 8/24/11	6.25				14.5				
	12.5				14.5				
WQ Time: 1030	25				14.5				
	50				14.5				
Technician: BG	100				14.4				
48 Hours	Control	2	7.8	2	15.3	6	30.1	4	7.9
	~~Brine Control~~		—		—		—		—
Date: 8/25/11	6.25		7.7		14.9		30.6		7.9
WQ Time: 1420	12.5		7.9		14.9		30.7		7.9
	25		8.0		14.9		31.4		8.0
Technician: SH/BG	50		8.0		15.0		31.8		8.0
	100		8.0		14.8		33.7 ① ks		8.0

*Water quality measurements taken in surrogate water quality chambers. ① Salinity is above the test protocol range of 30±2 ppt. 1/3/12 ks

START TIME:	1845	Initials:	SH
END TIME:	1745	Initials:	KC
ORGANISM BATCH:	TSF 5708		
HOBO TEMP. NO.:	2296		
TEST LOCATION:	Room 2		

DILUTION WATER BATCH: SI072511

TEST ACCEPTABILITY:

- [x] ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- [ ] ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- [x] MSD < 25%

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

Weston Test ID: C110823.0142 ~~Port of San Diego~~ ①KS	Client: Port of San Diego ~~Shelter Island Yacht Basin~~	Client Sample ID: ①KS SIYB-1-7 ; ~~SIYB-Ref~~

SPAWNING DATA				
Initial Spawning Time: 1600	Final Spawning Time: 1700	Fertilization Time: 1701	No. of Females: 2	No. of Males: 3
Embryo Density (count/mL):	1. 98 / 77	2. 81 / 86	3. 91 / 99	Average: 88.7
Stocking Volume Calculation:	2700/(88.7x50) = .608 or 6/ml			

ZERO TIME COUNTS					
1. 186	2. 203	3. 209	4. 269	5. 203	6. 238
Average Count: 218			Technician: KS		

LARVAL COUNT DATA

Conc.	Rep 1 Normal	Rep 1 Abnormal	Rep 2 Normal	Rep 2 Abnormal	Rep 3 Normal	Rep 3 Abnormal	Rep 4 Normal	Rep 4 Abnormal	Rep 5 Normal	Rep 5 Abnormal	Date	Initials
Control	177	25	145	22	184	25	160	26			8/31/11	KS
~~Brine~~												
6.25	172	28	186	20	184	23	157	27			9/16/11	KS
12.5	188	18	184	11	177	10	189	10				
25	180	13	168	14	198	10	167	5				
50	199	7	160	11	165	7	173	5				
100	150	37	179	29	152	23	131	13			9/20/11	

QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	6.25 / 3	50 / 4	/	/
Total #	206	179		
# Normal	182	171	~~171~~ ②SH	
Date / Initials	10/13/11 / SH	10/13/11 / SH	/	/

QA Check Acceptability: ☑ <5% difference in means of QA & orig. counts

① WP 9/16/11 KS
② WU 10/13/11 SH

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-2	**Test ID No.:**	C110823.0242

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	87.1	87.6
6.25%	87.3	96.4
12.5%	89.7	91.6
25%	90.8	93.9
50%	89.4	89.0
100%	97.3	80.1

QA Unit 1/3/12 Date

Approved 1/5/12 Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-2	**Test ID No.:**	C110823.0242

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.15$). Dunnett's Multiple-Comparison Test provided a NOEC (No Observed Effect Concentration) of 100 percent and a LOEC (Lowest Observed Effect Concentration) of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.90$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	100%	>100%	100%	>100%	SIYB-2

Protocol Deviations: Control normality was slightly below the protocol limit of ≥90 percent for the test and the associated Reference Toxicant test. Sample arrived at 9.9°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity. The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt. Temperature in the water quality surrogate on Day 0 for the 100% concentration was above the protocol limit of 15°C±1.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-2	**Test ID No.:**	C110823.0242

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis.*

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	16.0	30.0	8.0
6.25	7.5	16.1	30.2	8.0
12.5	7.5	16.0	30.5	8.0
25	7.6	16.2	30.9	8.0
50	7.7	16.4	31.6	8.0
100	8.0	16.6	33.1	8.1
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.5		
6.25		14.5		
12.5		14.3		
25		14.6		
50		14.5		
100		14.5		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.8	15.3	30.1	7.9
6.25	7.7	14.8	30.7	7.9
12.5	7.9	14.7	31.0	7.9
25	7.9	15.0	31.1	8.0
50	8.0	14.8	31.8	8.0
100	8.2	14.6	34.0	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-2	**Test ID No.:**	C110823.0242

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	30.0 ppt
pH	8.0
Dissolved Oxygen	7.5 mg/L
Temperature	16.0°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis.* Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on August 22, 2011, at 1625 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0920 hours. The temperature of the sample upon receipt was 9.9°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 218 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.42 ppb survival, 6.07 ppb proportion normal
	48 hr EC_{50}:	13.47 ppb survival, 7.38 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.65 ppb survival, 7.17 ppb proportion normal
	Test Date:	8/23/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith, J. Hansen

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 18:45	Test ID:	C110823.0242	Sample ID:	SIYB - 2
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:25	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

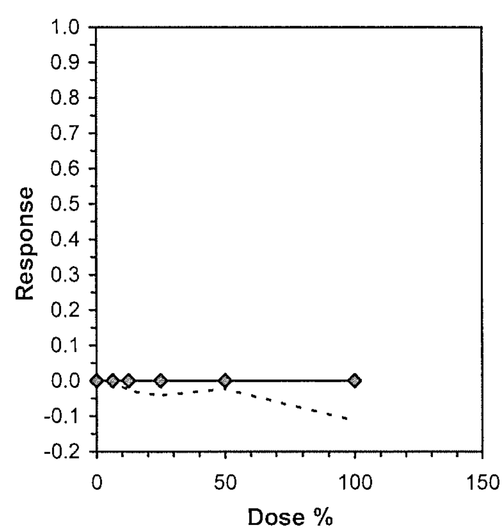
Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.8713	0.8898	0.8476	0.8815
12.5	0.8750	0.8708	0.9369	0.9034
25	0.9191	0.8685	0.9502	0.8930
50	0.8693	0.8462	0.9299	0.9290
100	0.9659	0.9669	0.9728	0.9844

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4				0.9020	1.0000
6.25	0.8726	1.0015	1.2064	1.1698	1.2324	2.241	4	-0.072	2.410	0.0799	0.9020	1.0000
12.5	0.8965	1.0290	1.2461	1.2031	1.3169	4.214	4	-1.269	2.410	0.0799	0.9020	1.0000
25	0.9077	1.0419	1.2664	1.1998	1.3459	4.960	4	-1.884	2.410	0.0799	0.9020	1.0000
50	0.8936	1.0256	1.2432	1.1677	1.3028	5.572	4	-1.182	2.410	0.0799	0.9020	1.0000
100	0.9725	1.1162	1.4058	1.3849	1.4455	1.985	4	-6.089	2.410	0.0799	0.9020	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.97365		0.884		0.22078	-0.4713
Bartlett's Test indicates equal variances (p = 0.15)					8.14602		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.058	0.06656	0.02222	0.0022	9.8E-05	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by:

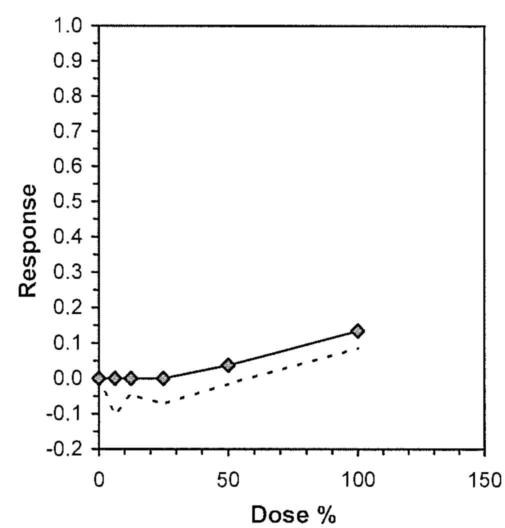
Bivalve Larval Survival and Development Test-Proportion Alive					
Start Date:	8/23/2011 18:45	Test ID:	C110823.0242	Sample ID:	SIYB - 2
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:25	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
Control	0.9266	0.7661	0.9587	0.8532
6.25	0.9266	1.0000	0.9633	0.9679
12.5	0.9541	0.9587	0.9450	0.8073
25	1.0000	0.9771	0.9220	0.8578
50	0.9128	0.9541	0.9817	0.7110
100	0.9404	0.8303	0.8440	0.5872

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8761	1.0000	1.2265	1.0659	1.3662	10.793	4				0.9240	1.0000
6.25	0.9644	1.1008	1.4005	1.2965	1.5369	7.145	4	-1.638	2.410	0.2560	0.9240	1.0000
12.5	0.9163	1.0458	1.2929	1.1164	1.3662	9.159	4	-0.624	2.410	0.2560	0.9240	1.0000
25	0.9392	1.0720	1.3569	1.1841	1.5369	11.326	4	-1.227	2.410	0.2560	0.9240	1.0000
50	0.8899	1.0157	1.2661	1.0032	1.4349	14.813	4	-0.372	2.410	0.2560	0.8899	0.9631
100	0.8005	0.9136	1.1270	0.8730	1.3241	16.613	4	0.937	2.410	0.2560	0.8005	0.8663

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.94758		0.884		-0.5116	-0.5649
Bartlett's Test indicates equal variances (p = 0.90)					1.62468		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.20516	0.23153	0.03763	0.02257	0.19342	5, 18

			Linear Interpolation (200 Resamples)	
Point	%	SD	95% CL(Exp)	Skew
IC05	56.755			
IC10	82.580			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Test: BV-Bivalve Larval Survival and Development Test						Test ID: C110823.0242		
Species: MG-Mytilus galloprovincialis						Protocol: EPAW 95-EPA West Coast		
Sample ID: SIYB - 2						Sample Type: AMB1-Ambient water		
Start Date: 8/23/2011 18:45				End Date: 8/25/2011 17		Lab ID: CCA-Weston, Carlsbad		

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	202	202	177	
	2	2	Control	218	167	167	145	
	3	3	Control	218	209	209	184	
	4	4	Control	218	186	186	160	
	5	1	6.250	218	202	202	176	
	6	2	6.250	218	245	245	218	
	7	3	6.250	218	210	210	178	
	8	4	6.250	218	211	211	186	
	9	1	12.500	218	208	208	182	
	10	2	12.500	218	209	209	182	
	11	3	12.500	218	206	206	193	
	12	4	12.500	218	176	176	159	
	13	1	25.000	218	235	235	216	
	14	2	25.000	218	213	213	185	
	15	3	25.000	218	201	201	191	
	16	4	25.000	218	187	187	167	
	17	1	50.000	218	199	199	173	
	18	2	50.000	218	208	208	176	
	19	3	50.000	218	214	214	199	
	20	4	50.000	218	155	155	144	
	21	1	100.000	218	205	205	198	
	22	2	100.000	218	181	181	175	
	23	3	100.000	218	184	184	179	
	24	4	100.000	218	128	128	126	

Comments:

 ToxCalc 5.0 Reviewed by: [signature]

Bivalve Counts Worksheet

Test ID: C110823.02 SIYB - 2

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	177	25	202
	2	145	22	167
	3	184	25	209
	4	160	26	186
6.25	1	176	26	202
	2	218	27	245
	3	178	32	210
	4	186	25	211
12.5	1	182	26	208
	2	182	27	209
	3	193	13	206
	4	159	17	176
25	1	216	19	235
	2	185	28	213
	3	191	10	201
	4	167	20	187
50	1	173	26	199
	2	176	32	208
	3	199	15	214
	4	144	11	155
100	1	198	7	205
	2	175	6	181
	3	179	5	184
	4	126	2	128
	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

WESTON SOLUTIONS

BIO042

CLIENT:	Port of San Diego
PROJECT:	Shelter Island Yacht Basin
CLIENT SAMPLE ID:	SIYB-2
WESTON TEST ID:	C110823.0242
SPECIES:	M. galloprovincialis

DATE RECEIVED:	8/23/11
DATE TEST STARTED:	8/23/11
DATE TEST ENDED:	8/25/11
WESTON SOP NO.:	BIO 042
STUDY DIRECTOR:	K. Skrivseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours)	Control	2	7.5	2	16.0	6	30.0	3	8.0
Date: 8/23/11	~~Brine Control~~		—		—		—		—
Sample ID: C110823.02	①SH 6.25		7.5		16.1		30.2		8.0
Dilutions (Tech): KC	~~25~~ 12.5		7.5		16.0		30.5		8.0
WQ Time: 1810	~~50~~ 25		7.6		16.2		30.9		8.0
Technician: BG	~~10~~ 50		7.7		16.4		31.6		8.0
	100		8.0		16.6 ④KS		33.1 ③KS		8.1
24 Hours	Control			6B	14.5				
	~~Brine Control~~				—				
Date: 8/24/11	6.25				14.5				
WQ Time: 1035	12.5				14.3				
Technician: BG	25				14.6				
	50				14.5				
	100				14.5				
48 Hours	Control	2	7.8	2	15.3	6	30.1	②SH ~~3~~	7.9
Date: 8/25/11	Brine Control		—		—		—		—
WQ Time: 1420	6.25		7.7		14.8		30.7		7.9
Technician: SH/BG	12.5		7.9		14.7		31.0		7.9
	25		7.9		15.6		31.1		8.0
	50		8.0		14.8		31.8		8.0
	100		8.2		14.6		34.0 ③KS		8.0

*Water quality measurements taken in surrogate water quality chambers.

START TIME:	1845	Initials:	SH
END TIME:	1745	Initials:	KC
ORGANISM BATCH:	TSF 5708		
HOBO TEMP. NO.:	2296		
TEST LOCATION:	Room 2		

DILUTION WATER BATCH: SIO072511

TEST ACCEPTABILITY:

- ☒ ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- ☐ ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- ☒ MSD < 25%

① IE 8/23/11 SH ② IE 8/25/11 ③ Salinity is above the test protocol limit of 30±2 ppt 1/3/12 KS
④ temperature above protocol limit of 15°C±1 1/3/12 KS

WESTON SOLUTIONS

BIVALVE 48-HOUR② CHRONIC TOXICITY TEST

BIO042

Weston Test ID: C110823.0242	Client: Port of San Diego ~~Shelter Island Yacht Basin~~ ③JH	Client Sample ID: SIYB -2

SPAWNING DATA

Initial Spawning Time: 1600	Final Spawning Time: 1700	Fertilization Time: 1701	No. of Females: 2	No. of Males: 3
Embryo Density (count/mL):	1. 98/77	2. 81/86	3. 91/99	Average: 88.7
Stocking Volume Calculation: 2700 / (88.7 × 50) = 0.608				

ZERO TIME COUNTS

1. 186	2. 203	3. 209	4. 269	5. 203	6. 238
Average Count: 218			Technician: KS		

LARVAL COUNT DATA

Conc.	Rep 1 Normal	Rep 1 Abnormal	Rep 2 Normal	Rep 2 Abnormal	Rep 3 Normal	Rep 3 Abnormal	Rep 4 Normal	Rep 4 Abnormal	Rep 5 Normal	Rep 5 Abnormal	Date	Initials
Control												
Brine												
6.25	176	26	218	27	178	32	186	25			9/27/11	SH
12.5 ①SH	~~218~~ 182	① ~~27~~ 26	182	27	193	13	159	17				
25	~~178~~ 216	~~32~~ 19	185	28	191	10	167	20				
50	173	26	176	32	199	15	144	11				
100	198	7	175	6	179	5	126	2			9/28/11	KS

①WC 9/27/11 SH

QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	12.5 / 2	~~100~~ 50 ②KS / 3	/	/
Total #	207	②KS ~~193~~ 200		
# Normal	182	①KS ~~7~~ 193		
Date / Initials	10/12/11 / KS	10/12/11 / KS	/	/
QA Check Acceptability: ☒ <5% difference in means of QA & orig. counts				

② IE 10/12/11 KS

③ IE 1/3/12 JH

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-3	**Test ID No.:**	C110823.0342

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	87.1	87.6
6.25%	92.4	93.9
12.5%	90.7	88.5
25%	93.9	82.2
50%	94.7	80.6
100%	95.0	71.1

QA Unit 1/5/12 Date

Approved 1/6/12 Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-3	**Test ID No.:**	C110823.0342

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.42$). Bonferroni t Test provided a NOEC (No Observed Effect Concentration) of 100 percent and a LOEC (Lowest Observed Effect Concentration) of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.06$). Bonferroni t Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	100%	>100%	100%	>100%	SIYB-3

Protocol Deviations: Control normality was slightly below the protocol limit of ≥90 percent for the test and the associated Reference Toxicant test. Sample arrived at 10.3°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity. The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt. Replicate 3 of the 100 percent concentration was found to be an outlier and was therefore excluded from statistical analysis.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-3	**Test ID No.:**	C110823.0342

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis.*

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	16.0	30.0	8.0
6.25	7.6	16.3	30.2	8.0
12.5	7.5	16.2	30.5	8.0
25	7.5	16.4	30.9	8.0
50	7.6	16.4	31.6	8.0
100	7.7	16.4	33.2	8.1
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.5		
6.25		14.6		
12.5		14.5		
25		14.7		
50		14.5		
100		14.5		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.8	15.3	30.1	7.9
6.25	7.9	15.0	30.2	8.0
12.5	8.0	14.9	30.5	8.0
25	8.0	15.1	31.2	8.0
50	8.0	14.9	32.0	8.0
100	8.1	14.8	33.7	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-3	**Test ID No.:**	C110823.0342

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	30.0 ppt
pH	8.0
Dissolved Oxygen	7.5 mg/L
Temperature	16.0°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis.* Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on August 22, 2011, at 1615 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0920 hours. The temperature of the sample upon receipt was 10.3°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 218 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.42 ppb survival, 6.07 ppb proportion normal
	48 hr EC_{50}:	13.47 ppb survival, 7.38 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.65 ppb survival, 7.17 ppb proportion normal
	Test Date:	8/23/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith, J. Hansen

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 18:45	Test ID:	C110823.0342	Sample ID:	SIYB-3
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:15	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

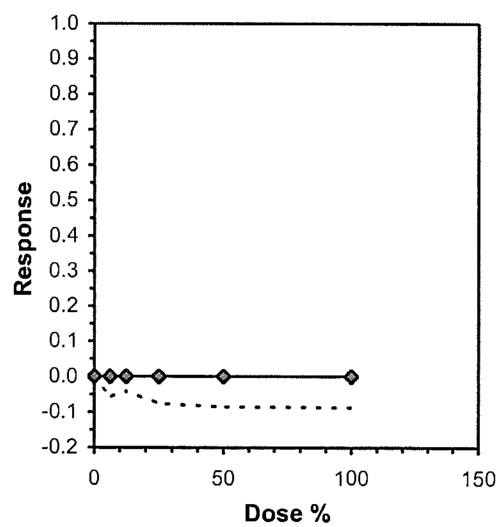
Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.9031	0.9440	0.8904	0.9572
12.5	0.8976	0.9274	0.9289	0.8757
25	0.9483	0.9222	0.9213	0.9622
50	0.9588	0.9731	0.9415	0.9148
100	0.9353	0.9416	0.9716	

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4				0.9230	1.0000
6.25	0.9237	1.0601	1.2955	1.2334	1.3625	4.753	4	-2.765	2.567	0.0849	0.9230	1.0000
12.5	0.9074	1.0414	1.2636	1.2105	1.3009	3.460	4	-1.802	2.567	0.0849	0.9230	1.0000
25	0.9385	1.0772	1.3228	1.2865	1.3750	3.263	4	-3.590	2.567	0.0849	0.9230	1.0000
50	0.9471	1.0870	1.3434	1.2745	1.4061	4.186	4	-4.214	2.567	0.0849	0.9230	1.0000
100	0.9495	1.0898	1.3473	1.3136	1.4016	3.524	3	-4.009	2.567	0.0917	0.9230	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.9567		0.881		0.05312	-1.154
Bartlett's Test indicates equal variances (p = 0.42)					4.9424		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Bonferroni t Test	100	>100		1	0.06731	0.07725	0.01154	0.00219	0.00419	5, 17

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 18:45	Test ID:	C110823.0342	Sample ID:	SIYB-3
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:15	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

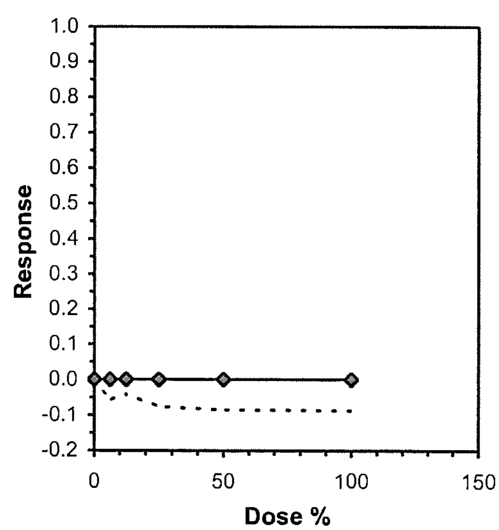
Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.9031	0.9440	0.8904	0.9572
12.5	0.8976	0.9274	0.9289	0.8757
25	0.9483	0.9222	0.9213	0.9622
50	0.9588	0.9731	0.9415	0.9148
100	0.9353	0.9416	0.9716	

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4				0.9230	1.0000
6.25	0.9237	1.0601	1.2955	1.2334	1.3625	4.753	4	-2.765	2.567	0.0849	0.9230	1.0000
12.5	0.9074	1.0414	1.2636	1.2105	1.3009	3.460	4	-1.802	2.567	0.0849	0.9230	1.0000
25	0.9385	1.0772	1.3228	1.2865	1.3750	3.263	4	-3.590	2.567	0.0849	0.9230	1.0000
50	0.9471	1.0870	1.3434	1.2745	1.4061	4.186	4	-4.214	2.567	0.0849	0.9230	1.0000
100	0.9495	1.0898	1.3473	1.3136	1.4016	3.524	3	-4.009	2.567	0.0917	0.9230	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.9567		0.881		0.05312	-1.154
Bartlett's Test indicates equal variances (p = 0.42)					4.9424		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Bonferroni t Test	100	>100		1	0.06731	0.07725	0.01154	0.00219	0.00419	5, 17

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	8/23/2011 18:45	Test ID:	C110823.0342	Sample ID:	SIYB-3
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:15	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
Control	0.9266	0.7661	0.9587	0.8532
6.25	0.8991	1.0000	1.0000	0.8578
12.5	0.9404	0.8211	0.9679	0.8119
25	0.7982	0.8257	0.8165	0.8486
50	0.7798	0.8532	0.7844	0.8073
100	0.7798	0.7064	0.6468	

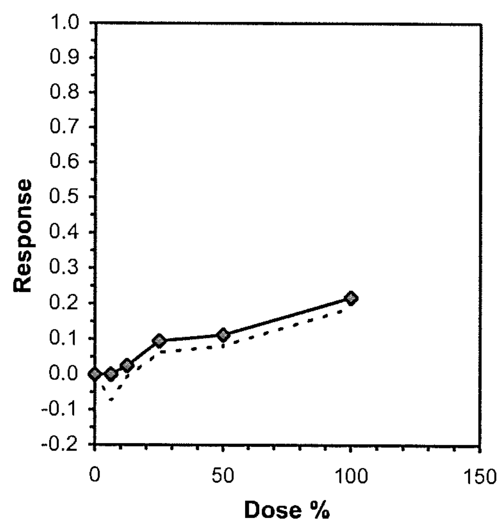
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8761	1.0000	1.2265	1.0659	1.3662	10.793	4				0.9077	1.0000
6.25	0.9392	1.0720	1.3764	1.1841	1.5369	13.600	4	-1.816	2.567	0.2118	0.9077	1.0000
12.5	0.8853	1.0105	1.2428	1.1222	1.3906	10.877	4	-0.196	2.567	0.2118	0.8853	0.9754
25	0.8222	0.9385	1.1361	1.1049	1.1712	2.430	4	1.097	2.567	0.2118	0.8222	0.9059
50	0.8062	0.9202	1.1161	1.0824	1.1776	3.911	4	1.339	2.567	0.2118	0.8062	0.8882
100	0.7110	0.8115	1.0050	0.9344	1.0824	7.386	3	2.486	2.567	0.2288	0.7110	0.7833

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.9646	0.881	-0.0521	-0.7616
Bartlett's Test indicates equal variances (p = 0.06)	10.4232	15.0863		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test	100	>100		1	0.18007	0.20322	0.05831	0.01362	0.01054	5, 17

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	17.063	5.839	3.959	32.903	1.4653
IC10	33.304	16.461	0.000	87.871	0.4439
IC15	68.208				
IC20	92.048				
IC25	>100				
IC40	>100				
IC50	>100				



ToxCalc v5.0.23

Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test   Test ID: C110823.0342
Species: MG-Mytilus galloprovincialis   Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB-3   Sample Type: AMB1-Ambient water
Start Date: 8/23/2011 18:45   End Date: 8/25/2011 17   Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	202	202	177	
	2	2	Control	218	167	167	145	
	3	3	Control	218	209	209	184	
	4	4	Control	218	186	186	160	
	5	1	6.250	218	196	196	177	
	6	2	6.250	218	250	250	236	
	7	3	6.250	218	219	219	195	
	8	4	6.250	218	187	187	179	
	9	1	12.500	218	205	205	184	
	10	2	12.500	218	179	179	166	
	11	3	12.500	218	211	211	196	
	12	4	12.500	218	177	177	155	
	13	1	25.000	218	174	174	165	
	14	2	25.000	218	180	180	166	
	15	3	25.000	218	178	178	164	
	16	4	25.000	218	185	185	178	
	17	1	50.000	218	170	170	163	
	18	2	50.000	218	186	186	181	
	19	3	50.000	218	171	171	161	
	20	4	50.000	218	176	176	161	
	21	1	100.000	218	170	170	159	
	22	2	100.000	218	154	154	145	
	23	3	100.000	218	141	141	137	

Comments:

    Reviewed by: JA

Grubb's Test for Detecting Outliers

$$Z = \frac{|\text{mean - value}|}{\text{SD}}$$

	Data Set (# Alive)
suspected outlier	15
	137
	145
	159

Mean	Standard Deviation	Z
114	66.62331924	1.485966192

Instructions: Look up the critical value of Z in the table below, where N is the number of values in the group. If your value of Z is higher than the tabulated value, the P value is less than 0.05. If P value is less than 0.05, the number is an outlier.

N	Critical Z
3	1.15
4	1.48
5	1.71
6	1.89
7	2.02
8	2.13
9	2.21
10	2.29

WESTON SOLUTIONS

Bivalve Counts Worksheet

Test ID: C110823.03 SIYB - 3

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	177	25	202
	2	145	22	167
	3	184	25	209
	4	160	26	186
6.25	1	177	19	196
	2	236	14	250
	3	195	24	219
	4	179	8	187
12.5	1	184	21	205
	2	166	13	179
	3	196	15	211
	4	155	22	177
25	1	165	9	174
	2	166	14	180
	3	164	14	178
	4	178	7	185
50	1	163	7	170
	2	181	5	186
	3	161	10	171
	4	161	15	176
100	1	159	11	170
	2	145	9	154
	3	137	4	141
	4	0	0	0
	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT:	Port of San Diego
PROJECT:	Shelter Island Yacht Basin
CLIENT SAMPLE ID:	SIYB-3
WESTON TEST ID:	C110823.03
SPECIES:	M. galloprovincialis

DATE RECEIVED:	8/23/11
DATE TEST STARTED:	8/23/11
DATE TEST ENDED:	8/25/11
WESTON SOP NO.:	BIO 042
STUDY DIRECTOR:	K. Skrivseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours)	Control	2	7.5	2	16.0	6	30.0	3	8.0
Date: 8/23/11	~~Brine Control~~		—		—		—		—
Sample ID: C110823.03	6.25		7.6		16.3		30.2		8.0
Dilutions (Tech): KC	12.5		7.5		16.2		30.5		8.0
WQ Time: 1815	25		7.5		16.4		30.9		8.0
	50		7.6		16.4		31.6		8.0
Technician: BG	100		7.7		16.4		33.2 ①ks		8.1
24 Hours	Control			6B	14.5				
	~~Brine Control~~				—				
Date: 8/24/11	6.25				14.6				
	12.5				14.5				
WQ Time: 1040	25				14.7				
	50				14.5				
Technician: BG	100				14.5				
48 Hours	Control	2	7.8	2	15.3	6	30.1	3	7.9
Date: 8/25/11	Brine Control		—		—		—		—
	6.25		7.9		15.0		30.2		8.0
WQ Time: 1420	12.5		8.0		14.9		30.5		8.0
	25		8.0		15.1		31.2		8.0
Technician: SH\BG	50		8.0		14.9		32.0		8.0
	100		8.1		14.8		33.7 ①ks		8.0

*Water quality measurements taken in surrogate water quality chambers. ① salinity is above the test protocol range of 30±2 ppt. 1/5/12 ks

START TIME:	1845	Initials:	SH
END TIME:	1745	Initials:	KC
ORGANISM BATCH:	TSF 5708		
HOBO TEMP. NO.:	2296		
TEST LOCATION:	Room 2		

DILUTION WATER BATCH: S100725 II

TEST ACCEPTABILITY:

- [x] ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- [ ] ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- [x] MSD < 25%

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

Weston Test ID: C110823.0342	Client: Port of San Diego ~~Shelter Island Yacht Basin~~ @JH	Client Sample ID: SIYB-3

SPAWNING DATA

Initial Spawning Time: 1600	Final Spawning Time: 1700	Fertilization Time: 1701	No. of Females: 2	No. of Males: 3
Embryo Density (count/mL):	1. 98/77	2. 81/86	3. 91/99	Average: 88.7
Stocking Volume Calculation:	2700 / (88.7 x 50) = 0.608			

ZERO TIME COUNTS

1. 186	2. 203	3. 209	4. 269	5. 203	6. 238
Average Count: 218			Technician: KS		

LARVAL COUNT DATA

Conc.	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Date	Initials
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal		
Control												
~~Brine~~												
6.25	177	19	236	14	195	24	179	8			9/20/11	KS
12.5	184	21	166	13	196	15	155	22				
25	165	9	166	14	164	14	178	7				
50	163	7	181	5	161	10	161	15			9/20/11	KS
100	159	11	145	9	15	158	137	4			9/20/11	KS

QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	6.25 / 2	25 / 1	/	/
Total #	254	170		
# Normal	SH① ~~250~~ 240	161		
Date / Initials	10/13/11 / SH	10/13/11 / SH	/	/

QA Check Acceptability: ☑ <5% difference in means of QA & orig. counts

①IE 10/13/11 SH

②IE 1/5/12 JH

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-4	**Test ID No.:**	C110823.0442

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	87.1	87.6
6.25%	87.7	90.3
12.5%	87.9	90.3
25%	92.3	96.9
50%	88.1	93.8
100%	95.0	91.2

Jessu Hum
QA Unit

1/5/12
Date

[signature]
Approved

1/5/12
Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-4	**Test ID No.:**	C110823.0442

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.08$). Dunnett's Multiple-Comparison Test provided a NOEC (No Observed Effect Concentration) of 100 percent and a LOEC (Lowest Observed Effect Concentration) of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.80$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	100%	>100%	100%	>100%	SIYB-4

Protocol Deviations: Control normality was slightly below the protocol limit of ≥90 percent for the test and the associated Reference Toxicant test. Sample arrived at 8.4°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity. The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-4	**Test ID No.:**	C110823.0442

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis.*

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	16.0	30.0	8.0
6.25	7.6	16.3	30.2	8.0
12.5	7.5	16.4	30.5	8.0
25	7.6	16.4	30.9	8.0
50	7.7	16.4	31.6	8.0
100	8.2	16.2	33.1	8.1
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.5		
6.25		14.5		
12.5		14.8		
25		15.0		
50		15.0		
100		15.0		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.8	15.3	30.1	7.9
6.25	7.8	14.9	31.0	8.0
12.5	7.7	15.0	30.9	8.0
25	7.8	15.2	31.2	8.0
50	7.8	15.1	31.8	8.0
100	7.9	15.2	33.5	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-4	**Test ID No.:**	C110823.0442

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	30.0 ppt
pH	8.0
Dissolved Oxygen	7.5 mg/L
Temperature	16.0°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis.* Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on August 22, 2011, at 1610 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0920 hours. The temperature of the sample upon receipt was 8.4°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 218 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.42 ppb survival, 6.07 ppb proportion normal
	48 hr EC_{50}:	13.47 ppb survival, 7.38 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.65 ppb survival, 7.17 ppb proportion normal
	Test Date:	8/23/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith, J. Hansen

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 18:45	Test ID:	C110823.0442	Sample ID:	SIYB - 4
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:10	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

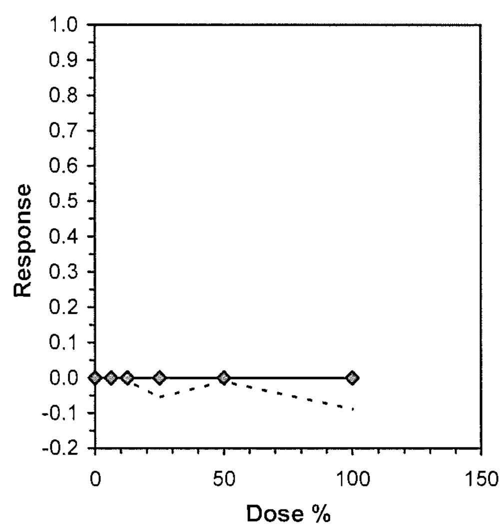
Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.8744	0.8684	0.8557	0.9101
12.5	0.8597	0.8571	0.9077	0.8906
25	0.9476	0.9360	0.9439	0.8631
50	0.9052	0.8848	0.8889	0.8462
100	0.9950	0.9556	0.9246	0.9259

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4				0.8962	1.0000
6.25	0.8771	1.0067	1.2139	1.1812	1.2662	3.023	4	-0.251	2.410	0.0950	0.8962	1.0000
12.5	0.8788	1.0086	1.2165	1.1832	1.2621	3.134	4	-0.317	2.410	0.0950	0.8962	1.0000
25	0.9226	1.0590	1.2946	1.1917	1.3399	5.356	4	-2.297	2.410	0.0950	0.8962	1.0000
50	0.8813	1.0115	1.2203	1.1677	1.2578	3.104	4	-0.413	2.410	0.0950	0.8962	1.0000
100	0.9503	1.0907	1.3616	1.2927	1.5000	7.138	4	-3.996	2.410	0.0950	0.8962	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.96092		0.884		0.45442	1.82867
Bartlett's Test indicates equal variances (p = 0.08)					9.81343		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.06995	0.08027	0.01588	0.00311	0.00435	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	8/23/2011 18:45	Test ID:	C110823.0442	Sample ID:	SIYB - 4
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:10	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

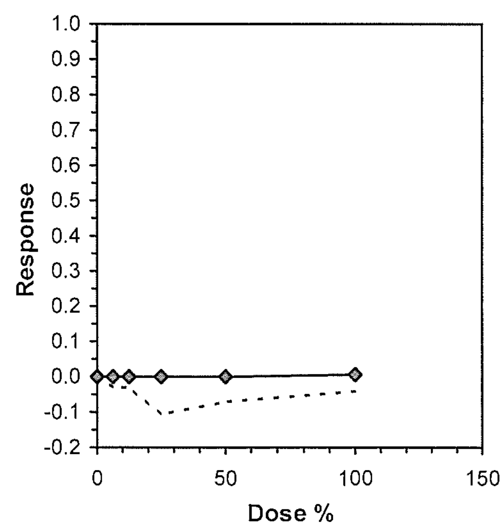
Conc-%	1	2	3	4
Control	0.9266	0.7661	0.9587	0.8532
6.25	0.9495	0.8716	0.9220	0.8670
12.5	1.0000	0.8349	0.8945	0.8807
25	0.9633	0.9312	0.9817	1.0000
50	0.9679	0.8761	0.9083	1.0000
100	0.9174	0.8257	0.9128	0.9908

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8761	1.0000	1.2265	1.0659	1.3662	10.793	4				0.9177	1.0000
6.25	0.9025	1.0301	1.2584	1.1975	1.3442	5.596	4	-0.347	2.410	0.2215	0.9177	1.0000
12.5	0.9025	1.0301	1.2869	1.1523	1.5369	13.275	4	-0.656	2.410	0.2215	0.9177	1.0000
25	0.9690	1.1060	1.4138	1.3054	1.5369	6.911	4	-2.037	2.410	0.2215	0.9177	1.0000
50	0.9381	1.0707	1.3504	1.2112	1.5369	10.767	4	-1.348	2.410	0.2215	0.9177	1.0000
100	0.9117	1.0406	1.2914	1.1401	1.4749	10.684	4	-0.705	2.410	0.2215	0.9117	0.9935

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.94877		0.884		0.57063	-0.4997
Bartlett's Test indicates equal variances (p = 0.80)					2.3137		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.17347	0.19577	0.0182	0.0169	0.40592	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test
Test ID: C110823.0442
Species: MG-Mytilus galloprovincialis
Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB - 4
Sample Type: AMB1-Ambient water
Start Date: 8/23/2011 18:45
End Date: 8/25/2011 17
Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	202	202	177	
	2	2	Control	218	167	167	145	
	3	3	Control	218	209	209	184	
	4	4	Control	218	186	186	160	
	5	1	6.250	218	207	207	181	
	6	2	6.250	218	190	190	165	
	7	3	6.250	218	201	201	172	
	8	4	6.250	218	189	189	172	
	9	1	12.500	218	221	221	190	
	10	2	12.500	218	182	182	156	
	11	3	12.500	218	195	195	177	
	12	4	12.500	218	192	192	171	
	13	1	25.000	218	210	210	199	
	14	2	25.000	218	203	203	190	
	15	3	25.000	218	214	214	202	
	16	4	25.000	218	241	241	208	
	17	1	50.000	218	211	211	191	
	18	2	50.000	218	191	191	169	
	19	3	50.000	218	198	198	176	
	20	4	50.000	218	234	234	198	
	21	1	100.000	218	200	200	199	
	22	2	100.000	218	180	180	172	
	23	3	100.000	218	199	199	184	
	24	4	100.000	218	216	216	200	

Comments:

ToxCalc 5.0
Reviewed by: JA

Bivalve Counts Worksheet

Test ID: C110823.04 SIYB - 4

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	177	25	202
	2	145	22	167
	3	184	25	209
	4	160	26	186
6.25	1	181	26	207
	2	165	25	190
	3	172	29	201
	4	172	17	189
12.5	1	190	31	221
	2	156	26	182
	3	177	18	195
	4	171	21	192
25	1	199	11	210
	2	190	13	203
	3	202	12	214
	4	208	33	241
50	1	191	20	211
	2	169	22	191
	3	176	22	198
	4	198	36	234
100	1	199	1	200
	2	172	8	180
	3	184	15	199
	4	200	16	216
	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0

JA

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT: Port of San Diego	DATE RECEIVED: 8/23/11
PROJECT: Shelter Island Yacht Basin	DATE TEST STARTED: 8/23/11
CLIENT SAMPLE ID: SIYB-4	DATE TEST ENDED: 8/25/11
WESTON TEST ID: C110823.0442	WESTON SOP NO.: BIO 042
SPECIES: M. galloprovincialis	STUDY DIRECTOR: K. Skirvseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours)	Control	2	7.5	2	16.0	6	30.0	3	8.0
Date: 8/23/11	~~Brine Control~~		—		—		—		—
Sample ID: C110823.04	6.25		7.6		16.3		30.2		8.0
Dilutions (Tech): BG	12.5		7.5		16.4		30.5		8.0
WQ Time: 1825	25		7.6		16.4		30.9		8.0
Technician: BG	50		7.7		16.4		31.6		8.0
	100		8.2		16.2		33.1 ① KS		8.1
24 Hours	Control			6B	14.5				
	~~Brine Control~~				—				
Date: 8/24/11	6.25				14.5				
WQ Time: 1042	12.5				14.8				
Technician: BG	25				15.0				
	50				15.0				
	100				15.0				
48 Hours	Control	2	7.8	2	15.3	6	30.1	3	7.9
Date: 8/25/11	~~Brine Control~~		—		—		—		—
WQ Time: 1420	6.25		7.8		14.9		31.0		8.0
Technician: SH/BG	12.5		7.7		15.0		30.9		8.0
	25		7.8		15.2		31.2		8.0
	50		7.8		15.1		31.8		8.0
	100		7.9		15.2		33.5 ① KS		8.0

*Water quality measurements taken in surrogate water quality chambers. ① salinity is above the test protocol range of 30±2 ppt. 1/5/12 KS

START TIME: 1845	Initials: SH
END TIME: 1745	Initials: KE
ORGANISM BATCH: TSF 5708	
HOBO TEMP. NO.: 2296	
TEST LOCATION: Room 2	

DILUTION WATER BATCH: S1007251 1

TEST ACCEPTABILITY:

- ☒ ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- ☐ ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- ☒ MSD < 25%

- BIVALVE 48-HOUR -
CHRONIC TOXICITY TEST

BIO042

Weston Test ID:	Client:	Client Sample ID:
C110823.0442	Port of San Diego QIH ~~Shelter Island Yacht Basin~~	SIYB-4

SPAWNING DATA

Initial Spawning Time:	Final Spawning Time:	Fertilization Time:	No. of Females:	No. of Males:
1600	1700	1701	2	3
Embryo Density (count/mL):	1. 98/77	2. 81/86	3. 91/99	Average: 88.7
Stocking Volume Calculation:	2700 (88.7 x 50) = 0.608			

ZERO TIME COUNTS

1.	2.	3.	4.	5.	6.
Average Count:			Technician:		

LARVAL COUNT DATA

Conc.	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Date	Initials
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal		
Control												
~~Brine~~												
6.25	181	26	165	25	172	29	172	17			9/27/11	SH
12.5	196	31	156	26	177	18	171	21				
25	199	11	190	13	202	12	208	33			9/30/11	
50	191	20	169	22	176	22	198	36				
100	199	1	172	8	184	15	200	16			9/20/11	KS

QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	6.25 / 1	50 / 4	/	/
Total #	206	229		
# Normal	179	198		
Date / Initials	10/12/11 / KS	10/12/11 / KS	/	/

QA Check Acceptability: ☑ <5% difference in means of QA & orig. counts

DIE 1/5/12 JH

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-5	**Test ID No.:**	C110823.0542

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	87.1	87.6
6.25%	88.4	93.1
12.5%	87.7	92.2
25%	90.8	89.7
50%	92.5	88.2
100%	93.0	85.7

QA Unit 1/5/12 Date

Approved 1/5/12 Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-5	**Test ID No.:**	C110823.0542

Bivalve Larvae Chronic 48-Hour Bioassay

Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.72$). Bonferroni t Test provided a NOEC (No Observed Effect Concentration) of 100 percent and a LOEC (Lowest Observed Effect Concentration) of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.25$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	100%	>100%	100%	>100%	SIYB-5

Protocol Deviations: Control normality was slightly below the protocol limit of ≥90 percent for the test and the associated Reference Toxicant test. Sample arrived at 10.1°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity. The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt. Replicate 3 of the 12.5 percent concentration was shown to be an outlier and was therefore removed from statistical analysis for normality.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-5	**Test ID No.:**	C110823.0542

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis.*

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	16.0	30.0	8.0
6.25	7.6	16.3	30.2	8.0
12.5	7.6	15.8	30.6	8.0
25	7.5	16.4	30.9	8.0
50	7.6	16.3	31.6	8.0
100	7.8	15.9	33.2	8.0
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.5		
6.25		15.0		
12.5		15.0		
25		15.2		
50		15.0		
100		14.9		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.8	15.3	30.1	7.9
6.25	7.9	15.3	30.2	8.0
12.5	7.7	15.4	30.7	7.9
25	7.7	15.4	31.1	8.0
50	7.8	15.4	32.1	8.0
100	7.7	15.3	33.7	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-5	**Test ID No.:**	C110823.0542

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	30.0 ppt
pH	8.0
Dissolved Oxygen	7.5 mg/L
Temperature	16.0°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis.* Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on August 22, 2011, at 1600 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0920 hours. The temperature of the sample upon receipt was 10.1°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 218 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.42 ppb survival, 6.07 ppb proportion normal
	48 hr EC_{50}:	13.47 ppb survival, 7.38 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.65 ppb survival, 7.17 ppb proportion normal
	Test Date:	8/23/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith, J. Hansen

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 18:45	Test ID:	C110823.0542	Sample ID:	SIYB - 5
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:00	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:	Removed replicate 3 of 12.5% as an outlier for Proportion Normal only				

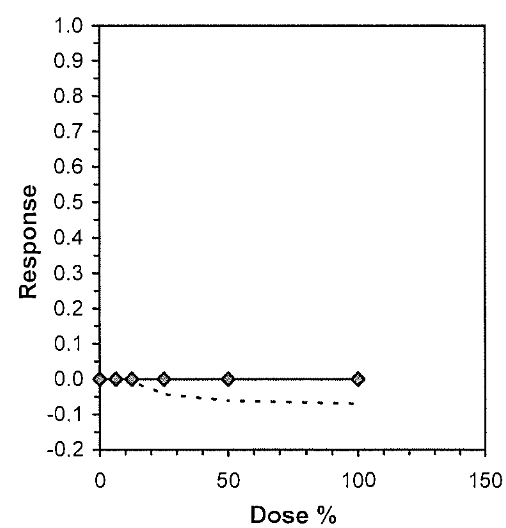
Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.9040	0.8899	0.8876	0.8527
12.5	0.8750	0.9050	0.8515	
25	0.8838	0.9312	0.9053	0.9122
50	0.9109	0.9149	0.9282	0.9444
100	0.9381	0.9462	0.9333	0.9032

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4				0.8994	1.0000
6.25	0.8836	1.0141	1.2236	1.1769	1.2558	2.724	4	-0.872	2.567	0.0576	0.8994	1.0000
12.5	0.8772	1.0068	1.2140	1.1752	1.2575	3.405	3	-0.414	2.567	0.0623	0.8994	1.0000
25	0.9081	1.0423	1.2641	1.2230	1.3054	2.690	4	-2.677	2.567	0.0576	0.8994	1.0000
50	0.9246	1.0612	1.2937	1.2677	1.3329	2.277	4	-3.995	2.567	0.0576	0.8994	1.0000
100	0.9302	1.0677	1.3051	1.2545	1.3367	2.723	4	-4.502	2.567	0.0576	0.8994	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.95022		0.881		-0.2363	-0.6909
Bartlett's Test indicates equal variances (p = 0.72)					2.8454		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Bonferroni t Test	100	>100		1	0.04097	0.04702	0.00712	0.00101	9.7E-04	5, 17

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by: [signature]

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	8/23/2011 18:45	Test ID:	C110823.0542	Sample ID:	SIYB - 5
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 16:00	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

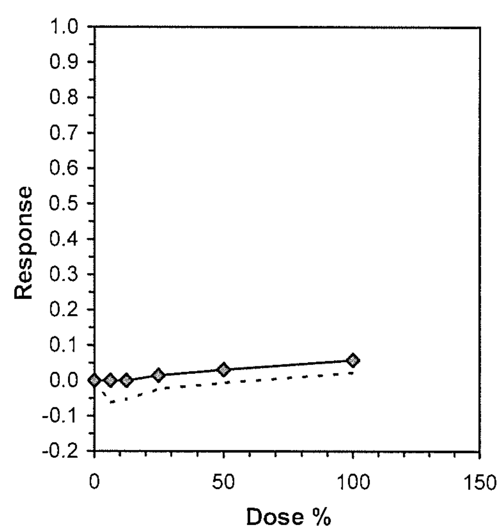
Conc-%	1	2	3	4
Control	0.9266	0.7661	0.9587	0.8532
6.25	0.9083	1.0000	0.8165	1.0000
12.5	0.8440	0.9174	1.0000	0.9266
25	0.9083	0.8670	0.8716	0.9404
50	0.9266	0.8624	0.8303	0.9083
100	0.8899	1.0000	0.8257	0.7110

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8761	1.0000	1.2265	1.0659	1.3662	10.793	4				0.9098	1.0000
6.25	0.9312	1.0628	1.3663	1.1281	1.5369	14.977	4	-1.279	2.410	0.2633	0.9098	1.0000
12.5	0.9220	1.0524	1.3194	1.1648	1.5369	11.851	4	-0.850	2.410	0.2633	0.9098	1.0000
25	0.8968	1.0236	1.2472	1.1975	1.3241	4.740	4	-0.189	2.410	0.2633	0.8968	0.9857
50	0.8819	1.0065	1.2241	1.1462	1.2965	5.568	4	0.022	2.410	0.2633	0.8819	0.9693
100	0.8567	0.9777	1.2282	1.0032	1.5369	18.429	4	-0.015	2.410	0.2633	0.8567	0.9416

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.97746		0.884		0.33815	-0.0805
Bartlett's Test indicates equal variances (p = 0.25)					6.68492		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.21196	0.23921	0.01436	0.02387	0.69939	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	84.848			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test
Test ID: C110823.0542
Species: MG-Mytilus galloprovincialis
Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB - 5
Sample Type: AMB1-Ambient water
Start Date: 8/23/2011 18:45
End Date: 8/25/2011 17
Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	202	202	177	
	2	2	Control	218	167	167	145	
	3	3	Control	218	209	209	184	
	4	4	Control	218	186	186	160	
	5	1	6.250	218	198	198	179	
	6	2	6.250	218	218	218	194	
	7	3	6.250	218	178	178	158	
	8	4	6.250	218	224	224	191	
	9	1	12.500	218	184	184	161	
	10	2	12.500	218	200	200	181	
	11	3	12.500	218	202	202	172	
	12	1	25.000	218	198	198	175	
	13	2	25.000	218	189	189	176	
	14	3	25.000	218	190	190	172	
	15	4	25.000	218	205	205	187	
	16	1	50.000	218	202	202	184	
	17	2	50.000	218	188	188	172	
	18	3	50.000	218	181	181	168	
	19	4	50.000	218	198	198	187	
	20	1	100.000	218	194	194	182	
	21	2	100.000	218	223	223	211	
	22	3	100.000	218	180	180	168	
	23	4	100.000	218	155	155	140	

Comments: Removed 12.5% Replicate 3 as an outlier for Proportion Normal

ToxCalc 5.0
Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test   Test ID: C110823.0542
Species: MG-Mytilus galloprovincialis   Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB - 5   Sample Type: AMB1-Ambient water
Start Date: 8/23/2011 18:45   End Date: 8/25/2011 17   Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	202	202	177	
	2	2	Control	218	167	167	145	
	3	3	Control	218	209	209	184	
	4	4	Control	218	186	186	160	
	5	1	6.250	218	198	198	179	
	6	2	6.250	218	218	218	194	
	7	3	6.250	218	178	178	158	
	8	4	6.250	218	224	224	191	
	9	1	12.500	218	184	184	161	
	10	2	12.500	218	200	200	181	
	11	3	12.500	218	223	223	0	
	12	4	12.500	218	202	202	172	
	13	1	25.000	218	198	198	175	
	14	2	25.000	218	189	189	176	
	15	3	25.000	218	190	190	172	
	16	4	25.000	218	205	205	187	
	17	1	50.000	218	202	202	184	
	18	2	50.000	218	188	188	172	
	19	3	50.000	218	181	181	168	
	20	4	50.000	218	198	198	187	
	21	1	100.000	218	194	194	182	
	22	2	100.000	218	223	223	211	
	23	3	100.000	218	180	180	168	
	24	4	100.000	218	155	155	140	

Comments:

Bivalve Counts Worksheet

Test ID: C110823.05 SIYB - 5

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	177	25	202
	2	145	22	167
	3	184	25	209
	4	160	26	186
6.25	1	179	19	198
	2	194	24	218
	3	158	20	178
	4	191	33	224
12.5	1	161	23	184
	2	181	19	200
	3	0	223	223
	4	172	30	202
25	1	175	23	198
	2	176	13	189
	3	172	18	190
	4	187	18	205
50	1	184	18	202
	2	172	16	188
	3	168	13	181
	4	187	11	198
100	1	182	12	194
	2	211	12	223
	3	168	12	180
	4	140	15	155
	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0

NA

Dixon's Outlier Test

ordered data (increasing or decreasing values)	Bivalve # Normal	
	0	<--suspected outlier
	161	
	172	
	181	

$$C = \frac{X_{(2)} - X_{(1)}}{X_{(n)} - X_{(1)}} \text{ for } 3 \le n \le 7$$

C = 0.889503

Table of critical values of Q

N	Q_{crit} (CL:90%)	Q_{crit} (CL:95%)	Q_{crit} (CL:99%)
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

If the C exceeds the critical value from Table for the specified significance level α, $X_{(1)}$ is an outlier and should be further investigated. C should be compared to Qcrit (CL:95%) column.

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT:	Port of San Diego
PROJECT:	Shelter Island Yacht Basin
CLIENT SAMPLE ID:	SIYB-5
WESTON TEST ID:	C110823.0542
SPECIES:	M. galloprovincialis

DATE RECEIVED:	8/23/11
DATE TEST STARTED:	8/23/11
DATE TEST ENDED:	8/25/11
WESTON SOP NO.:	BIO042
STUDY DIRECTOR:	K. Skirseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours) Date: 8/23/11 Sample ID: C110823.0542 Dilutions (Tech): BG DJH WQ Time: 1835 Technician: BG	Control	2	7.5	2	16.0	6	30.0	3	8.0
	~~Brine Control~~		—		—		—		—
	6.25		7.6		16.3		30.2		8.0
	12.5		7.6		15.8		30.6		8.0
	25		7.5		16.4		30.9		8.0
	50		7.6		16.3		31.6		8.0
	100		7.8		15.9		33.2 ② KS		8.0
24 Hours Date: 8/24/11 WQ Time: 1044 Technician: BG	Control			6B	14.5				
	~~Brine Control~~				—				
	6.25				15.0				
	12.5				15.0				
	25				15.2				
	50				15.0				
	100				14.9				
48 Hours Date: 8/25/11 WQ Time: 1120 Technician: SH/BG	Control	2	7.8	2	15.3	6	30.1	3	7.9
	Brine Control		—		~~15~~		—		~~8.0~~
	6.25		7.9		15.3		30.2		8.0
	12.5		7.7		15.4		30.7		7.9
	25		7.7		15.4		31.1		8.0
	50		7.8		15.4		32.1		8.0
	100		7.7		15.3		33.7 ② KS		8.0

*Water quality measurements taken in surrogate water quality chambers.

START TIME:	1845	Initials:	SH
END TIME:	1745 KE	Initials:	KE
ORGANISM BATCH:	TSF 5708		
HOBO TEMP. NO.:	2296		
TEST LOCATION:	Room 2		

DILUTION WATER BATCH: S1007251I

TEST ACCEPTABILITY:

- ☒ ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- ☐ ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- ☒ MSD < 25%

① IE 8/30/11 JH ② salinity is above the test protocol range of 30±2 ppt. 1/5/12 KS

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

Weston Test ID:	Client:	Client Sample ID:
C110823.0542	Port of San Diego ~~Shelter Island Yacht Basin~~ DJH	SIYB-5

SPAWNING DATA

Initial Spawning Time: 1600	Final Spawning Time: 1700	Fertilization Time: 1701	No. of Females: 2	No. of Males: 3
Embryo Density (count/mL):	1. 98/77	2. 81/86	3. 91/99	Average: 88.7
Stocking Volume Calculation:	2700 (88.7 × 50) = 0.608			

ZERO TIME COUNTS

1. 186	2. 203	3. 209	4. 269	5. 203	6. 238
Average Count: 218			Technician: KS		

LARVAL COUNT DATA

Conc.	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Date	Initials
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal		
Control												
~~Brine~~												
6.25	179	19	194	24	158	20	191	33			9/30/11	SH
12.5	161	23	181	19	Ø	223	172	30			9/30/11	SH
25	175	23	176	13	172	18	187	18			10/10/11	KS
50	184	18	172	16	168	13	187	11			↓	↓
100	182	12	211	12	168	12	140	15			9/20/11	KS

QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	6.25 / 4	25 / 1	/	/
Total #	209	206		
# Normal	182	180		
Date / Initials	10/12/11 / KS	10/13/11 / SH	/	/

QA Check Acceptability: ☐ <5% difference in means of QA & orig. counts

① IE 1/5/12 JH

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-6	**Test ID No.:**	C110823.0642

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	87.1	87.6
6.25%	90.5	94.2
12.5%	92.3	93.4
25%	88.3	95.6
50%	91.6	94.3
100%	89.9	92.3

[signature] QA Unit | 1/5/12 Date | [signature] Approved | 1/5/12 Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-6	**Test ID No.:**	C110823.0642

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data did not meet the assumptions of normality (Shapiro-Wilk's Test, $p \leq 0.01$). Variances were equal (Bartlett's Test, $p = 0.05$). Steel's Many-One Rank Test provided a NOEC (No Observed Effect Concentration) of 100 percent and a LOEC (Lowest Observed Effect Concentration) of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.77$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	100%	>100%	100%	>100%	SIYB-6

Protocol Deviations: Control normality was slightly below the protocol limit of ≥90 percent for the test and the associated Reference Toxicant test. Sample arrived at 7.3°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity. pMSD for survival was slightly above upper bound limit of <25%. The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-6	**Test ID No.:**	C110823.0642

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis.*

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	16.0	30.0	8.0
6.25	7.5	16.4	30.2	8.0
12.5	7.5	16.4	30.5	8.0
25	7.6	16.4	30.9	8.0
50	7.7	16.4	31.6	8.0
100	8.0	16.3	33.1	8.1
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.5		
6.25		15.0		
12.5		15.0		
25		15.4		
50		15.0		
100		15.0		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.8	15.3	30.1	7.9
6.25	7.5	15.6	30.4	8.0
12.5	7.6	15.5	31.2	7.9
25	7.5	15.6	31.2	8.0
50	7.8	15.6	32.1	8.0
100	7.8	15.2	35.5	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-6	**Test ID No.:**	C110823.0642

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	30.0 ppt
pH	8.0
Dissolved Oxygen	7.5 mg/L
Temperature	16.0°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis.* Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on August 22, 2011, at 1540 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0920 hours. The temperature of the sample upon receipt was 7.3°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 218 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.42 ppb survival, 6.07 ppb proportion normal
	48 hr EC_{50}:	13.47 ppb survival, 7.38 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.65 ppb survival, 7.17 ppb proportion normal
	Test Date:	8/23/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith, J. Hansen

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 18:45	Test ID:	C110823.0642	Sample ID:	SIYB - 6
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 15:40	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.9063	0.9135	0.8811	0.9200
12.5	0.9378	0.9390	0.8962	0.9200
25	0.8945	0.8778	0.8969	0.8622
50	0.8393	0.9369	0.9319	0.9538
100	0.9073	0.9086	0.8750	0.9052

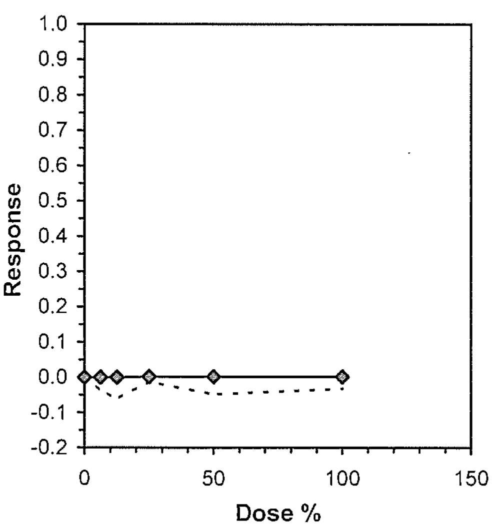
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4			0.9003	1.0000
6.25	0.9052	1.0389	1.2587	1.2187	1.2840	2.261	4	26.00	10.00	0.9003	1.0000
12.5	0.9232	1.0596	1.2916	1.2427	1.3212	2.845	4	26.00	10.00	0.9003	1.0000
25	0.8828	1.0133	1.2220	1.1905	1.2438	2.039	4	22.00	10.00	0.8986	0.9982
50	0.9155	1.0508	1.2841	1.1583	1.3543	6.721	4	22.00	10.00	0.8986	0.9982
100	0.8990	1.0319	1.2481	1.2094	1.2637	2.075	4	24.00	10.00	0.8986	0.9982

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.87169	0.884	-1.5395	4.40559
Bartlett's Test indicates equal variances (p = 0.05)	11.1315	15.0863		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 18:45	Test ID:	C110823.0642	Sample ID:	SIYB - 6
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 15:40	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:	For pMSD only				

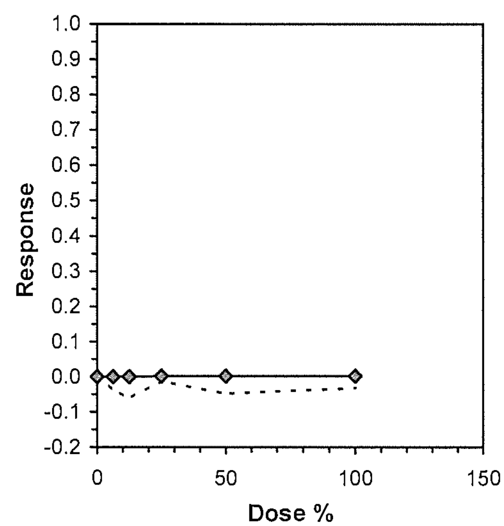
Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.9063	0.9135	0.8811	0.9200
12.5	0.9378	0.9390	0.8962	0.9200
25	0.8945	0.8778	0.8969	0.8622
50	0.8393	0.9369	0.9319	0.9538
100	0.9073	0.9086	0.8750	0.9052

			Transform: Arcsin Square Root					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4				0.9003	1.0000
6.25	0.9052	1.0389	1.2587	1.2187	1.2840	2.261	4	-1.800	2.410	0.0732	0.9003	1.0000
12.5	0.9232	1.0596	1.2916	1.2427	1.3212	2.845	4	-2.885	2.410	0.0732	0.9003	1.0000
25	0.8828	1.0133	1.2220	1.1905	1.2438	2.039	4	-0.593	2.410	0.0732	0.8986	0.9982
50	0.9155	1.0508	1.2841	1.1583	1.3543	6.721	4	-2.637	2.410	0.0732	0.8986	0.9982
100	0.8990	1.0319	1.2481	1.2094	1.2637	2.075	4	-1.452	2.410	0.0732	0.8986	0.9982

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)					0.87169		0.884		-1.5395	4.40559
Bartlett's Test indicates equal variances (p = 0.05)					11.1315		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.05283	0.06062	0.00469	0.00185	0.06573	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by: [signature]

Bivalve Larval Survival and Development Test-Proportion Alive

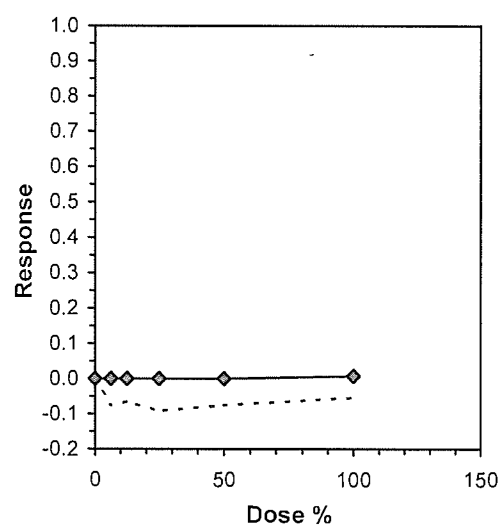
Start Date:	8/23/2011 18:45	Test ID:	C110823.0642	Sample ID:	SIYB - 6
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 15:40	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
Control	0.9266	0.7661	0.9587	0.8532
6.25	1.0000	0.8486	1.0000	0.9174
12.5	1.0000	0.9771	0.8394	0.9174
25	1.0000	0.8257	1.0000	1.0000
50	1.0000	1.0000	0.8761	0.8945
100	0.9404	0.9037	0.8807	0.9679

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8761	1.0000	1.2265	1.0659	1.3662	10.793	4				0.9300	1.0000
6.25	0.9415	1.0746	1.3811	1.1712	1.5369	13.416	4	-1.353	2.410	0.2753	0.9300	1.0000
12.5	0.9335	1.0654	1.3484	1.1585	1.5369	12.210	4	-1.067	2.410	0.2753	0.9300	1.0000
25	0.9564	1.0916	1.4377	1.1401	1.5369	13.801	4	-1.849	2.410	0.2753	0.9300	1.0000
50	0.9427	1.0759	1.3812	1.2112	1.5369	13.042	4	-1.354	2.410	0.2753	0.9300	1.0000
100	0.9232	1.0537	1.2970	1.2182	1.3906	5.882	4	-0.617	2.410	0.2753	0.9232	0.9926

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.91852		0.884		-0.4453	-1.0559
Bartlett's Test indicates equal variances (p = 0.77)					2.54492		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.22328	0.25198	0.02204	0.0261	0.53585	5, 18

Linear Interpolation (200 Resamples)				
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



ToxCalc v5.0.23

Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test
Test ID: C110823.0642
Species: MG-Mytilus galloprovincialis
Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB - 6
Sample Type: AMB1-Ambient water
Start Date: 8/23/2011 18:45
End Date: 8/25/2011 17
Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	202	202	177	
	2	2	Control	218	167	167	145	
	3	3	Control	218	209	209	184	
	4	4	Control	218	186	186	160	
	5	1	6.250	218	224	224	203	
	6	2	6.250	218	185	185	169	
	7	3	6.250	218	227	227	200	
	8	4	6.250	218	200	200	184	
	9	1	12.500	218	241	241	226	
	10	2	12.500	218	213	213	200	
	11	3	12.500	218	183	183	164	
	12	4	12.500	218	200	200	184	
	13	1	25.000	218	218	218	195	
	14	2	25.000	218	180	180	158	
	15	3	25.000	218	223	223	200	
	16	4	25.000	218	225	225	194	
	17	1	50.000	218	224	224	188	
	18	2	50.000	218	222	222	208	
	19	3	50.000	218	191	191	178	
	20	4	50.000	218	195	195	186	
	21	1	100.000	218	205	205	186	
	22	2	100.000	218	197	197	179	
	23	3	100.000	218	192	192	168	
	24	4	100.000	218	211	211	191	

Comments:

Reviewed by: [signature]

Bivalve Counts Worksheet

Test ID: C110823.06 SIYB - 6

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	177	25	202
	2	145	22	167
	3	184	25	209
	4	160	26	186
6.25	1	203	21	224
	2	169	16	185
	3	200	27	227
	4	184	16	200
12.5	1	226	15	241
	2	200	13	213
	3	164	19	183
	4	184	16	200
25	1	195	23	218
	2	158	22	180
	3	200	23	223
	4	194	31	225
50	1	188	36	224
	2	208	14	222
	3	178	13	191
	4	186	9	195
100	1	186	19	205
	2	179	18	197
	3	168	24	192
	4	191	20	211
	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT:	Port of San Diego
PROJECT:	Shelter Island Yacht Basin
CLIENT SAMPLE ID:	SIYB-6
WESTON TEST ID:	C110823.0642
SPECIES:	M. galloprovincialis

DATE RECEIVED:	8/23/11
DATE TEST STARTED:	8/23/11
DATE TEST ENDED:	8/25/11
WESTON SOP NO.:	BIO042
STUDY DIRECTOR:	K. Skrivseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours)	Control	2	7.5	2	16.0	6	30.0	3	8.0
Date: 8/23/11	~~Brine Control~~		—		—		—		—
Sample ID: C110823.06	6.25		7.5		16.4		30.2		8.0
Dilutions (Tech): KC	12.5		7.5		16.4		30.5		8.0
WQ Time: 1840	25		7.6		16.4		30.9		8.0
Technician: BG	50		7.7		16.4		31.6		8.0
	100		8.0		16.3		33.1 ① KS		8.1
24 Hours	Control			6B	14.5				
	~~Brine Control~~				—				
Date: 8/24/11	6.25				15.0				
	12.5				15.0				
WQ Time: 1046	25				15.4				
	50				15.0				
Technician: BG	100				15.0				
48 Hours	Control	2	7.8	2	15.3	6	30.1	3	7.9
Date: 8/25/11	~~Brine Control~~		—		—		—		—
	6.25		7.5		15.6		30.4		8.0
WQ Time: 1420	12.5		7.6		15.5		31.2		7.9
	25		7.5		15.6		31.2		8.0
Technician: SH / BG	50		7.8		15.6		32.1		8.0
	100		7.8		15.2		35.5 ① KS		8.0

*Water quality measurements taken in surrogate water quality chambers.
① salinity is above the test protocol range of 20 ± 2 ppt 1/5/12 KS

START TIME:	1845	Initials:	SH
END TIME:	1745	Initials:	KC
ORGANISM BATCH:	TSF 5708		
HOBO TEMP. NO.:	2296		
TEST LOCATION:	Room 2		

DILUTION WATER BATCH: S10072511

TEST ACCEPTABILITY:

- [x] ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- [ ] ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- [ ] MSD < 25%

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

Weston Test ID:	Client:	Client Sample ID:
C110823.0642	Port of San Diego ~~Shelter Island Yacht Basin~~ DJH	SIYB-6

SPAWNING DATA

Initial Spawning Time:	Final Spawning Time:	Fertilization Time:	No. of Females:	No. of Males:
1600	1700	1701	2	3
Embryo Density (count/mL):	1. 98/77	2. 81/86	3. 91/99	Average: 88.7
Stocking Volume Calculation:	2700/(88.7 x 50) = 0.608			

ZERO TIME COUNTS

1.	2.	3.	4.	5.	6.
186	203	209	269	203	238
Average Count: 218			Technician: KS		

LARVAL COUNT DATA

Conc.	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Date	Initials
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal		
Control												
~~Brine~~												
6.25	203	21	169	16	200	27	184	16			10/10/11	KS
12.5	226	15	200	13	164	19	184	16			10/12/11	
25	195	23	158	22	200	23	194	31				
50	188	36	208	14	178	13	186	9				
100	186	19	179	18	168	24	191	20			9/20/11	KS

QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	6.25 / 3	50 / 1	/	/
Total #	227	223		
# Normal	197	187		
Date / Initials	10/13/11 / SH	10/13/11 / SH	/	/

QA Check Acceptability: ☑ <5% difference in means of QA & orig. counts

① IE 1/5/12 JH

Weston Solutions, Inc.

Client: Port of San Diego
Project: Shelter Island Yacht Basin
Sample Matrix: Liquid
Sample Name/ID: SIYB-REF

Date Received: 23 Aug 11
Date Test Started: 23 Aug 11
Date Test Ended: 25 Aug 11
Test ID No.: C110823.0742

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	87.1	87.6
6.25%	87.7	85.8
12.5%	88.4	94.4
25%	87.7	97.7
50%	87.7	95.4
100%	89.1	93.6

QA Unit 1/5/12 Date

Approved 1/6/12 Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-REF	**Test ID No.:**	C110823.0742

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.16$). Dunnett's Multiple-Comparison Test provided a NOEC (No Observed Effect Concentration) of 100 percent and a LOEC (Lowest Observed Effect Concentration) of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.95$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	100%	>100%	100%	>100%	SIYB-REF

Protocol Deviations: Control normality was slightly below the protocol limit of ≥90 percent for the test and the associated Reference Toxicant test.. Sample arrived at 6.7°C which is outside of the temperature protocol limits of 0-6°C. It should be noted that insufficient cooling of a sample may result in an underestimation of sample toxicity. pMSD for survival was above upper bound limit of <25%. The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-REF	**Test ID No.:**	C110823.0742

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*.

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	16.0	30.0	8.0
6.25	7.6	16.4	30.2	8.0
12.5	7.6	16.4	30.5	8.0
25	7.6	16.4	30.9	8.0
50	7.8	16.4	31.6	8.1
100	8.3	16.2	33.1	8.1
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.5		
6.25		15.0		
12.5		15.0		
25		15.4		
50		15.5		
100		15.3		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.8	15.3	30.1	7.9
6.25	7.7	15.6	30.7	7.9
12.5	7.7	15.5	31.2	7.9
25	7.6	15.8	31.0	8.0
50	7.8	15.9	31.6	8.0
100	7.8	15.8	33.2	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	23 Aug 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	23 Aug 11
Sample Matrix:	Liquid	**Date Test Ended:**	25 Aug 11
Sample Name/ID:	SIYB-REF	**Test ID No.:**	C110823.0742

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	30.0 ppt
pH	8.0
Dissolved Oxygen	7.5 mg/L
Temperature	16.0°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis*. Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on August 22, 2011, at 1525 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0920 hours. The temperature of the sample upon receipt was 6.7°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 218 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.42 ppb survival, 6.07 ppb proportion normal
	48 hr EC_{50}:	13.47 ppb survival, 7.38 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.65 ppb survival, 7.17 ppb proportion normal
	Test Date:	8/23/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith, J. Hansen

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 18:45	Test ID:	C110823.0742	Sample ID:	SIYB - REF
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 15:25	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

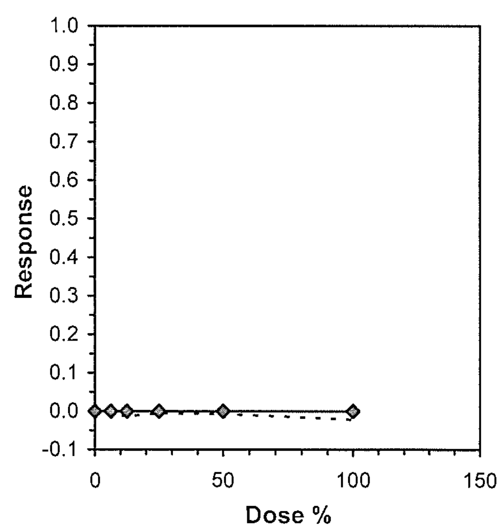
Conc-%	1	2	3	4
Control	0.8762	0.8683	0.8804	0.8602
6.25	0.8909	0.8563	0.8942	0.8678
12.5	0.8889	0.8839	0.8688	0.8939
25	0.8750	0.9120	0.8821	0.8371
50	0.8619	0.8930	0.8761	0.8772
100	0.9352	0.8718	0.8876	0.8676

			Transform: Arcsin Square Root					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8713	1.0000	1.2040	1.1876	1.2176	1.104	4				0.8798	1.0000
6.25	0.8773	1.0069	1.2136	1.1820	1.2395	2.289	4	-0.409	2.410	0.0566	0.8798	1.0000
12.5	0.8839	1.0145	1.2233	1.2001	1.2391	1.372	4	-0.824	2.410	0.0566	0.8798	1.0000
25	0.8766	1.0061	1.2137	1.1553	1.2697	3.865	4	-0.413	2.410	0.0566	0.8798	1.0000
50	0.8771	1.0066	1.2129	1.1900	1.2376	1.605	4	-0.378	2.410	0.0566	0.8798	1.0000
100	0.8906	1.0221	1.2364	1.1984	1.3134	4.288	4	-1.378	2.410	0.0566	0.8798	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.96353		0.884		0.62067	1.29764
Bartlett's Test indicates equal variances (p = 0.16)					7.96332		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.0402	0.04613	0.0005	0.0011	0.80639	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	8/23/2011 18:45	Test ID:	C110823.0742	Sample ID:	SIYB - REF
End Date:	8/25/2011 17:45	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	8/22/2011 15:25	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

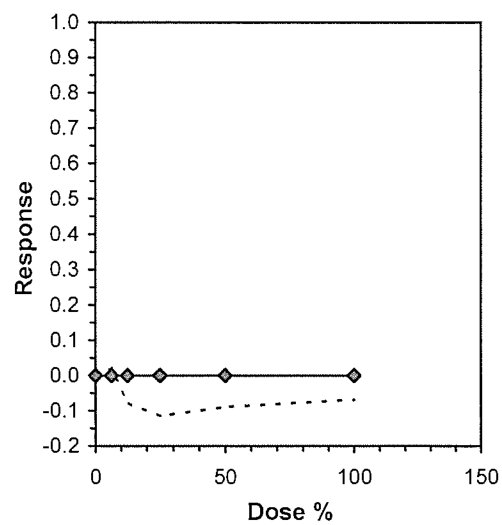
Conc-%	1	2	3	4
Control	0.9266	0.7661	0.9587	0.8532
6.25	1.0000	0.7661	0.8670	0.7982
12.5	0.8670	1.0000	1.0000	0.9083
25	0.9174	0.9908	1.0000	1.0000
50	0.8303	0.9862	1.0000	1.0000
100	0.9908	1.0000	0.8165	0.9358

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8761	1.0000	1.2265	1.0659	1.3662	10.793	4				0.9241	1.0000
6.25	0.8578	0.9791	1.2263	1.0659	1.5369	17.476	4	0.002	2.410	0.2938	0.9241	1.0000
12.5	0.9438	1.0772	1.3836	1.1975	1.5369	12.942	4	-1.288	2.410	0.2938	0.9241	1.0000
25	0.9771	1.1152	1.4570	1.2793	1.5369	8.374	4	-1.891	2.410	0.2938	0.9241	1.0000
50	0.9541	1.0890	1.4183	1.1462	1.5369	13.091	4	-1.573	2.410	0.2938	0.9241	1.0000
100	0.9358	1.0681	1.3636	1.1281	1.5369	13.407	4	-1.125	2.410	0.2938	0.9241	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.95778		0.884		-0.0816	-0.8377
Bartlett's Test indicates equal variances (p = 0.95)					1.17365		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.24084	0.2718	0.0383	0.02972	0.31191	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



 ToxCalc v5.0.23 Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test . Test ID: C110823.07 42.
Species: MG-Mytilus galloprovincialis . Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB - REF Sample Type: AMB1-Ambient water
Start Date: 8/23/2011 18:45 End Date: 8/25/2011 17 Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	202	202	177	
	2	2	Control	218	167	167	145	
	3	3	Control	218	209	209	184	
	4	4	Control	218	186	186	160	
	5	1	6.250	218	220	220	196	
	6	2	6.250	218	167	167	143	
	7	3	6.250	218	189	189	169	
	8	4	6.250	218	174	174	151	
	9	1	12.500	218	189	189	168	
	10	2	12.500	218	224	224	198	
	11	3	12.500	218	221	221	192	
	12	4	12.500	218	198	198	177	
	13	1	25.000	218	200	200	175	
	14	2	25.000	218	216	216	197	
	15	3	25.000	218	229	229	202	
	16	4	25.000	218	221	221	185	
	17	1	50.000	218	181	181	156	
	18	2	50.000	218	215	215	192	
	19	3	50.000	218	226	226	198	
	20	4	50.000	218	228	228	200	
	21	1	100.000	218	216	216	202	
	22	2	100.000	218	234	234	204	
	23	3	100.000	218	178	178	158	
	24	4	100.000	218	204	204	177	

Comments:

 Reviewed by: [illegible]

Bivalve Counts Worksheet

Test ID: C110823.07 SIYB - REF

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	177	25	202
	2	145	22	167
	3	184	25	209
	4	160	26	186
6.25	1	196	24	220
	2	143	24	167
	3	169	20	189
	4	151	23	174
12.5	1	168	21	189
	2	198	26	224
	3	192	29	221
	4	177	21	198
25	1	175	25	200
	2	197	19	216
	3	202	27	229
	4	185	36	221
50	1	156	25	181
	2	192	23	215
	3	198	28	226
	4	200	28	228
100	1	202	14	216
	2	204	30	234
	3	158	20	178
	4	177	27	204
	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0

JA

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT:	Port of San Diego
PROJECT:	Shelter Island Yacht Basin
CLIENT SAMPLE ID:	SIYB - Ref
WESTON TEST ID:	C110823.0742
SPECIES:	M. galloprovincialis

DATE RECEIVED:	8/23/11
DATE TEST STARTED:	8/23/11
DATE TEST ENDED:	8/25/11
WESTON SOP NO.:	BIO042
STUDY DIRECTOR:	K. Skrivseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours)	Control	2	7.5	2	16.0	6	30.0	3	8.0
Date: 8/23/11	~~Brine Control~~		—		—		—		—
Sample ID: C110823.07	6.25		7.6		16.4		30.2		8.0
Dilutions (Tech): BG	12.5		7.6		16.4		30.5		8.0
WQ Time: 1845	25		7.6		16.4		30.9		8.0
Technician: BG	50		7.8		16.4		31.6		8.1
	100		8.3		16.2		33.1 ⓪ks		8.1
24 Hours	Control			6B	14.5				
Date: 8/24/11	~~Brine Control~~				—				
WQ Time: 1048	6.25				15.0				
Technician: BG	12.5				15.0				
	25				15.4				
	50				15.5				
	100				15.3				
48 Hours	Control	2	7.8	2	15.3	6	30.1	3	7.9
Date: 8/25/11	Brine Control		—		—		—		—
WQ Time: 1420	6.25		7.7		15.6		30.7		7.9
Technician: SH	12.5		7.7		15.5		31.2		7.9
	25		7.6		15.8		31.0		8.0
	50		7.8		15.9		31.6		8.0
	100		7.8		15.8		33.2 ⓪ks		8.0

*Water quality measurements taken in surrogate water quality chambers.

⓪ Salinity is above the test protocol range of 30±2 ppt 1/5/12 ks

START TIME:	1845	Initials:	SH
END TIME:	1745	Initials:	KC
ORGANISM BATCH:	TSF 5708		
HOBO TEMP. NO.:	2296		
TEST LOCATION:	Room 2		

DILUTION WATER BATCH: SI007251I

TEST ACCEPTABILITY:

- ☒ ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- ☐ ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- ☐ MSD < 25%

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

Weston Test ID:	Client:	Client Sample ID:
C110823.0742	Port of San Diego ~~Shelter Island Yacht Basin~~ DJH	SIYB-Ref

SPAWNING DATA				
Initial Spawning Time: 1600	Final Spawning Time: 1700	Fertilization Time: 1701	No. of Females: 2	No. of Males: 3
Embryo Density (count/mL):	1. 98 / 77	2. 81 / 86	3. 91 / 99	Average: 88.7
Stocking Volume Calculation:	2700 / (88.7 × 50) = 0.608			

ZERO TIME COUNTS					
1. 186	2. 203	3. 209	4. 269	5. 203	6. 238
Average Count: 218			Technician: KS		

LARVAL COUNT DATA

Conc.	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Date	Initials
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal		
Control												
~~Brine~~												
6.25	196	24	143	24	169	20	151	23			10/12/11	KS
12.5	168	21	198	26	192	29	177	21			↓	↓
25	175	25	197	19	202	27	185	36				
50	156	25	192	23	198	28	200	28				
100	202	14	204	30	158	20	177	27			9/20/11	KS

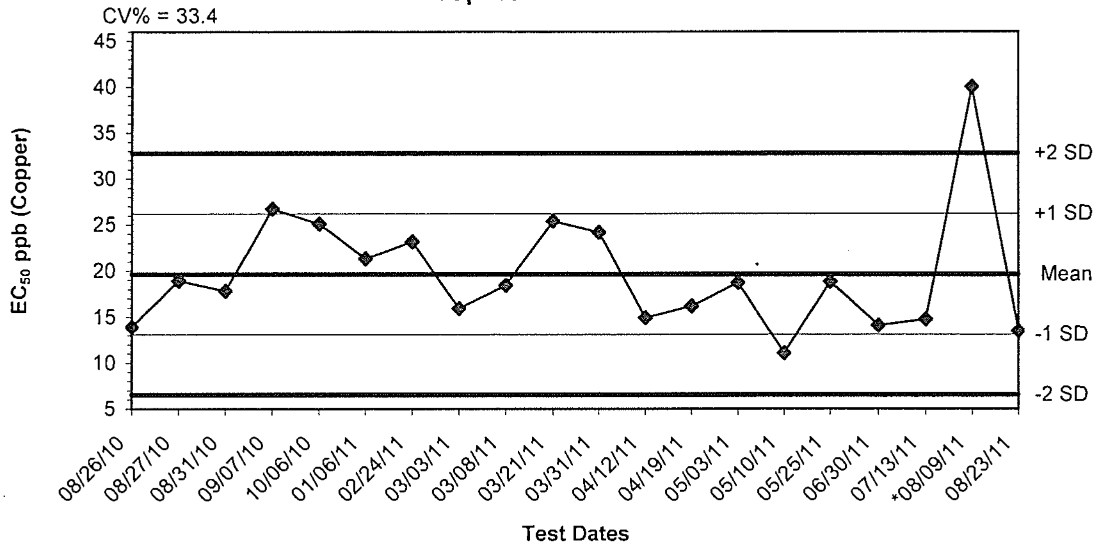
QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	12.5 / 4	50 / 1	/	/
Total #	203	180		
# Normal	181	153		
Date / Initials	10/13/11 / SH	10/13/11 / SH	/	/

QA Check Acceptability: ☑ <5% difference in means of QA & orig. counts

DIE 1/5/12 JH

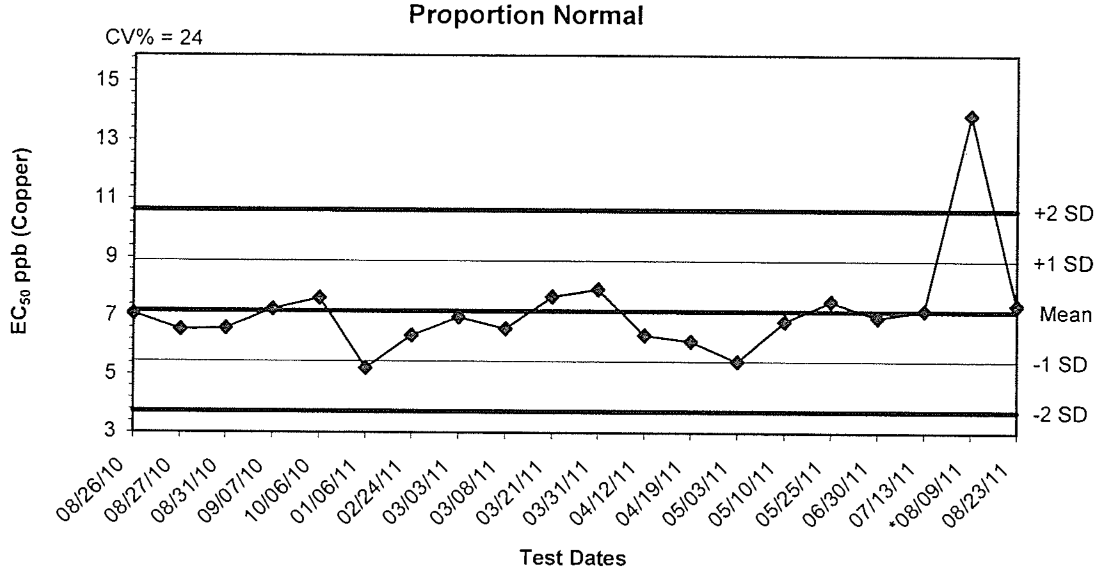
Mytilus galloprovincialis Reference Toxicant Control Chart: Proportion Alive



Dates	Values	Mean	-1 SD	-2 SD	+1 SD	+2 SD
08/26/10	13.9020	19.6450	13.0862	6.5274	26.2039	32.7627
08/27/10	18.9430	19.6450	13.0862	6.5274	26.2039	32.7627
08/31/10	17.8030	19.6450	13.0862	6.5274	26.2039	32.7627
09/07/10	26.7381	19.6450	13.0862	6.5274	26.2039	32.7627
10/06/10	25.0730	19.6450	13.0862	6.5274	26.2039	32.7627
01/06/11	21.3210	19.6450	13.0862	6.5274	26.2039	32.7627
02/24/11	23.1600	19.6450	13.0862	6.5274	26.2039	32.7627
03/03/11	15.9270	19.6450	13.0862	6.5274	26.2039	32.7627
03/08/11	18.4500	19.6450	13.0862	6.5274	26.2039	32.7627
03/21/11	25.3810	19.6450	13.0862	6.5274	26.2039	32.7627
03/31/11	24.1720	19.6450	13.0862	6.5274	26.2039	32.7627
04/12/11	14.9140	19.6450	13.0862	6.5274	26.2039	32.7627
04/19/11	16.1650	19.6450	13.0862	6.5274	26.2039	32.7627
05/03/11	18.7380	19.6450	13.0862	6.5274	26.2039	32.7627
05/10/11	11.0648	19.6450	13.0862	6.5274	26.2039	32.7627
05/25/11	18.8430	19.6450	13.0862	6.5274	26.2039	32.7627
06/30/11	14.0890	19.6450	13.0862	6.5274	26.2039	32.7627
07/13/11	14.7460	19.6450	13.0862	6.5274	26.2039	32.7627
*08/09/11	40.0000	19.6450	13.0862	6.5274	26.2039	32.7627
08/23/11	13.4710	19.6450	13.0862	6.5274	26.2039	32.7627

*Value was out of 95% CI range at time of testing.
Updated 10/3/11 KC

Mytilus galloprovincialis Reference Toxicant Control Chart: Proportion Normal



Dates	Values	Mean	-1 SD	-2 SD	+1 SD	+2 SD
08/26/10	7.0762	7.1714	5.4484	3.7253	8.8945	10.6176
08/27/10	6.5364	7.1714	5.4484	3.7253	8.8945	10.6176
08/31/10	6.5794	7.1714	5.4484	3.7253	8.8945	10.6176
09/07/10	7.2430	7.1714	5.4484	3.7253	8.8945	10.6176
10/06/10	7.6168	7.1714	5.4484	3.7253	8.8945	10.6176
01/06/11	5.2082	7.1714	5.4484	3.7253	8.8945	10.6176
02/24/11	6.3415	7.1714	5.4484	3.7253	8.8945	10.6176
03/03/11	6.9707	7.1714	5.4484	3.7253	8.8945	10.6176
03/08/11	6.5694	7.1714	5.4484	3.7253	8.8945	10.6176
03/21/11	7.6651	7.1714	5.4484	3.7253	8.8945	10.6176
03/31/11	7.9275	7.1714	5.4484	3.7253	8.8945	10.6176
04/12/11	6.3555	7.1714	5.4484	3.7253	8.8945	10.6176
04/19/11	6.1428	7.1714	5.4484	3.7253	8.8945	10.6176
05/03/11	5.4518	7.1714	5.4484	3.7253	8.8945	10.6176
05/10/11	6.8235	7.1714	5.4484	3.7253	8.8945	10.6176
05/25/11	7.5181	7.1714	5.4484	3.7253	8.8945	10.6176
06/30/11	6.9573	7.1714	5.4484	3.7253	8.8945	10.6176
07/13/11	7.2116	7.1714	5.4484	3.7253	8.8945	10.6176
*08/09/11	13.8550	7.1714	5.4484	3.7253	8.8945	10.6176
08/23/11	7.3790	7.1714	5.4484	3.7253	8.8945	10.6176

*Value out of 95% CI range at time of testing.
Updated 10/3/11 KC

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	8/23/2011 19:05	Test ID:	C110713.10	Sample ID:	REF-Ref Toxicant
End Date:	8/25/2011 18:10	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

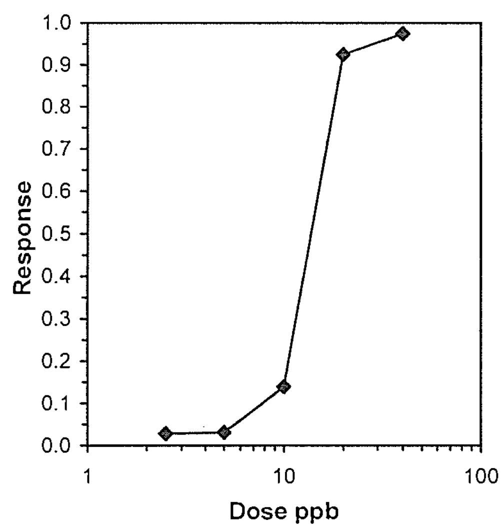
Conc-ppb	1	2	3	4
Control	0.8761	0.9817	0.9817	0.8991
2.5	0.9862	0.8165	0.8761	0.9541
5	0.8991	0.9862	0.8440	0.8945
10	0.7890	0.8807	0.8119	0.7385
20	0.0688	0.0734	0.0872	0.0550
40	0.0183	0.0275	0.0229	0.0275

			Transform: Arcsin Square Root					Number	Total
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	Resp	Number
Control	0.9346	1.0000	1.3321	1.2112	1.4349	8.979	4	57	872
2.5	0.9083	0.9718	1.2869	1.1281	1.4532	11.282	4	80	872
5	0.9060	0.9693	1.2764	1.1648	1.4532	9.688	4	82	872
10	0.8050	0.8613	1.1170	1.0341	1.2182	6.876	4	170	872
20	0.0711	0.0761	0.2691	0.2368	0.2997	9.640	4	810	872
40	0.0241	0.0258	0.1553	0.1359	0.1667	9.453	4	851	872

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96487	0.884	0.35037	-0.1853
Bartlett's Test indicates equal variances (p = 0.02)	14.0127	15.0863		

Trimmed Spearman-Karber

Trim Level	EC50	95% CL	
0.0%			
5.0%	13.494	13.203	13.791
10.0%	13.686	13.341	14.040
20.0%	13.757	13.575	13.941
Auto-2.8%	13.471	13.152	13.797



 ToxCalc v5.0.23 Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Alive					
Start Date:	8/23/2011 19:05	Test ID:	C110713.10	Sample ID:	REF-Ref Toxicant
End Date:	8/25/2011 18:10	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:	For PMSD only				

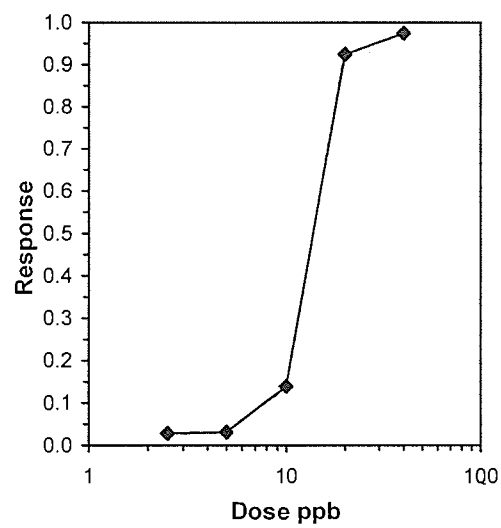
Conc-ppb	1	2	3	4
Control	0.8761	0.9817	0.9817	0.8991
2.5	0.9862	0.8165	0.8761	0.9541
5	0.8991	0.9862	0.8440	0.8945
10	0.7890	0.8807	0.8119	0.7385
20	0.0688	0.0734	0.0872	0.0550
40	0.0183	0.0275	0.0229	0.0275

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
Control	0.9346	1.0000	1.3321	1.2112	1.4349	8.979	4				57	872
2.5	0.9083	0.9718	1.2869	1.1281	1.4532	11.282	4	0.654	2.410	0.1668	80	872
5	0.9060	0.9693	1.2764	1.1648	1.4532	9.688	4	0.806	2.410	0.1668	82	872
*10	0.8050	0.8613	1.1170	1.0341	1.2182	6.876	4	3.109	2.410	0.1668	170	872
*20	0.0711	0.0761	0.2691	0.2368	0.2997	9.640	4	15.362	2.410	0.1668	810	872
*40	0.0241	0.0258	0.1553	0.1359	0.1667	9.453	4	17.006	2.410	0.1668	851	872

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.96487		0.884		0.35037	-0.1853
Bartlett's Test indicates equal variances (p = 0.02)					14.0127		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	5	10	7.07107		0.09968	0.10558	1.18205	0.00958	2.8E-13	5, 18

Trimmed Spearman-Karber

Trim Level	EC50	95% CL	
0.0%			
5.0%	13.494	13.203	13.791
10.0%	13.686	13.341	14.040
20.0%	13.757	13.575	13.941
Auto-2.8%	13.471	13.152	13.797



 ToxCalc v5.0.23 Reviewed by: YB

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	8/23/2011 19:05	Test ID:	C110713.10	Sample ID:	REF-Ref Toxicant
End Date:	8/25/2011 18:10	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:	For IC25 only				

Conc-ppb	1	2	3	4
Control	0.8761	0.9817	0.9817	0.8991
2.5	0.9862	0.8165	0.8761	0.9541
5	0.8991	0.9862	0.8440	0.8945
10	0.7890	0.8807	0.8119	0.7385
20	0.0688	0.0734	0.0872	0.0550
40	0.0183	0.0275	0.0229	0.0275

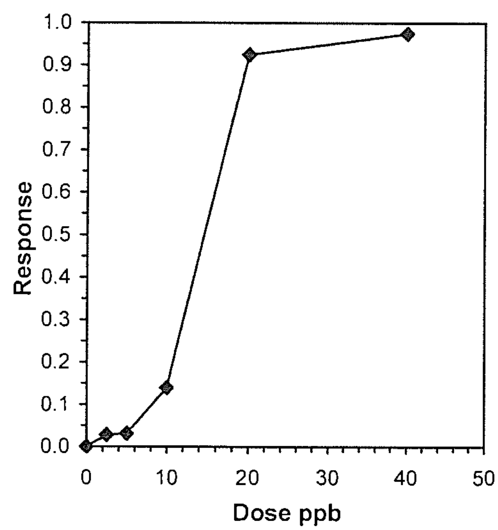
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.9346	1.0000	1.3321	1.2112	1.4349	8.979	4				0.9346	1.0000
2.5	0.9083	0.9718	1.2869	1.1281	1.4532	11.282	4	0.654	2.410	0.1668	0.9083	0.9718
5	0.9060	0.9693	1.2764	1.1648	1.4532	9.688	4	0.806	2.410	0.1668	0.9060	0.9693
*10	0.8050	0.8613	1.1170	1.0341	1.2182	6.876	4	3.109	2.410	0.1668	0.8050	0.8613
*20	0.0711	0.0761	0.2691	0.2368	0.2997	9.640	4	15.362	2.410	0.1668	0.0711	0.0761
*40	0.0241	0.0258	0.1553	0.1359	0.1667	9.453	4	17.006	2.410	0.1668	0.0241	0.0258

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96487	0.884	0.35037	-0.1853
Bartlett's Test indicates equal variances (p = 0.02)	14.0127	15.0863		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	5	10	7.07107		0.09968	0.10558	1.18205	0.00958	2.8E-13	5, 18

Linear Interpolation (200 Resamples)

Point	ppb	SD	95% CL(Exp)		Skew
IC05	5.895	1.896	0.000	8.931	-0.5803
IC10	8.210	1.708	1.762	11.545	-0.8184
IC15	10.145	0.894	6.115	11.326	-1.5034
IC20	10.781	0.473	8.834	11.885	-1.2328
IC25	11.418	0.389	9.982	12.444	-0.3691
IC40	13.328	0.308	12.179	14.121	-0.3729
IC50	14.602	0.254	13.642	15.239	-0.3775



ToxCalc v5.0.23

Reviewed by: [signature]

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 19:05	Test ID:	C110713.10	Sample ID:	REF-Ref Toxicant
End Date:	8/25/2011 18:10	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

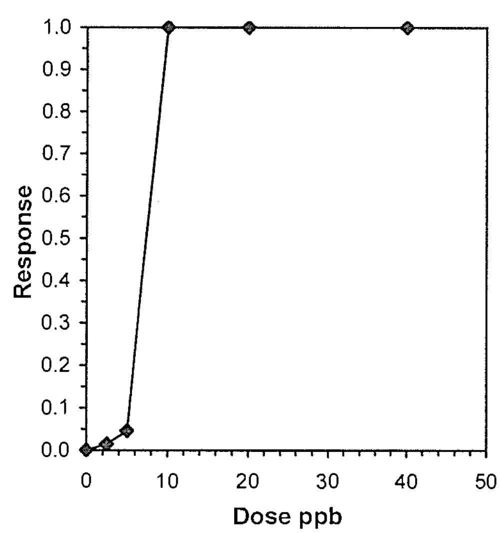
Conc-ppb	1	2	3	4
Control	0.8901	0.8879	0.8598	0.8776
2.5	0.8744	0.8820	0.8586	0.8510
5	0.7551	0.8465	0.8696	0.8821
10	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root					Isotonic	
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	Mean	N-Mean
Control	0.8788	1.0000	1.2156	1.1870	1.2328	1.716	4	0.8785	1.0000
2.5	0.8665	0.9860	1.1971	1.1744	1.2202	1.749	4	0.8662	0.9859
5	0.8383	0.9539	1.1607	1.0531	1.2202	6.452	4	0.8380	0.9538
10	0.0000	0.0000	0.0378	0.0361	0.0394	3.640	4	0.0000	0.0000
20	0.0000	0.0000	0.1286	0.1150	0.1448	9.639	4	0.0000	0.0000
40	0.0000	0.0000	0.2223	0.2056	0.2527	10.034	4	0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.88819	0.805	-1.4433	3.56652
Bartlett's Test indicates equal variances (p = 0.05)	5.86119	9.21034		

Linear Interpolation (200 Resamples)

Point	ppb	SD	95% CL(Exp)		Skew
IC05	5.0201	0.6390	2.3347	5.3277	-0.7181
IC10	5.2822	0.2006	4.2710	5.5736	-1.8846
IC15	5.5443	0.1428	4.9917	5.8195	-0.5467
IC20	5.8064	0.1344	5.2863	6.0654	-0.5467
IC25	6.0685	0.1260	5.5809	6.3113	-0.5467
IC40	6.8548	0.1008	6.4647	7.0491	-0.5467
IC50	7.3790	0.0840	7.0539	7.5409	-0.5467



Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	8/23/2011 19:05	Test ID: C110713.10		Sample ID:	REF-Ref Toxicant
End Date:	8/25/2011 18:10	Lab ID: CCA-Weston, Carlsbad		Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol: EPAW 95-EPA West Coast		Test Species:	MG-Mytilus galloprovincialis
Comments:	For PMSD only				

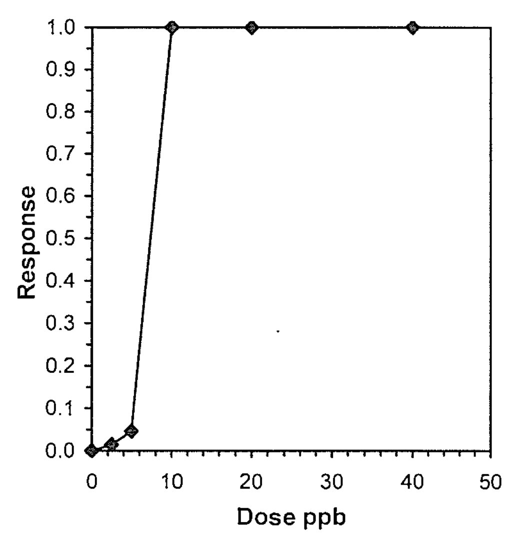
Conc-ppb	1	2	3	4
Control	0.8901	0.8879	0.8598	0.8776
2.5	0.8744	0.8820	0.8586	0.8510
5	0.7551	0.8465	0.8696	0.8821
10	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.8788	1.0000	1.2156	1.1870	1.2328	1.716	4				0.8785	1.0000
2.5	0.8665	0.9860	1.1971	1.1744	1.2202	1.749	4	0.562	2.180	0.0716	0.8662	0.9859
5	0.8383	0.9539	1.1607	1.0531	1.2202	6.452	4	1.670	2.180	0.0716	0.8380	0.9538
10	0.0000	0.0000	0.0378	0.0361	0.0394	3.640	4				0.0000	0.0000
20	0.0000	0.0000	0.1286	0.1150	0.1448	9.639	4				0.0000	0.0000
40	0.0000	0.0000	0.2223	0.2056	0.2527	10.034	4				0.0000	0.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.88819		0.805		-1.4433	3.56652
Bartlett's Test indicates equal variances (p = 0.05)					5.86119		9.21034			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	5	10	7.07107		0.05045	0.05739	0.00312	0.00216	0.28566	2, 9

Linear Interpolation (200 Resamples)

Point	ppb	SD	95% CL(Exp)		Skew
IC05	5.0201	0.6219	2.1664	5.3224	-1.2589
IC10	5.2822	0.2405	4.1053	5.5686	-3.2307
IC15	5.5443	0.1457	4.9603	5.8148	-1.2107
IC20	5.8064	0.1372	5.2568	6.0609	-1.2107
IC25	6.0685	0.1286	5.5532	6.3071	-1.2107
IC40	6.8548	0.1029	6.4426	7.0457	-1.2107
IC50	7.3790	0.0857	7.0355	7.5381	-1.2107



Test: BV-Bivalve Larval Survival and Development Test
Species: MG-Mytilus galloprovincialis
Sample ID: REF-Ref Toxicant
Start Date: 8/23/2011 19:05 End Date: 8/25/2011 18

Test ID: C110713.10
Protocol: EPAW 95-EPA West Coast
Sample Type: CUSO-Copper sulfate
Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	218	191	191	170	
	2	2	Control	218	214	214	190	
	3	3	Control	218	214	214	184	
	4	4	Control	218	196	196	172	
	5	1	2.500	218	215	215	188	
	6	2	2.500	218	178	178	157	
	7	3	2.500	218	191	191	164	
	8	4	2.500	218	208	208	177	
	9	1	5.000	218	196	196	148	
	10	2	5.000	218	215	215	182	
	11	3	5.000	218	184	184	160	
	12	4	5.000	218	195	195	172	
	13	1	10.000	218	172	172	0	
	14	2	10.000	218	192	192	0	
	15	3	10.000	218	177	177	0	
	16	4	10.000	218	161	161	0	
	17	1	20.000	218	15	15	0	
	18	2	20.000	218	16	16	0	
	19	3	20.000	218	19	19	0	
	20	4	20.000	218	12	12	0	
	21	1	40.000	218	4	4	0	
	22	2	40.000	218	6	6	0	
	23	3	40.000	218	5	5	0	
	24	4	40.000	218	6	6	0	

Comments:

ToxCalc 5.0

Reviewed by: [signature]

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Bivalve Counts Worksheet

Test ID: C110713.10 Copper RT

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	170	21	191
	2	190	24	214
	3	184	30	214
	4	172	24	196
2.5	1	188	27	215
	2	157	21	178
	3	164	27	191
	4	177	31	208
5	1	148	48	196
	2	182	33	215
	3	160	24	184
	4	172	23	195
10	1	0	172	172
	2	0	192	192
	3	0	177	177
	4	0	161	161
20	1	0	15	15
	2	0	16	16
	3	0	19	19
	4	0	12	12
40	1	0	4	4
	2	0	6	6
	3	0	5	5
	4	0	6	6

JA

WESTON SOLUTIONS

48 Hour Bivalve Development Reference Toxicant Test

Test ID: C110713.16	Replicates: 4	Study Director: K. Ewing	Location: Rm 2
Dilution Water Batch: SI082511	Organism Batch: TSF 5708	Associated Test(s): SIYB	Organism: Mytilus galloprovincialis

Toxicant: Copper Sulfate (0.509gCu/LCuSO$_4$)	Lot #: 2008506	Date Prepared: 8/23/11	Initials: BG

Target Concentrations: 40 ppb	Quantity of Stock: Target: 0.039 mL	Quantity of Diluent: Target: 500 mL
40 ppb	Actual: 0.0390	Actual: 500.0

Serial Dilute by ½ to obtain concentrations of 20, 10, 5, and 2.5 ppb.

0 Hours Date: 8/23/11 WQ Time: 1750 Start Time: 1905 Initials: BG

STOCK

	Control	2.5	5	10	20	40
D.O. (mg/L)	7.7	7.7	7.7	7.7	7.7	7.7
Temperature	16.4	16.3	16.4	16.4	16.3	16.3
Salinity	30.2	30.1	30.1	30.2	30.2	30.2
pH	7.9	7.9	7.9	7.9	7.9	7.9

48 Hours Date: 8/25/11 WQ Time: 1820 End Time: 1810 Initials: KE

STOCK

	Control	2.5	5	10	20	40
D.O. (mg/L)	7.7	7.8	7.7	7.7	7.7	7.8
Temperature	16.4	16.3	16.2	16.3	16.3	16.4
Salinity	30.2	30.2	30.2	30.2	30.3	30.3
pH	7.8	7.9	7.9	7.9	7.9	7.9

COUNTS

Zero Times	186	203	209	269	203	238	Initials: KS

AVG: 218

Conc.	Rep 1 Normal	Rep 1 Abnormal	Rep 2 Normal	Rep 2 Abnormal	Rep 3 Normal	Rep 3 Abnormal	Rep 4 Normal	Rep 4 Abnormal	Initials
Control	170	21	190	24	184	30	172	24	BG
2.5	188	27	157	21	164	27	177	31	BG
5	148	48	182	33	160	24	172	23	BG
10	Ø	172	Ø	192	Ø	177	Ø ~~161~~ ①BG	161	BG
20	Ø ~~Ø~~	15 ~~5~~	Ø ~~Ø~~	16 ~~8~~	Ø ~~Ø~~	19 ~~5~~	Ø ~~Ø~~	12 ~~4~~ ②BG	BG
40	Ø ~~Ø~~	4 ~~11~~	Ø ~~Ø~~	6 ~~14~~	Ø ~~Ø~~	5 ~~10~~	Ø ~~Ø~~	6 ~~20~~	BG

Q/A 9/12/11 KS
Rep2 188/23
Rep3 Ø/173

① WC 8/30/11 BG

☐ Pass ☐ Fail

② Concentrations were recounted after QA check. 9/20/11 BG

WESTON SOLUTIONS

Bivavlve RT
8/23/11

	1	9
	2	11
Ø	3	6
	4	10
	5	19
	6	14
2.5	7	3
	8	21
	9	22
5	10	17
	11	5
	12	18
	13	23
	14	12
10	15	20
	16	8
	17	4
	18	13
20	19	15
	20	7
	21	16
	22	1
40	23	2
	24	24

Weston Solutions, Inc.

Client: Port of San Diego
Project: Shelter Island Yacht Basin
Sample Matrix: Liquid
Sample Name/ID: SIYB-1

Date Received: 27 Oct 11
Date Test Started: 27 Oct 11
Date Test Ended: 29 Oct 11
Test ID No.: C111027.0142

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	96.6	92.8
6.25%	97.0	97.2
12.5%	97.2	92.1
25%	96.7	94.3
50%	83.0	91.7
100%	7.12	86.0

QA Unit 1/5/12 Date

Approved 1/5/12 Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-1	**Test ID No.:**	C111027.0142

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.15$). Dunnett's Multiple-Comparison Test provided a NOEC (No Observed Effect Concentration) of 25 percent and a LOEC (Lowest Observed Effect Concentration) of 50 percent test substance.

The Maximum Likelihood-Probit Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} was estimated to be 55.64 percent test substance and EC_{50} was estimated to be 67.04 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 4.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.06$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Maximum Likelihood-Probit Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	25%	67.04%	100%	>100%	SIYB-1

Protocol Deviations: The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt. In the associated Reference Toxicant test replicate 4 of the control, replicate 1 of the 2.5ppb concentration and replicate 4 of the 5ppb concentration were found to be outliers and were therefore excluded from statistical analysis.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-1	**Test ID No.:**	C111027.0142

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis.*

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.2	15.7	29.8	8.2
6.25	7.2	15.2	30.1	8.2
12.5	7.3	15.2	30.3	8.2
25	7.3	15.3	30.7	8.0
50	7.3	15.3	31.4	8.1
100	7.7	15.1	32.8	8.0
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.7		
6.25		14.5		
12.5		14.8		
25		14.5		
50		14.3		
100		14.6		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	15.3	30.0	8.0
6.25	7.9	14.5	30.5	8.0
12.5	7.8	14.7	30.4	8.0
25	7.8	14.7	31.2	8.0
50	7.9	14.5	31.9	8.0
100	7.8	14.8	32.8	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-1	**Test ID No.:**	C111027.0142

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	29.8 ppt
pH	8.2
Dissolved Oxygen	7.2 mg/L
Temperature	15.7°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis*. Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on October 26, 2011, at 0850 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0945 hours. The temperature of the sample upon receipt was 6.0°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 211 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.59 ppb survival, 4.88 ppb proportion normal
	48 hr EC_{50}:	13.06 ppb survival, 5.28 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.61 ppb survival, 7.02 ppb proportion normal
	Test Date:	10/27/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	10/27/2011 15:10	Test ID:	C111027.0142	Sample ID:	SIYB-1
End Date:	10/29/2011 13:15	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	10/26/2011 08:50	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis

Comments:

Conc-%	1	2	3	4
Control	0.9290	0.9747	0.9909	0.9688
6.25	0.9724	0.9684	0.9638	0.9760
12.5	0.9945	0.9765	0.9725	0.9425
25	0.9457	0.9728	0.9684	0.9816
50	0.8902	0.8476	0.8230	0.7582
100	0.1264	0.0549	0.0924	0.0112

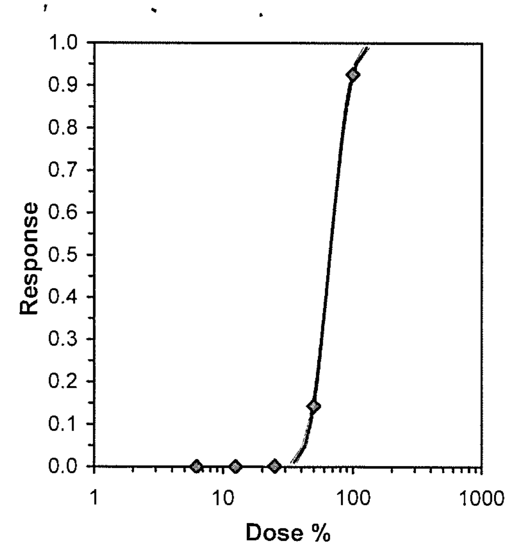
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
Control	0.9658	1.0000	1.3951	1.3011	1.4751	5.152	4				26	817
6.25	0.9701	1.0045	1.3976	1.3794	1.4151	1.098	4	-0.051	2.410	0.1197	25	836
12.5	0.9715	1.0059	1.4116	1.3287	1.4964	4.865	4	-0.332	2.410	0.1197	22	786
25	0.9671	1.0014	1.3919	1.3356	1.4346	2.982	4	0.064	2.410	0.1197	27	812
*50	0.8298	0.8591	1.1490	1.0568	1.2330	6.386	4	4.954	2.410	0.1197	132	774
*100	0.0712	0.0738	0.2538	0.1062	0.3634	43.840	4	22.979	2.410	0.1197	674	726

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.95419		0.884		-0.4525	0.28546
Bartlett's Test indicates equal variances (p = 0.15)					8.19426		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	25	50	35.3553	4	0.0542	0.05591	0.8399	0.00493	1.7E-14	5, 18

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	8.3321	0.31265	7.71931	8.9449	0.03182	0.36618	7.81473	0.95	1.82631	0.12002	3
Intercept	-10.217	0.57366	-11.341	-9.0927							
TSCR	0.03071	0.00303	0.02477	0.03665							

Point	Probits	%	95% Fiducial Limits	
EC01	2.674	35.2461	33.251	37.0957
EC05	3.355	42.5503	40.6611	44.3019
EC10	3.718	47.0441	45.2375	48.7284
EC15	3.964	50.3412	48.5942	51.982
EC20	4.158	53.1256	51.4235	54.7384
EC25	4.326	55.6369	53.9672	57.2347
EC40	4.747	62.504	60.8615	64.1336
EC50	5.000	67.0369	65.3455	68.7632
EC60	5.253	71.8985	70.0869	73.8036
EC75	5.674	80.7727	78.5732	83.1915
EC80	5.842	84.5908	82.1684	87.2939
EC85	6.036	89.2697	86.5377	92.3634
EC90	6.282	95.5262	92.3283	99.2036
EC95	6.645	105.615	101.568	110.353
EC99	7.326	127.502	121.316	134.926



Dose response relationships are considered reliable.

ToxCalc v5.0.23

Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	10/27/2011 15:10	Test ID:	C111027.0142	Sample ID:	SIYB-1
End Date:	10/29/2011 13:15	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	10/26/2011 08:50	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

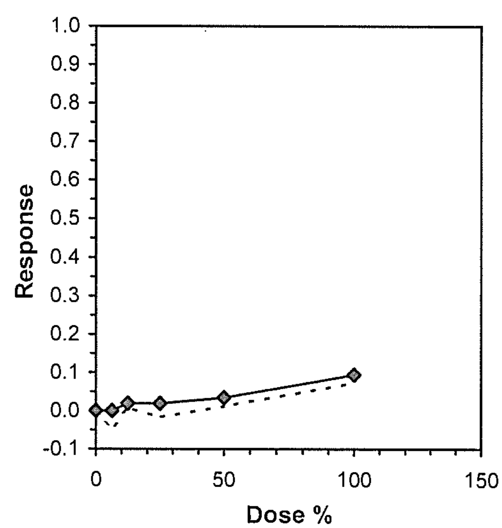
Conc-%	1	2	3	4
Control	0.8009	1.0000	1.0000	0.9100
6.25	1.0000	0.9005	1.0000	0.9858
12.5	0.8578	1.0000	1.0000	0.8246
25	1.0000	0.8720	0.9005	1.0000
50	0.8199	0.9953	0.9905	0.8626
100	0.8626	0.8626	0.8720	0.8436

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.9277	1.0000	1.3618	1.1083	1.5364	15.541	4				0.9496	1.0000
6.25	0.9716	1.0473	1.4435	1.2498	1.5364	9.364	4	-0.669	2.410	0.2942	0.9496	1.0000
12.5	0.9206	0.9923	1.3489	1.1387	1.5364	16.106	4	0.105	2.410	0.2942	0.9319	0.9813
25	0.9431	1.0166	1.3819	1.2050	1.5364	12.976	4	-0.165	2.410	0.2942	0.9319	0.9813
50	0.9171	0.9885	1.3247	1.1325	1.5019	14.342	4	0.304	2.410	0.2942	0.9171	0.9657
100	0.8602	0.9272	1.1878	1.1642	1.2050	1.435	4	1.425	2.410	0.2942	0.8602	0.9058

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.89144		0.884		-0.1845	-1.529
Bartlett's Test indicates equal variances (p = 0.06)					10.582		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.18949	0.19802	0.02912	0.0298	0.45812	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	63.099			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Dose response relationships are considered reliable.

ToxCalc v5.0.23

Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test
Test ID: C111027.0142
Species: MG-Mytilus galloprovincialis
Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB-1
Sample Type: AMB1-Ambient water
Start Date: 10/27/2011 15:10
End Date: 10/29/2011
Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	211	169	169	157	
	2	2	Control	211	237	237	231	
	3	3	Control	211	219	219	217	
	4	4	Control	211	192	192	186	
	5	1	6.250	211	217	217	211	
	6	2	6.250	211	190	190	184	
	7	3	6.250	211	221	221	213	
	8	4	6.250	211	208	208	203	
	9	1	12.500	211	181	181	180	
	10	2	12.500	211	213	213	208	
	11	3	12.500	211	218	218	212	
	12	4	12.500	211	174	174	164	
	13	1	25.000	211	221	221	209	
	14	2	25.000	211	184	184	179	
	15	3	25.000	211	190	190	184	
	16	4	25.000	211	217	217	213	
	17	1	50.000	211	173	173	154	
	18	2	50.000	211	210	210	178	
	19	3	50.000	211	209	209	172	
	20	4	50.000	211	182	182	138	
	21	1	100.000	211	182	182	23	
	22	2	100.000	211	182	182	10	
	23	3	100.000	211	184	184	17	
	24	4	100.000	211	178	178	2	

Comments:

Reviewed by: [signature]

WESTON SOLUTIONS

Bivalve Counts Worksheet

Test ID: C111027.01 SIYB - 1

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	157	12	169
	2	231	6	237
	3	217	2	219
	4	186	6	192
6.25	1	211	6	217
	2	184	6	190
	3	213	8	221
	4	203	5	208
12.5	1	180	1	181
	2	208	5	213
	3	212	6	218
	4	164	10	174
25	1	209	12	221
	2	179	5	184
	3	184	6	190
	4	213	4	217
50	1	154	19	173
	2	178	32	210
	3	172	37	209
	4	138	44	182
100	1	23	159	182
	2	10	172	182
	3	17	167	184
	4	2	176	178

JTA

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT:	Port of San Diego
PROJECT:	SIYB - 1 (Shelter Island Yacht Basin)
CLIENT SAMPLE ID:	SIYB - 1
WESTON TEST ID:	C111027.0142
SPECIES:	Mytilus galloprovincialis

DATE RECEIVED:	~~10/26/11~~ 27 ④JH
DATE TEST STARTED:	10/27/11
DATE TEST ENDED:	10/29/11
WESTON SOP NO.:	BIO042
STUDY DIRECTOR:	K. Skrivseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours) Date: 10/27/11	Control	3	7.2	3	15.7	5	29.8	2	8.2
Sample ID: C111027.01	~~Brine Control~~		7.2		15.2		30.1		8.2 KC ②
Dilutions (Tech): KC	6.25		↓		↓		↓		↓
WQ Time: 1410	12.5		7.3		15.2		30.3		8.2
Technician: KC/SH	25		7.3		15.3		30.7		8.0
	50		7.3		15.3		31.4		8.1
	100		7.7		15.1		32.8 ③KS		8.0
24 Hours	Control			7B	14.7				
Date: 10/28/11	~~Brine Control~~				—				
WQ Time: 1045	6.25				14.5				
Technician: KC	12.5				14.8				
	25				14.5				
	50				14.3				
	100				14.6				
48 Hours	Control	3	7.5	3	15.3	5	30.0	4	8.0
Date: 10/29/11	~~Brine Control~~		—		—		—		—
WQ Time: 1220	6.25		7.9		14.5		30.5		8.0
Technician: BG	12.5		7.8		14.7		30.4		8.0
	25		7.8		14.7		31.2		8.0
	50		7.9		14.5		31.9		8.0
	100		7.8		14.8		32.8 ③KS		8.0

*Water quality measurements taken in surrogate water quality chambers.

START TIME:	1510	Initials:	SH
END TIME:	1315	Initials:	BG
ORGANISM BATCH:	TSF 9788		
HOBO TEMP. NO.:	119279		
TEST LOCATION:	Rm 2		

DILUTION WATER BATCH: SIO 102411

TEST ACCEPTABILITY:

- ☒ ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- ☒ ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- ☒ MSD < 25%

①WC 10/27/11 SH
②WC 10/27/11 KC
④WD 1/5/12 JH

③ salinity above protocol limit of 30±2 ppt 1/3/12 KS

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

Weston Test ID:	Client:	Client Sample ID:
C111027.0142	port of San Diego	SIYB-1

SPAWNING DATA

Initial Spawning Time: 1115	Final Spawning Time: 1310	Fertilization Time: 1312	No. of Females: 3	No. of Males: 3
Embryo Density (count/mL):	1. 116 / 86	2. 95 / 102	3. 89 / 117	Average: 100.8
Stocking Volume Calculation:	2700 / (100.8 x 50) = 0.5357 or 53.6 ml			

ZERO TIME COUNTS

1. 208	2. 217	3. 231	4. 219	5. 190	6. 203
Average Count: 211			Technician: KS		

LARVAL COUNT DATA

Conc.	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Date	Initials
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal		
Control	157	12	231	6	217	2	186	6			10/31/11	KS
Brine	~~211~~	①BG ~~6~~	—	—	—	—	—	—	—	—		
6.25	211	6	184	6	213	8	203	5			11/16/11	BG
12.5	180	1	208	5	212	6	164	10			11/17/11	BG
25	209	12	179	5	184	6	213	4				
50	154 ~~162~~	19 ~~11~~	178 ~~192~~	32 ~~13~~	172 ~~185~~	37 ~~24~~	138 ~~164~~	44 ~~19~~				
100	②BG 23 ~~43~~	157 ~~139~~	10 ~~29~~	172 ~~158~~	17 ~~29~~	167 ~~150~~	2 ~~7~~	176 ~~171~~				

QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	12.5 / 2	50 / 3	100 / 1	/
Total #	211	210	183	
# Normal	207	174	19	
Date / Initials	11/29/11 / KS	11/18/11 / KS	11/18/11 / KS	/
QA Check Acceptability: ☒ <5% difference in means of QA & orig. counts				

① WC 11/16/11 BG

② 50 and 100 concentrations counted again after QA. 11/28/11 BG

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-3	**Test ID No.:**	C111027.0242

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	96.6	92.8
6.25%	98.2	94.4
12.5%	97.4	94.7
25%	95.4	91.5
50%	96.1	93.1
100%	91.5	91.5

QA Unit 1/5/12 Date

Approved 1/5/12 Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-3	**Test ID No.:**	C111027.0242

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.55$). Dunnett's Multiple-Comparison Test provided a NOEC (No Observed Effect Concentration) of 50 percent and a LOEC (Lowest Observed Effect Concentration) of 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 2.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.99$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	50%	>100%	100%	>100%	SIYB-3

Protocol Deviations: The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt. In the associated Reference Toxicant test replicate 4 of the control, replicate 1 of the 2.5ppb concentration and replicate 4 of the 5ppb concentration were found to be outliers and were therefore excluded from statistical analysis.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-3	**Test ID No.:**	C111027.0242

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*.

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.2	15.7	29.8	8.2
6.25	7.3	15.5	30.1	8.2
12.5	7.3	15.4	30.3	8.2
25	7.3	15.6	30.7	8.2
50	7.4	13.5	31.4	8.1
100	7.5	15.4	32.8	8.0
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.7		
6.25		14.5		
12.5		14.3		
25		14.5		
50		14.8		
100		14.9		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	15.3	30.0	8.0
6.25	7.8	14.8	30.4	8.0
12.5	7.8	14.7	30.7	8.0
25	7.9	14.9	31.1	8.0
50	7.8	14.9	31.7	8.0
100	7.8	15.0	32.8	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-3	**Test ID No.:**	C111027.0242

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136**,** Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	29.8 ppt
pH	8.2
Dissolved Oxygen	7.2 mg/L
Temperature	15.7°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis.* Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on October 26, 2011, at 0905 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0945 hours. The temperature of the sample upon receipt was 6.0°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 211 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.59 ppb survival, 4.88 ppb proportion normal
	48 hr EC_{50}:	13.06 ppb survival, 5.28 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.61 ppb survival, 7.02 ppb proportion normal
	Test Date:	10/27/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	10/27/2011 15:10	Test ID: C111027.0242		Sample ID:	SIYB-3
End Date:	10/29/2011 13:15	Lab ID: CCA-Weston, Carlsbad		Sample Type:	AMB1-Ambient water
Sample Date:	10/26/2011 09:05	Protocol: EPAW 95-EPA West Coast		Test Species:	MG-Mytilus galloprovincialis
Comments:					

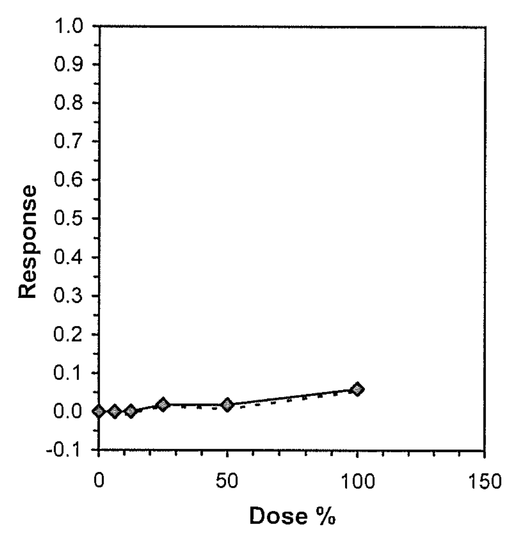
Conc-%	1	2	3	4
Control	0.9290	0.9747	0.9909	0.9688
6.25	0.9545	0.9840	0.9904	1.0000
12.5	0.9665	0.9645	0.9835	0.9816
25	0.9514	0.9701	0.9543	0.9384
50	0.9851	0.9670	0.9192	0.9717
100	0.9231	0.9585	0.9299	0.8495

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.9658	1.0000	1.3951	1.3011	1.4751	5.152	4				0.9748	1.0000
6.25	0.9822	1.0170	1.4518	1.3559	1.5345	5.114	4	-1.265	2.410	0.1080	0.9748	1.0000
12.5	0.9740	1.0085	1.4111	1.3812	1.4421	2.241	4	-0.359	2.410	0.1080	0.9739	0.9991
25	0.9535	0.9873	1.3552	1.3200	1.3972	2.352	4	0.889	2.410	0.1080	0.9571	0.9819
50	0.9607	0.9947	1.3802	1.2826	1.4483	5.072	4	0.331	2.410	0.1080	0.9571	0.9819
*100	0.9152	0.9476	1.2827	1.1723	1.3658	6.291	4	2.507	2.410	0.1080	0.9161	0.9398

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.92309		0.884		-0.5256	-0.201
Bartlett's Test indicates equal variances (p = 0.55)					4.02706		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	50	100	70.7107	2	0.04781	0.04932	0.01314	0.00402	0.02826	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	87.911			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Dose response relationships are considered reliable.

 ToxCalc v5.0.23 Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	10/27/2011 15:10	Test ID:	C111027.0242	Sample ID:	SIYB-3
End Date:	10/29/2011 13:15	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	10/26/2011 09:05	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

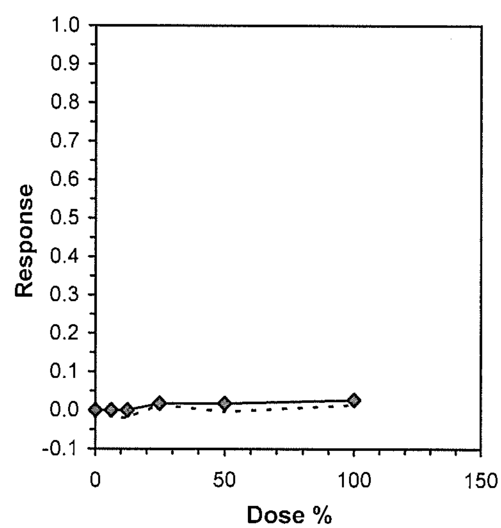
Conc-%	1	2	3	4
Control	0.8009	1.0000	1.0000	0.9100
6.25	1.0000	0.8863	0.9905	0.9005
12.5	0.9905	0.9336	0.8626	1.0000
25	0.8768	0.9526	0.8294	1.0000
50	0.9526	0.8626	0.9100	1.0000
100	0.8626	0.9147	1.0000	0.8815

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.9277	1.0000	1.3618	1.1083	1.5364	15.541	4				0.9396	1.0000
6.25	0.9443	1.0179	1.3716	1.2268	1.5364	11.395	4	-0.082	2.410	0.2875	0.9396	1.0000
12.5	0.9467	1.0204	1.3777	1.1910	1.5364	11.378	4	-0.134	2.410	0.2875	0.9396	1.0000
25	0.9147	0.9860	1.3112	1.1450	1.5364	13.192	4	0.424	2.410	0.2875	0.9230	0.9823
50	0.9313	1.0038	1.3362	1.1910	1.5364	11.126	4	0.215	2.410	0.2875	0.9230	0.9823
100	0.9147	0.9860	1.3053	1.1910	1.5364	12.096	4	0.474	2.410	0.2875	0.9147	0.9735

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.92154		0.884		0.18471	-1.3733
Bartlett's Test indicates equal variances (p = 0.99)					0.48006		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.18385	0.19212	0.00388	0.02846	0.98169	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Dose response relationships are considered reliable.

Test: BV-Bivalve Larval Survival and Development Test
Test ID: C111027.0212
Species: MG-Mytilus galloprovincialis
Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB-3
Sample Type: AMB1-Ambient water
Start Date: 10/27/2011 15:10
End Date: 10/29/2011
Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	211	169	169	157	
	2	2	Control	211	237	237	231	
	3	3	Control	211	219	219	217	
	4	4	Control	211	192	192	186	
	5	1	6.250	211	220	220	210	
	6	2	6.250	211	187	187	184	
	7	3	6.250	211	209	209	207	
	8	4	6.250	211	190	190	190	
	9	1	12.500	211	209	209	202	
	10	2	12.500	211	197	197	190	
	11	3	12.500	211	182	182	179	
	12	4	12.500	211	217	217	213	
	13	1	25.000	211	185	185	176	
	14	2	25.000	211	201	201	195	
	15	3	25.000	211	175	175	167	
	16	4	25.000	211	211	211	198	✓
	17	1	50.000	211	201	201	198	
	18	2	50.000	211	182	182	176	
	19	3	50.000	211	192	192	182	
	20	4	50.000	211	212	212	206	
	21	1	100.000	211	182	182	168	
	22	2	100.000	211	193	193	185	
	23	3	100.000	211	214	214	199	
	24	4	100.000	211	186	186	158	

Comments:

Reviewed by: JA

WESTON SOLUTIONS

Bivalve Counts Worksheet

Test ID: C111027.02 SIYB - 3

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	157	12	169
	2	231	6	237
	3	217	2	219
	4	186	6	192
6.25	1	210	10	220
	2	184	3	187
	3	207	2	209
	4	190	0	190
12.5	1	202	7	209
	2	190	7	197
	3	179	3	182
	4	213	4	217
25	1	176	9	185
	2	195	6	201
	3	167	8	175
	4	198	13	211
50	1	198	3	201
	2	176	6	182
	3	182	10	192
	4	206	6	212
100	1	168	14	182
	2	185	8	193
	3	199	15	214
	4	158	28	186

JDA

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT:	Port of San Diego
PROJECT:	SIYB (Shelter Island Yacht Basin)
CLIENT SAMPLE ID:	SIYB-3
WESTON TEST ID:	C111027.0242
SPECIES:	mytilus galloprovincialis

DATE RECEIVED:	~~10/26/11~~ 27 ③JH
DATE TEST STARTED:	10/27/11
DATE TEST ENDED:	10/29/11
WESTON SOP NO.:	BI0042
STUDY DIRECTOR:	K. Skinseth

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours) Date:	Control	3	7.2	3	15.7	5	29.8	2	8.2
Sample ID: C111027.02	~~Brine Control~~		—		—		—		—
Dilutions (Tech): KC	6.25		7.3		15.5		30.1		8.2
WQ Time: 1416	12.5		7.3		15.4		30.3		8.2
Technician: SH/KC	25		7.3		15.6		30.7		8.2
	50		7.4		13.5		31.4		8.1
	100		7.5		15.4		32.8 ②KS		8.0
24 Hours	Control			7B	14.7				
Date: 10/28/11	~~Brine Control~~				—				
WQ Time: 1050	6.25				14.5				
Technician: KC	12.5				14.3				
	25				14.5				
	50				14.8				
	100				14.9				
48 Hours	Control	3	7.5	3	15.3	5	30.0 ①BG ~~30.4~~	4	8.0
Date: 10/29/11	~~Brine Control~~		—		—		—		—
WQ Time: 1215	6.25		7.8		14.8		30.4		8.0
Technician: BG	12.5		7.8		14.7		30.7		8.0
	25		7.9		14.9		31.1		8.0
	50		7.8		14.9		31.7		8.0
	100		7.8		15.0		32.8 ②KS		8.0

*Water quality measurements taken in surrogate water quality chambers.

①WC 10/29/11 BG ② salinity above protocol limit of 30±2 ppt. 1/3/12 KS ③ WD 1/5/12 JH

START TIME:	1510	Initials:	SH
END TIME:	1315	Initials:	BG
ORGANISM BATCH:	TSF 9788		
HOBO TEMP. NO.:	119279		
TEST LOCATION:	Rm 2		

DILUTION WATER BATCH: SIO 102411

TEST ACCEPTABILITY:

- ☒ ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- ☒ ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- ☒ MSD < 25%

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

Weston Test ID:	Client:	Client Sample ID:
C111027.0242	Port of San Diego	SIYB-3

SPAWNING DATA

Initial Spawning Time:	Final Spawning Time:	Fertilization Time:	No. of Females:	No. of Males:
1115	1310	1312	3	3
Embryo Density (count/mL):	1. 116 / 88	2. 95 / 102	3. 89 / 117	Average: 100.8
Stocking Volume Calculation:	2700/(100.8x 50) = 0.5357 or 53.6 ml			

ZERO TIME COUNTS

1. 208	2. 217	3. 231	4. 219	5. 190	6. 203
Average Count: 211			Technician: KS		

LARVAL COUNT DATA

Conc.	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Date	Initials
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal		
Control	157	12	231	6	217	2	186	6			10/31/11	KS
~~Brine~~												
6.25	210	10	184	3	207	2	190	Ø			11/17/11	BG
12.5	202	7	190	7	179	3	213	4				
25	176	9	195	6	167	8	198	13				
50	198	3	176	6	182	10	206	6				
100	168	14	185	8	199	15	158	28				

QA COUNT CHECKS

	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	12.5 / 2	50 / 3	100 / 1	/
Total #	197	202	184	
# Normal	192	191	165	
Date / Initials	11/28/11 / KS	11/28/11 / KS	11/28/11 / KS	/

QA Check Acceptability: ☒ <5% difference in means of QA & orig. counts

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-5	**Test ID No.:**	C111027.0342

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Results

Concentration	Average Proportion Normal (%)	Average Proportion Alive (%)
Control	96.6	92.8
6.25%	95.6	94.6
12.5%	96.7	99.9
25%	95.7	99.1
50%	96.9	94.4
100%	94.8	95.4

QA Unit 1/5/12 Date

Approved 1/5/12 Date

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-5	**Test ID No.:**	C111027.0342

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis*

Chronic Toxicity - Development

Development data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.10$). Dunnett's Multiple-Comparison Test provided a NOEC (No Observed Effect Concentration) of 100 percent and a LOEC (Lowest Observed Effect Concentration) of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in normal development. The EC_{25} and EC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Chronic Toxicity - Survival

Survival data met the assumptions of normality (Shapiro-Wilk's Test, $p > 0.01$). Variances were equal (Bartlett's Test, $p = 0.04$). Dunnett's Multiple-Comparison Test provided a NOEC of 100 percent test substance and a LOEC of greater than 100 percent test substance.

The Linear Interpolation Method was used to calculate a point estimate for the concentrations causing 5, 10, 15, 20, 25, 40 and 50 percent reductions in survival. The LC_{25} and LC_{50} were both estimated to be greater than 100 percent test substance.

Toxicity, expressed as Toxic Units Chronic (TUc), was 1.

Summary of Results

Species	Exposure	Development		Survival		Tested Substance
		NOEC	EC_{50}	NOEC	LC_{50}	
Mytilus galloprovincialis	48 hrs	100%	>100%	100%	>100%	SIYB-5

Protocol Deviations: The salinity of the 100 percent concentration was above the protocol limit of 30±2ppt. In the associated Reference Toxicant test replicate 4 of the control, replicate 1 of the 2.5ppb concentration and replicate 4 of the 5ppb concentration were found to be outliers and were therefore excluded from statistical analysis.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-5	**Test ID No.:**	C111027.0342

Bivalve Larvae Chronic 48-Hour Bioassay
Weston Testing Protocol No. BIO042
EPA/600/R-95/136
Test Organism: *Mytilus galloprovincialis.*

Test Solution Physical and Chemical Data

Initial				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.2	15.7	29.8	8.2
6.25	7.2	15.9	30.1	8.2
12.5	7.3	15.7	30.3	8.2
25	7.4	15.9	30.7	8.2
50	7.5	15.8	31.4	8.1
100	7.7	15.5	32.8	8.0
24 Hours				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control		14.7		
6.25		14.5		
12.5		14.5		
25		14.8		
50		15.0		
100		14.9		
Final				
Concentration (%)	**D.O. (mg/L)***	**Temp. (°C)***	**Salinity (ppt)***	**pH***
Control	7.5	15.3	30.0	8.0
6.25	7.6	15.3	30.4	8.0
12.5	7.8	15.2	30.7	8.0
25	7.7	15.2	31.1	8.0
50	7.8	15.3	31.5	8.0
100	7.8	15.2	33.3	8.0

*Water quality measured on surrogate chambers.

Weston Solutions, Inc.

Client:	Port of San Diego	**Date Received:**	27 Oct 11
Project:	Shelter Island Yacht Basin	**Date Test Started:**	27 Oct 11
Sample Matrix:	Liquid	**Date Test Ended:**	29 Oct 11
Sample Name/ID:	SIYB-5	**Test ID No.:**	C111027.0342

APPENDIX

Pertinent Test Data

TEST: Chronic 48-Hour Survival/Growth Bioassay with Bivalve Larvae (*Mytilus galloprovincialis.*), EPA/600/R-95/136, Weston Testing Protocol No. BIO042

DILUTION WATER: Control water (zero time). Treated Seawater, Scripps Institution of Oceanography, La Jolla, CA.

Salinity	29.8 ppt
pH	8.2
Dissolved Oxygen	7.2 mg/L
Temperature	15.7°C

TEST ORGANISM: Mussel larvae, *Mytilus galloprovincialis.* Source: Taylor Shellfish, Shelton, WA.

TEST CHAMBER: Four replicates, concentrations of 6.25, 12.5, 25, 50, and 100 percent, plus a seawater control. Test substance volume per replicate = 10 mL.

EXPERIMENTAL DESIGN:

1. Weston Solutions personnel collected a sample on October 26, 2011, at 0920 hours. The sample was received in one 10-liter plastic cubitainer at the Weston Solutions, Inc. laboratory on the following day at 0945 hours. The temperature of the sample upon receipt was 6.0°C.
2. The temperature of the test substance was adjusted to 15 ± 1 °C.
3. Approximately 211 test organisms were placed into each chamber.
4. Test chambers were held at 15 ± 1°C for 48 hours with a photoperiod of 16 hours light, 8 hours darkness.
5. Test substance was not renewed.

MORTALITY CRITERIA: Absence of larvae, or completely developed shells without meat.

ACCEPTABILITY CRITERIA: ≥50% survival of controls; ≥90% normal shell development in surviving controls; minimum significant difference < 25%.

REFERENCE TOXICITY:	Toxicant:	$CuSO_4$, Lot No. 2008506, received 07/13/11, opened 07/28/11, expires 08/31/12.
(control chart included)	Species:	*Mytilus galloprovincialis*, larvae
	48 hr EC_{25}:	11.59 ppb survival, 4.88 ppb proportion normal
	48 hr EC_{50}:	13.06 ppb survival, 5.28 ppb proportion normal
	Laboratory Mean (EC_{50}):	19.61 ppb survival, 7.02 ppb proportion normal
	Test Date:	10/27/11 (within 95% confidence limits)

STUDY DIRECTOR: K. Skrivseth

INVESTIGATORS: K. Skrivseth, S. Hasan, K. Curry, B. Griffith

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	10/27/2011 15:10	Test ID: C111027.0342		Sample ID:	SIYB-5
End Date:	10/29/2011 13:15	Lab ID: CCA-Weston, Carlsbad		Sample Type:	AMB1-Ambient water
Sample Date:	10/26/2011 09:20	Protocol: EPAW 95-EPA West Coast		Test Species:	MG-Mytilus galloprovincialis
Comments:					

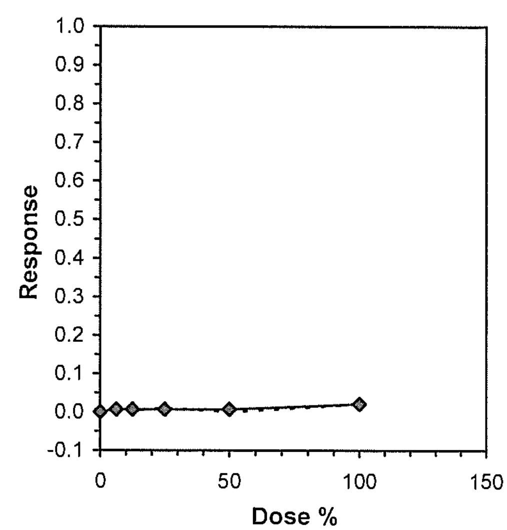
Conc-%	1	2	3	4
Control	0.9290	0.9747	0.9909	0.9688
6.25	0.9901	0.9417	0.9326	0.9583
12.5	0.9696	0.9714	0.9670	0.9583
25	0.9493	0.9463	0.9522	0.9811
50	0.9671	0.9895	0.9521	0.9662
100	0.9515	0.9437	0.9412	0.9565

			Transform: Arcsin Square Root					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.9658	1.0000	1.3951	1.3011	1.4751	5.152	4				0.9682	1.0000
6.25	0.9557	0.9895	1.3679	1.3083	1.4711	5.322	4	0.757	2.410	0.0866	0.9620	0.9937
12.5	0.9666	1.0008	1.3874	1.3652	1.4010	1.132	4	0.213	2.410	0.0866	0.9620	0.9937
25	0.9572	0.9911	1.3660	1.3370	1.4330	3.294	4	0.809	2.410	0.0866	0.9620	0.9937
50	0.9687	1.0030	1.3982	1.3502	1.4683	3.567	4	-0.088	2.410	0.0866	0.9620	0.9937
100	0.9482	0.9818	1.3416	1.3258	1.3607	1.197	4	1.489	2.410	0.0866	0.9480	0.9791

Auxiliary Tests					Statistic		Critical			Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.94303		0.884			0.51867	0.70947
Bartlett's Test indicates equal variances (p = 0.10)					9.33479		15.0863				
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**		**df**
Dunnett's Test	100	>100		1	0.03667	0.03783	0.00187	0.00258	0.61376		5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Dose response relationships are considered reliable.

ToxCalc v5.0.23

Reviewed by:

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	10/27/2011 15:10	Test ID:	C111027.0342	Sample ID:	SIYB-5
End Date:	10/29/2011 13:15	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	AMB1-Ambient water
Sample Date:	10/26/2011 09:20	Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis
Comments:					

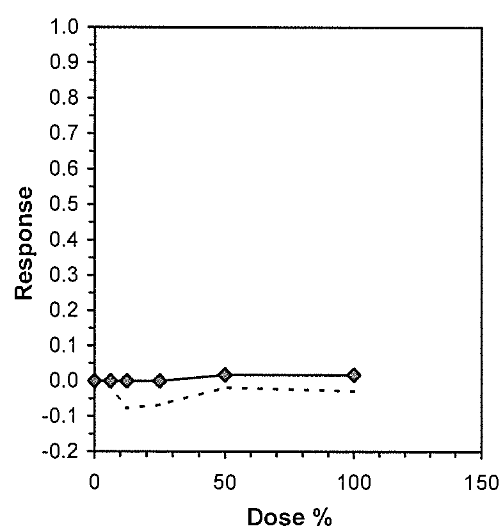
Conc-%	1	2	3	4
Control	0.8009	1.0000	1.0000	0.9100
6.25	0.9573	1.0000	0.9147	0.9100
12.5	1.0000	0.9953	1.0000	1.0000
25	1.0000	0.9716	0.9905	1.0000
50	1.0000	0.9052	0.8910	0.9810
100	0.9763	1.0000	0.9668	0.8720

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.9277	1.0000	1.3618	1.1083	1.5364	15.541	4				0.9656	1.0000
6.25	0.9455	1.0192	1.3599	1.2660	1.5364	9.231	4	0.020	2.410	0.2250	0.9656	1.0000
12.5	0.9988	1.0766	1.5278	1.5019	1.5364	1.128	4	-1.778	2.410	0.2250	0.9656	1.0000
25	0.9905	1.0677	1.4868	1.4014	1.5364	4.324	4	-1.340	2.410	0.2250	0.9656	1.0000
50	0.9443	1.0179	1.3653	1.2343	1.5364	10.572	4	-0.038	2.410	0.2250	0.9491	0.9828
100	0.9538	1.0281	1.3863	1.2050	1.5364	9.882	4	-0.263	2.410	0.2250	0.9491	0.9828

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.95035		0.884		-0.1072	-0.3612
Bartlett's Test indicates equal variances (p = 0.04)					11.728		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.13377	0.13979	0.02163	0.01743	0.33117	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Dose response relationships are considered reliable.

 ToxCalc v5.0.23 Reviewed by:

Test: BV-Bivalve Larval Survival and Development Test | Test ID: C111027.0342
Species: MG-Mytilus galloprovincialis | Protocol: EPAW 95-EPA West Coast
Sample ID: SIYB-5 | Sample Type: AMB1-Ambient water
Start Date: 10/27/2011 15:10 | End Date: 10/29/2011 | Lab ID: CCA-Weston, Carlsbad

Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	211	169	169	157	
	2	2	Control	211	237	237	231	
	3	3	Control	211	219	219	217	
	4	4	Control	211	192	192	186	
	5	1	6.250	211	202	202	200	
	6	2	6.250	211	223	223	210	
	7	3	6.250	211	193	193	180	
	8	4	6.250	211	192	192	184	
	9	1	12.500	211	230	230	223	
	10	2	12.500	211	210	210	204	
	11	3	12.500	211	212	212	205	
	12	4	12.500	211	216	216	207	
	13	1	25.000	211	217	217	206	
	14	2	25.000	211	205	205	194	
	15	3	25.000	211	209	209	199	
	16	4	25.000	211	212	212	208	
	17	1	50.000	211	213	213	206	
	18	2	50.000	211	191	191	189	
	19	3	50.000	211	188	188	179	
	20	4	50.000	211	207	207	200	
	21	1	100.000	211	206	206	196	
	22	2	100.000	211	213	213	201	
	23	3	100.000	211	204	204	192	
	24	4	100.000	211	184	184	176	

Comments:

 ToxCalc 5.0 Reviewed by:

WESTON SOLUTIONS

Bivalve Counts Worksheet

Test ID: C111027.03 SIYB - 5

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	157	12	169
	2	231	6	237
	3	217	2	219
	4	186	6	192
6.25	1	200	2	202
	2	210	13	223
	3	180	13	193
	4	184	8	192
12.5	1	223	7	230
	2	204	6	210
	3	205	7	212
	4	207	9	216
25	1	206	11	217
	2	194	11	205
	3	199	10	209
	4	208	4	212
50	1	206	7	213
	2	189	2	191
	3	179	9	188
	4	200	7	207
100	1	196	10	206
	2	201	12	213
	3	192	12	204
	4	176	8	184

JA

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

CLIENT:	Port of San Diego
PROJECT:	SIYB (Shelter Island Yacht Basin)
CLIENT SAMPLE ID:	SIYB-5
WESTON TEST ID:	C111027-0342
SPECIES:	mytilus galloprovincialis

DATE RECEIVED:	10/~~26~~ 27 JH /11
DATE TEST STARTED:	10/27/11
DATE TEST ENDED:	10/29/11
WESTON SOP NO.:	BT0042
STUDY DIRECTOR:	

	Concentration	meter #	DO* (mg/l)	meter #	Temp* (°C)	meter #	Salinity* (ppt)	meter #	pH*
Day 0 (0 Hours)	Control	3	7.2	3	15.7	5	29.8	2	8.2
Date: 10/27/11	~~Brine Control~~		—		—		—		—
Sample ID: C111027-03	6.25		7.2		15.9		30.1		8.2
Dilutions (Tech): KC	12.5		7.3		15.7		30.3		8.2
WQ Time: 1425	25		7.4		15.9		30.7		8.2
Technician: SH/KC	50		7.5		15.8		31.4		8.1
	100		7.7		15.5		32.8 ① KS		8.0
24 Hours	Control			7B	14.7				
Date: 10/28/11	~~Brine Control~~				—				
WQ Time: 1040	6.25				14.5				
Technician: KC	12.5				14.5				
	25				14.8				
	50				15.0				
	100				14.9				
48 Hours	Control	3	7.5	3	15.3	5	30.0	4	8.0
Date: 10/29/11	~~Brine Control~~		—		—		—		—
WQ Time: 1210	6.25		7.6		15.3		30.4		8.0
Technician: BG	12.5		7.8		15.2		30.7		8.0
	25		7.7		15.2		31.1		8.0
	50		7.8		15.3		31.5		8.0
	100		7.8		15.2		33.3 ① KS		8.0

*Water quality measurements taken in surrogate water quality chambers.
① Salinity above protocol limit of 30±1 ppt. 1/3/12 KS ② WD 1/9/12 JH

START TIME:	1510	Initials:	SH
END TIME:	1315	Initials:	BG
ORGANISM BATCH:	TSF 9788		
HOBO TEMP. NO.:	119279		
TEST LOCATION:	Rm 2		

DILUTION WATER BATCH: SIO 102411

TEST ACCEPTABILITY:

- [x] ≥70% SURVIVAL IN CONTROL (oysters) or 50% SURVIVAL FOR MUSSELS
- [x] ≥ 90% NORMAL SHELL DEVELOPMENT IN SURVIVING CONTROLS
- [x] MSD < 25%

WESTON SOLUTIONS

BIVALVE 48-HOUR CHRONIC TOXICITY TEST

BIO042

Weston Test ID:	Client:	Client Sample ID:
C111027.0342	port of San Diego	SIYB-5

SPAWNING DATA

Initial Spawning Time:	Final Spawning Time:	Fertilization Time:	No. of Females:	No. of Males:
1115	1310	1312	3	3
Embryo Density (count/mL):	1. 116 / 86	2. 95 / 102	3. 89 / 117	Average: 100.8
Stocking Volume Calculation:	2700/(100.8 x 50) = 0.5357 or 53.6 ml			

ZERO TIME COUNTS

1.	2.	3.	4.	5.	6.
208	217	231	219	190	203
Average Count: 211			Technician: KS		

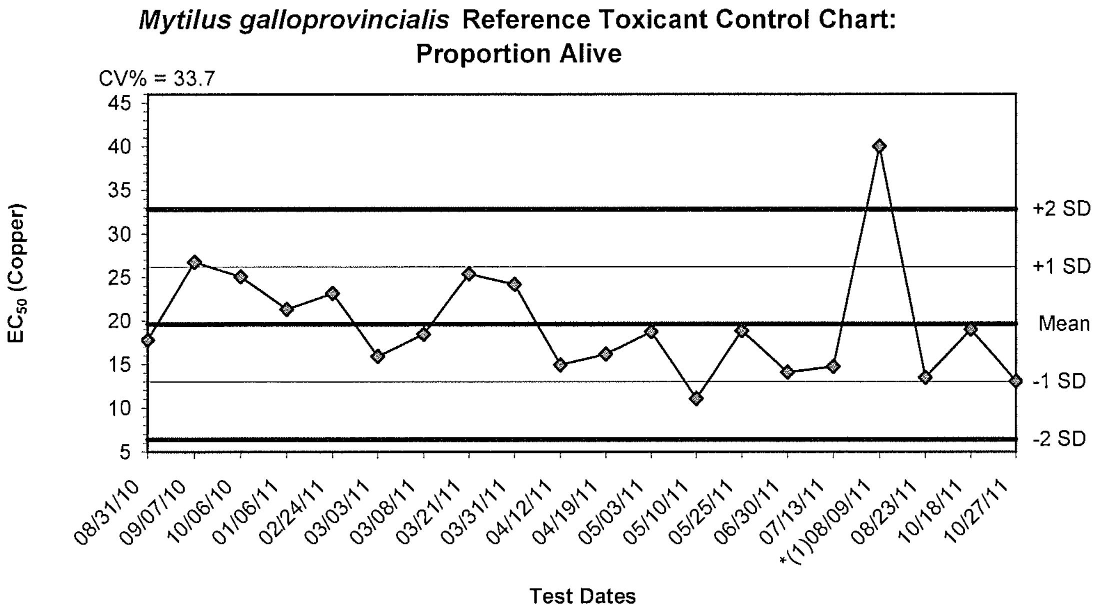
LARVAL COUNT DATA

Conc.	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Date	Initials
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal		
Control	157	12	231	6	217	2	186	6			10/31/11	KS
~~Brine~~												
6.25	200	2	210	13	180	13	184	8			11/17/11	BG
12.5	223	7	204	6	205	7	207	9			11/23/11	BG
25	206	11	194	11	199	10	208	4			↓	↓
50	206	7	189	2	179	9	200	7				
100	196	10	201	12	192	12	176	8				

QA COUNT CHECKS

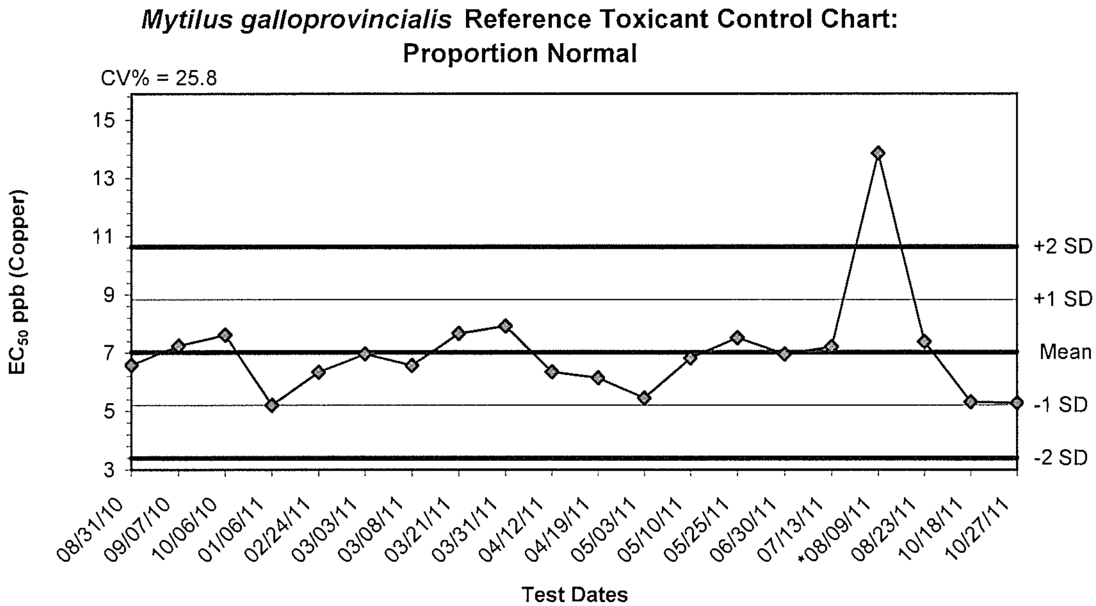
	QA Check #1	QA Check #2	QA Check #3	QA Check #4
Concentration / Replicate	6.25 / 1	25 / 4	100 / 3	/
Total #	205	204	201	
# Normal	203	201	195	
Date / Initials	11/28/11 / KS	11/28/11 / KS	11/28/11 / KS	/

QA Check Acceptability: ☑ <5% difference in means of QA & orig. counts



Dates	Values	Mean	-1 SD	-2 SD	+1 SD	+2 SD
08/31/10	17.8030	19.6051	13.0051	6.4051	26.2051	32.8051
09/07/10	26.7381	19.6051	13.0051	6.4051	26.2051	32.8051
10/06/10	25.0730	19.6051	13.0051	6.4051	26.2051	32.8051
01/06/11	21.3210	19.6051	13.0051	6.4051	26.2051	32.8051
02/24/11	23.1600	19.6051	13.0051	6.4051	26.2051	32.8051
03/03/11	15.9270	19.6051	13.0051	6.4051	26.2051	32.8051
03/08/11	18.4500	19.6051	13.0051	6.4051	26.2051	32.8051
03/21/11	25.3810	19.6051	13.0051	6.4051	26.2051	32.8051
03/31/11	24.1720	19.6051	13.0051	6.4051	26.2051	32.8051
04/12/11	14.9140	19.6051	13.0051	6.4051	26.2051	32.8051
04/19/11	16.1650	19.6051	13.0051	6.4051	26.2051	32.8051
05/03/11	18.7380	19.6051	13.0051	6.4051	26.2051	32.8051
05/10/11	11.0648	19.6051	13.0051	6.4051	26.2051	32.8051
05/25/11	18.8430	19.6051	13.0051	6.4051	26.2051	32.8051
06/30/11	14.0890	19.6051	13.0051	6.4051	26.2051	32.8051
07/13/11	14.7460	19.6051	13.0051	6.4051	26.2051	32.8051
*(1)08/09/11	40.0000	19.6051	13.0051	6.4051	26.2051	32.8051
08/23/11	13.4710	19.6051	13.0051	6.4051	26.2051	32.8051
10/18/11	18.9860	19.6051	13.0051	6.4051	26.2051	32.8051
10/27/11	13.0600	19.6051	13.0051	6.4051	26.2051	32.8051

*Value out of 95% CI range at time of testing.
(1)NOEC used since IC50 gave >40 as a result
Updated 12/19/11 BG



Dates	Values	Mean	-1 SD	-2 SD	+1 SD	+2 SD
08/31/10	6.5794	7.0206	5.2059	3.3913	8.8352	10.6499
09/07/10	7.2430	7.0206	5.2059	3.3913	8.8352	10.6499
10/06/10	7.6168	7.0206	5.2059	3.3913	8.8352	10.6499
01/06/11	5.2082	7.0206	5.2059	3.3913	8.8352	10.6499
02/24/11	6.3415	7.0206	5.2059	3.3913	8.8352	10.6499
03/03/11	6.9707	7.0206	5.2059	3.3913	8.8352	10.6499
03/08/11	6.5694	7.0206	5.2059	3.3913	8.8352	10.6499
03/21/11	7.6651	7.0206	5.2059	3.3913	8.8352	10.6499
03/31/11	7.9275	7.0206	5.2059	3.3913	8.8352	10.6499
04/12/11	6.3555	7.0206	5.2059	3.3913	8.8352	10.6499
04/19/11	6.1428	7.0206	5.2059	3.3913	8.8352	10.6499
05/03/11	5.4518	7.0206	5.2059	3.3913	8.8352	10.6499
05/10/11	6.8235	7.0206	5.2059	3.3913	8.8352	10.6499
05/25/11	7.5181	7.0206	5.2059	3.3913	8.8352	10.6499
06/30/11	6.9573	7.0206	5.2059	3.3913	8.8352	10.6499
07/13/11	7.2116	7.0206	5.2059	3.3913	8.8352	10.6499
*08/09/11	13.8550	7.0206	5.2059	3.3913	8.8352	10.6499
08/23/11	7.3790	7.0206	5.2059	3.3913	8.8352	10.6499
10/18/11	5.3130	7.0206	5.2059	3.3913	8.8352	10.6499
10/27/11	5.2822	7.0206	5.2059	3.3913	8.8352	10.6499

*Value out of 95% CI range at time of testing.
Updated 12/19/11 BG

Bivalve Larval Survival and Development Test-Proportion Normal

Start Date:	10/27/2011 15:27	Test ID: C110713.27		Sample ID:	REF-Ref Toxicant
End Date:	10/29/2011 13:30	Lab ID: CCA-Weston, Carlsbad		Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol: EPAW 95-EPA West Coast		Test Species:	MG-Mytilus galloprovincialis

Comments: Rep 4 of Control, rep 1 of 2.5ppb, rep 4 of 5ppb were found to be outliers using Dixon's Outlier Test and were dropped from stats.

Conc-ppb	1	2	3	4
Control	0.9695	0.9545	0.9536	
2.5	0.9283	0.8785	0.9429	
5	0.6878	0.6528	0.5819	
10	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000

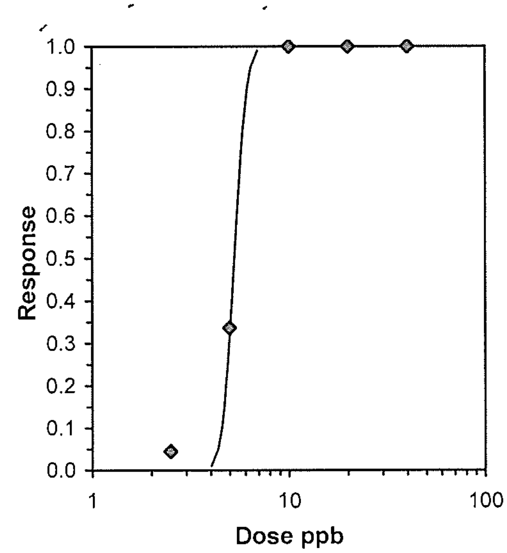
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
Control	0.9592	1.0000	1.3683	1.3537	1.3954	1.713	3				24	589
2.5	0.9165	0.9555	1.2813	1.2148	1.3294	4.644	3	2.171	2.340	0.0938	55	661
*5	0.6409	0.6681	0.9288	0.8677	0.9780	6.041	3	10.961	2.340	0.0938	223	614
10	0.0000	0.0000	0.0375	0.0349	0.0420	8.663	4				723	723
20	0.0000	0.0000	0.3237	0.2255	0.5236	42.060	4				13	13
40	0.0000	0.0000	0.4019	0.3614	0.5236	20.182	4				7	7

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.90905		0.764		-0.563	-0.8498
Bartlett's Test indicates equal variances (p = 0.51)					1.35809		9.21034			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	2.5	5	3.53553		0.04482	0.04671	0.16252	0.00241	7.7E-05	2, 6

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	19.5904	84.4453	-145.92	185.103	0.04075	4.46904	7.81473	0.22	0.72281	0.05105	50
Intercept	-9.1602	59.0249	-124.85	106.529							
TSCR	0.0632	0.00688	0.04971	0.07669							

Point	Probits	ppb	95% Fiducial Limits
EC01	2.674	4.01848	
EC05	3.355	4.3536	
EC10	3.718	4.54353	
EC15	3.964	4.67634	
EC20	4.158	4.78465	
EC25	4.326	4.87957	
EC40	4.747	5.12718	
EC50	5.000	5.28215	
EC60	5.253	5.44181	
EC75	5.674	5.71795	
EC80	5.842	5.83139	
EC85	6.036	5.96645	
EC90	6.282	6.14085	
EC95	6.645	6.40875	
EC99	7.326	6.94321	



 ToxCalc v5.0.23 Reviewed by: KB

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	10/27/2011 15:27	Test ID: C110713.27		Sample ID:	REF-Ref Toxicant
End Date:	10/29/2011 13:30	Lab ID: CCA-Weston, Carlsbad		Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol: EPAW 95-EPA West Coast		Test Species:	MG-Mytilus galloprovincialis

Comments: Rep 4 of Control, rep 1 of 2.5ppb, rep 4 of 5ppb were found to be outliers using Dixon's Outlier Test and were dropped from stats.

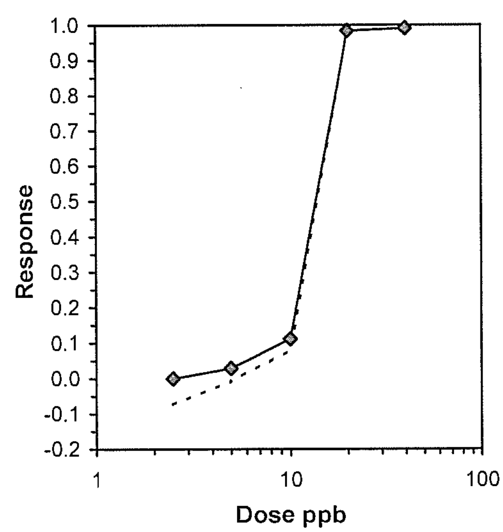
Conc-ppb	1	2	3	4
Control	0.9336	0.9384	0.9194	
2.5	1.0000	1.0000	0.9953	
5	0.8957	0.9147	1.0000	
10	0.9716	0.9526	0.8294	0.6730
20	0.0190	0.0142	0.0237	0.0047
40	0.0047	0.0095	0.0095	0.0095

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
Control	0.9305	1.0000	1.3044	1.2830	1.3200	1.469	3				44	633
2.5	0.9984	1.0730	1.5249	1.5019	1.5364	1.305	3	-2.461	2.602	0.2332	1	633
5	0.9368	1.0068	1.3509	1.2420	1.5364	11.948	3	-0.519	2.602	0.2332	40	633
10	0.8566	0.9206	1.2149	0.9620	1.4014	16.613	4	1.068	2.602	0.2181	121	844
*20	0.0154	0.0166	0.1203	0.0689	0.1546	30.863	4	14.130	2.602	0.2181	831	844
*40	0.0083	0.0089	0.0904	0.0689	0.0975	15.834	4	14.487	2.602	0.2181	837	844

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.88072		0.873		-0.1916	2.3193
Bartlett's Test indicates unequal variances (p = 2.69E-04)					23.518		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Bonferroni t Test	10	20	14.1421		0.14763	0.15862	1.54044	0.01204	9.5E-12	5, 15

Trimmed Spearman-Karber

Trim Level	EC50	95% CL	
0.0%			
5.0%	13.398	13.162	13.638
10.0%	13.605	13.258	13.961
20.0%	13.614	13.478	13.751
Auto-0.9%	13.060	12.816	13.309



ToxCalc v5.0.23

Reviewed by: YB

Bivalve Larval Survival and Development Test-Proportion Alive

Start Date:	10/27/2011 15:27	Test ID:	C110713.27	Sample ID:	REF-Ref Toxicant
End Date:	10/29/2011 13:30	Lab ID:	CCA-Weston, Carlsbad	Sample Type:	CUSO-Copper sulfate
Sample Date:		Protocol:	EPAW 95-EPA West Coast	Test Species:	MG-Mytilus galloprovincialis

Comments: Rep 4 of Control, rep 1 of 2.5ppb, rep 4 of 5ppb were found to be outliers using Dixon's Outlier Test and were dropped from stats. For IC25 only.

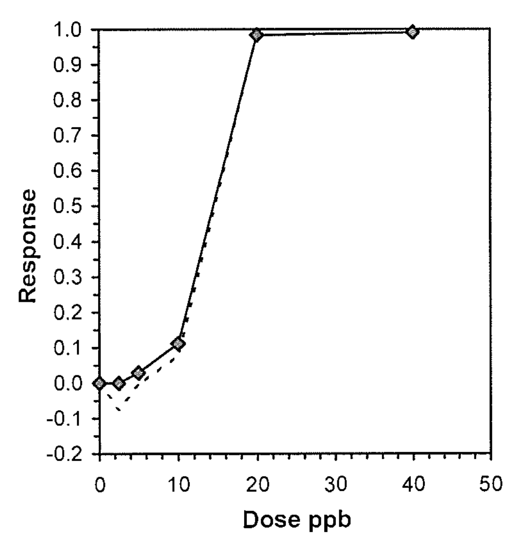
Conc-ppb	1	2	3	4
Control	0.9336	0.9384	0.9194	
2.5	1.0000	1.0000	0.9953	
5	0.8957	0.9147	1.0000	
10	0.9716	0.9526	0.8294	0.6730
20	0.0190	0.0142	0.0237	0.0047
40	0.0047	0.0095	0.0095	0.0095

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-ppb	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
Control	0.9305	1.0000	1.3044	1.2830	1.3200	1.469	3				0.9645	1.0000
2.5	0.9984	1.0730	1.5249	1.5019	1.5364	1.305	3	-2.461	2.440	0.2186	0.9645	1.0000
5	0.9368	1.0068	1.3509	1.2420	1.5364	11.948	3	-0.519	2.440	0.2186	0.9368	0.9713
10	0.8566	0.9206	1.2149	0.9620	1.4014	16.613	4	1.068	2.440	0.2045	0.8566	0.8882
*20	0.0154	0.0166	0.1203	0.0689	0.1546	30.863	4	14.130	2.440	0.2045	0.0154	0.0160
*40	0.0083	0.0089	0.0904	0.0689	0.0975	15.834	4	14.487	2.440	0.2045	0.0083	0.0086

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)					0.88072		0.873		-0.1916	2.3193
Bartlett's Test indicates unequal variances (p = 2.69E-04)					23.518		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	10	20	14.1421		0.13651	0.14667	1.54044	0.01204	9.5E-12	5, 15

Linear Interpolation (200 Resamples)

Point	ppb	SD	95% CL(Exp)		Skew
IC05	6.283	1.814	3.117	12.615	0.8540
IC10	9.291	1.519	4.100	11.645	-0.3152
IC15	10.438	1.118	5.323	11.790	-1.1514
IC20	11.011	0.853	6.894	12.279	-1.3051
IC25	11.585	0.709	8.590	12.769	-1.1046
IC40	13.304	0.544	11.076	14.256	-0.9352
IC50	14.451	0.450	12.590	15.226	-0.9371



ToxCalc v5.0.23

Reviewed by: YS

Test: BV-Bivalve Larval Survival and Development Test						Test ID: C110713.27		
Species: MG-Mytilus galloprovincialis						Protocol: EPAW 95-EPA West Coast		
Sample ID: REF-Ref Toxicant						Sample Type: CUSO-Copper sulfate		
Start Date: 10/27/2011 15:27				End Date: 10/29/2011		Lab ID: CCA-Weston, Carlsbad		
Pos	ID	Rep	Group	Initial Density	Final Density	Total Counted	Number Normal	Notes
	1	1	Control	211	197	197	191	
	2	2	Control	211	198	198	189	
	3	3	Control	211	194	194	185	
	4	1	2.500	211	237	237	220	
	5	2	2.500	211	214	214	188	
	6	3	2.500	211	210	210	198	
	7	1	5.000	211	189	189	130	
	8	2	5.000	211	193	193	126	
	9	3	5.000	211	232	232	135	
	10	1	10.000	211	205	205	0	
	11	2	10.000	211	201	201	0	
	12	3	10.000	211	175	175	0	
	13	4	10.000	211	142	142	0	
	14	1	20.000	211	4	4	0	
	15	2	20.000	211	3	3	0	
	16	3	20.000	211	5	5	0	
	17	4	20.000	211	1	1	0	
	18	1	40.000	211	1	1	0	
	19	2	40.000	211	2	2	0	
	20	3	40.000	211	2	2	0	
	21	4	40.000	211	2	2	0	

Comments: Rep 4 of Control, rep 1 of 2.5ppb, rep 4 of 5ppb were found to be outliers using Dixon's Outlier Test and were dropped from stats

 ToxCalc 5.0 Reviewed by: YB

Dixon's Outlier Test

	Bivalve # Normal	
ordered data	62	<--suspected outlier
(increasing or decreasing values)	126	
	130	
	135	

$$C = \frac{X_{(2)} - X_{(1)}}{X_{(n)} - X_{(1)}} \text{ for } 3 \leq n \leq 7$$

C = 0.876712

Table of critical values of Q

N	Q_{crit} (CL:90%)	Q_{crit} (CL:95%)	Q_{crit} (CL:99%)
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

If the C exceeds the critical value from Table for the specified significance level α, $X_{(1)}$ is an outlier and should be further investigated. C should be compared to Qcrit (CL:95%) column.

Dixon's Outlier Test

	Bivalve # Normal	
ordered data	0	<--suspected outlier
(increasing or decreasing values)	188	
	198	
	220	

$$C = \frac{X_{(2)} - X_{(1)}}{X_{(n)} - X_{(1)}} \text{ for } 3 \le n \le 7$$

C = 0.854545

Table of critical values of Q

N	Q_{crit} (CL:90%)	Q_{crit} (CL:95%)	Q_{crit} (CL:99%)
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

If the C exceeds the critical value from Table for the specified significance level α, $X_{(1)}$ is an outlier and should be further investigated. C should be compared to Qcrit (CL:95%) column.

Dixon's Outlier Test

	Bivalve # Normal	
ordered data	6	<--suspected outlier
(increasing or decreasing values)	185	
	189	
	191	

$$C = \frac{X_{(2)} - X_{(1)}}{X_{(n)} - X_{(1)}} \text{ for } 3 \leq n \leq 7$$

C = 0.967568

Table of critical values of Q

N	Q_{crit} (CL:90%)	Q_{crit} (CL:95%)	Q_{crit} (CL:99%)
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

If the C exceeds the critical value from Table for the specified significance level α, $X_{(1)}$ is an outlier and should be further investigated. C should be compared to Qcrit (CL:95%) column.

Bivalve Counts Worksheet

Test ID: C110713.27 Copper RT

Concentration	Replicate	Number Normal	Number Abnormal	Total Counted
Control	1	191	6	197
	2	189	9	198
	3	185	9	194
	4	6	201	207
2.5	1	0	113	113
	2	220	17	237
	3	188	26	214
	4	198	12	210
5	1	130	59	189
	2	126	67	193
	3	135	97	232
	4	62	123	185
10	1	0	205	205
	2	0	201	201
	3	0	175	175
	4	0	142	142
20	1	0	4	4
	2	0	3	3
	3	0	5	5
	4	0	1	1
40	1	0	1	1
	2	0	2	2
	3	0	2	2
	4	0	2	2

dropped from stats since found to be an outlier

YS

WESTON SOLUTIONS

48 Hour Bivalve Development Reference Toxicant Test

Test ID: 2110713.27	Replicates: 4	Study Director: K. Cong	Location: Rm 2
Dilution Water Batch: S10102411	Organism Batch: TSF 9788	Associated Test(s): S14B	Organism: Mytilus galloprovincialis

Toxicant: Copper Sulfate (0.509gCu/LCuSO$_4$)	Lot #: 2008506	Date Prepared: 9/1/11	Initials: KS

Target Concentrations: 40 ppb	Quantity of Stock: Target: 0.039 mL	Quantity of Diluent: Target: 500 mL
40 ppb	Actual: 0.0392 ml	Actual: 500.0 ml Yfe

Serial Dilute by ½ to obtain concentrations of 20, 10, 5, and 2.5 ppb.

0 Hours Date: 10/27/11 WQ Time: 1430 Start Time: 1527 Initials: SH

STOCK

	Control	2.5	5	10	20	40
D.O. (mg/L)	7.1	7.2	7.2	7.2	7.2	7.3
Temperature	16.1	16.1	15.9	16.0	16.2	15.4
Salinity	29.8	30.0	30.0	30.0	30.0	30.0
pH	8.3	8.3	8.3	8.3	8.3	8.3

48 Hours Date: 10/29/11 WQ Time: 1225 End Time: 1330 Initials: BG

STOCK

	Control	2.5	5	10	20	40
D.O. (mg/L)	7.8	7.8	7.8	7.8	7.8	7.8
Temperature	15.3	16.3	15.0	15.2	15.4	15.2
Salinity	30.1	30.3	31.1	30.6	30.1	30.6
pH	8.1	8.1	8.0	8.0	8.1	8.0

COUNTS

Zero Times	208	217	231	219	190	203	Initials
							KS

Avg: 211

Conc.	Rep 1 Normal	Rep 1 Abnormal	Rep 2 Normal	Rep 2 Abnormal	Rep 3 Normal	Rep 3 Abnormal	Rep 4 Normal	Rep 4 Abnormal	Initials
Control	191	6	189	9	185	9	~~20~~ 6 ①BG	~~179~~ 201	BG
2.5	Ø	113	220	17	188	26	198	12	KS
5	130	59	126	67	135	97	62	123	↓
10	Ø	205	Ø	201	Ø	175	Ø	142	↓
20	Ø	4	Ø	3	Ø	5	Ø	1	BG
40	Ø	1	Ø	2	Ø	2	Ø	2	BG

QA 11/18/11 KS Rep 4 4/204

① Rep counted again after QA 11/28/11 BG

☒ Pass ☐ Fail

Addendum 1

Shelter Island Yacht Basin Dissolved Copper Total Maximum Daily Load 2011 Monitoring and Progress Final Report

Prepared for:
California Regional Water Quality Control Board, San Diego Region

Prepared by:
Weston Solutions, Inc.

In Coordination with:
Port of San Diego

March 2012

Addendum 1

Shelter Island Yacht Basin Dissolved Copper Total Maximum Daily Load 2011 Monitoring and Progress Final Report

Prepared for:
California Regional Water Quality Control Board,
San Diego Region

In Coordination with:

Port of San Diego

Prepared by:

Weston Solutions, Inc.
2433 Impala Drive
Carlsbad, California 92010

March 2012

The purpose of this Addendum is to clarify water quality methods and results reported in the March 2012 Shelter Island Yacht Basin (SIYB) Dissolved Copper Total Maximum Daily Load (TMDL) Annual Monitoring and Progress Report that was prepared in compliance with Investigative Order No. R9-2011-0036. The addendum also provides corrections to the list of references. It should be noted that the information presented in this addendum does not affect the validity of the TMDL-required water quality data (i.e., dissolved copper) or vessel conversion data.

2.0 METHODS

The method detection and reporting limits for total organic carbon (TOC) and dissolved organic carbon (DOC) in Table 2-7 were revised to be consistent with the SunStar Laboratories, Inc. September 29, 2011 Analytical Report (included as Appendix 1).

Table 2-7. Laboratory Analytical Methods and Detection Limits

Water Quality Measurement	Method	Method Detection Limit	Reporting Limit
Total Copper	USEPA 1640	0.01 µg/L	0.02 µg/L
Dissolved Copper	USEPA 1640	0.01 µg/L	0.02 µg/L
Total Zinc	USEPA 1640	0.005 µg/L	0.01 µg/L
Dissolved Zinc	USEPA 1640	0.005 µg/L	0.01 µg/L
Total Organic Carbon	SM5310 B	0.062 mg/L	0.5 mg/L
Dissolved Organic Carbon	SM5310 B	0.062 mg/L	0.5 mg/L

3.0 RESULTS

Results section 3.3.1, entitled Surface Water Chemistry, was revised to include replicate water quality data for station SIYB-1 for dissolved and total copper and dissolved and total zinc for the August 2011 survey (Table 3-2) and dissolved copper for the October 2011 survey (Table 3-3). Replicate 2 water quality data for SIYB-1 were included in the final report, and were used to calculate averages and report ranges in dissolved copper and zinc values. The use of SIYB-1 replicate 1 data would slightly reduce the reported dissolved copper average concentration for the August 2011 survey to 7.46 ± 1.03 µg/L (mean ± standard error).

The revision of the TOC reporting limit from 0.2 mg/L to 0.5 mg/L (Table 2-7) required that the second sentence of the third paragraph of the results discussion in section 3.3.1.1 be modified to read, "TOC ranged from 0.65 to 0.81 mg/L." because TOC was not detected below the correct reporting limit.

TOC and DOC values for the August 2011 survey were originally misreported in the SunStar Laboratories, Inc. Analytical Report that was a component of the Physis Environmental Laboratories, Inc. September 19, 2011 Analytical Report (included in Appendix C of the 2011 SIYB TMDL Final Progress and Monitoring Report). The SunStar Laboratories, Inc. September 29, 2011 Analytical Report corrects the original transcription error and is consistent with the data presented in the Final Report (revised laboratory reports and relevant communications are included as Appendix 1).

It is noteworthy that the DOC values reported by SunStar Laboratories for the October 2011 survey were greater than TOC values at the three SIYB stations that were assessed. While this finding is consistent with the Analytical Report, DOC levels are typically below TOC for a given station since DOC is a component of TOC. Thus, it is possible that DOC and TOC may have been misreported, as originally occurred in the August 2011 survey. It is important to note that DOC and TOC are not considered primary analytes for tracking improvements in water quality in compliance with the TMDL.

Table 3-2. Chemistry Results for SIYB Surface Waters, August 2011 Event.

Station	Dissolved Copper (µg/L)	Total Copper (µg/L)	Dissolved Zinc (µg/L)	Total Zinc (µg/L)	DOC (mg/L)	TOC (mg/L)	Salinity (ppt)[1]	Temp. (°C)[1]	pH[1]
SIYB-1-Rep 1	11.32	14.36	33.126	35.968	0.22	0.81	34.1	21.6	7.9
SIYB-1-Rep 2	11.48	13.8	33.566	33.51					
SIYB-2	7.22	10.53	22.743	25.455	0.23	0.78	34.3	21.2	8.0
SIYB-3	7.55	10.37	22.684	24.377	0.22	0.75	34.2	21.2	8.0
SIYB-4	7.81	10.7	23.842	25.028	0.21	0.74	34.2	21.1	8.0
SIYB-5	8.72	11.19	29.392	30.252	0.21	0.65	34.2	21.0	7.9
SIYB-6	7.48	9.51	23.896	24.895	0.22	0.66	34.1	20.8	7.9
SIYB-REF	2.14	3.05	7.458	8.37	0.23	0.65	34.3	20.4	7.9

[1] *In situ* measurements.

Table 3-3. Chemistry Results for SIYB Surface Waters, October 2011 Event.

Station	Dissolved Copper (µg/L)	DOC, SSL[1] (mg/L)	DOC, CEL[2] (mg/L)	TOC, SSL[1] (mg/L)	TOC, CEL[2] (mg/L)	Free Copper (pCu)[3]	Salinity (ppt)[3]	Temp. (°C)[3]	pH[3]
SIYB-1-Rep 1	8.08	0.55	1.2	0.41	ND	10.47	33.6	17.6	7.7
SIYB-1-Rep 2	7.05								
SIYB-2						10.71	33.7	17.4	7.7
SIYB-3	6.51	0.45	1.3	0.34	1	10.22	33.6	17.4	7.3
SIYB-4						10.37	33.7	17.1	7.7
SIYB-5	5.01	0.38	1.3	0.35	ND	10.09	33.7	17.3	7.7
SIYB-6						10.02	33.7	16.8	7.6
SIYB-REF						10.29	33.6	14.4	7.4

ND Non-detect
[1] SSL – SunStar Laboratories
[2] CEL – Calscience Environmental Laboratory
[3] In Situ measurements

5.0 REFERENCES

The References section excluded the citation for Chadwick et al. 2008, which is provided below. The reference list incorrectly included citations for Neira et al. 2011 and Zirino and Seligman 2002.

Chadwick DB, Rivera-Duarte I, Wang PF, Santore RC, Ryan AC, Paquin PR, Hafner SD, Choi W. 2008. Demonstration of an integrated compliance model for predicting copper fate and effects in DoD harbors. Environmental Security Technology Certification Program (ESTCP) Project ER-0523. Technical Report 1973. SSC Pacific, San Diego, CA.

Appendix 1

SunStar Laboratories, Inc.
September 29, 2011 Analytical Report

The following excerpt from email correspondence between Dan Chavez of SunStar Laboratories and Misty Mercier of Physis Laboratories on September 29, 2011 documents that a re-analysis of the original water samples provided evidence of a data entry error for total organic carbon (TOC) and dissolved organic carbon (DOC).

I had our chemist re-run these samples. It looks like there may have been a data entry error initially, due to the fact that the results for the TOCs are consistently higher than the results for the DOCs (like it should be). I've gone ahead and revised the report, and have attached it to this email.

The revised analytical report is provided as follows.

SunStar
Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

25712 Commercentre Drive
Lake Forest, California 92630
949.297.5020 Phone
949.297.5027 Fax

29 September 2011

Misty Mercier
PHYSIS Environmental Laboratories, Inc.
1904 E. Wright Circle
Anaheim, CA 92806
RE: 1108003-001

Enclosed are the results of analyses for samples received by the laboratory on 08/23/11 16:00. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Daniel J Chavez

Daniel Chavez
Project Manager

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

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Lake Forest, California 92630
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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
SIYB-1	T111152-01	Water	08/22/11 16:35	08/23/11 16:00
SIYB-2	T111152-02	Water	08/22/11 16:25	08/23/11 16:00
SIYB-3	T111152-03	Water	08/22/11 16:15	08/23/11 16:00
SIYB-4	T111152-04	Water	08/22/11 16:10	08/23/11 16:00
SIYB-5	T111152-05	Water	08/22/11 16:00	08/23/11 16:00
SIYB-6	T111152-06	Water	08/22/11 15:40	08/23/11 16:00
SIYB-REF	T111152-07	Water	08/22/11 15:25	08/23/11 16:00

Daniel J. Chavez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

SIYB-1
T111152-01(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.22**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	J
Total Organic Carbon	**0.81**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

SIYB-2
T111152-02(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.23**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	J
Total Organic Carbon	**0.78**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

SIYB-3
T111152-03(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.22**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	J
Total Organic Carbon	**0.75**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	

SunStar Laboratories, Inc.

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Daniel J Chávez

SunStar Laboratories, Inc.
Providing Quality Analytical Services Nationwide

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

SIYB-4
T111152-04(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.21**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	J
Total Organic Carbon	**0.74**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	

SunStar Laboratories, Inc.

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Daniel J Chavez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

SIYB-5

T111152-05(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.21**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	J
Total Organic Carbon	**0.65**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

SIYB-6
T111152-06(Water)

SunStar Laboratories, Inc.

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Dissolved Organic Carbon	**0.22**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	J
Total Organic Carbon	**0.66**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

SIYB-REF
T111152-07(Water)

SunStar Laboratories, Inc.

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Conventional Chemistry Parameters by APHA/EPA/ASTM Methods										
Dissolved Organic Carbon	**0.23**	0.062	0.50	mg/l	1	1082412	08/24/11	08/25/11	SM 5310 B	J
Total Organic Carbon	**0.65**	0.062	0.50	"	"	1081914	08/25/11	08/26/11	"	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Daniel J Chávez

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PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

Conventional Chemistry Parameters by APHA/EPA/ASTM Methods - Quality Control

SunStar Laboratories, Inc.

Analyte	Result	MDL	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1081914 - General Preparation											
Blank (1081914-BLK1)					Prepared: 08/19/11 Analyzed: 08/25/11						
Total Organic Carbon	ND	0.062	0.50	mg/l							
Duplicate (1081914-DUP1)		**Source: T111159-10**			Prepared: 08/19/11 Analyzed: 08/26/11						
Total Organic Carbon	7.72	0.062	0.50	mg/l		7.38			4.60	20	
Batch 1082412 - General Preparation											
Blank (1082412-BLK1)					Prepared: 08/24/11 Analyzed: 08/25/11						
Dissolved Organic Carbon	ND	0.062	0.50	mg/l							
Duplicate (1082412-DUP1)		**Source: T111152-01**			Prepared: 08/24/11 Analyzed: 08/25/11						
Dissolved Organic Carbon	0.246	0.062	0.50	mg/l		0.220			11.2	20	J

SunStar Laboratories, Inc.

Daniel J Chávez

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

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949.297.5020 Phone
949.297.5027 Fax

PHYSIS Environmental Laboratories, Inc.	Project: 1108003-001	
1904 E. Wright Circle	Project Number: 1108003	**Reported:**
Anaheim CA, 92806	Project Manager: Misty Mercier	09/29/11 14:06

Notes and Definitions

J	Detected but below the Standard Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

PHYSIS ENVIRONMENTAL LABORATORIES, INC.

CHAIN of CUSTODY

SEND TO: SunStar

COMPANY NAME: PHYSIS Environmental Laboratories, Inc.	E-MAIL: sc@physislabs.com	PROJECT NAME / NUMBER: 1108003-001	COC PAGE: 1 of 1
PROJECT MANAGER: Misty Mercier	FAX: 714 602-5321	PO #: / PHYSIS SOS #: 1108003	TYPE OF ICE USED: ☑ WET ☐ BLUE ☐ DRY
COMPANY ADDRESS: 1904 E. Wright Circle, Anaheim, CA 92806	PHONE: 714 602-5320 x202 office; 714 335-5918 cell	SAMPLED BY:	SHIPPED VIA: ☐ FEDEX ☐ UPS ☐ USPS ☐ Client ☐ Physis ☑ other

TURNAROUND TIME: ☐ NORMAL ☐ RUSH business days

REPORT FORMAT: ☑ PDF/EDD ☐ SWAMP EDD ☐ other

SPECIAL INSTRUCTIONS:

please report down to MDL

T111152 3.6°

PHYSIS MATRIX CODES

SW = seawater FW = freshwater RW = rainwater
WW = wastewater DW = drinking water
S = sediment T = tissue E = extract O = other (specify)

REQUESTED ANALYSES

PLEASE SEE PHYSIS SOS

lab use		SAMPLE ID	SAMPLE DESCRIPTION	SAMPLE date	SAMPLE time	physis matrix code	no. of bottles	Total Organic Carbon	Dissolved Organic Carbon
	1	SIYB-1		8/22/11	16:35	SW	~~1~~ 4	X	X
	2	SIYB-2		8/22/11	16:25	SW		X	X
	3	SIYB-3		8/22/11	16:15	SW		X	X
	4	SIYB-4		8/22/11	16:10	SW		X	X
	5	SIYB-5		8/22/11	16:00	SW	1	X	X
	6	SIYB-6		8/22/11	15:40	SW		X	X
	7	SIYB-REF		8/22/11	15:25	SW	~~1~~ 3	X	X
	8								
	9								
	10								

HOLD

RELINQUISHED BY print	signature	company	date & time	RECEIVED BY print	signature	company	date & time
Kevin Ward	[signature]	PHYSIS	8/23/11 1600	Dan Marteski	[signature]	SunStar Labs	8/23/11 1600

SunStar Laboratories, Inc.
PROVIDING QUALITY ANALYTICAL SERVICES NATIONWIDE

SAMPLE RECEIVING REVIEW SHEET

BATCH # T111152

Client Name: PHYSIS Project: 1108003-001

Received by: DAN Date/Time Received: 8/23/11 1600

Delivered by: ☐ Client ☒ SunStar Courier ☐ GSO ☐ FedEx ☐ Other ______

Total number of coolers received 0 **Temp criteria = 6°C > 0°C (no <u>frozen</u> containers)**

Temperature: cooler #1 3.8 °C +/- the CF (- 0.2°C) = 3.6 °C corrected temperature

cooler #2 ____ °C +/- the CF (- 0.2°C) = ____ °C corrected temperature

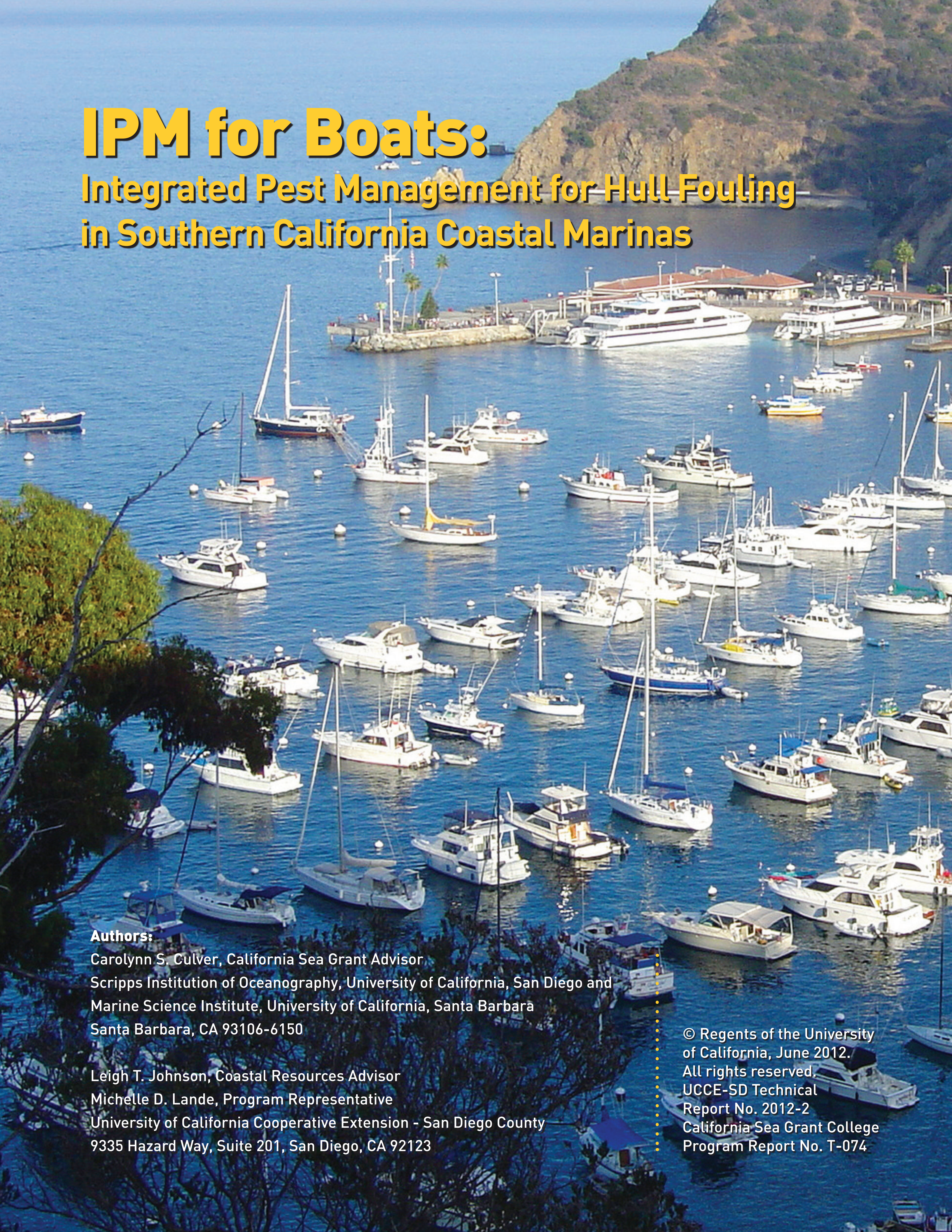
cooler #3 ____ °C +/- the CF (- 0.2°C) = ____ °C corrected temperature

Samples outside temp. but received on ice, w/in 6 hours of final sampling.	☒ Yes	☐ No*	☐ N/A
Custody Seals Intact on Cooler/Sample	☐ Yes	☐ No*	☒ N/A
Sample Containers Intact	☒ Yes	☐ No*	
Sample labels match COC ID's	☒ Yes	☐ No*	
Total number of containers received match COC	☒ Yes	☐ No*	
Proper containers received for analyses requested on COC	☒ Yes	☐ No*	
Proper preservative indicated on COC/containers for analyses requested	☒ Yes	☐ No*	☐ N/A

Complete shipment received in good condition with correct temperatures, containers, labels, volumes preservatives and within method specified holding times. ☒ **Yes** ☐ **No***

* Complete Non-Conformance Receiving Sheet if checked Cooler/Sample Review - Initials and date BC 8/23/11

Comments:



IPM for Boats:

Integrated Pest Management for Hull Fouling in Southern California Coastal Marinas

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PHOTO: R. MATTHEW NEWNHAM


PHOTO: LEIGH JOHNSON

INTRODUCTION

Marine fouling species are organisms that attach and grow on surfaces exposed to salt water, including boats, docks, buoys and lines.[A] They are a nuisance to boaters because they reduce vessel speed and increase fuel consumption. Biofilm (earliest fouling stage) can reduce speed by 3% and increase required shaft power by 10%. Heavy growth can reduce speed by 11% and increase required shaft power by 59%.[1]

Marine fouling species can be transported along coastlines and around the world on the hulls of vessels. Most fouling species begin life as free-swimming larvae in the water column. The larvae grow, age, settle and attach to a submerged surface, such as hulls or docks, where they mature through juvenile stages to adults. Larvae are transported via ballast-water and bait tanks, sea chests, and bilges. Juveniles and adults are transported on hulls or other surfaces (fenders, ropes, etc). Adults that remain on the hull eventually release larvae that attach to other vessels, docks and surfaces.

A Fouling organisms and invasive species are also problems for boats operating in fresh water habitats but they are not the focus of this report. Information on fouling of boats by invasive, Dreissenid mussels in California's fresh water habitats is available at http://www.dfg.ca.gov/invasives/quaggamussel/

Transport of fouling species can be a problem because some species are not native to the areas where they are transported. Non-native (NN) species have caused economic and ecological problems worldwide.[2,3] For example, the marine wood-boring Teredo shipworm is estimated to cost the United States $205 million annually in losses and damages to docks and ships.[4]

Historically, ships have been considered the main vector for moving species across oceans, leading to the establishment of NN species in large ports. Boats are now also recognized as a vector for spreading NN species from major international ports to small craft harbors along the coast.[5] For example a number of invasive species in Elkhorn Slough in Monterey Bay were most likely carried there on hulls of boats returning from the highly invaded, international port, San Francisco Bay.[6] In recognition of these problems, the California Aquatic Invasive Species Management Plan calls for limiting new introductions of aquatic invasive species occurring from recreational boating, fishing and other recreational activities, including introductions from boat hulls.[7]

One goal of this report and the supporting research is to assist boat owners and boating facility managers in addressing invasive species policies when planning boating activities and fouling control programs.

With this in mind and because non-native species can create problems, in this report we identify the origin of the various fouling species relative to the location of our research: south-central and southern California. A native (N) species is believed to have originated in the area where it is found, in this case California. A non-native (NN) species is believed to have originated somewhere other than the area being discussed, in this case outside of California. If the origin of a species is unknown, it is called cryptogenic (C). Some species have not been fully identified by scientists; we refer to them as unresolved (Unr) and no origin can be assigned.

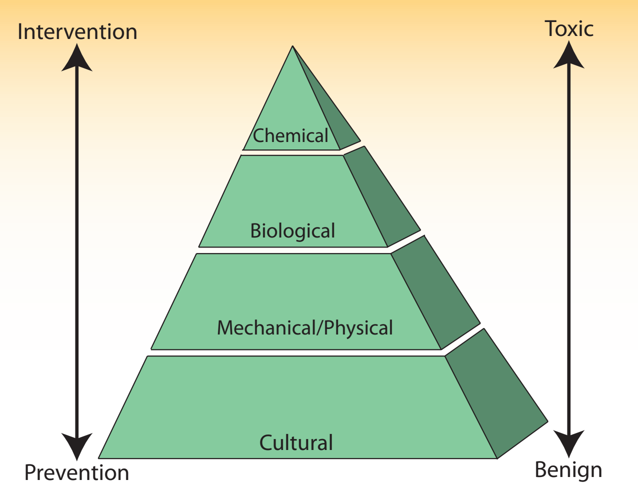
Invasive species typically are NN species that become well established in an area, outcompete N species and/or create problems for boat or harbor infrastructure or operations.[8] They are often referred to as non-native invasive species and in aquatic habitats as aquatic invasive species. They are able to flourish, at least initially, in new areas in part because their natural enemies (parasites, diseases, predators and competitors) are absent.[9,10]

While invasive species are typically NN, not all NN species become invasive everywhere they are introduced. Further, C and Unr species may be considered invasive due to their impacts. Although uncommon, a native species can become invasive, usually as a result of a change in the ecosystem or environment. For example, native sea urchins were considered pests in California giant kelp beds during the 1970s.[11,12]

Antifouling paints are commonly used to deter fouling growth on hulls of recreational and commercial vessels. For many years toxic copper-based paints have been widely applied to ship and boat hulls around the world. However, growing governmental attention to these paints may affect boat owners and boating industries. For example, California regulatory agencies are acting to address accumulation and associated impacts of copper leached from antifouling paints in boat basins.[13,14,15] Washington State passed a bill in 2011 that will restrict copper content of antifouling paints to 0.5% by 2020 for recreational boats up to 65 feet long.[16] Further, scientific literature has reported that some hull fouling species, especially NN, have demonstrated tolerance to copper paints[17] making the paints less effective at reducing fouling.

Thus, a second goal of this report is to assist boat owners in addressing water quality policies and scientific findings related to antifouling paints when choosing fouling control strategies.

FIGURE 1. Pyramid of Integrated Pest Management Tactics[18]



Integrated Pest Management (IPM)

Because of the complexity of factors that influence fouling growth, one control tactic may not be sufficient to manage fouling on boats. We propose applying a terrestrial approach to boating: Integrated Pest Management (IPM). IPM has long been employed to control pests in agriculture and buildings, while reducing the need for chemicals that may affect the environment and human health. An IPM program is a strategy, which uses multiple tactics, such as chemical, biological, mechanical, physical, and cultural as shown in the IPM pyramid (Fig. 1). Our explanations of tactics that can be used to create an IPM strategy are based on several sources.[19,20,21,22] We will discuss how to adapt them for controlling hull fouling on recreational boats. Thus, we introduce **IPM for Boats**. We anticipate this approach will continue to evolve with boaters' experiences, as new tactics become available, and as scientific research continues. Basic concepts of IPM include:

Multiple Tactics

- Chemical tactics include pesticides that kill target pests and limit future populations. They should be applied at the pest's most vulnerable life stage.
- Biological tactics use natural enemies, sometimes called "beneficials" or "biological control agents" to help suppress pest populations. If NN species for biological control are to be released, they must be carefully studied beforehand to ensure they themselves will not become invasive or harm non-target species.
- Mechanical/Physical tactics include mechanical pest removal, using barriers or changing physical factors such as light, temperature, moisture, salinity or surface characteristics.
- Cultural tactics prevent or delay pest outbreaks. Examples include choosing sites that do not favor the pest, removing sources of the pest, making changes that favor beneficial native species, and scheduling management practices to achieve pest management goals.

Multiple Pest Life Stages

- Pest life cycles must be considered in an effective IPM program. Methods may be chosen or combined to target larval, juvenile and/or adult stages of the pest.

Plan, Evaluate, Adjust, Improve

- The IPM program (strategy) should be planned and records should be kept on which, when, where and how specific tactics were used for which pests and life stages, as well as their effects on the pest populations.
- Systematic evaluation and record-keeping may show conditions under which a tactic or strategy (combination of tactics) works well versus conditions under which another tactic or strategy may be needed. The information will enable boaters and facility managers to adjust and improve their strategies over time.

INTEGRATED PEST MANAGEMENT FOR BOATS

The goal of **IPM for Boats** is to balance efficient boating operations with ecosystem health (protecting water quality and preventing the spread of non-native invasive species). In accordance with the IPM concept, we propose an integrated control program (strategy) that targets different life stages of hull fouling organisms using multiple tactics.

Specific recommendations are based on our recent research (see Appendices 2-4), earlier studies[23,24,25,26,27] and scientific literature. Details of our research are provided in Appendices 1-4 and they are referred to where appropriate in the discussion. We investigated the biology of hull fouling species and how they respond to the environment, hull coatings, hull cleaning practices and nearby sources of pest populations.

Based on our studies, we consider a small group of common fouling organisms, regardless of origin, to be "species of concern" in southern California due to their impacts on boating activities and harbor operations. They are considered together when discussing management of fouling on boats.

Photographs and descriptions appear in Appendix 1: "Species of Concern."

The principles of **IPM for Boats**, while based on results in coastal waters of south-central and southern California, can be applied widely if they are adjusted to suit local conditions and fouling species. This program has been developed for salt water boating, where boats typically move from location to location without being removed from the water. This differs from fresh water boating where boats are often hauled out of the water and trailered to other locations. Nonetheless, many of our recommendations could be applied to management of fouling in fresh water systems.

IPM for Boats is a new concept that requires review and modification as additional research results become available. As a first step, we concentrated on factors influencing fouling for boats that rarely move, as our earlier research indicated that this represents about half of California boaters.[28] Additional research on the influence of boat use frequency and cruising speed on fouling is critically needed to make the program applicable to more boaters, as we have suggested in Appendices 2-4.

IPM PROGRAM COMPONENTS

Chemical Tactics

Chemical tactics include pesticides that kill target pests and limit future populations. Because they are the most toxic tactics used in pest control, they appear at the top of the IPM pyramid (Fig. 1). IPM programs seek to limit toxic chemicals by applying them only when needed, at the pest's most vulnerable life stage, and in a way that minimizes their impacts on people and the environment.[29,30,31,32] Therefore, we will suggest ways to reduce toxic chemical use while balancing issues of boating operations, water quality and transport of invasive species.

Toxic hull coatings are the most widely used chemical tactic for fouling control. Much less common are legally permitted liquid chlorine products, used with a slip liner and according to label directions (see below). These tactics target the larval stage, inhibiting settlement and early survival of fouling organisms. Liquid chlorine in slip liners may also kill other life stages of some fouling organisms, including juveniles and adults.[33,34]

When deciding whether to use chemical tactics in an IPM program, boat owners and boating businesses first need to consider regulations and policies regarding use of toxic substances (e.g., antifouling paints and liquid chlorine products). Marina/harbor authorities should be consulted on policies regarding slip liners, as some do not permit them.

Toxic Hull Coatings:[B] When considering toxic hull coatings, a boat owner should take into account travel patterns and slip location. Those who travel regularly over longer distances, and whose boats thus spend less time in the slip, pose a lower risk for leaching antifouling toxins into the water of harbors and marinas. However, because of their frequent travel, they pose a higher risk for transporting invasive species to new areas. Boat owners who fit this profile may wish to include toxic hull coatings in their fouling control strategy, because of reduced impacts on water quality in boat basins. Further, a toxic hull coating will reduce the likelihood of carrying species of concern because fewer organisms will settle on them than on nontoxic coatings (see Appendix 2). Given regulatory concerns and evidence that some species tolerate copper, boat owners may want to consider an alternative toxic coating.

Boats with toxic hull coatings should be located in slips with high water circulation to reduce accumulation of toxins in the harbor. Further, boaters using this strategy should consider only applying toxic coatings to underwater areas that are critical for boat operations and difficult to clean (e.g. water intakes, housing for outdrives). Reducing the amount of toxic coating on the boat will help to reduce water quality impacts.

In contrast, boat owners who travel infrequently or only short distances may want to avoid toxic hull coatings. Because these boats stay in the slip for extended periods, they would be a source of leached toxins if toxic hull coatings were applied. Even though they will become more highly fouled if they use nontoxic coatings

B We refer to metal-based antifouling paints (e.g. copper) as toxic and we refer to epoxy, slick (siliconized) and gel hull coatings that lack such toxins as nontoxic. Our choice of terminology is discussed in, "Crossing Boundaries: Managing Invasive Species and Water Quality Risks for Coastal Boat Hulls in California and Baja California," available at http://ucanr.org/sites/coast/publications.

(see Appendix 2) boats that travel short distances are more likely to carry the same hull fouling species that are already present in nearby areas, posing less risk of introducing new species elsewhere. Such boats represent substantial numbers, as half of California's coastal boats rarely or never leave the home marina[35] and half of California's boats rarely travel more than 100 miles from home.[36] An important and notable exception is short distance travel to offshore islands that are especially vulnerable to invasions.[37,38]

Chlorine Treatment: A legally permitted liquid chlorine product, used with a slip liner and according to label directions, is another chemical tactic for boats with nontoxic hull coatings. An advantage to this method is that the chemical treatment can penetrate hard-to-reach areas where mechanical removal would be difficult. As noted, this method may kill juvenile and adult stages that may already be attached to the boat. Label directions for the liquid chlorine product must be followed closely to ensure that the correct concentration has been achieved and that the concentration has fallen below a specified level before the slip liner is opened to avoid water quality impacts.[C] Poorly maintained slip liners that allow chlorine to leak are a hazard to marine life in the surrounding waters.[39,40]

Biological Tactics

Biological tactics use natural enemies, sometimes called beneficial species or biological control agents, to help suppress pest populations. They may be predators, parasites, pathogens or competitors. If biological control agents, especially those that are non-native, are to be released into the environment, they must be evaluated carefully beforehand to ensure they will not become invasive or harm non-target species. While they are generally less harmful than chemical methods, biological controls still present some risks and are near the top of the IPM pyramid.

Using biological tactics to reduce fouling on boats has received little attention. Applying biological control agents directly to boat hulls is logistically complicated and potentially harmful because they would need to be removed and reapplied or could cause damage to the hull coating. However, predators that consume larvae, juveniles and/or adult fouling organisms could potentially be used as a control tactic for minimizing sources of fouling on docks, piers and other structures. This application would be similar to biological control tactics used to reduce fouling on aquaculture nets and cages at sea.[41,42,43] Careful research would be needed to develop a safe and effective biological control for hull fouling.

Mechanical Tactics

Mechanical tactics include removal of the target pest from the target location (boat hulls in this case) by mechanical means. Hull cleaning that removes juvenile and adult fouling organisms is a fairly benign (and therefore close to the base of the IPM pyramid) yet effective strategy that is widely used in California. Hull cleaning may be performed on land or in the water.

Land-based Hull Cleaning: This tactic could help to reduce risks of introducing invasive species by boats with fouled hulls that are arriving from other regions, as well as for heavily fouled boats that are leaving the home port and traveling to islands or locations far away. The boat is hauled from the water and, typically, washed with a high-pressure water sprayer. It is important to get the small, hard-to-reach areas. Wash waters should be contained and filtered to remove larvae or older stages that may regenerate or release larvae. Removed debris should be disposed in a land fill that does not drain to surface waters. The boat should be left on a stand for several days to dry thoroughly and allow any remaining fouling growth to die.

In-water Hull Cleaning: This tactic is typically performed periodically by certified hull cleaning professionals as part of routine hull maintenance. To clean hull coatings divers typically use hand tools, such as 3M™ pads, or hydraulically powered, rotating brushes. For metal parts they may use scrapers. Best management practices (BMPs) developed by the California Professional Divers Association include cleaning frequently enough to use the gentlest cleaning tool and least amount of effort to remove fouling species.[44] Such practices are beneficial for: 1) extending the life of a hull coating by avoiding the need for more aggressive tools and effort levels; 2) reducing transport of non-native organisms that are reproductively

C Information on liquid chlorine products for slip liners from the April 2007 County of San Diego Department of Agriculture, Weights and Measures, "Official Notice to Dock Masters and Marine Suppliers," is excerpted in our "Alternative Antifouling Strategies Sampler" at http://ucanr.org/coast/Nontoxic_Antifouling_Strategies/. Other regulations may apply in other areas.

PHOTO: LEIGH JOHNSON

Diver uses a soft pad to clean boat hull in water

mature; 3) decreasing survivorship of removed organisms; 4) preventing stimulation of new fouling growth (Appendix 3); and 5) removing algal growth to reduce risk of staining the hull coating (Appendix 4). Research is needed to determine whether fouling organisms survive after being cleaned off the hull. If so, systems for removing and disposing them should be considered.

In California and Baja California, in-water hull cleaning by divers is more cost effective than land-based cleaning as an ongoing tactic. Our economic research found that average costs to haul a boat and clean its hull ranged from about $11 per foot for boats 15-20 feet long to about $13 per foot for boats 51-60 feet long. In contrast, average costs for in-water hull cleaning by professional divers ranged from $1.03 per foot for sailboats up to 25 feet long in Mexico to $2.59 per foot for powerboats 26-40 feet long in California.[D,45]

Another in-water hull cleaning tactic involves driving or towing a boat through a facility that is outfitted with powered brushes. No such facilities were found in California during our economic research.

Physical Tactics

Physical tactics include using barriers or changing physical factors such as light, temperature, salinity, moisture, oxygen or hull coating surface characteristics. They are lower on the IPM pyramid because they are often fairly benign. Thus, they should be considered before tactics that are higher on the pyramid.

Barriers: A slip liner acts as a barrier (when properly employed and maintained) that isolates the boat hull from larval, juvenile and adult stages of fouling species in the surrounding harbor water and on docks. The liner's bag and seals should be inspected for leaks and supporting lines should be taut enough to prevent water from lapping over the sides. Because the outside of the liner can become fouled, it should be cleaned regularly to prevent the liner from sagging and eventually sinking. Consult the vendor for cleaning instructions. Before selecting this tactic, consult harbor or marina management to determine whether slip liners are allowed and policies for using and maintaining them.

Reduced Salinity: Decreasing the salinity of water surrounding the boat to a level that kills fouling pests can be achieved by using a slip liner and adding fresh water. Substituting fresh water for liquid chlorine reduces risks to marine life in nearby waters. Water quality and natural resource agencies should be consulted to determine whether it is permissible to add fresh water to a slip liner.

Desiccation: Desiccation, or the elimination of moisture, kills fouling larvae and, over time, juveniles and adults. This can be applied to boats by allowing the hull to dry for an appropriate amount of time, depending on temperature and humidity, after the boat is used. Examples include storing a boat on a trailer or raising it above the water on a boat lift until fouling organisms die. Wet gear and areas where water accumulates, such as bilges and bait tanks, should be drained and allowed to dry. It may also be advisable to flush the engine cooling

PHOTO: LEIGH JOHNSON

Slip liner creates a barrier around boat hull

D For more economic research results see, "Crossing Boundaries: Managing Invasive Species and Water Quality Risks for Coastal Boat Hulls in California and Baja California," at http://ucanr.org/sites/coast/publications.

PHOTO: SCOTT PARKER

Boat lift isolates hull from water

system.[E] Removing the boat from the water also prevents fouling larvae from reaching the hull between trips. While highly effective and quite benign, these tactics are most feasible for smaller boats. Boat lifts may be cost prohibitive, especially for larger boats,[46] and may not be permitted in some marinas or harbors.

Hull Coating Surface Characteristics: Surface characteristics of nontoxic hull coatings differ from those of copper paints. They do not deter fouling, must be combined with another tactic, and currently require special hull preparation. Thus, a longer service life may be needed to make them cost effective within an IPM strategy.[47] As they are not pesticides,[48] they likely have less impact on water quality than toxic coatings. For more information on nontoxic hull coatings see *Alternative Antifouling Strategies Sampler*.[49]

Nontoxic epoxy coatings are simply very durable. Boat owners who participated in our earlier research reported that nontoxic epoxy coatings lasted for up to 8 years. Copper paints are replaced on average every 2.5 years in San Diego Bay. Owners of a sail boat that received a nontoxic epoxy coating in our earlier research reported that they had saved $2940 versus anticipated costs for a copper paint over an 8-year period.[50,51,52,53]

Surface qualities of "slick" (silicone, siliconized epoxy) coatings cause fouling organisms to attach loosely.[54] They are often called "foul release" coatings because fouling may be removed more easily or, if the boat regularly exceeds 12 knots, they may slough off.[55]

E For more information on dessication and cleaning tactics for recreational boats, see "What boaters can do to help," and, "Boat cleaning guide book," available at http://www.dfg.ca.gov/invasives/quaggamussel/

Cultural Tactics

Cultural tactics prevent or delay pest outbreaks. They include choosing sites that do not favor the pest, removing sources of the pest, making changes that favor beneficial native species, and scheduling (timing) management practices to achieve pest management goals. They are the most benign tactics, and therefore appear at the base of the IPM Pyramid.

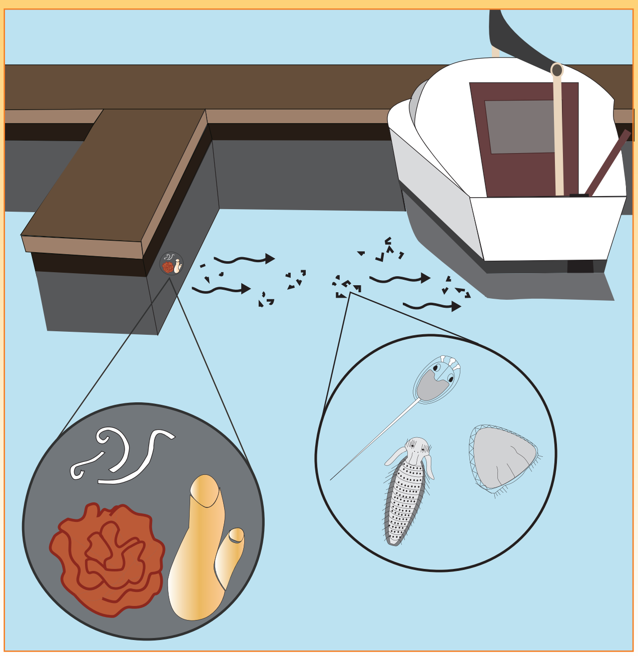
Removing Sources of the Pest: Fouling growth on docks provides a source of larvae to re-infest cleaned boat hulls (Fig. 2). The harbor or marina manager should periodically inspect dock floats and pilings for "hot spots" where species of concern are abundant. Boat owners and hull cleaners may identify hot spots if they notice fouling species that are especially prevalent on their boats or nearby docks. If so, they should advise the harbor or marina manager, who could inspect the dock.

Understanding the harbor's environmental conditions may help in identifying hot spots. For example, we found that the NN bryozoan *Watersipora subtorquata* was more abundant where water flow was faster and the NN tunicate (sea squirt) *Ciona* spp. was more abundant where it was slower (see Appendix 4).

If hot spots are found, the marina or harbor manager may consider cleaning dock floats, pilings and other submerged structures periodically. The goal is to remove reproductively mature organisms to reduce the amount

FIGURE 2. Fouling species of concern on docks release larvae that settle and grow on boat hulls.

GRAPHIC: CHRISTINA WEBB



of fouling species' larvae in and near boat slips.

Cost-effective methods for removing fouling organisms from docks are needed. Focusing on cleaning hot spots will help to contain costs. Research is also needed to determine whether organisms scraped from docks into the water survive and continue to reproduce once released into the harbor. If so, systems for removing and disposing them should be considered.

Boat owners can address other sources of fouling pests in the harbor. They can employ this tactic by: 1) keeping the hulls of their boats cleaned to prevent fouling species from maturing and reproducing; 2) cleaning the outsides of slip liners according to the vendor's instructions; 3) cleaning and flushing bilge and bait tanks;[E] and 4) removing trash, lines and other objects from the water.

Favoring Native Species: Promoting beneficial native species can reduce the success of the pest species.[56] For example, removing NN species when larvae of N species are highly abundant could reduce competition for the N larvae. Further, some NN invasive species are more tolerant than N species of copper antifouling paint.[57] Thus, reducing copper pollution in a harbor may allow non-tolerant N individuals to outcompete copper-tolerant NN individuals on docks and other surfaces. Although reducing copper pollution would not reduce fouling as a whole, it would improve water quality and could help reduce the abundance and potential spread of copper-tolerant, NN invasive species.

Scheduling (Timing) of IPM Tactics: The time of year affects the amount of larvae available to recruit[F] to surfaces on a boat. In our research, more larvae were available from the late spring through early fall (May-October) (Appendix 4). Timing control tactics in accordance with the recruitment of larvae can improve the effectiveness of the overall IPM strategy.

Scheduling Application of Toxic Hull Coatings: A copper antifouling paint may be most effective if it is applied just before this peak recruitment season for many fouling species. However, this may not suffice to control copper-tolerant "species of concern" or species such as *Watersipora subtorquata* that recruit earlier (January-March) than other species in southern California (see Appendix 4). Additional tactics should be applied to control these species where they are abundant.

Scheduling Hull Cleaning: Boat owners should also consider scheduling hull cleaning to improve the effectiveness of control efforts. In particular, our research indicates that hull cleaning frequency should be adjusted for the following factors:

- Type and Age of Hull Coating
- Time of Year
- Harbor and Slip Locations and Conditions
- Travel Plans

Boat use frequency and cruising speed may also affect the hull cleaning schedule. Investigating these factors was beyond the scope of our research discussed in the Appendices.

Type and Age of Hull Coating: In general, boats with newly applied (less than six months) toxic copper coatings will need to be cleaned less often than boats with nontoxic coatings. However, cleaning frequency for copper coatings will need to increase as they age (Appendix 2).

Nontoxic coatings require frequent cleaning regardless of age, as they do not inhibit fouling growth. Further, boats with epoxy and slick nontoxic coatings may require more frequent cleaning in areas where species that recruit strongly to these coatings are abundant. Examples are the NN tube worms *Hydroides* spp. and the NN bryozoan *Watersipora subtorquata* (Appendix 2).

Time of Year: More frequent cleaning is required during the peak recruitment period (May-October in southern California). However some species of concern, such as the copper tolerant NN bryozoan *W. subtorquata*, recruited more heavily during January-March in our study. Where this species is abundant in southern California, hull cleaning should also be frequent during the winter.

Harbor and Slip Locations and Conditions: Both harbor and slip location should be considered when determining cleaning frequency. In temperate climates, boats docked in harbors in warmer water regions will require more frequent cleaning than boats docked in harbors in cooler water regions.[58] This was quite evident during our study, as much less fouling occurred at our northern site (Santa Barbara) than our southern site (San Diego) (Appendices 2–4).

F "Settle" and "recruit" mean that a fouling organism has begun to live on a surface. Although we use the terms interchangeably, settlement technically occurs first.

In a shaded area, the hull may need more frequent cleaning, as invertebrates recruit more heavily to darker areas (Appendix 4). Because most of the NN species identified in our study were invertebrates, frequent cleaning would likely remove them before they could reproduce. Also, some invertebrates become hardened as they mature, requiring more aggressive cleaning tools that increase risk of damage to the hull coating.

Travel Plans: Hull cleaning schedules also should consider travel plans. For example, boats should be cleaned before departing on a trip to a different region, an island or an event attended by boats from many regions. Hulls should also be cleaned before returning from extended stays at other regions or events. This is especially important from May through October in southern California when more fouling larvae are in the water. These actions will help to minimize transport of invasive species.

GRAPHIC: RYAN KRASON AND MICHELLE LANDE

CONCLUSIONS

IPM for Boats can help to minimize impacts on boating and facility operations, costs and ecosystem health by reducing fouling (especially by species of concern), use of toxic materials, and the risk of spreading NN invasive species. This integrated approach recognizes and addresses the complexities associated with the recruitment of fouling organisms on boat hulls and the diversity of boating activities.

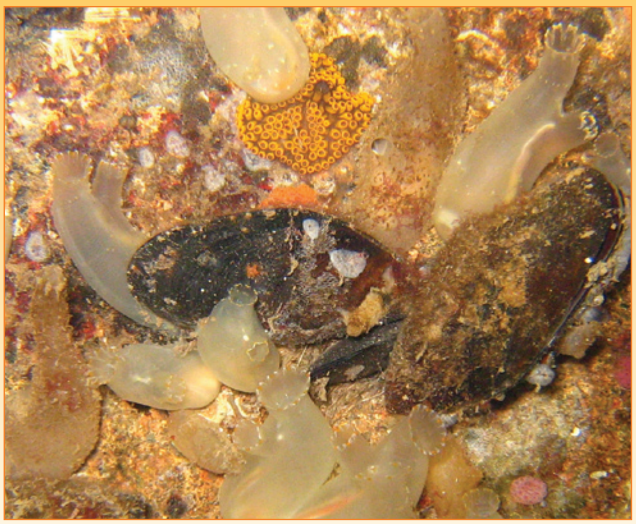
IPM for Boats is not a “one size fits all” approach; it should be tailored to local conditions and individual boating patterns. Boat owners and facility managers will improve their abilities to manage fouling by developing an integrated pest management program (strategy) that takes into consideration location of the facility or slip within the facility, travel patterns, feasibility of various control tactics for the specific situation, and other factors discussed in this report. Implementing a combination of control tactics that target all life stages (larvae, juveniles, adults) can improve effectiveness of the IPM strategy. Further, the IPM program should be evaluated and updated as the boat owner or the boating facility manager learns from experience, from IPM program records, and as additional research becomes available.

APPENDICES

APPENDIX 1. HULL FOULING SPECIES OF CONCERN

During our series of field studies (see Appendices 2-4), we found over 40 fouling organisms at our two study sites in California (Table 1). Seven of them were common, often abundant, and are especially troublesome for boaters or coastal ecosystems. Thus, we consider them to be top marine fouling "species of concern" in southern California.

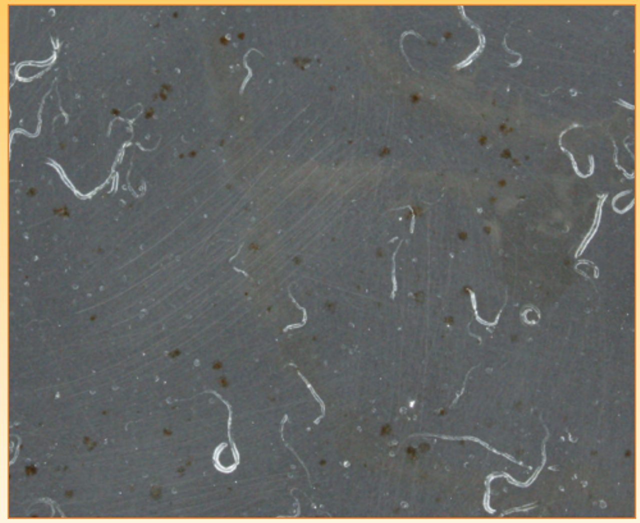
PHOTO: CAROLYNN CULVER



Adult fouling organisms on dock are a source of larvae to infest boats

Most of these species of concern rapidly colonize surfaces, forming very dense accumulations. They are tolerant of copper antifouling paints. They typically outcompete native (N) species for space, thereby reducing survival chances for the N species. All these species of concern compete with N species for microscopic food in the water; some filter food from the water very rapidly and efficiently. When mature, some are difficult to remove, requiring more abrasive cleaning that can reduce the life of the hull coating. Further, the calcareous (calcium carbonate or limestone) tubes of tube worms are a white, gritty material that can scratch hull coatings during cleaning, even when soft pads are used.

PHOTO: CAROLYNN CULVER, LEIGH JOHNSON, MICHELLE LANDE



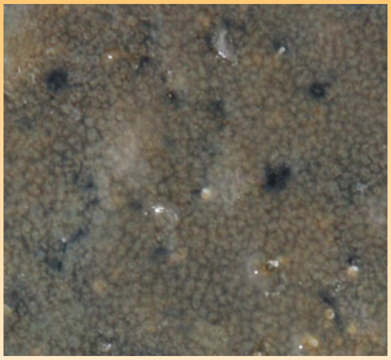
Scars and scratches left by removing *Hydroides* tubes illustrate that removing such hardened structures can damage the hull coating.

Most of these species of concern are non-native (NN), two have unknown origins (C, Unr) and one is native (N). The NN tube worm *Hydroides elegans* and the N tube worm *Hydroides gracilis* can only be distinguished by careful dissection and microscopic evaluation of their internal structure, which we performed for subsamples from our study. *H. gracilis* was rare in the subsamples, so this N species was probably rare overall. In order to process the more than 1000 experimental panels, we were limited to external visual examination to identify species. Thus, we simply identified these two tube worm species as *Hydroides* spp. for the study results. Although it did not settle on our experimental panels, the Asian kelp *Undaria pinnatifida* is also a species of concern in California harbors.[59]

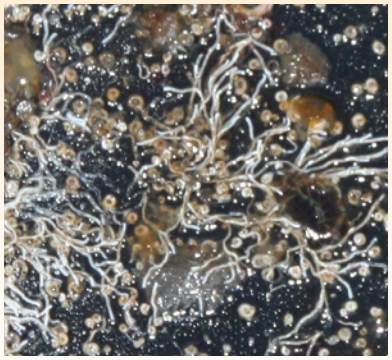
HULL FOULING SPECIES OF CONCERN

PHOTOS: CAROLYNN CULVER, LEIGH JOHNSON, MICHELLE LANDE

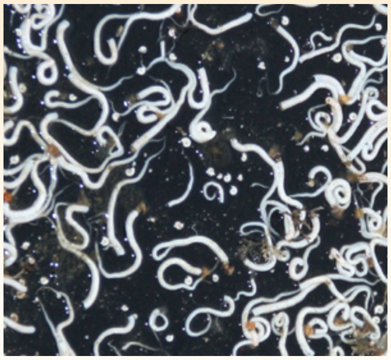
1. *Ciona spp.* (*C. intestinalis*, *C. savignyi*) NN sea squirts (individual tunicates). These two were not identified to the species level. Form large groups of translucent "chimneys." Rapidly filter food from water. Copper tolerant.



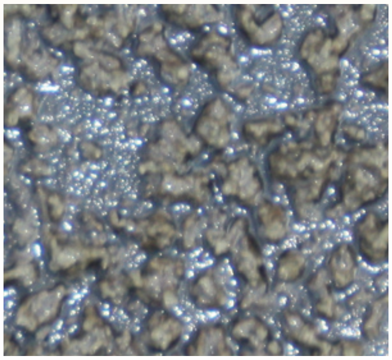
2. *Diplosoma listerianum* NN colonial tunicate. Forms dense, flat, dull-colored, mucous-covered colonies that are difficult to remove. Copper tolerant.



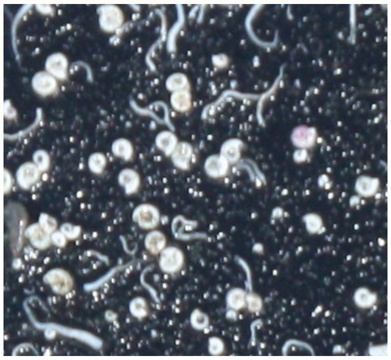
3. *Filograna implexa* NN tube worm. Very thin, long calcareous tubes. Form large aggregations. Copper tolerant.



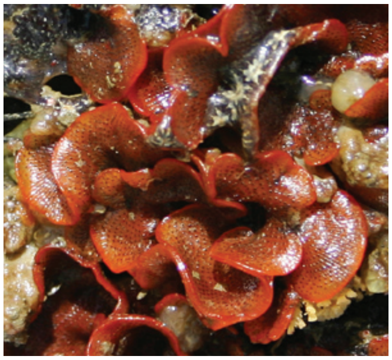
4. *Hydroides* spp. NN (*H. elegans*) and N (*H. gracilis*) tube worms. Form long calcareous tubes that are difficult to remove. Form large aggregations. Copper tolerant. In southern California they are sometimes called South China Seas coral worm, but they are not related to corals.



5. *Laticorophium baconi* C amphipod. Build and live in dense, irregular, brown mud tubes. Copper tolerant. Provides foundation for less copper tolerant species to attach.



6. *Spirorbid* sp. Unr tube worm. Highly abundant. Forms small, semicircular, calcareous spiral tubes that are difficult to remove. Copper tolerant. Often look like small white dots or curls.



7. *Watersipora subtorquata* NN encrusting bryozoan. Forms large masses of pink, orange or reddish, wavy, brittle "petals." Copper tolerant. Provides a foundation for less copper tolerant fouling species to attach.

APPENDIX 2. FACTORS AFFECTING FOULING GROWTH: TYPE AND AGE OF HULL COATINGS

Developing an effective IPM program for boats requires understanding the factors that influence hull fouling. Some factors are directly associated with boats, such as the type and age of hull coatings (this appendix) and hull cleaning practices (Appendix 3). The geographic location of the harbor, the location of the slip within the harbor and environmental factors that vary within harbors also may play a role (Appendix 4). Fouling on nearby docks also produces spores and larvae that can re-infest boats (Appendix 4).

To develop **IPM for Boats**, we conducted a series of experiments to improve understanding of these factors. This and the next two appendices describe the experiments and findings of our research that were used to formulate our recommendations for an integrated fouling control program.

General Methods

Methods common to all experiments are described in this section. Methods specific to a particular experiment are described in the appropriate section.

Experimental Sites:

Experiments were conducted at two coastal sites in southern California. The northern site, Santa Barbara Harbor (SBH), is a small craft harbor for recreational and commercial boats. Sixteen stations were distributed equally among four locations arranged from the outer to inner sections of SBH (Fig. 3a).

The southern site, Shelter Island Yacht Basin (SIYB) of San Diego Bay, is a recreational boat basin. Twelve stations were distributed equally among three locations in SIYB, ranging from outer [Kona Kai Marina (KKM)] to middle [Southwestern Yacht Club (SWYC)] to inner [Half Moon Anchorage (HMA)] sections of this basin (Fig. 3b).

Experimental Design:

Experimental 15 cm x 15 cm (6 in x 6 in) fiberglass panels were coated by a reputable boat repair yard in San Diego, using standard protocols for boats. Coatings represented one antifouling and three nontoxic brands typically used on recreational boats in southern California.[G] All panels received 1) a base, “gel” coating (Cook Composites polyester gel base coat), which is typically applied to the hull beneath the outer coating. Some panels also received one of three additional coatings: 2) Copper-based antifouling paint or hereafter “copper” coating (Interlux Epoxy Modified Antifouling); 3) nontoxic, ceramic epoxy or “epoxy” coating (CeRamKote Marine); or 4) nontoxic, siliconized epoxy or “slick” coating (Eco-5 Marine). All coatings were black (the only color available for all). Although a variety of toxic coatings are available, we focused on copper as it is the most widely used type.

G Product names do **not** imply endorsement.

GRAPHIC: LORIN LIMA

FIGURE 3A. Santa Barbara Harbor: 16 experimental stations (colored dots) organized in 4 locations (Roman numerals)

FIGURE 3B. Shelter Island Yacht Basin: 12 experimental stations (colored dots) organized in 3 locations (marina labels)

GRAPHIC: LORIN LIMA

PHOTO: LEIGH JOHNSON

Attaching experimental frame to dock

PHOTO: CESAR ALVAREZ

Identifying *Hydroides* tube worms to species level by dissecting them

For more information on nontoxic hull coatings see *Alternative Antifouling Strategies Sampler*.[60]

Panels were attached to PVC pipe frames. Frames were bolted to docks at study stations so that panels were submerged 1 m (~ 3 ft) below the water's surface (Fig. 4). The frame size, number of panels per frame, coating types, and the length of time and season left in the water varied according to the aims of each experiment.

Data Collection and Analysis:

Panels were collected at the end of each experimental period. For all but one experiment, fouling (settled or recruited[F] stages) was identified to the lowest taxonomic[H] level possible and quantified by the percentage cover of colonial fouling organisms[I,61] and the density (counts per panel) of individual organisms. Species were identified as native to the area (N), non-native (NN), cryptogenic (unknown origin) (C) or as unresolved (Unr) for organisms whose taxonomy has yet to be clarified.[62,63,64] Table 1 lists the species found on panels in our study, organized in their taxonomic groups. For the one experiment (hull cleaning) where we did not use these methods, we determined the amount of fouling on the panels by scraping off the fouling, drying the resulting material and then weighing it to measure the biomass of fouling organisms.

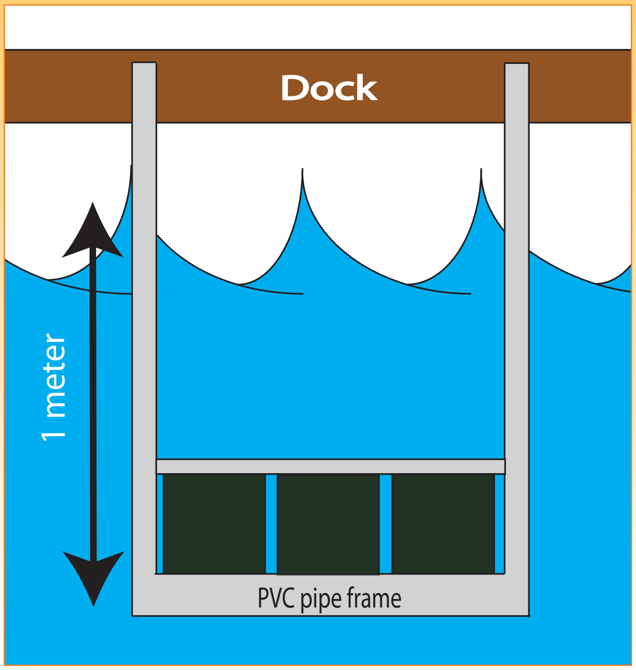
At each station we also measured several environmental parameters that were known to influence where and how abundant a species may be:

- water temperature[65,66,67]
- salinity[68]
- water motion or flow[69]
- shading[70,71]
- nearby members of the same species[72,73]
- proximity to the seafloor (i.e. water depth)[74]

We used submersible data loggers to continuously

GRAPHIC:MICHELLE LANDE

FIGURE 4. Experimental frame design



H Taxonomy is a system for classifying (organizing) living things into related groups. A phylum is a high taxonomic level, e.g. brown algae (kelp, etc.) or mollusks (mussel, abalone, squid, etc.). The species is the basic unit of taxonomy. Each species belongs to a genus and is called by its genus and species names, which are italicized, e.g. *Filograna implexa*. If the species is uncertain, the genus will be followed by sp. or spp. for one or more species. After the first time a species is mentioned the initial of the genus may be used, followed by the species name (e.g., *F. implexa*).

I A "colonial" invertebrate species lives in a matrix. Coral reefs are well-known examples. Many bryozoans are colonial, such as *Watersipora subtorquata*. In contrast tube worms, such as *Hydroides* spp., are "individuals," although large numbers may live close together.

TABLE 1. Species recruiting to panels. Origin: C = cryptogenic; N = native; NN = non-native; Unr = unresolved; UnID = unidentified. Coating Type: E = nontoxic epoxy; S = nontoxic slick; G = nontoxic gel base; C = toxic copper. X = Species present. Asterisks: * = very rare species found on only one nontoxic panel at one time at a site; ** = rare species found on one to five panels. Diamonds: ◆ = species found on only one copper panel at one time at a single site; ◆◆ = species that did not recruit directly to copper panels. Species with names in **bold** occupied the most space **on copper** over time. Results from two experiments are shown in the table:1) 1-month (at a time) submersions over a year for sets of 4 coatings at all 28 stations and 2) 3-, 6- and 12-month continuous submersions for copper coating at KKM and HMA, only.

			Submersion Time and Coating Type Results						
			1) Occurred at any of 28 stations				2) KKM and/or HMA		
Phyla	**Species**	**Origin**	**1 mo E**	**1 mo S**	**1 mo G**	**1 mo C**	**3 mo C**	**6 mo C**	**12 mo C**
ALGAE									
Chlorophyta	*Cladophora sp.*	Unr	X	X	X	X**			
	Colpomenia sp.	Unr	X	X	X			X◆	
	Ectocarpacea	Unr	X	X	X				
	Enteromorpha sp.	Unr	X	X	X	X**			
	Green monofilament	UnID					X◆		
	Ulva sp.	Unr	X**	X**	X**				
Rhodophyta	***Rhodymenia pacifica***	N			X*			X◆◆	X
	Antithamnion sp.	Unr	X	X	X				
INVERTEBRATES									
Annelida	***Filograna implexa***	NN	X	X	X		X	X	X
	Hydroides spp. complex *H. elegans, H. gracilis*	NN, N	X	X	X	X**	X	X	X
	Myxicola sp. A - Harris	Unr	X*						
	Sabellid (likely *Pseudopotamilla* sp.)	UnID	X*			X**			
	Spirorbid sp.	Unr	X	X	X	X**	X	X	X
Mollusca	*Mytilus* sp.	UnID	X*						
Chordata[A]	***Aplidium californicum***	N	X	X	X				X
	Botrylloides diegensis	N	X	X	X				X◆
	Botrylloides violaceus	NN	X	X	X				X◆
	Botryllus schlosseri	NN	X	X	X				
	Ciona spp. C. intestinalis or C. savignyi	NN/ NN	X	X	X		X◆		X
	Diplosoma listerianum	NN	X	X	X	X**	X◆		X
	Styela clava	NN	X						
	Styela plicata	NN	X	X	X				
	Molgula sp. (most likely *M. ficus* or *M. verrucifera*)	Unr	X**	X**					
	Unidentified tunicates (n=3)	UnID	X	X	X**				
Crustacea[B]	***Laticorophium baconi*** (amphipod with tube mats)	C	X	X	X	X◆	X	X	X
Bryozoa[C]	***Bowerbankia* sp.**	Unr	X	X	X		X	X	X
	Bugula californica	N	X	X	X				X
	Bugula neritina	NN	X	X	X			X	X
	Celleporaria brunnea	N	X	X	X			X◆	
	Crisulipora occidentalis	N	X	X	X				X◆
	Cryptosula pallasiana	NN	X	X	X				X◆
	Membranipora sp.	Unr	X	X	X				
	Thalamoporella californica	N	X	X	X			X◆	
	Tubulipora sp. (Either T. *tuba* or *T. pacifica*)	N	X	X	X				
	Watersipora subtorquata	NN	X	X	X			X	X
Porifera	Unidentified sponges (n=2)	UnID		X**	X*				X◆

[A] All species listed as Chordata belong to a sub-phylum Urochordata, also known as tunicates.
[B] Crustacea is a sub-phylum of the Arthropoda. [C] Bryozoa is also known as Ectoprocta.

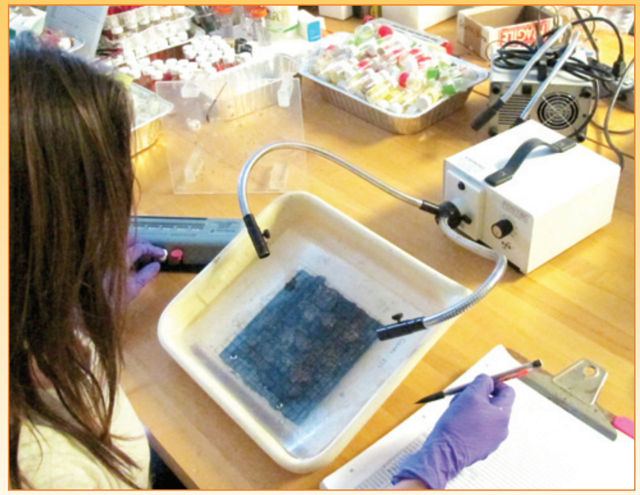
record water temperature, a refractometer for salinity, SLODS™ cards[J,75] for water flow, and a tape measure for determining water depth. Presence of nearby members of the same species was determined by taking photographs of three, small panel-sized (15 cm x 15 cm) sections of the dock where the frame was later attached after the fouling organisms were removed. The percentage of cover of fouling organisms on each dock section was quantified from the photographs. Shading was not directly measured. However, all frames were arranged facing northeast in SBH and northwest in SIYB, so that the fronts of all panels received similar angles of light during the day. The backs faced the shaded undersides of the docks.

Does the Type of Hull Coating Matter?

We studied the influence of different types of hull coatings on fouling recruitment over one-month periods. In general some coatings fouled more heavily and certain species were more abundant on specific coatings.

Using methods described above, we placed sets of four panels in the water on experimental frames at all 28 study stations in both harbors. Each set had one panel with the toxic copper coating, one with the nontoxic epoxy coating, one with the nontoxic slick coating; and one with the nontoxic gel base coating. At the end of each month in the water, they were removed and replaced with sets of fresh new panels. This was repeated 12 times over the span of a year (July 2008-June 2009).

Only a few species (Table 1) recruited to the copper panels during the 12, one-month intervals. Two are NN species: the colonial tunicate *Diplosoma listerianum* and the tube worm *Hydroides elegans*. It is possible, but less likely that the N tube worm *Hydroides gracilis* may have been present but was mixed in with the NN *H. elegans*. (Table 1) The amphipod *Laticorophium baconi* is C. The remaining species found on the panels are Unr: a sabellid worm that could not be fully identified; spirorbid tube worms; and two types of algae, *Cladophora* sp. and *Enteromorpha* sp. Recruitment of these species was quite low. They occurred on only 13 of the 672 panels. Generally, colonial species like the tunicate *D. listerianum* covered less than 1%-2% of the panel surface and there were just a few (on average 2-4) individual *Hydroides* spp. tube worms. Apparently, these species tolerate copper,



Counting fouling organisms using grid placed over experimental panel

PHOTO: CAROLYNN CULVER

having settled so quickly (within one month) on surfaces with newly applied toxic paint.

In contrast, the nontoxic coatings were readily fouled by many species (Table 1). About 20% of the fouling on the panels at the northern site SBH, and 30% at the southern site SIYB, was comprised of NN species. At both sites the most abundant NN species were the branching and encrusting bryozoans *Bugula neritina, Watersipora subtorquata* and *Cryptosula pallasiana,* the tube worm *H. elegans*, and the colonial tunicates *D. listerianum* and *Botrylloides violaceus*. At SIYB two more NN species also were common: the tube worm *Filograna implexa* and the colonial tunicate *Botrylloides schlosseri*.

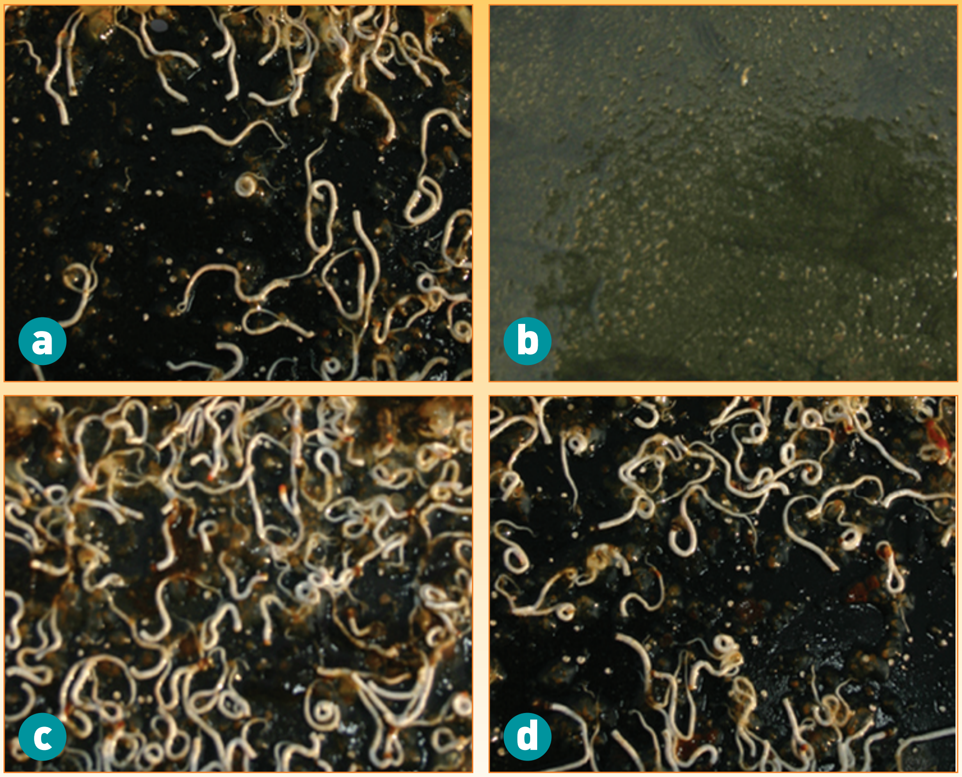
Although only a few tube worms occurred on the panels with toxic copper coatings, many occurred on the panels with nontoxic coatings. At both sites spirorbid worms were the most abundant, averaging hundreds per panel. *Hydroides* spp. tube worms were also common, averaging 10-30 per panel. At SIYB there were also many NN *Filograna implexa* tube worms, averaging 16 per panel.

At both harbors, fouling was generally similar on the panels with the various nontoxic coatings. At SIYB there were two exceptions: 1. recruitment of the NN encrusting bryozoan *Watersipora subtorquata* was higher on the slick and epoxy coatings than on the gel coating; and 2. recruitment of the *Hydroides* spp. tube worms was also higher on the panels with the epoxy coating than on the slick or gel-coated panels. These exceptions occurred in SIYB only, and not in SBH, possibly due to lower abundance of these fouling species there.

These findings illustrate how the amount and type of

J A SLODS™ card is composed of molded plaster affixed to a hard plastic "card" that can be attached to an experimental frame. Plaster is lost from the card at a rate that is proportional to the speed of water flowing over it.

PHOTOS: CAROLYNN CULVER, LEIGH JOHNSON, MICHELLE LANDE



Panels with (a) gel, (b) copper, (c) epoxy and (d) slick coatings allowed to foul for one month. Note more recruitment of *Hydroides* spp. to epoxy

control fouling effectively without periodic hull cleaning.

To answer these questions we deployed another set of panels in SIYB at 4 stations in the inner location (HMA) and 4 stations in the outer location (KKM). All panels were coated with the copper coating (over a gel-coat base) and allowed to foul for 3, 6 or 12 months. Using the methods described above, we compared fouling on these panels over time.

After twelve months, two species that were common to both SIYB locations occupied the most space on the copper panels: the C amphipod *Laticorophium baconi*, as evident from tube mats it made, and the NN colonial tunicate *Diplosoma listerianum*. Eight more fouling species were common on the panels, but they did not all occur at both locations.

fouling can be affected by the type of hull coating. The toxic copper coating clearly had less fouling than the nontoxic coatings, although some fouling still occurred and included NN organisms. The three nontoxic coatings (epoxy, slick and gel) were not effective at decreasing fouling. Further, recruitment of two species of concern was higher on the epoxy and/or slick coatings than the gel base coating. This suggests that some fouling organisms preferred the surface characteristics of these coatings. Thus, both toxic and nontoxic coatings represent a risk for spreading invasive species. While this risk is higher for the nontoxic coatings, they are not considered pesticides in California.[76] Thus, they likely have less impact on water quality than toxic coatings.

How Important Is the Age of a Hull Coating?

As shown above, fouling was greatly reduced on panels with newly applied, toxic copper coatings submerged for a short (1 month) time. Given that copper coatings are designed to leach (lose) copper, we wanted to determine whether more fouling would occur as it aged. And, as some non-native species are known to be copper-tolerant,[77] we wanted to know whether NN species would appear first and cover more of the panels over time than N species. Further, we wanted to test reports that a copper coating could

The amount of space that the commonly occurring species covered increased substantially over time. Particularly striking was the increase in space covered by the amphipod *L. baconi* tube mats from 3 months to 6 months and that remained high after 12 months. An increase in cover from 6 months to 12 months was also evident for the the NN encrusting bryozoan *Watersipora subtorquata* at KKM and the Unr encrusting bryozoan *Bowerbankia* sp. and the NN tube worm *Filograna implexa* at HMA.

Five more species were detected only after 12 months of submersion at one or both locations: NN *Diplosoma listerianum* (HMA), N *Aplidium californicum* (both sites), NN *Filograna implexa* (KKM), NN *Bugula neritina* (KKM) and N *Bugula californica* (KKM). These species may have settled so late due to a lack of larvae in the area or a sensitivity to copper. For NN *D. listerianum* at HMA, and for NN *B. neritina* and NN *Filograna implexa* at KKM, it was likely that a lack of larvae at the particular location delayed recruitment, as each had settled earlier on the copper panels at the other location.

However, at HMA, only a few NN *F. implexa* tube worms occurred on the copper panels after three months of exposure. This was surprising, as many of these worms

Accumulation of fouling as copper panels age (a) 3, (b) 6 and (c) 12 months

PHOTOS: CAROLYNN CULVER, LEIGH JOHNSON, MICHELLE LANDE

settled on the nontoxic coatings during the same time. Further, one year later during the same time of year and after 12 months of exposure, hundreds of these tube worms settled on the aged copper panels. This finding suggests that the worms may have been more sensitive to the younger copper coating, but that they were able to tolerate the more aged copper coating. N *Bugula californica* also may be more sensitive to copper as this species did not occur at either site until panels were submerged for 12 months.

Interestingly, recruitment of the N red algal species *Rhodymenia californica* was aided by the presence of the NN bryozoan *Watersipora subtorquata*. The N alga was found on top of the NN bryozoan on copper panels after being submerged for only 6 months at KKM. It wasn't until after 12 months of submersion at KKM that this alga recruited directly onto the copper panels. Also at KKM the N bryozoan *Bugula californica* recruited on top of NN *W. subtorquata* but not until the copper panels had been submerged for 12 months. The N bryozoan *B. californica* also recruited directly onto some copper panels submerged for 12 months. These findings illustrate how one copper tolerant species may provide a foundation to which less tolerant species may attach.

These data also suggest that the copper coating was less toxic after being submerged for 12 months, presumably due to decrease in the toxin by leaching over time. This conclusion is supported by the fact that some species did not attach directly to the panel until the panel was submerged for more than 6 months.

In general, NN species appeared sooner than N species on copper panels, albeit at very low levels. At KKM after 3 months of submersion the NN colonial tunicate *Diplosoma listerianum*, but no N species, had fouled the panels. At HMA three NN species and possibly one N species fouled the panels within three months: NN *Ciona* spp., NN *Filograna implexa,* NN *Hydroides elegans* and possibly N *Hydroides gracilis*.

Overall, more NN than N species occupied space on copper panels submerged for 12 months. At HMA five NN species (*Diplosoma listeranium*, *Filograna implexa*, *Watersipora subtorquata*, *Bugula neritina* and *Hydroides elegans*), but only one N species (*Aplidium californicum*), recruited to the 12-month panels. At KKM five NN species (*D. listeranium*, *F. implexa, W. subtorquata*, *B. neritina*, and *Ciona* spp.) and three N species (*Rhodymenia californica*, *Bugula californica*, *A. californicum*) recruited to the 12-month copper panels. Four of the five NN species were the same for both locations.

At KKM after 12 months NN species covered significantly more space than N species on copper panels. At HMA a similar trend for higher recruitment of NN than N was also evident. Results at HMA were not statistically significant, likely because there was greater variation in recruitment among panels at those four experimental stations.

These results clearly show that as a copper coating ages, its ability to control fouling is reduced; increased fouling levels occurred as soon as six months. Further, NN species that can tolerate copper are first to settle on the surfaces and they become more abundant over time. Thus, NNs may be more readily spread on boats with a copper hull coating if the fouling is not removed within six months after the paint was applied.

APPENDIX 3. FACTORS AFFECTING FOULING GROWTH: HULL CLEANING

As we have shown (Appendix 2), hull coatings, no matter the type, do not entirely prevent fouling. Additional tactics are therefore needed to help control fouling. In-water hull cleaning is commonly practiced in California to help control fouling and maintain boat performance. However, scientists in Australia published studies that concluded hull cleaning practices promoted the next generation of fouling organisms. That is, experimental panels that were cleaned by Australian methods had more new fouling than uncleaned panels.[78] Different hull cleaning practices are used in California, but their effectiveness had not been assessed scientifically.

Are California hull cleaning practices effective?

We designed a hull cleaning experiment to quantify the effects of California hull cleaning practices on fouling growth. We used the California Professional Divers Association's (CPDA's) best management practices (BMPs).[79] They call for cleaning hulls as often as necessary in order to use the most gentle cleaning tool possible. In contrast, the Australian scientists allowed fouling to grow for seven months and then removed it with a scraper, which is an abrasive tool, and left behind traces of organisms.

This experiment was conducted at one location in SBH and two locations in SIYB, for four warm-water months, when fouling rates are high. Sets of nine panels were used at four stations at each location. The nine panels included 3 coating types (copper, epoxy and slick) and 3 cleaning treatments, described below. Each time we cleaned any of the panels, we used the 5-point scale of the CPDA's BMPs (Table 2) to assess the level of

TABLE 2. Five-point Scale of the California Hull Cleaning Best Management Practices[81,82]

*	Coating Condition	Fouling Growth	Cleaning Tool***,****	Diver Effort
1	New, slick finish, still shiny if appropriate to type of coating	Light silting (looks like dust) that can be brushed off with a piece of carpet. Some plumes of discoloration.	Use for Level 1 Fouling Growth: a. Carpet, soft, medium to long shag b. White pad, soft c. Soft nylon bristle brush, bristle thickness .028-.032 d. Soft polypropylene brush, bristle thickness .022-.032	Light pressure: very easy to remove growth with one wipe
2	Shine is gone or surface is lightly etched on all of coating, no physical blemishes or defects	Moderate silting (a solid, discernible, physical layer) that must be removed with a soft brush or green 3M® pad.	Use for Level 2 Fouling Growth: a. Green pad, medium b. Nylon bristle brush, medium, bristle thickness .040	Light to medium pressure: still easy to remove growth but may require two or more passes in some areas to remove growth
3	Some blemishes or defects in coating on up to 20% of boat bottom	Dark algae impregnation. Algae must be scrubbed off; can't just wipe it off.	Use for Level 3 Fouling Growth: a. Purple pad, medium b. Nylon bristle brush, medium, bristle thickness .050	Light scrub, firm effort: firm wipe and/or multiple wipes or passes with brush to remove growth
4	Some blemishes or defects in coating on 20%-50% of boat bottom	Hard growth. Need heavier tools, such as steel wool, plastic and metal scrapers.	Use for Level 4 Fouling Growth: a. Brown pad, coarse b. Black pad, coarse c. Stainless steel row bristle brush	Firm scrub, hard effort: firm scrub and continuous passes required to remove fouling growth
5	Blemishes or defects on over 50% of boat bottom	Lengthy, soft algae and hard, tube worms and possibly barnacles impregnating the coatings. Coral** growth can be seen to extend out from the hull. Clean with metal scrapers and stainless steel brushes.	Use for Level 5 Fouling Growth a. Steel pad, abrasive b. Flat wire bristle brush, very coarse c. Whirlaway® tool, very abrasive	Hard scrub, very hard effort: even with hard physical effort, growth presented a challenge to remove with pad or brush

* 1 is best condition; 5 is worst condition
** Coral is a common name used in San Diego for tube worms, e.g. *Hydroides* spp.
*** Carpet and pads are hand operated tools; brushes and Whirlaway® are powered tools.
**** In practice, choice of tool did not always correspond to fouling growth level.

GRAPHIC: RYAN KRASON

FIGURE 5. Procedure for hull cleaning experiment

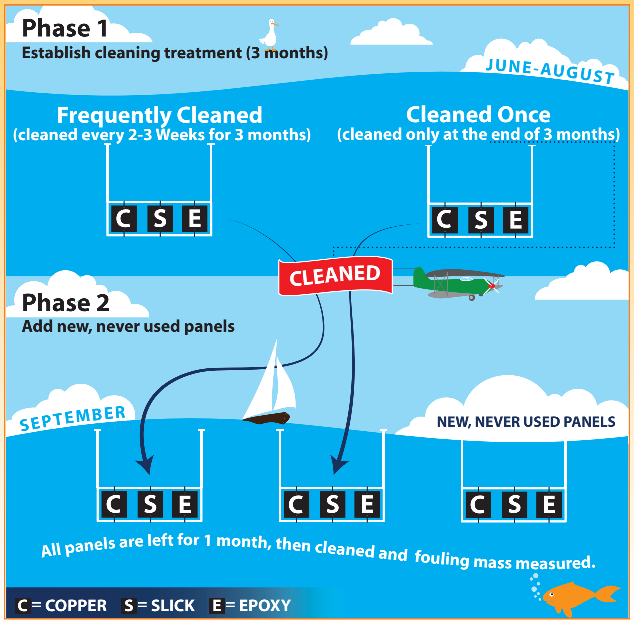
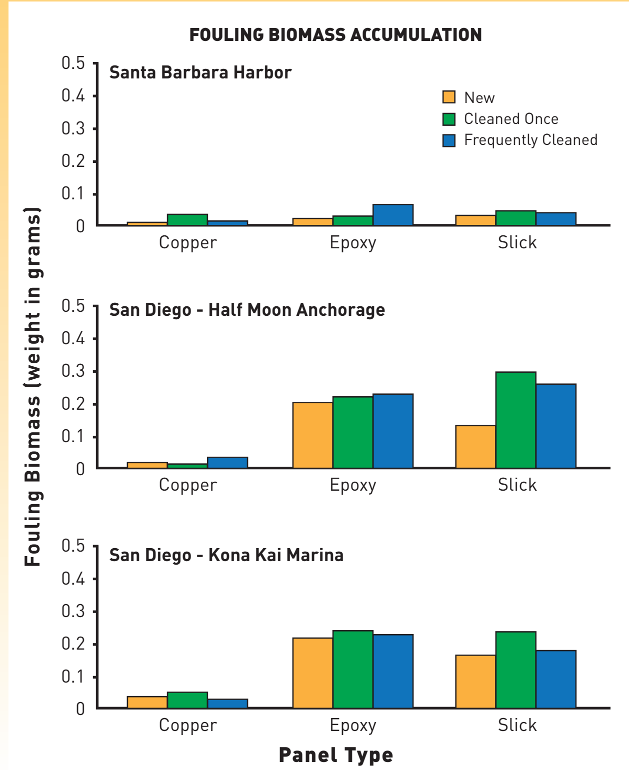


FIGURE 6. Amount of fouling growth accumulating on panels of differing coatings and cleaning treatments

GRAPHIC: CAROLYNN CULVER



fouling, the harshness of the tool and the level of effort required to remove fouling on each panel.

We began by submerging two sets of panels at each station for three months (June-August). During this time, one set of panels with the 3 coatings was cleaned according to the CPDA's BMPs for summer in southern California: every two weeks for nontoxic coatings and every three weeks for the toxic copper coating.[80] These panels represented the "frequently cleaned" experimental treatment. The second set of panels was cleaned only once at the end of the three-month period, representing the "cleaned once" treatment. The "cleaned once" treatment simulated methods used in the Australian study, albeit not as extreme.

After three months, these two sets of panels were cleaned and placed back into the water for a fourth month (September) and another set of new panels that had never been used was added to each frame. The new panels represented the new, "never cleaned" treatment for each of the three coating types.

After the fourth month, the accumulated fouling was removed from all panels. The resulting material was dried and weighed to determine whether the amount of fouling that accumulated in month four was different for the three cleaning treatments. Figure 5 illustrates the procedure for the hull cleaning experiment.

Statistical analyses showed that the coating type had a significant influence on the type of fouling organisms that settled on the panels. Copper panels were mostly fouled by a biofilm. Epoxy and slick panels were dominated by dark green algae and organisms with a calcareous (calcium carbonate) shell or tube, e.g. *Hydroides* spp. tube worms and spirorbid worms. Similar types of fouling were found in both SBH and SIYB as well as among all three cleaning treatments.

In contrast, statistics showed that during the fourth month, panels that had been frequently cleaned had accumulated the same amount of fouling as the panels that had been cleaned once and as those that had never been cleaned (new panels). In other words, panels that underwent the three cleaning treatments did not accumulate different amounts of fouling during the fourth month. (Fig. 6) Unlike the Australian study, our results showed that frequent, gentle cleaning did not stimulate new fouling growth.

A slightly more abrasive tool and more effort were needed to clean the epoxy and slick coatings than the copper coating. Further, panels that were cleaned frequently and panels that were cleaned once required a slightly more abrasive tool and effort than the new panels that were not fouled or cleaned until the fourth month. Tools ranged from

PHOTO: CAROLYNN CULVER

Examples of common hull cleaning tools: (a) carpet, (b) white pad, and (c) green pad

level 1 to level 2, i.e. from a piece of shag carpet or a white 3M™ pad to a green 3M™ pad. No scrapers or wire brushes were used.

The difference between our conclusions and those of the Australian scientists is most likely due to the difference in hull cleaning practices. Our panels were cleaned frequently and gently, according to the BMPs of the CPDA. In contrast, the other scientists allowed fouling growth to accumulate and mature for seven months. It then had to be cleaned with a scraper, which is abrasive, and left remnants of fouling organisms. The scraper may have scratched the coating on their experimental panels, which may have helped new fouling spores and larvae gain a "foothold." Further, the Australian scientists suggested that scraping or scrubbing fouling organisms may release chemical signals, which attract species that prefer to live in groups (such as hull fouling species).[83,84]

PHOTO: LEIGH JOHNSON

Capturing accumulated fouling at end of experiment

Our results support the use of the CPDA's BMPs for hull cleaning. These practices not only help control fouling without stimulating it, but the frequent gentle cleaning also has the added benefits of:

- extending the life of a hull coating,[85] as a less aggressive tool is needed, leading to fewer deep scratches/chipping and fewer remnant parts of fouling organisms;
- decreasing time available for development of NN and other fouling organisms, thereby reducing the likelihood that they will reach maturity and reproduce in the home port or elsewhere; and
- increasing the likelihood that organisms will be damaged and removed while they are smaller and less developed, thereby not surviving in the harbor.

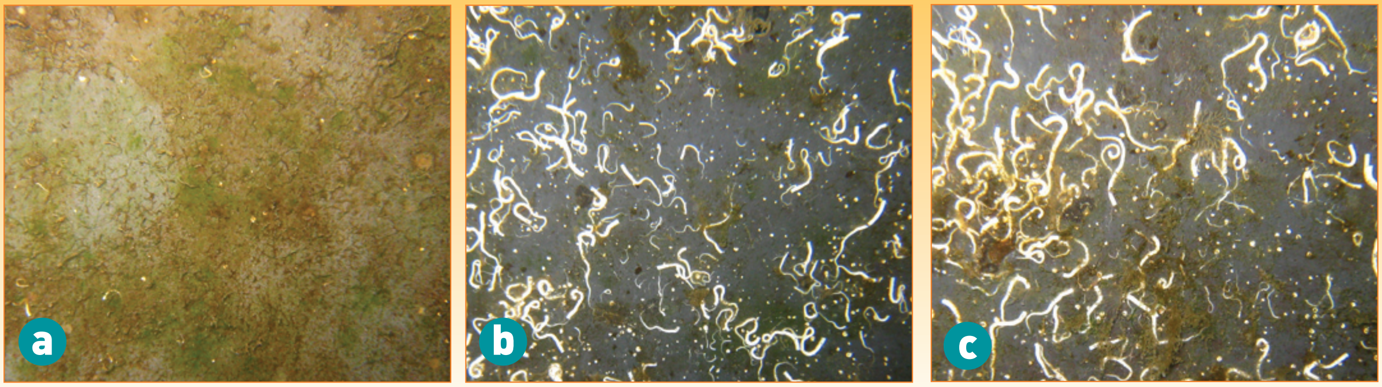
APPENDIX 4. FACTORS AFFECTING FOULING GROWTH: LOCATION AND ENVIRONMENTAL FACTORS

We also investigated the biology of hull fouling species and how they respond in different locations to the environment and nearby sources of pest populations.

Is Fouling a Greater Problem in Some Harbors?

Our two study sites are characterized by different oceanographic conditions. SBH is within the "California Transition Zone" where warm and cold water masses mix, whereas the San Diego region is influenced by a single warmer water mass.[86] Fouling rates are believed to be higher in southern California harbors than in central and northern California harbors. Because we gathered data at the same time and used the same experimental methods at these locations, we were able to compare fouling at the two sites.

For the hull cleaning experiment (Appendix 3),



Panels from (a) SBH, (b) HMA and (c) KKM show location, not cleaning treatment, influenced fouling

PHOTOS: CAROLYNN CULVER, LEIGH JOHNSON, MICHELLE LANDE

statistical analysis showed that geographic location influenced the amount of fouling, with much less fouling at SBH than at SIYB. Further, the experiment that evaluated fouling on different hull coatings over one-month time periods (Appendix 2) illustrated that there was far less fouling on the gel-coated panels in SBH than in SIYB. Differences in fouling at the two sites may be explained by different water temperatures. Fouling rates may have been greater in SIYB because average water temperature was 2°-3° C (~ 5° F) warmer than in SBH. Marine organisms tend to mature earlier and reproduce more often in warmer waters.[87,88]

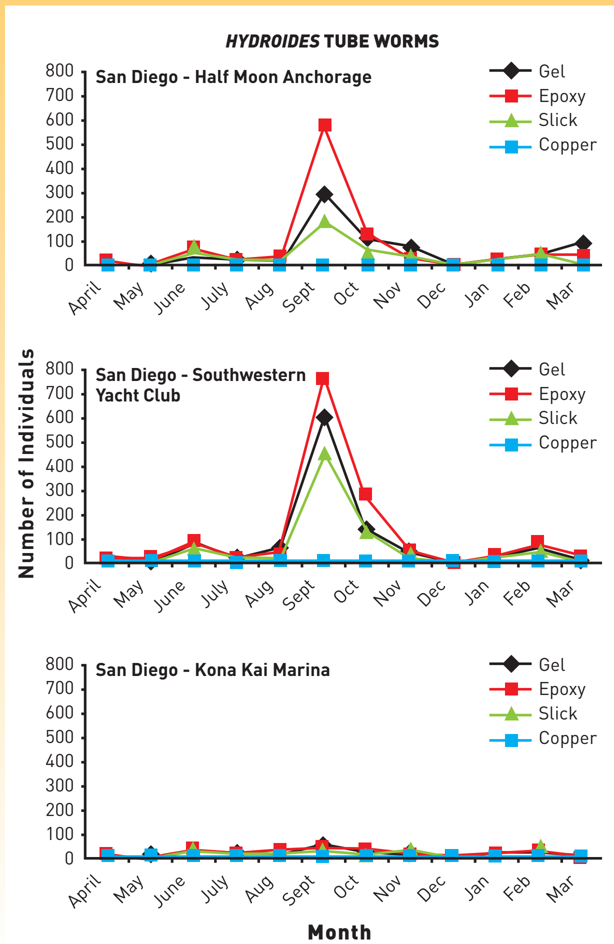
These findings support the idea that fouling may be a greater challenge for boats kept in California's warmer, more southern harbors. Additional studies are needed to validate this claim and factors that may explain it. For example, food availability or larval supply may also play a role.

Is Fouling a Greater Problem in Certain Slips?

To determine whether slip location influenced fouling, we compared fouling on our gel-coated panels that were exposed for one-month intervals at the various stations within each study site. (The same gel-coated panels were part of the study on influence of hull coating type on fouling described in Appendix 2.)

For both sites, location within the harbor significantly influenced recruitment of certain fouling organisms. From outer (I) to inner (IV) locations within SBH, recruitment increased for the NN individual tunicate (sea squirt) *Ciona* spp. and decreased for the NN encrusting bryozoan *Watersipora subtorquata* and C spirorbid worms. From outer (KKM) to inner (HMA) locations within SIYB, recruitment increased for the NN tube worm *Filograna implexa* and decreased for the colonial tunicate *Diplosoma listerianum* and spirorbid worms. However, at the middle location (SWYC) recruitment was highest for the NN encrusting bryozoan *Watersipora subtorquata*, *Hydroides* spp. tube worms and NN branching bryozoan *Bugula neritina* (Fig. 7.).

FIGURE 7. Recruitment of *Hydroides* tube worms to panels with differing coatings at three locations in Shelter Island Yacht Basin, San Diego Bay.



GRAPHIC: CAROLYNN CULVER

What is the Role of Environmental Factors?

Based on these findings, we further explored environmental factors that might explain why recruitment of these particular species was influenced by the location within each harbor. Only three of the measured factors were found to be important: presence of members of the same species (sources of pests) on dock floats, water flow and shading.

Sources of Fouling Species (Pests)

We wanted to determine whether the fouling on our panels may have been influenced by nearby "parent populations" (adult members of the same species). First, we examined photographs that showed the amount of various fouling species on nearby dock floats. We compared findings from the photographs to the amount of fouling on our panels using the experimental methods described above.

Duration of the free-swimming larval phase affects how far they can travel from the source (parent) population. Depending on the species, the larval phase can last a few minutes or many months. The longer that larvae remain in the water, the more likely they will move and be dispersed over longer distances. The shorter the larval phase, the more likely they are to settle near the parent population.

Recruitment of only the NN encrusting bryozoan *W. subtorquata* was associated with greater numbers of its species on nearby dock floats. Its larvae have a very short, free-swimming phase (on the order of hours or less) and thus have limited dispersal ability.

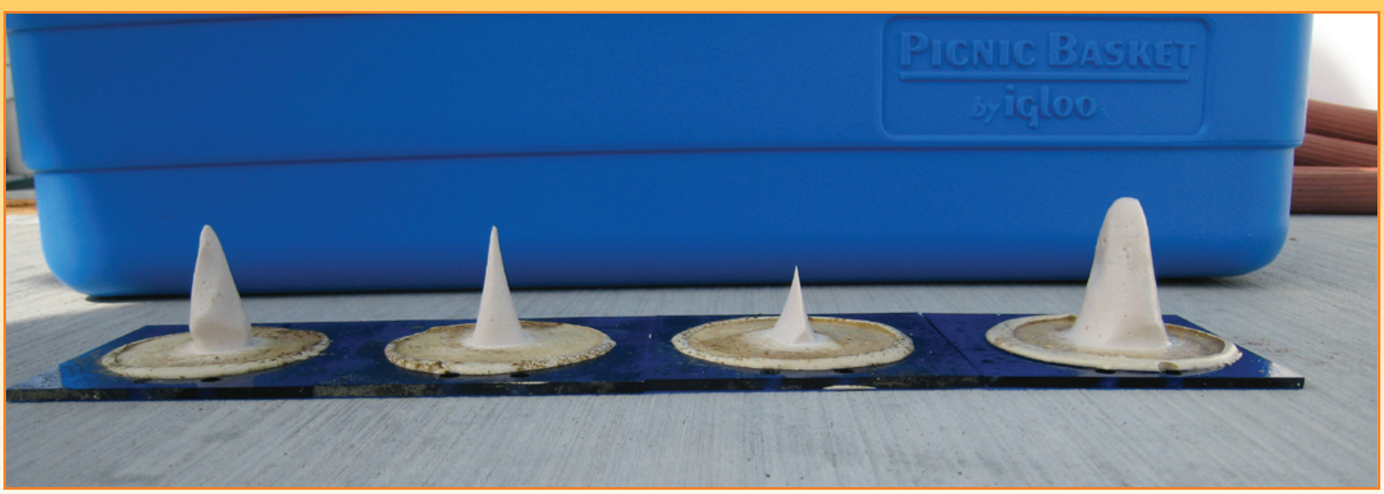
Although the presence of a nearby parent population on the faces of docks only mattered for one species in our study, more were likely present on other surfaces of the docks. Fouling organisms on the dock continually reproduce. Thus, cleaning "hot spots" (areas with abundant fouling and/or sources of species of concern) on docks should be considered as part of a control effort within the harbor or boat basin.

Water Flow in the Harbor

Water flow within a harbor is typically influenced by the tide. Generally, it is greater in slips that are near the harbor's mouth and center channel. Understanding how water flow influences the type and amount of fouling is useful for determining which hot spots, if any, are more likely to become fouled by species that prefer high or low water flow.

We evaluated the influence of ambient and experimentally manipulated water flow on fouling. We measured ambient water flow in both harbors with SLODS™ cards (see General Methods) that were attached to the experimental frame at each station. We compared the amount of material that was lost from each SLODS™ card to the type and amount of fouling on panels at each station over 12 one-month intervals. We manipulated water flow at SBH by attaching a small underwater pump to one end of an experimental frame. There were two panels at either end of the frame, and three frames with pumps for this particular experiment. We compared fouling on panels from the end of the frame with the enhanced flow (with the pump) to panels at the other end

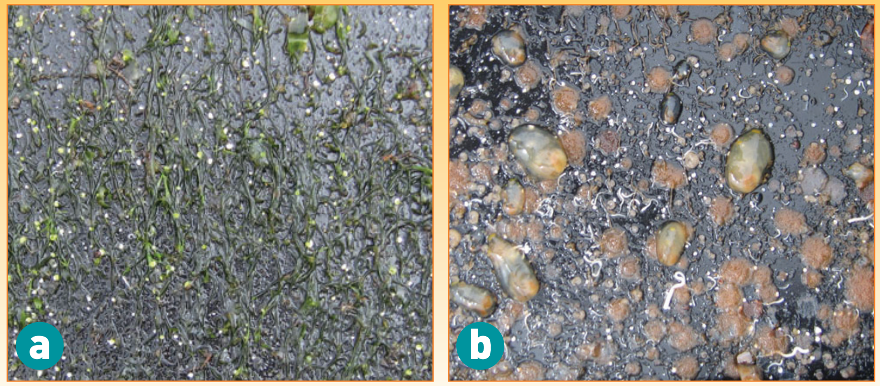
PHOTO: CAROLYNN CULVER



SLODS™ cards measure water flow

of the frame with ambient flow (no pump).

Water flow influenced fouling of only two species, the NN bryozoan *W. subtorquata* and the NN individual tunicate (sea squirt) *Ciona* spp., and it affected them differently. Greater ambient water flow resulted in more recruitment for the bryozoan *W. subtorquata*. In contrast, lower ambient and manipulated water flow resulted in more recruitment for *Ciona* spp. Results suggest that these species will be more abundant in areas where water flow rates favor them. Inspecting boats and docks in high and low flow areas of the harbor could determine hot spots where these NN species are abundant and assist in planning control efforts.



Examples from SBH (a) algae fouling on front versus (b) invertebrates on back

Sunny versus Shady Slips

In both SBH and SIYB we compared fouling rates and species on the fronts versus the backs of our one-month panels at each station throughout the year. As they were secured to frames extending down from the docks, the fronts of the panels faced out toward the sunlight and the backs of the panels faced in toward the shaded undersides of the docks. Algae are plants and therefore need sunlight to grow. Thus, algae primarily occurred on the fronts of the panels, with very little algae on the backs, especially during the summer. In sharp contrast, both the fronts and backs of the panels were fouled by invertebrates, including sea squirts, bryozoans, amphipods and tube worms. When algae was present on the front, fouling by invertebrates was typically much higher on the back than the front.

These results suggest that the amount of sunlight that reaches a hull should be considered when developing strategies for managing fouling, particularly in harbors where algae is abundant. (Algae were much more common on our panels in SBH than in SIYB.) If the hull is in a well-lighted area, be alert for the presence of NN algal species, such as the Asian kelp *Undaria pinnatifida*. Frequent cleaning may help to minimize spread of NN species and reduce staining of hull coatings by algae.

Time of the Year (Season)

Understanding the influence of season is critical for determining when to apply fouling control strategies. Thus, we analyzed monthly recruitment of fouling organisms on gel-coated panels submerged for 12, one-month intervals (described in the section on hull coatings) at both harbors.

Fouling was not limited to a single month or season, but it varied throughout the year. In general, recruitment of NN and other species of concern was greatest from the late spring to early fall (May-October), being quite limited in the winter (January-March). In contrast, recruitment of a few fouling species peaked in the winter, such as the NN bryozoan *Watersipora subtorquata*.

Some species recruited more intensely at certain locations within the harbor during their peak recruitment times. For example in SIYB the NN tube worm *Hydroides spp.* recruited more heavily at the inner (HMA) and middle (SWYC) locations than at the outer location (KKM), and specifically during the late summer/early fall (Fig. 7).

More frequent application of control strategies will be needed during spring and summer when more larvae of most species are in the water. However, fouling control strategies may be required throughout the year, particularly in areas where *W. subtorquata* is abundant.

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Agriculture and Natural Resources

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County of Ventura, California

County of Santa Barbara, California

California Department of Boating and Waterways

NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Sea Grant
California

TITLE 2. ADMINISTRATION
DIVISION 3. STATE PROPERTY OPERATIONS
CHAPTER 1. STATE LANDS COMMISSION
ARTICLE 4.8. BIOFOULING MANAGEMENT REGULATIONS FOR VESSELS OPERATING IN CALIFORNIA WATERS

NOTICE OF PROPOSED REGULATORY ACTION

The California State Lands Commission (Commission) proposes to amend the regulations described below after considering all comments, objections or recommendations regarding the proposed action.

PROPOSED REGULATORY ACTION

The Commission proposes to amend and renumber Section 2298 and adopt Sections 2298.1, 2298.2, 2298.3, 2298.4, 2298.5, 2298.6, 2298.7, and 2298.8 under Article 4.8 in Title 2, Division 3, Chapter 1 of the California Code of Regulations (CCR). These sections would establish regulations governing the management of hull fouling (hereafter referred to as biofouling) on vessels arriving to a California port or place, as required by Public Resources Code (PRC) Section 71204.6. The proposed regulatory action would establish performance standards for biofouling management, and would set record keeping and reporting requirements for all vessels specified in PRC Section 71201. Additionally, the proposed regulatory action would establish inspection or cleaning requirements for high risk vessels remaining in a port, place, or shared waters for ninety days or greater. Provisions are also included to provide a process for the submission and approval of petitions for alternatives to Article 4.8, should such cases occur.

WRITTEN COMMENT PERIOD

Any interested person or his or her authorized representative may submit written comments relevant to the proposed regulatory action to the Commission. The written comment period closes at 5:00 pm on October 31, 2011. All written comments must be received at the Commission by that time. Written comments should be submitted to:

Ravindra Varma
Supervisor, Planning Branch
California State Lands Commission
Marine Facilities Division
200 Oceangate, Suite 900
Long Beach, CA 90802

Written comments may also be submitted by facsimile at (562) 499-6317 or by email to Ravi.varma@slc.ca.gov.

PUBLIC HEARING

The Commission has not scheduled a public hearing for this proposed action. However, the Commission will hold a hearing if it receives a written request for a public hearing from any interested person, or his or her authorized representative, no later than 15 days before the close of the written comment period.

AUTHORITY AND REFERENCE

PRC Section 71201(d) declares that the purpose of the Marine Invasive Species Act (the Act) is to move the State expeditiously towards elimination of the discharge of nonindigenous species into waters of the State. In enforcing the provisions of the Act, the Commission is authorized to adopt the proposed regulations, which would implement, interpret, and make specific PRC Section 71204.6. This statute directs the Commission to develop and adopt regulations governing the management of biofouling on vessels arriving to a California port or place.

INFORMATIVE DIGEST/POLICY STATEMENT OVERVIEW

PRC Section 71204.6 requires the Commission to develop and adopt regulations governing the management of biofouling on vessels arriving to a California port or place. PRC Section 71204.6 also mandates the Commission to consider vessel design and voyage duration in developing these regulations. The section further requires the Commission to develop the regulations based on the best available technology economically achievable and to design the regulations to protect the waters of the state.

Accordingly, the proposed regulation would implement and make specific the biofouling management requirements under PRC Section 71204.6. Without the regulations, the purpose of the Act as described in PRC Section 71201(d) cannot be achieved.

Section 2298 of the California Code of Regulations is amended and renumbered as 2CCR2298.7 to align with PRC Section 71205(e), which mandates that the requirements contained within 2 CCR Section 2298 continue until the date the regulations described in PRC Section 71204.6 (i.e. the proposed regulations) are adopted. The "Hull Husbandry Reporting Form" revision date has been amended from June 6, 2008 to August 18, 2011. The revised form is reincorporated by reference and is available for review.

The purpose of the Hull Husbandry Reporting Form revision was to change the timing of annual submission from "within 60-days of receiving a written or electronic request from the Commission" to "twenty-four hours in advance of the first arrival of the calendar year to a California port or place."

Section 2298.1(a) would set the purpose of Article 4.8.
Section 2298.1(b) would specify the vessels to which these regulations apply.

Section 2298.1(c) would identify the date of implementation of these regulations.

Section 2298.2 would narrowly define key terms that are used throughout the language of the regulations to describe management requirements and regulation applicability. These definitions ensure that the regulatory language is clear to the regulated industry and ensure that compliance occurs as intended by the regulations.

Section 2298.3 would prescribe performance standards for biofouling management that have been deemed the most biologically effective and economically feasible actions that will move the state expeditiously toward elimination of the discharge of nonindigenous species into the waters of the state. This section also describes the implementation timeline for new and existing vessels, and describes the requirements to maintain compliance-related documentation onboard.

Section 2298.4 would prescribe requirements for a Biofouling Management Plan, which would be maintained onboard the vessel and made available to Commission Marine Safety personnel upon request. The Biofouling Management Plan would contain specific information about the vessel's biofouling management strategies and the types of anti-fouling systems used.

Section 2298.5 would prescribe requirements for a Biofouling Record Book, which would be maintained onboard the vessel and made available to Commission Marine Safety personnel upon request. The Biofouling Record Book would contain specific information about the vessel's biofouling management actions.

Section 2298.6 would set specific inspection or cleaning requirements for vessels that remain in a specific port, place or shared waters for ninety days or greater prior to arriving to a California port or place.

Section 2298.7 would require submission of an annual reporting form to enable the Commission to collect necessary data to prioritize boarding and inspection, based on a per-vessel risk assessment. It would also provide the necessary data to evaluate the efficacy of the proposed regulations and to inform any further revisions of these regulations, if necessary.

Section 2298.8 would describe a process for the submission and approval of petitions for alternatives to Article 4.8, should such cases occur. Alternatives proposed in petitions must fulfill the purpose of the regulation in Section 2298.1(a), and will be approved or withdrawn by the Division Chief.

DIFFERENCES FROM FEDERAL REGULATIONS

Federal requirements for biofouling management to prevent the introduction of nonindigenous species can be found within the Code of Federal Regulations, specifically 33CFR151.2035 (a)(5) and 33CFR151.2035 (a)(6). These regulations require rinsing of the anchors and anchor chains to remove organisms at their place of origin as well as a requirement to remove biofouling from the hull, piping, and tanks on a regular basis and to dispose of any removed substances in accordance with local, State and Federal regulations. These requirements are also included in the Act, specifically PRC 71204(e) and 71204(f). The federal requirements do not offer any guidance as to the frequency of biofouling removal, other than the undefined phrase "regular basis." Therefore, there is no specific federal requirement to maintain biofouling below a defined threshold and no federal requirement to keep onboard records, or to submit reporting forms, detailing biofouling management activities. There also are no federal requirements for high-risk vessels that remain in one location for extended periods of time to manage biofouling prior to entering a United States (US) port or place.

The biofouling management practices and performance standards prescribed by these proposed regulations are necessary to minimize the transport of NIS into and throughout the waters of the State of California.

Small Business Determination

The Commission has determined that these regulations do not affect small businesses as defined in Government Code (Gov. C.) Section 11342.610, because all affected businesses are commercial maritime transport owners and operators, as specified under Gov C. Section 11342.610(c)(7) and having annual gross receipts of more than $1,500,000.

Plain English Policy Overview

The proposed regulations have been drafted in a plain and straightforward manner and do not contain technical terms that require a plain English policy overview.

ESTIMATED COSTS TO THE STATE

No costs to the State would be incurred in implementing and enforcing these proposed regulations. The programs mandated by the Act are funded exclusively by the Marine Invasive Species Control Fund, through fees collected from the owners of vessels subject to the Act.

DISCLOSURES REGARDING THE PROPOSED ACTION

The Commission has made the following determinations:

The Commission has determined that the proposed regulation does not impose any mandates on local agencies or school districts.

The Commission has determined that the proposed regulation does not impose any mandate requiring state reimbursement to any local agency or school district, pursuant to Government Code Sections 17500 *et seq.* No other non-discretionary cost or savings imposed on local agencies is anticipated.

The Commission has determined that no costs or savings to any other state agencies are anticipated.

The Commission has determined that the proposed regulation will have no significant impact upon any of the following:

(1) Creation or elimination of jobs within the State of California;

(2) Creation of new business or the elimination of existing businesses within the State of California; and

(3) Expansion of businesses currently doing business within the State of California.

The Commission has determined that the adoption of this regulation will not affect small businesses. None of the businesses that will be governed by these proposed regulations can be considered to be a 'small business' as defined in Gov. Code § 11342.610.

The Commission has determined that the proposed regulation will have no significant effects on housing costs.

The Commission has determined that the proposed regulation will have no impact on costs or savings in Federal funding to the State.

The Commission finds that the adoption of this regulation is necessary for the health, safety, or welfare of the people of this state.

The Commission has determined that the proposed regulation will have no significant statewide adverse economic impact directly affecting business, including the ability of California businesses to compete with businesses in other states.

Cost impact on private persons or directly affected businesses: The estimates presented here were obtained through three sources: 1) estimates provided by shipping industry representatives who were involved in the development of the proposed regulations. These were reported estimates which were not verified against official financial documentation; 2) data collected from the shipping industry by the Commission through mandatory submission of the Hull Husbandry Reporting Form since 2008. Only data from 2008 and 2009 have been analyzed to date, thus data from 2010 and 2011 are not utilized here; and 3) academic peer-reviewed papers and scientific gray literature.

The potential costs associated with the proposed regulatory action relate to several provisions in the proposed regulations. The costs associated with inspection and maintenance of the wetted surfaces to meet the performance standards for biofouling management are dependent on the current frequency of a vessel's maintenance practices. At a bare minimum, most vessels are already required by the International Convention for the Safety of Life at Sea (SOLAS) to undergo out-of-water maintenance every five years. Commission-collected data indicates that the average vessel arriving to California undergoes out-of-water maintenance more frequently than this minimum. In 2008 and 2009, approximately 67 percent of vessels had been dry docked or delivered as new within the prior two years, and 84 percent within the prior three years. Additionally, most vessels are required by classification societies to undergo an intermediate survey approximately 2.5 years after the out-of-water maintenance. In addition, many vessel owners or operators elect to undertake additional in-water cleaning or propeller polishing in order to remove biofouling from the vessel to reduce biofouling-induced drag, the associated decrease in fuel efficiency, and the consequent increase in fuel costs. Propeller polishing is typically conducted as a first measure to address fuel efficiency, is often conducted every six months, and often includes a biofouling evaluation of the other underwater surfaces. Several shipping companies have indicated that they undergo propeller polishing and/or in-water inspection on a six-month interval. One company indicated that propeller polishing frequency is dependent on the vessel charterer; some request propeller polishing every six months, others every twelve months, and still others do not request propeller polishing until the intermediate inspection or the out-of-water maintenance. A regional maritime trade association indicated that it is the intent of its members to arrange for inspections on a six-month basis, but this is influenced by vessel type and trade lanes. Finally, a single company indicated that its vessels undergo hull cleaning every three years.

The estimated costs associated with the requirement to evaluate biofouling every six months (or within twelve months of out-of-water maintenance) ranges between "no impact" for vessel owners that currently undergo this type of maintenance on a six month interval to between $4,000 and $6,500 per vessel per survey. Therefore, the per-vessel cost of the required biofouling evaluations will likely be: 1) no impact if vessel is already inspected or undergoes propeller polishing on a six-month interval; 2) $4,000 - $6,500 per year if a vessel is on a 12-month inspection/polishing schedule (i.e. one additional evaluation per 12 months); or as much as 3) $6,400 - $10,400 per year for vessels that currently do not conduct any underwater maintenance other than the currently required intermediate survey (i.e. up to four additional evaluations totaling $16,000 - $26,000 over the 2.5 year period). One company indicated that if they were required to remove their vessel from service for an entire day to conduct the inspection, it would cost an additional $50,000 due to the loss of a day of service. However, this assumes that the vessel would need to be removed from service for an entire day in order to conduct an inspection or propeller polishing. The same company also indicated on three separate occasions that their vessels undergo inspection or propeller polishing on a six-month frequency, thus not requiring any additional evaluations to meet the proposed regulations. This company later revised their frequency to every twelve months.

Several studies indicate that the potential costs associated with increased frequency of inspection or cleaning may be offset by a larger fiscal benefit from maintaining lower levels of biofouling. Increased levels of biofouling contribute towards increased hydrodynamic drag, reducing the fuel efficiency, and ultimately resulting in elevated fuel consumption and operating costs. Proper maintenance of biofouling will result in lower operating costs, and studies suggest that the fuel savings would far outweigh the potential maintenance costs (Munk et al. 2009, Hydrex 2010, Schultz et al 2011). Schultz et al. (2011) evaluated costs associated with mid-sized US naval surface ships using the US Navy fouling rating system (FR), which at lower biofouling levels is consistent with the Level of Fouling ranking scale proposed in these regulations. The authors determined that a decrease from FR 30 (equivalent to the proposed Level of Fouling rank 2) to FR 20 (equivalent to the proposed Level of Fouling rank 1) would result in savings of approximately $300,000 to $400,000 in fuel costs per ship per year. These estimates were developed based on a mid-sized naval surface vessel so the exact savings may not be directly equivalent to the average merchant vessel, but the principles would be similar and there would undoubtedly be significant financial benefits to a vessel that was maintained to a Level of Fouling rank 1. Hydrex (2010) indicates that even a layer of microfouling (Level of Fouling rank 1) on a typical commercial cargo vessel travelling at twenty knots would result in an additional $4,500 per day in fuel costs. This would equate to a cost of $1.2 million per year for a single vessel.

There may also be costs associated with the development and maintenance of the required Biofouling Management Plan and Biofouling Record Book. Several companies have indicated that although there would be some costs associated with the development of these documents, most of the information is already kept onboard or as part of the Ship Management System. In these cases, the costs are expected to be minimal. One company indicated that it would cost $4,000 per vessel to develop the Biofouling Management Plan and Biofouling Record Book. Finally several companies have indicated that the development of the two documents would require 80 person-hours, and the ongoing management and training would require 200 person-hours per year, with costs dependent on variable person-hour costs.

Companies which own or operate multiple vessels should be able to spread the cost of developing multiple sets of documents across these vessels resulting in reduced per-vessel costs. Additionally, both the Biofouling Management Plan and Biofouling Record Book proposed in these regulations are also part of the International Maritime Organization's Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species. Although the IMO Biofouling Guidelines are voluntary, it is reasonable to assume that responsible owners and operators will adopt the guidelines and develop these documents, whether or not they are mandatory in California.

Section 2298.6, pertaining to the small minority of vessels remaining in one location for ninety days or greater may also have costs associated with it; however these costs will only be associated with a small percentage of the California fleet. In 2009, only 1.7% of the fleet reported remaining in one location for ninety days or greater since their most recent out-of-water maintenance. The costs for this specific regulation depend on the severity of the biofouling associated with the vessel and may range from $4,000 to $6,500 for in-water inspection, $19,000 to $27,000 for in-water cleaning, $150,000 to

$800,000 for out-of-water cleaning, or $300,000 to $1,200,000 for full out-of-water maintenance (including repainting). These cost ranges for these options are wide and the exact amount is dependent on the size and type of vessel. However, any costs incurred to comply with this regulation may be recouped (possibly surpassed) through fuel savings as a result of the decrease in biofouling-induced hydrodynamic drag, as discussed previously.

Finally, there may be minor costs associated with completing and submitting the Hull Husbandry Reporting Form. However, mandatory annual submission of this form has been required from every vessel operating in California since 2008. Therefore, there should be no significant increase in costs to continue to comply with this requirement.

CONSIDERATION OF ALTERNATIVES

In accordance with Government Code Section 11346.5, subdivision (a)(13), the Commission must determine that no reasonable alternative it considered or that has otherwise been identified and brought to the attention of the Commission would be more effective in carrying out the purpose for which the action is proposed or would be as effective and less burdensome to affected private persons than the proposed regulation.

The Commission invites interested persons to present statements or arguments with respect to alternatives to the proposed regulation during the written comment period.

CONTACT PERSONS

Inquiries concerning the substance of the proposed regulation may be directed to:

Christopher Scianni
Staff Environmental Scientist
California State Lands Commission
Marine Facilities Division
100 Howe Avenue, Suite 100 South
Sacramento, CA 95825-8202
Telephone: (916) 574-0209
Facsimile: (916) 574-1950

Or to: Mark A. Meier
Senior Staff Counsel
California State Lands Commission
100 Howe Avenue, Suite 100 South
Sacramento, CA 95825-8202
Telephone: (916) 574-1853
Facsimile: (916) 574-1855

Requests for copies of the proposed text of the regulations, the initial statement of reasons, the modified text of the regulations if any, or other information upon which the rulemaking is based should be directed to:

Ravindra Varma
Supervisor, Planning Branch
California State Lands Commission
Marine Facilities Division
200 Oceangate, Suite 900
Long Beach, CA 90802-4335
Telephone: (562) 499-6400
Facsimile: (562) 499-6317
Ravi.varma@slc.ca.gov

AVAILABILITY OF STATEMENT OF REASONS AND TEXT OF PROPOSED REGULATIONS

The Commission will have the entire rulemaking file available for inspection and copying throughout the rulemaking process at its offices at either of the above addresses. As of the date this notice is published in the Notice register, the rulemaking file consists of this notice, the proposed text of the regulations and the initial statement of reasons. Copies may be obtained by contacting Ravindra Varma as listed above.

AVAILABILITY OF CHANGED OR MODIFIED TEXT

After considering all timely and relevant comments, the Commission may adopt the proposed regulations substantially as described in this notice. If modifications are made which are sufficiently related to the original proposed text, the modified text, with changes clearly indicated, shall be made available to the public for at least fifteen days prior to the date on which the Commission adopts the regulations. Requests for copies of any modified regulations should be sent to the attention of Ravindra Varma at the address indicated above. The Commission will accept written comments on the modified regulation for fifteen days after the date on which they are made available.

AVAILABILITY OF THE FINAL STATEMENT OF REASONS

Upon its completion, copies of the Final Statement of Reasons may be obtained by contacting Ravindra Varma at the address or telephone number listed above or by accessing the web address listed below.

AVAILABILITY OF DOCUMENTS ON THE INTERNET

Copies of the Notice of Proposed Action, the Initial Statement of Reasons, the text of regulations, and other relevant documents can be accessed through our website at:

http://www.slc.ca.gov/Spec_Pub/MFD/Ballast_Water/Ballast_Water_Default.html

ANNEX 26

RESOLUTION MEPC.207(62)

Adopted on 15 July 2011

2011 GUIDELINES FOR THE CONTROL AND MANAGEMENT OF SHIPS' BIOFOULING TO MINIMIZE THE TRANSFER OF INVASIVE AQUATIC SPECIES

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38 of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee relating to any matter within the scope of the Organization concerned with the prevention and control of marine pollution from ships,

RECALLING ALSO that Member States of the International Maritime Organization made a clear commitment to minimizing the transfer of invasive aquatic species by shipping in adopting the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004,

RECALLING FURTHER that studies have shown biofouling on ships to be an important means of transferring invasive aquatic species which, if established in new ecosystems, may pose threats to the environment, human health, property and resources,

NOTING the objectives of the Convention on Biological Diversity, 1992, and that the transfer and introduction of aquatic invasive species through ships' biofouling threatens the conservation and sustainable use of biological diversity,

NOTING ALSO that implementing practices to control and manage ships' biofouling can greatly assist in reducing the risk of the transfer of invasive aquatic species,

NOTING FURTHER that this issue, being of worldwide concern, demands a globally consistent approach to the management of biofouling,

HAVING CONSIDERED, at its sixty-second session, the draft Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species, developed by the Sub-Committee on Bulk Liquids and Gases,

1. ADOPTS the 2011 Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species, as set out in the annex to the present resolution;

2. REQUESTS Member States to take urgent action in applying these Guidelines, including the dissemination thereof to the shipping industry and other interested parties, taking these Guidelines into account when adopting measures to minimize the risk of introducing invasive aquatic species via biofouling, and reporting to the MEPC on any experience gained in their implementation; and

3. AGREES to keep these Guidelines under review in light of the experience gained.

ANNEX

2011 GUIDELINES FOR THE CONTROL AND MANAGEMENT OF SHIPS' BIOFOULING TO MINIMIZE THE TRANSFER OF INVASIVE AQUATIC SPECIES

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1 INTRODUCTION

1.1 In the adoption of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention), Member States of the International Maritime Organization (IMO) made a clear commitment to minimizing the transfer of invasive aquatic species by shipping. Studies have shown that biofouling can also be a significant vector for the transfer of invasive aquatic species. Biofouling on ships entering the waters of States may result in the establishment of invasive aquatic species which may pose threats to human, animal and plant life, economic and cultural activities and the aquatic environment.

1.2 While the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001 (AFS Convention) addresses anti-fouling systems on ships, its focus is on the prevention of adverse impacts from the use of anti-fouling systems and the biocides they may contain, rather than preventing the transfer of invasive aquatic species.

1.3 The potential for invasive aquatic species transferred through biofouling to cause harm has been recognized by the IMO, the Convention on Biological Diversity (CBD), several UNEP Regional Seas Conventions (e.g., Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution), the Asia Pacific Economic Cooperation forum (APEC), and the Secretariat of the Pacific Region Environmental Program (SPREP).

1.4 All ships have some degree of biofouling, even those which may have been recently cleaned or had a new application of an anti-fouling coating system. Studies have shown that the biofouling process begins within the first few hours of a ship's immersion in water. The biofouling that may be found on a ship is influenced by a range of factors, such as follows:

.1 design and construction, particularly the number, location and design of niche areas;

.2 specific operating profile, including factors such as operating speeds, ratio of time underway compared with time alongside, moored or at anchor, and where the ship is located when not in use (e.g., open anchorage or estuarine port);

.3 places visited and trading routes; and

.4 maintenance history, including: the type, age and condition of any anti-fouling coating system, installation and operation of anti-fouling systems and dry-docking/slipping and hull cleaning practices.

1.5 Implementing practices to control and manage biofouling can greatly assist in reducing the risk of the transfer of invasive aquatic species. Such management practices can also improve a ship's hydrodynamic performance and can be effective tools in enhancing energy efficiency and reducing air emissions from ships. This concept has been identified by the IMO in the "Guidance for the development of a ship energy efficiency management plan (SEEMP)" (MEPC.1/Circ.683).

1.6 These Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (hereafter "the Guidelines") are intended to provide a globally consistent approach to the management of biofouling. As scientific and technological advances are made, the Guidelines will be refined to enable the risk to be more adequately addressed. Port States, flag States, coastal States and other parties that can assist in mitigating the problems associated with biofouling should exercise due diligence to implement the Guidelines to the maximum extent possible.

2 DEFINITIONS

2.1 For the purposes of these Guidelines, the following definitions apply:

AFS Convention means the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001.

Anti-fouling coating system means the combination of all component coatings, surface treatments (including primer, sealer, binder, anti-corrosive and anti-fouling coatings) or other surface treatments, used on a ship to control or prevent attachment of unwanted aquatic organisms.

Anti-fouling system means a coating, paint, surface treatment, surface, or device that is used on a ship to control or prevent attachment of unwanted organisms.

Biofouling means the accumulation of aquatic organisms such as micro-organisms, plants, and animals on surfaces and structures immersed in or exposed to the aquatic environment. Biofouling can include microfouling and macrofouling (see below).

In-water cleaning means the physical removal of biofouling from a ship while in the water.

Invasive aquatic species means a species which may pose threats to human, animal and plant life, economic and cultural activities and the aquatic environment.

Marine Growth Prevention System (MGPS) means an anti-fouling system used for the prevention of biofouling accumulation in internal seawater cooling systems and sea chests and can include the use of anodes, injection systems and electrolysis.

Member States means States that are Members of the International Maritime Organization.

Macrofouling means large, distinct multicellular organisms visible to the human eye such as barnacles, tubeworms, or fronds of algae.

Microfouling means microscopic organisms including bacteria and diatoms and the slimy substances that they produce. Biofouling comprised of only microfouling is commonly referred to as a slime layer.

Niche areas mean areas on a ship that may be more susceptible to biofouling due to different hydrodynamic forces, susceptibility to coating system wear or damage, or being inadequately, or not, painted, e.g., sea chests, bow thrusters, propeller shafts, inlet gratings, dry-dock support strips, etc.

Organization means the International Maritime Organization.

Port State authority means any official or organization authorized by the Government of a port State to verify the compliance and enforcement of standards and regulations relevant to the implementation of national and international shipping control measures.

Ship means a vessel of any type whatsoever operating in the aquatic environment and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft, fixed or floating platforms, floating storage units (FSUs) and floating production storage and off-loading units (FPSOs).

States means coastal, port or Member States as appropriate.

Treatment means a process which may use a mechanical, physical, chemical or biological method to remove or render sterile, invasive or potentially invasive aquatic species fouling a ship.

3 APPLICATION

3.1 The Guidelines are intended to provide useful recommendations on general measures to minimize the risks associated with biofouling for all types of ships and are directed to States, shipmasters, operators and owners, shipbuilders, ship cleaning and maintenance operators, port authorities, ship repair, dry-docking and recycling facilities, ship designers, classification societies, anti-fouling paint manufacturers and suppliers and any other interested parties. A State should determine the extent that the Guidelines are applied within that particular State.

3.2 A separate guidance document, based on these Guidelines, provides advice relevant to owners and/or operators of recreational craft less than 24 metres in length, using terminology appropriate for that sector.

3.3 States should inform the Organization of any relevant biofouling regulations, management requirements or restrictions they are applying to international shipping.

4 OBJECTIVES

4.1 The objectives of these Guidelines are to provide practical guidance to States, ship masters, operators and owners, shipbuilders, ship repair, dry-docking and recycling facilities, ship cleaning and maintenance operators, ship designers, classification societies, anti-fouling paint manufacturers and suppliers and any other interested parties, on measures to minimize the risk of transferring invasive aquatic species from ships' biofouling. It is important that biofouling management procedures be effective as well as environmentally safe, practical, designed to minimize costs and delays to the ship, and based upon these Guidelines whenever possible.

4.2 To minimize the transfer of invasive aquatic species, a ship should implement biofouling management practices, including the use of anti-fouling systems and other operational management practices to reduce the development of biofouling. The intent of such practices is to keep the ship's submerged surfaces, and internal seawater cooling systems, as free of biofouling as practical. A ship following this guidance and minimizing macrofouling would have a reduced potential for transferring invasive aquatic species via biofouling.

4.3 The management measures outlined within these Guidelines are intended to complement current maintenance practices carried out within the industry.

5 BIOFOULING MANAGEMENT PLAN AND RECORD BOOK

5.1 Implementation of an effective biofouling management regime is critical for minimizing the transfer of invasive aquatic species. The biofouling management measures to be undertaken on a ship should be outlined in a biofouling management plan, and records of biofouling management practices kept in a biofouling record book, as outlined below.

Biofouling Management Plan

5.2 It is recommended that every ship should have a biofouling management plan. The intent of the plan should be to provide effective procedures for biofouling management. An example of a Biofouling Management Plan is outlined in appendix 1 of these Guidelines. The Biofouling Management Plan may be a stand-alone document, or integrated in part or fully, into the existing ships' operational and procedural manuals and/or planned maintenance system.

5.3 The biofouling management plan should be specific to each ship and included in the ship's operational documentation. Such a plan should address, among other things, the following:

.1 relevant parts of these Guidelines;

.2 details of the anti-fouling systems and operational practices or treatments used, including those for niche areas;

.3 hull locations susceptible to biofouling, schedule of planned inspections, repairs, maintenance and renewal of anti-fouling systems;

.4 details of the recommended operating conditions suitable for the chosen anti-fouling systems and operational practices;

.5 details relevant for the safety of the crew, including details on the anti-fouling system(s) used; and

.6 details of the documentation required to verify any treatments recorded in the Biofouling Record Book as outlined in appendix 2.

5.4 The biofouling management plan should be updated as necessary.

Biofouling Record Book

5.5 It is recommended that a Biofouling Record Book is maintained for each ship. The book should record details of all inspections and biofouling management measures undertaken on the ship. This is to assist the shipowner and operator to evaluate the efficacy of the specific anti-fouling systems and operational practices on the ship in particular, and of the biofouling management plan in general. The record book could also assist interested State authorities to quickly and efficiently assess the potential biofouling risk of the ship, and thus minimize delays to ship operations. The Biofouling Record Book may be a stand-alone document, or integrated in part, or fully, into the existing ships' operational and procedural manuals and/or planned maintenance system.

5.6 It is recommended that the Biofouling Record Book be retained on the ship for the life of the ship.

5.7 Information that should be recorded in a Biofouling Record Book includes the following:

.1 details of the anti-fouling systems and operational practices used (where appropriate as recorded in the Anti-fouling System Certificate), where and when installed, areas of the ship coated, its maintenance and, where applicable, its operation;

.2 dates and location of dry-dockings/slippings, including the date the ship was re-floated, and any measures taken to remove biofouling or to renew or repair the anti-fouling system;

.3 the date and location of in-water inspections, the results of that inspection and any corrective action taken to deal with observed biofouling;

.4 the dates and details of inspection and maintenance of internal seawater cooling systems, the results of these inspections, and any corrective action taken to deal with observed biofouling and any reported blockages; and

.5 details of when the ship has been operating outside its normal operating profile including any details of when the ship was laid-up or inactive for extended periods of time.

5.8 An example of a Biofouling Record Book and information to be recorded is included as appendix 2 to these Guidelines.

6 ANTI-FOULING SYSTEM INSTALLATION AND MAINTENANCE

6.1 Anti-fouling systems and operational practices are the primary means of biofouling prevention and control for existing ships' submerged surfaces, including the hull and niche areas. An anti-fouling system can be a coating system applied to exposed surfaces, biofouling resistant materials used for piping and other unpainted components, marine growth prevention systems (MGPSs) for sea chests and internal seawater cooling systems, or other innovative measures to control biofouling.

6.2 The anti-fouling system used should comply with the AFS Convention, where necessary.

Choosing the anti-fouling system

6.3 Different anti-fouling systems are designed for different ship operating profiles so it is essential that ship operators, designers and builders obtain appropriate technical advice to ensure an appropriate system is applied or installed. If an appropriate anti-fouling system is not applied, biofouling accumulation increases.

6.4 Some factors to consider when choosing an anti-fouling system include the following:

.1 planned periods between dry-docking – including any mandatory requirements for ships survey;

.2 ship speed – different anti-fouling systems are designed to optimize anti-fouling performance for specific ship speeds;

.3 operating profile – patterns of use, trade routes and activity levels, including periods of inactivity, influence the rate of biofouling accumulation;

.4 ship type and construction; and

.5 any legal requirements for the sale and use of the anti-fouling systems.

6.5 Consideration should also be given to the need for tailored, differential installation of anti-fouling coating systems for different areas of the ship to match the required performance and longevity of the coating with the expected wear, abrasion and water flow rates in specific areas, such as the bow, rudder, or internal seawater cooling systems and sea chest interiors.

Installing, re-installing, or repairing the anti-fouling system

6.6 Whether installing, re-installing or repairing the anti-fouling system, care should be taken in surface preparation to ensure all biofouling residues, flaking paint, or other surface contamination is completely removed, particularly in niche areas, to facilitate good adhesion and durability of the anti-fouling system.

6.7 For sea chests the following should be considered when installing, re-installing, or repairing their anti-fouling systems:

.1 inlet grates and the internal surfaces of sea chests should be protected by an anti-fouling coating system that is suitable for the flow conditions of seawater over the grate and through the sea chest;

.2 care should be taken in surface preparation and application of any anti-fouling coating system to ensure adequate adhesion and coating thickness. Particular attention should be paid to the corners and edges of sea chests, blowout pipes, holding brackets and the bars of grates. Grates may require a major refurbishment type of surface preparation at each dry-docking to ensure coating durability; and

.3 the installation of MGPSs is encouraged to assist in treating the sea chest and internal seawater piping as part of the biofouling management plan. A careful evaluation of the consequential effects of MGPSs should be made before installation, including potential effects on the ship and/or the environment and the existence of regulations affecting the use of MGPSs.

6.8 Other niche areas can also be particularly susceptible to biofouling growth. Management measures for niche areas are outlined below.

.1 **Dry-docking support strips** – Positions of dry-docking blocks and supports should be varied at each dry-docking, or alternative arrangements made to ensure that areas under blocks are painted with anti-fouling, at least at alternate dry-dockings. These areas should receive a major refurbishment type of surface preparation and be coated at each dry-docking that they are accessible. Where it is not possible to alternate the position of dry-docking support strips, e.g., in critical weight bearing areas such as under the engine-room, these areas should be specially considered and managed by other means, e.g., the application of specialized coatings or procedures.

.2 **Bow and stern thrusters** – The body and area around bow, stern and any other thrusters prone to coating damage, should be routinely maintained at dry-dockings. Particular attention should be paid to any free flooding spaces which may exist around the thruster tunnel. The housings/recesses, and retractable fittings such as stabilizers and thruster bodies, should have an anti-fouling coating system of adequate thickness for optimal effectiveness.

.3 **Edges and weld joints** – Exposed edges on the hull, such as around bilge keels and scoops, and weld joints, should be faired and coated to ensure adequate coating thickness to optimize system effectiveness.

.4 **Rudder hinges and stabilizer fin apertures** – Recesses within rudder hinges and behind stabilizer fins need to be carefully and effectively cleaned and re-coated at maintenance dry-dockings. Rudders and stabilizer fins should be moved through their full range of motion during the coating process to ensure that all surfaces are correctly coated to the specification of the anti-fouling system. Rudders, rudder fittings and the hull areas around them should also be adequately coated to withstand the increased wear rates experienced in these areas.

.5 **Propeller and shaft** – Propellers and immersed propeller shafts should be coated with fouling release coatings where possible and appropriate, to maintain efficiency and enable self-cleaning, so that the need for regular in-water cleaning and polishing is minimized.

.6 **Stern tube seal assemblies and the internal surfaces of rope guards** – Exposed sections of stern tube seal assemblies and the internal surfaces of rope guards should be carefully painted with anti-fouling coating systems appropriate to the degree of water movement over and around these surfaces.

.7 **Cathodic protection (CP) anodes** – Niche areas for biofouling can be minimized if: anodes are flush-fitted to the hull; a rubber backing pad is inserted between the anode and the hull; or the gap is caulked. Caulking the gap will make the seam or joint watertight. If not flush-fitted, the hull surface under the anode and the anode strap should be coated with an anti-fouling coating system suitable for low water flow to prevent biofouling accumulation. If anodes are attached by bolts recessed into the anode surface, the recess should be caulked to remove a potential niche.

.8 **Pitot tubes** – Where retractable pitot tubes are fitted, the housing should be internally coated with an anti-fouling coating system suitable for static conditions.

.9 **Sea inlet pipes and overboard discharges** – Anti-fouling coating systems should be applied inside the pipe opening and accessible internal areas. The anti-corrosive or primer coating selected should be appropriate to the specific pipe material if this material is different to the hull. Care should be taken in surface preparation and coating application to ensure good adhesion and coating thickness.

Procedures for ship maintenance and recycling facilities

6.9 Ship maintenance and recycling facilities should adopt measures (consistent with applicable national and local laws and regulations) to ensure that viable biofouling organisms or chemical and physical pollutants are not released into the local aquatic environment. These measures include the following:

.1 capturing biological material to minimize the risk of organism survival and establishment and other impacts of biological material being released into the aquatic environment;

.2 treating and/or disposing of captured biological material in an environmentally appropriate manner;

.3 scheduling of ships' arrival and departure at cleaning and maintenance facilities and at locations where ships are moored while waiting for cleaning and maintenance to minimize the risk of fouled ships contaminating other ships and the surrounding environment;

.4 removing biofouling from all underwater surfaces of a ship when in dry-dock, including niche areas; and

.5 lowering or extending retractable equipment such as stabilizers, thrusters, transducers and similar when a ship is in dry-dock or slipped, to permit access for the removal of biofouling from the equipment and its housing.

7 IN-WATER INSPECTION, CLEANING AND MAINTENANCE

7.1 Despite the use of effective anti-fouling systems and operational practices, undesirable amounts of biofouling may still accumulate during the intended lifetime of the anti-fouling system. To maintain a ship as free of biofouling as practical, it may be advisable for the ship to undertake in-water inspection, cleaning and maintenance.

In-water inspection of ships

7.2 In-water inspection can be a useful and flexible means to inspect the condition of anti-fouling systems and the biofouling status of a ship. In-water inspections should be undertaken periodically as a general means of routine surveillance, augmented by specific inspections as necessary to address any situations of elevated risk. Specific occasions when an in-water inspection may be appropriate, include the following:

.1 before and after any planned period of inactivity or significant or unforeseen change to the ship's operating profile;

.2 prior to undertaking in-water cleaning to determine the presence of known or suspected invasive aquatic species or other species of concern on the ship;

.3 after a known or suspected marine pest or other species of concern is discovered in a ship's internal seawater cooling systems; and

.4 following damage to, or premature failure of, the anti-fouling system.

7.3 It is recommended that ship operators identify niche areas on the ship that may accumulate biofouling to enable these areas to be effectively targeted during inspections. Areas may include the following:

- propeller thrusters and propulsion units;
- sea chests;
- rudder stock and hinge;
- stabilizer fin apertures;
- rope guards, stern tube seals and propeller shafts;

- cathodic protection anodes;
- anchor chain and chain lockers;
- free flood spaces inherent to the ships' design;
- sea chest and thruster tunnel grates;
- echo sounders and velocity probes;
- overboard discharge outlets and sea inlets; and
- areas prone to anti-fouling coating system damage or grounding (e.g., areas of the hull damaged by fenders when alongside, leading edges of bilge keels and propeller shaft "y" frames).

7.4 Dive and remotely operated vehicle (ROV) surveys can be practical options for in-water inspections although they do have limitations regarding visibility and available dive time compared with the area to be inspected, and difficulties with effectively accessing many biofouling prone niches. Such surveys should be undertaken by persons who are suitably qualified and experienced and familiar with biofouling and associated invasive aquatic species risks and the safety risks relating to in-water surveys. Regulatory authorities may have recommended or accredited biofouling inspection divers.

In-water cleaning and maintenance

7.5 In-water cleaning can be an important part of biofouling management. In-water cleaning can also introduce different degrees of environmental risk, depending on the nature of biofouling (i.e. microfouling versus macrofouling), the amount of anti-fouling coating system residue released and the biocidal content of the anti-fouling coating system. Relative to macrofouling, microfouling can be removed with gentler techniques that minimize degradation of the anti-fouling coating system and/or biocide release. Microfouling removal may enhance a ship's hull efficiency, reducing fuel consumption and greenhouse gas emissions. It is, therefore, recommended that the ship's hull is cleaned when practical by soft methods if significant microfouling occurs. In-water cleaning can also reduce the risk of spreading invasive aquatic species by preventing macrofouling accumulation.

7.6 It may be appropriate for States to conduct a risk assessment to evaluate the risk of in-water cleaning activities and minimize potential threats to their environment, property and resources. Risk assessment factors could include the following:

.1 biological risk of the biofouling organisms being removed from the ship (including viability of the biofouling organisms or the ability to capture biofouling material);

.2 factors that may influence biofouling accumulation, such as changes to the operating profile of the ship;

.3 geographical area that was the source of the biofouling on the ship, if known; and

.4 toxic effects related to substances within the anti-fouling coating system that could be released during the cleaning activity, and any subsequent damage to the anti-fouling coating system.

7.7 Personnel proposing to undertake in-water cleaning should be aware of any regulations or requirements for the conduct of in-water cleaning, including any regulations regarding the discharge of chemicals into the marine environment and the location of sensitive areas (such as marine protected areas and ballast water exchange areas). Where significant macrofouling growth is detected, it should be removed or treated (if this can be done without damaging the anti-fouling system) in accordance with such regulations. Where available, appropriate technology should be used to minimize the release of both anti-fouling coating or paint debris, and viable adult, juvenile, or reproductive stages of macrofouling organisms. The collected material should be disposed of in a manner which does not pose a risk to the aquatic environment.

7.8 For immersed areas coated with biocidal anti-fouling coatings, cleaning techniques should be used that minimize release of biocide into the environment. Cleaning heavily fouled anti-fouling coating systems can not only generate biofouling debris, but prematurely depletes the anti-fouling coating system and may create a pulse of biocide that can harm the local environment and may impact on future applications by the port authority for the disposal of dredge spoil. Depleted anti-fouling coating systems on hulls will rapidly re-foul. In-water cleaning or scrubbing of hulls for the purpose of delaying dry-dockings beyond the specified service life of the coating is, therefore, not recommended.

7.9 Immersed areas coated with biocide-free anti-fouling coating systems may require regular in-water cleaning as part of planned maintenance to maintain hull efficiency and minimize the risk of transferring invasive aquatic species. Cleaning techniques should be used which do not damage the coating and impair its function.

7.10 Any maintenance or repair activities should take care not to impede future in-service cleaning and/or maintenance, e.g., care should be taken to ensure sea chest grates do not become welded shut during repair work.

7.11 Care should be taken to ensure that any MGPSs installed are operating effectively to prevent accumulation of biofouling.

7.12 Regular polishing of uncoated propellers to maintain operational efficiency will also minimize macrofouling accumulation. Uncoated propeller shafts may require cleaning at the same time as the propeller. As a ship's routine propeller polishing will involve the use of divers, it is recommended that this opportunity is taken to assess sea chests, and other similar areas, for macrofouling.

7.13 Internal seawater cooling systems need to be regularly monitored to ensure effective biofouling control is maintained. Seawater cooling systems that operate while the ship is in port may be vulnerable to biofouling accumulation, and should be closely monitored. If seawater cooling systems become fouled, they should be appropriately treated. Any discharge of treated water from internal seawater cooling systems should be undertaken in accordance with applicable regulations.

8 DESIGN AND CONSTRUCTION

8.1 Initial ship design and construction offers the most comprehensive, effective and durable means by which to minimize ship biofouling risks. In the design and construction of a ship, or when a ship is being significantly altered, the following should be taken into consideration:

.1 Small niches and sheltered areas should be excluded from the ship as far as practical, e.g., flush mounting pipes in sea chests. Where not practical, these should be designed so that they may be easily accessed for inspection, cleaning and application of anti-fouling measures.

.2 Rounding and/or bevelling of corners, gratings and protrusions to promote more effective coverage of anti-fouling coating systems, and hinging of gratings to enable diver access.

.3 Providing the capacity to blank off the sea chest and other areas, such as moon pools, floodable docks and other free flood spaces, for treatment and/or cleaning.

8.2 Internal seawater cooling systems should be designed and made of appropriate material to minimize biofouling and constructed with a minimum of bends, kinks and flanges in seawater piping.

8.3 To avoid creation of avoidable niches while ensuring effective safety and operation of the ship, where practical, particular attention should be given to avoidance of unfilled gaps in all skin fittings and the detailed design of the items as follows:

.1 sea chests – minimize size and number, and use smooth surfaces to maximize flow efficiency, fit MGPS, and steam or hot water cleaning systems, grills and their opening arrangements designed for in-water inspection and maintenance;

.2 retractable fittings and equipment – avoid external reinforcement (such as stiffeners) where possible, design for in-water inspection and maintenance;

.3 tunnel thrusters – tunnels to be above light water line or accessible to divers, grills and their opening arrangements designed for in-water inspection, maintenance and operation;

.4 sponsons and hull blisters – use fully enclosed in preference to free flooding types, with access provisions made for in-water inspection, cleaning and maintenance;

.5 stern tube seal assemblies and rope guards – design for in-water inspection, cleaning and maintenance; and

.6 immersible and seabed equipment – ensure facilities for equipment washdown during retrieval and enclosed washdown areas for cleaning of equipment on board, if necessary, are provided.

9 DISSEMINATION OF INFORMATION

9.1 States are encouraged to maintain and exchange information relevant to these Guidelines through the Organization. Accordingly, States are encouraged to provide the Organization with the information related to the management of biofouling as follows:

.1 copies of current regional, national and local laws, regulations, standards, exemptions or guidelines;

.2 technical and research information, including any studies on the impact and control of invasive aquatic species in ships' biofouling, and on the efficacy and practicality of environmentally protective in-water cleaning technologies;

.3 education materials such as CD's, DVD's or printed materials; and

.4 the location of and the terms of use for cleaning and maintenance services and facilities for ships and equipment that comply with these Guidelines.

9.2 State authorities should provide ships with timely, clear and concise information on biofouling management measures and treatment requirements that are being applied to shipping and ensure these are widely distributed. Shipowners and operators should endeavour to become familiar with all requirements related to biofouling by requesting such information from their port or shipping agents or competent authorities (i.e. State authorities). State authorities should also provide ships with any available information on particular invasive aquatic species that may be present in a port and could attach to a ship as biofouling (e.g., if a particular species of concern is spawning) in a timely manner.

9.3 Organizations or shipping agents representing shipowners and operators should be familiar with the requirements of State authorities with respect to biofouling management and treatment procedures, including information that will be needed to obtain entry clearance. Verification and detailed information concerning State requirements should be obtained by the ship prior to arrival.

9.4 To monitor the effectiveness of these Guidelines, States, as part of the evaluation process could provide to the Organization details of records describing reasons why ships could not apply these Guidelines, e.g., design, construction or operation of a ship, particularly from the view point of ships' safety, or lack of information concerning the Guidelines.

10 TRAINING AND EDUCATION

10.1 Training for ships' masters and crews, in-water cleaning or maintenance facility operators and those surveying or inspecting ships as appropriate should include instructions on the application of biofouling management and treatment procedures, based upon the information contained in these Guidelines. Instruction should also be provided on the following:

.1 maintenance of appropriate records and logs;

.2 impacts of invasive aquatic species from ships' biofouling;

.3 benefits to the ship of managing biofouling and the threats posed by not applying management procedures;

.4 biofouling management measures and associated safety procedures; and

.5 relevant health and safety issues.

10.2 States and industry organizations should ensure that relevant marine training organizations are aware of these Guidelines and include this in their syllabuses as appropriate.

11 OTHER MEASURES

11.1 To the extent practical, States and port authorities should aim to ensure smooth flow of ships going in and out of their ports to avoid keeping ships waiting offshore so that anti-fouling systems can operate as effectively as possible.

11.2 States may apply other measures on ships within their jurisdiction for the purpose of providing additional protection for their marine environment, or in emergency situations. In managing emergency situations for biofouling, States should consider the guidance document for ballast water emergency situations (BWM.2/Circ.17).

11.3 States should take into account these Guidelines when developing other measures and/or restrictions for managing ships' biofouling.

11.4 Where other measures are being applied, States should notify the Organization of the specific requirements, with supporting documentation, for dissemination to other States and non-governmental agencies where appropriate.

11.5 The application of other measures by States should not place the safety of the ship and crew at risk.

12 FUTURE WORK

Research needs

12.1 States and other interested parties should encourage and support research into, and development of technologies for:

.1 minimizing and/or managing both macrofouling and microfouling particularly in niche areas (e.g., new or different anti-fouling systems and different designs for niche areas to minimize biofouling);

.2 in-water cleaning that ensures effective management of the anti-fouling system, biofouling and other contaminants, including effective capture of biological material;

.3 comprehensive methods for assessing the risks associated with in-water cleaning;

.4 shipboard monitoring and detection of biofouling;

.5 reducing the macrofouling risk posed by the dry-docking support strips, (e.g., alternative keel block designs that leave less uncoated hull area);

.6 the geographic distribution of biofouling invasive aquatic species; and

.7 the rapid response to invasive aquatic species incursions, including diagnostic tools and eradication methods.

12.2 Potential operational benefits of such technologies should also be highlighted and relevant information provided to the Organization.

Independent information needs

12.3 Summaries are needed of the different types of anti-fouling systems and other biofouling management measures currently available, how they work and their performance under different operating conditions and situations. This information could assist shipowners and operators when making decisions about the most appropriate coatings and coating systems for their ship type and activity.

APPENDIX 1

BIOFOULING MANAGEMENT PLAN AND RECORD BOOK

Format and content of Biofouling Management Plan

The following information should be considered when developing a Biofouling Management Plan (the Plan). It is important that the Plan be specific to each ship.

The Plan may be a stand-alone document or integrated in part or full in the ships' operational and procedures manuals and/or planned maintenance systems.

INTRODUCTION

This section should contain a brief introduction for the ship's crew, explaining the need for biofouling management, and the importance of accurate record keeping.

The Plan should state that it is to be available for viewing on request by a port State authority and should be written in the working language of the crew.

SHIP PARTICULARS

At least the following details should be included:

- Ship's name.
- Flag.
- Port of registry.
- Gross tonnage.
- Registration number (i.e. IMO number and/or other registration numbers, if applicable).
- Regulation Length.
- Beam.
- Ship type (as classified by Lloyds Register – see Table 1).
- International call sign and Maritime Mobile Service Identity (MMSI).

Table 1: Ship types, as classified by Lloyd's Register

anchor handling fire fighting tug/supply	dredger	lighthouse/tender	roll on roll off
anchor handling tug	drill platform	Liquid Natural Gas Carrier	salvage tug
anchor handling tug/supply	drill ship	Liquid Petroleum Gas Carrier	seismographic research
asphalt tanker	ferry	livestock	semi-sub heavy lift vessel
barge	fire fighting tug	meteorological research	suction dredger
bulk carrier	fire fighting tug/supply	naval auxiliary tanker	supply
bulk carrier with container capacity	fish carrier	naval vessel	support
bulk cement carrier	fish factory	oceanographic research	tank barge
bulk ore carrier	fishery protection	offshore safety	tanker (unspecified)
bunkering tanker	fishing (general)	passenger (cruise)	trailing suction hopper dredger
cable ship	floating gas production	passenger roll on roll off	training
chemical tanker	floating production tanker	patrol ship	trawler (all types)
combined bulk and oil carrier	floating storage tanker	pipe layer	tug
combined chemical and oil tanker	fully cellular containership	pollution control vessel	tug/supply
combined LNG and LPG Gas Carrier	general cargo	pontoon	vehicle carrier
combined ore and oil carrier	general cargo with container capacity	product tanker	whaler
crane barge	grab dredger	pusher tug	wood-chip carrier
crane ship	hopper barge	reefer	yacht
crude oil tanker	hopper dredger	research	
cutter suction dredger	icebreaker	research/supply ship	
diving support	landing craft	roll on roll off with container capacity	

INDEX

A table of contents should be included.

PURPOSE

The purpose of the Plan is to outline measures for the control and management of ships' biofouling in accordance with the Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (the Guidelines). It provides operational guidance for the planning and actions required for ships' biofouling management.

DESCRIPTION OF THE ANTI-FOULING SYSTEMS

The Plan should describe the anti-fouling systems in place for different parts of the ship, including as follows:

- type(s) of anti-fouling coating systems applied;
- details of where anti-fouling systems are and are not applied or installed;
- manufacturer and product names of all coatings or products used in the anti-fouling coating systems; and
- anti-fouling system specifications (including dry film thickness for coatings, dosing and frequency for MGPSs, etc.) together with the expected effective life, operating conditions required for coatings to be effective, cleaning requirements and any other specifications relevant for paint performance.

Previous reports on the performance of the ship's anti-fouling systems should be included, if applicable, and the AFS certificate or statement of compliance or other documentation should also be referenced, as appropriate.

DESCRIPTION OF OPERATING PROFILE

The Plan should describe the ship's operating profile that has determined the performance specifications of the ship's anti-fouling systems and operational practices, including:

- typical operating speeds;
- periods underway at sea compared with periods berthed, anchored or moored;
- typical operating areas or trading routes; and
- planned duration between dry-dockings/slippings.

DESCRIPTION OF AREAS ON THE SHIP SUSCEPTIBLE TO BIOFOULING

The Plan should identify the hull areas, niche areas and seawater cooling systems on the ship that are particularly susceptible to biofouling and describe the management actions required for each area. It should also describe the actions to be taken if the ship is operating outside of the desired operating profile, or if excessive unexpected biofouling is observed, and any other actions that can be taken to minimize the accumulation of biofouling on the ship. Table 1 provides an example of an action plan.

Table 2: Biofouling management action plan

Areas of the ship which are particularly susceptible to biofouling	**Management actions required for each area** (e.g., inspections, cleaning, repairs and maintenance)	**Management actions to be undertaken if ship operates outside its usual operating profile**
External hull surfaces: - Vertical sides - Flats - Boottop - Bow dome - Transom		
Hull appendages and fittings: - Bilge keels - A-brackets - Stabilizer fins - CP anodes		

Steering and propulsion:
 	
- Propeller
- Propeller shaft
- Stern tube seal
- Anchor chain
- Chain locker
- Rope guard
- Rudder
- Bow/Stern thrusters
    - Propeller
    - Thruster body
    - Tunnel
- Tunnel grates		

Seawater intakes and internal seawater cooling systems: - Engine cooling system - Sea chests (identify number and position) - Sea chest grate - Internal pipework and heat exchanger - Fire-fighting system - Ballast uptake system - Auxiliary services system		

A diagram of the ship should be included in the Plan to identify the location of those areas of the ship that are particularly susceptible to biofouling (including access points in the internal seawater cooling systems). If necessary these should show both side and bottom views of the ship.

OPERATION AND MAINTENANCE OF THE ANTI-FOULING SYSTEM

This section should contain a detailed description of the operation and maintenance of the anti-fouling system(s) used, including schedule(s) of activities and step-by-step operational procedures.

Timing of operational and maintenance activities

This section should stipulate the schedule of planned inspections, repairs, maintenance and renewal of the anti-fouling systems.

In-water cleaning and maintenance procedures

This section should set out planned maintenance procedures (other than for on board treatment processes) that need to be completed between dry-docking events to minimize biofouling. This should include routine cleaning or other treatments. Details should be provided on the treatment/cleaning to be conducted, the specification of any equipment required, details of the areas to which each specific treatment/cleaning is to be applied, step-by-step operational procedures where relevant and any other details relevant to the processes (e.g., chemicals required for treatment, any discharge standards).

Operation of onboard treatment processes

This section should provide specific advice about MGPS fitted, internal seawater cooling systems covered by the system and any not covered, and the associated maintenance and inspection schedule and procedures. This would include information such as when each MGPS is run, for how long and any cleaning/maintenance requirements of the system once use is finished. This section should also include advice for ship operators on procedures for biofouling management if the MGPS is temporarily out of operation.

SAFETY PROCEDURES FOR THE SHIP AND THE CREW

Details of specific operational or safety restrictions, including those associated with the management system that affects the ship and/or the crew.

Details of specific safety procedures to be followed during ship inspections.

DISPOSAL OF BIOLOGICAL WASTE

This section should contain procedures for the disposal of biological waste generated by treatment or cleaning processes when the cleaning is conducted by, or under the direct supervision of, the shipowner, master or crew.

RECORDING REQUIREMENTS

This section should contain details of the types of documentation to be kept to verify the operations and treatments to be recorded in the Biofouling Record Book as outlined in appendix 2.

CREW TRAINING AND FAMILIARIZATION

This section should contain information on the provision of crew training and familiarization.

APPENDIX 2

BIOFOULING MANAGEMENT PLAN AND RECORD BOOK

Biofouling Record Book Form

2011 Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species

Period From: ……………………… To: ....

Name of Ship ....

Registration number* ....

Gross tonnage ....

Flag ....

* Registration number = IMO number and/or other registration numbers.

The ship is provided with a Biofouling Management Plan ☐

Diagram of ship indicating underwater hull form (showing both side and bottom views of the ship, if necessary) and recognized biofouling niches:

1 Introduction

The Guidelines recommend that a Biofouling Record Book is maintained for each ship, in which should be recorded the details of all inspections and biofouling management measures undertaken on the ship.

2 Entries in the Biofouling Record Book

The following information should be recorded in the Biofouling Record Book:

2.1 After each dry-docking:

a. Date and location that the ship was dry-docked.

b. Date that ship was re-floated.

c. Any hull cleaning that was performed while dry-docked, including areas cleaned, method used for cleaning and the location of dry-dock support blocks.

d. Any anti-fouling coating system, including patch repairs, that was applied while dry-docked. Detail the type of anti-fouling coating system, the area and locations it was applied to, the coating thickness achieved and any surface preparation work undertaken (e.g., complete removal of underlying anti-fouling coating system or application of new anti-fouling coating system over the top of existing anti-fouling coating system).

e. Name, position and signature of the person in charge of the activity for the ship.

2.2 When the hull area, fittings, niches and voids below the waterline have been inspected by divers:

a. Date and location of ship when dive surveyed and reason for survey.

b. Area or side of the ship surveyed.

c. General observations with regard to biofouling (i.e. extent of biofouling and predominant biofouling types, e.g., mussels, barnacles, tubeworms, algae and slime).

d. What action was taken, if any, to remove or otherwise treat biofouling.

e. Any supporting evidence of the actions taken (e.g., report from the classification society or contractor, photographs and receipts).

f. Name, position, signature of the person in charge of the activity.

2.3 When the hull area, fittings, niches and voids below the waterline have been cleaned by divers:

a. Date and location of ship when cleaning/treatment occurred.

b. Hull areas, fittings, niches and voids cleaned/treated.

c. Methods of cleaning or treatment used.

d. General observations with regard to biofouling (i.e. extent of biofouling and predominant biofouling types, e.g., mussels, barnacles, tubeworms, algae and slime).

e. Any supporting evidence of the actions taken (e.g., report from the classification society or contractor, photographs and receipts).

f. Records of permits required to undertake in-water cleaning if applicable.

g. Name, position and signature of the person in charge of the activity.

2.4 When the internal seawater cooling systems have been inspected and cleaned or treated:

a. Date and location of ship when inspection and/or cleaning occurred.

b. General observations with regard to biofouling of internal seawater cooling systems (i.e. extent of biofouling and predominant biofouling types, e.g., mussels, barnacles, tubeworms, algae, slime).

c. Any cleaning or treatment undertaken.

d. Methods of cleaning or treatment used.

e. Any supporting evidence of the actions taken (e.g., report from the classification society or contractor, photographs and receipts).

f. Name, position and signature of the person in charge of the activity.

2.5 For ships with a MGPS fitted:

a. Records of operation and maintenance (such as regularly monitoring the electrical and mechanical functions of the systems).

b. Any instances when the system was not operating in accordance with the biofouling management plan.

2.6 Periods of time when the ship was laid up/inactive for an extended period of time:

a. Date and location where ship was laid up.

b. Date when ship returned to normal operations.

c. Maintenance action taken prior to and following the period laid up.

d. Precautions taken to prevent biofouling accumulation (e.g., sea chests blanked off).

2.7 Periods of time when ship operating outside its normal operating profile:

a. Duration and dates when ship not operating in accordance with its normal operating profile.

b. Reason for departure from normal operating profile (e.g., unexpected maintenance required).

2.8 Details of official inspection or review of ship biofouling risk (for ships arriving internationally, if applicable):

a. Date and location of ship when inspection or review occurred.

b. Port State authority conducting the inspection/review and details of procedures followed or protocol adhered to and inspector/s involved.

c. Result of inspection/review.

d. Name, position, signature of the person in charge of the activity for the ship.

2.9 Any additional observations and general remarks:

a. Since the ship was last cleaned, has the ship spent periods of time in locations that may significantly affect biofouling accumulation (e.g., fresh water, high latitude (Arctic and Antarctic) or tropical ports).

Record of Biofouling Management Actions

SAMPLE BIOFOULING RECORD BOOK PAGE

Name of Ship: ....

Registration number: ....

Date	Item (number)	Record of management actions	Signature of officers in charge

Signature of master ……………………………...……

***

INTERNATIONAL MARITIME ORGANIZATION

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MEPC.1/Circ.792
12 November 2012

GUIDANCE FOR MINIMIZING THE TRANSFER OF INVASIVE AQUATIC SPECIES AS BIOFOULING (HULL FOULING) FOR RECREATIONAL CRAFT

1 The Marine Environment Protection Committee, at its sixty-fourth session (1 to 5 October 2012), approved the Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft (see MEPC 64/23, paragraph 11.8), developed by the Sub-Committee on Bulk Liquids and Gases at its sixteenth session (30 January to 3 February 2012), as set out in the annex.

2 Member Governments are invited to bring the circular to the attention of all parties concerned.

***

ANNEX

GUIDANCE FOR MINIMIZING THE TRANSFER OF INVASIVE AQUATIC SPECIES AS BIOFOULING (HULL FOULING) FOR RECREATIONAL CRAFT

1 WHAT IS BIOFOULING?

Biofouling is the accumulation of aquatic organisms such as microorganisms, plants and animals, on surfaces and structures immersed in or exposed to the aquatic environment. Biofouling may also be known as hull fouling.

2 WHY IS THE TRANSFER OF BIOFOULING ORGANISMS A PROBLEM?

Aquatic organisms may be transferred to new locations as biofouling and can be harmful and invasive in locations where they do not naturally occur.

The transfer of invasive aquatic organisms can threaten fresh water, brackish and marine environments, human, animal and plant life, and economic and cultural activities.

Even when there is no visible biofouling, it is important to undertake the minimizing measures outlined in this guidance as light fouling (e.g. the slime layer) is likely to be present and the measures will help ensure that heavier fouling does not develop. Once invasive aquatic species are established in a new location or habitat, they are often impossible to eradicate.

3 WHAT INFLUENCES THE AMOUNT OF BIOFOULING ON A RECREATIONAL CRAFT?

All recreational craft have some biofouling, even if recently cleaned or anti-fouled. The amount of biofouling is influenced by factors such as:

- the type, age and condition of anti-fouling coating systems and hull cleaning practices;
- operating profile, including speeds, time underway compared with time moored or anchored, water temperature, and where the craft is normally kept (e.g. on land, in a marina or on an estuarine mooring);
- places visited; and
- design and construction, particularly areas that are more susceptible to biofouling (e.g. rudders, propellers and propeller shafts).

Actively minimizing the biofouling on your craft will greatly reduce the risk of transferring invasive aquatic species and can also improve fuel efficiency and operating speeds.

4 WHO SHOULD USE THIS GUIDANCE MATERIAL?

This guidance is for use by all owners and operators of recreational craft less than 24 metres in length. All craft can potentially transfer invasive aquatic species, even trailered craft that are normally kept out of the water.

5 HOW CAN BIOFOULING BE MINIMIZED?

If your recreational craft is normally kept in the water (regardless of whether it is trailerable or not), an appropriate anti-fouling coating system and good maintenance are the best way of preventing biofouling accumulation. If you regularly operate recreational craft in both marine and fresh waters, this may help to reduce the accumulation of biofouling (many marine fouling species do not easily survive in fresh or brackish water and vice versa) however, a good maintenance regime is still essential.

6 IS ONE ANTI-FOULING COATING SYSTEM ACCEPTABLE FOR ALL CRAFT?

Different anti-fouling coating systems suit different craft and activities. When choosing an anti-fouling coating system, you should seek expert advice and consider:

- planned periods between hauling/drying out or maintenance – to make sure the coating is effective for that time period;
- craft speed and patterns of use – biofouling can rapidly accumulate when craft are stationary or inactive in port or coastal waters;
- construction material (steel, wood, aluminium, etc.) – systems are specific for different hull materials; and
- location to be applied on the craft – different coating types may be required for different parts of the hull or structure, such as around the propeller shaft or rudders, due to water flow conditions.

Anti-fouling coating systems are subject to legal requirements and it is recommended that these requirements are considered when purchasing an anti-fouling coating system. For example, the International Maritime Organization (IMO) International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001 (AFS 2001) bans the use of anti-fouling paints that contain organotins such as TBT – highly poisonous tributyltin*.

7 HOW CAN BIOFOULING BE MINIMIZED IN NICHE AREAS?

Niche areas are parts of a craft that are particularly susceptible to biofouling growth due to different water flow conditions, the exposure of the anti-fouling coating system to wear or damage, or areas that may be inadequately coated. For example, any hull projections or indentations that may generate turbulent flow which causes greater wear on the coating. Niche areas may include:

- propellers, thrusters and/or propulsion units;
- rudder stocks and hinges;
- rope guards, stern tube seals and propeller shafts;
- apertures or free flooding spaces;
- areas prone to anti-fouling damage from groundings;
- outlets, inlets, cooling pipes and grates;
- anodes;
- anchors, anchor wells, chains and chain lockers; and
- echo sounders and probes.

Biofouling in the niche areas of your craft can be minimized by ensuring an appropriate anti-fouling coating system is applied, including the entrances to inlet and discharge pipes, rudder fixtures, bow and stern thrusters, propellers and shafts (unless polished), rope cutters,

* TBT has been proven to pose a substantial risk of toxicity and other chronic impacts to marine organisms and can also harm human health as a result of the consumption of affected seafood.

etc. When hauling out and applying an anti-fouling coating system, you need to make sure that you change the positions of blocks or slings to ensure these areas are also coated.

Some niche areas are not protected by an anti-fouling coating system, e.g. anodes. You can minimize biofouling associated with these anodes if they are flush-fitted, or a rubber backing pad is inserted between the anode and the hull, or the gap is caulked. Otherwise, you need to ensure that the hull under the anode and its strap has an anti-fouling coating system suitable for low water flow. If your anodes are attached by recessed bolts, then the recesses should be caulked.

If your craft is equipped with a Marine Growth Prevention System (MGPS) (for example, injections of chemicals in internal seawater systems), it is important that you regularly check correct operation of the MGPS in accordance with the manufacturer's instructions.

8 WHAT ABOUT CLEANING?

It is important that you regularly assess the need for cleaning and the condition of the anti-fouling coating system. Where it is safe to do so, in-water inspections of your craft may be appropriate:

- at the beginning and end of a planned period of inactivity;
- before and after a significant change to the craft's operating profile; or
- following damage to, or failure of, the anti-fouling system.

Where craft can be readily hauled out it is always preferable to clean the hull and niche areas out of the water where the waste can be effectively captured for proper disposal in accordance with local requirements. When cleaning your craft it is important that you consider the following precautions:

- haul your craft out of the water to clean it at least once a year;
- always follow the manufacturer's instructions when applying and maintaining your anti-fouling coating system;
- use cleaning methods and facilities that capture biological, chemical and physical debris; and
- coordinate cleaning or maintenance of the anti-fouling coating system, hull and niche areas with voyage or trip planning to ensure that the craft starts significant journeys as clean as practical.

Checking, cleaning and drying gear and equipment such as anchors, chains, nets, bait wells, and sports equipment after each trip is also an effective way to avoid accidental transfer of invasive aquatic species between water bodies.

9 WHAT ABOUT IN-WATER CLEANING?

In-water cleaning can be suitable for removing light fouling (e.g. the slime layer) with gentle techniques that minimize both the release of toxic substances from the anti-fouling and the degradation of the anti-fouling coating system.

Before undertaking any in-water cleaning, check with the local authorities for regulations regarding the in-water cleaning of boat hulls and/or the discharge of chemicals into the water column. If possible, use appropriate technology that captures biological, chemical and physical debris so that it can be disposed of to an appropriate onshore facility.

When cleaning an area coated with a biocidal anti-fouling coating system, use cleaning techniques that minimize the release of biocide into the environment. In-water scrubbing of large and distinct biofouling (e.g. barnacles, tubeworms or fronds of algae) generates waste or debris that may create a pulse of biocide that could harm the local environment. Biocide in the sediments could affect future applications by the port authority for the disposal of dredge spoil. In-water scrubbing may also prematurely deplete the anti-fouling coating system which would then rapidly re-foul. Scrubbing your craft in-water is not recommended as an alternative to out-of-water cleaning beyond the specified service life of an anti-fouling coating system.

Craft with biocide-free anti-fouling coating systems are likely to require regular in-water cleaning. It is important to use cleaning techniques that do not damage the anti-fouling coating and impair its function.

10 IS RECORDING BIOFOULING ACTIVITIES IMPORTANT?

It may be useful for you to retain your craft's biofouling management information in one place, such as the craft's logbook. This information could include details of the anti-fouling system used on your craft, any inspections made and notes on the effectiveness of the coating system. The anti-fouling manufacturer's product data sheets may also provide useful information. A diagram of the hull of your craft showing niche area locations and a summary of plans for minimizing biofouling (e.g. planned time interval between anti-fouling system renewals and how the different niche areas will and/or have been treated) is also useful. Example diagrams are shown at the end of this guidance. Having this information could also assist interested marina, port or harbour authorities to quickly and efficiently assess the potential biofouling risk of your craft and minimize delays to your journey or trip.

11 WHAT ABOUT TRAILERED CRAFT KEPT OUT OF THE WATER?

Even if your trailered craft is normally kept out of the water, it still has the potential to transfer invasive aquatic species from one area to another via the craft, its trailer or associated gear and equipment. To reduce this risk, the following measures should be taken after removing the craft from the water and before transporting to another water body or storing it on land:

- remove attached biofouling (e.g. seaweeds, barnacles, mussels) from the craft, gear, equipment and trailer;
- drain hull compartments, pipework and outboard engines;
- rinse the craft inside and out with fresh water and, if possible, dry all areas before moving;
- dispose of biofouling and waste water ashore where it cannot drain back into the water or drains; and
- inspect, clean and dry the gear and equipment after each journey or trip.

12 HOW IS IMO INVOLVED?

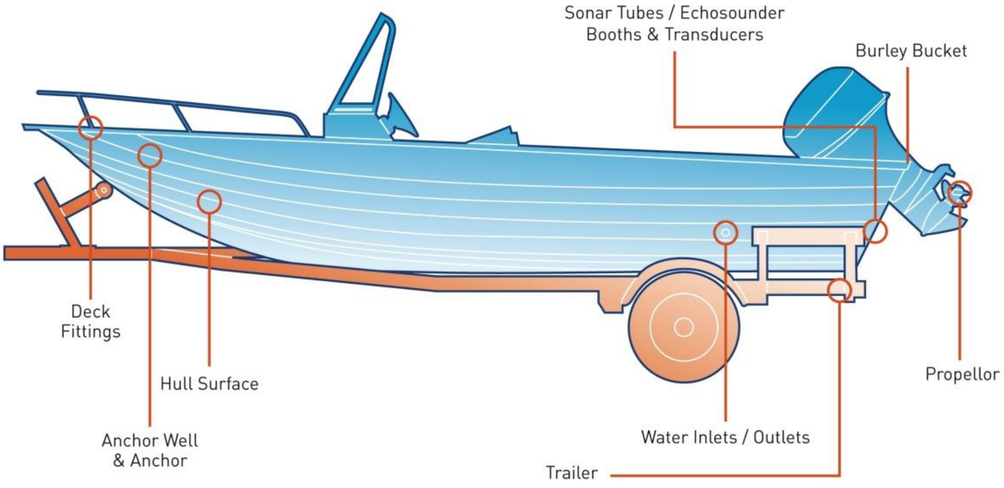
The International Maritime Organization (IMO) is the international body responsible for setting standards for the safety and security of shipping and prevention of marine pollution by ships. Some IMO regulations and/or guidelines may also apply to recreational craft. Due to global concerns about the effects of invasive aquatic species on the environment, IMO has adopted the Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species, adopted by resolution MEPC.207(62), to apply and provide information for ships of all sizes.

Please visit the link:

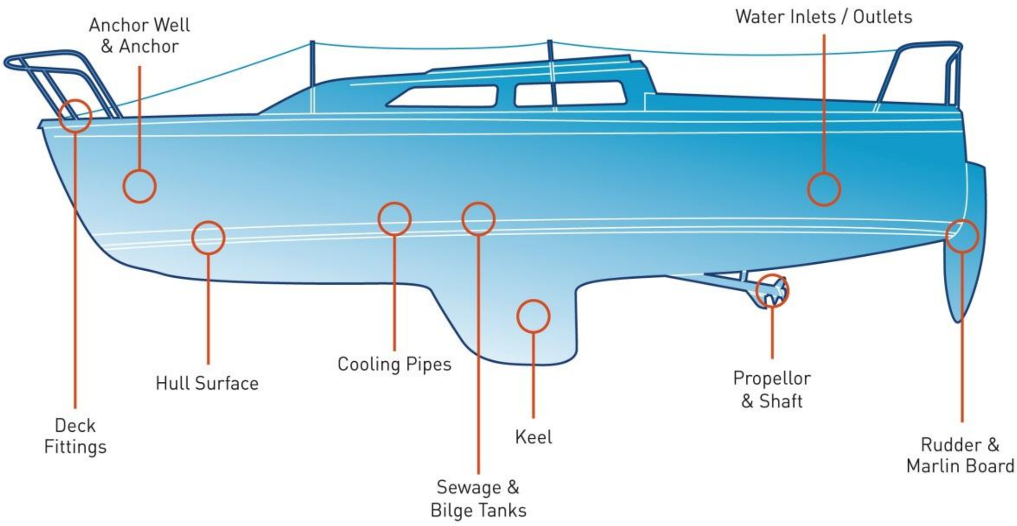
> http://www.imo.org/Knowledge Centre/How and where to find IMO information/Index of IMO resolutions/Marine Environment Protection Committee (MEPC)/MEPC.207(62)

This guidance document is specifically aimed at recreational craft less than 24 metres in length and provides information consistent with the IMO Guidelines.

Example of a recreational trailered craft diagram



Example of a recreational craft diagram



Environmental Protection Authority
Te Mana Rauhī Taiao

Evaluation and Review Report

APP201051 – Antifouling Paints

May 2013

New Zealand Government

www.epa.govt.nz

Executive Summary

This is the Evaluation and Review report that incorporates information received in stakeholder submissions on the reassessment of antifouling paints, and should be read in conjunction with the Application.

The Application, which was publicly notified in January 2013, included an explanation of the reassessment process and the methodology used to analyse the risks and benefits of antifouling paints. Proposals for additional controls to mitigate adverse effects were also included, and recommendations were made to help inform decision makers.

Following notification of the Application, submissions were received by the EPA. The EPA staff (the staff) have taken the information received during submissions into account and revised the information contained in the Application where appropriate. This document contains an explanation of those revisions. The staff will provide advice to the decision-making committee prior to any hearings held for this reassessment.

The EPA would like to thank everyone who responded to our requests for information and who made a submission. The time and effort you have spent has been invaluable to the evaluation process. All submissions have been summarised and responded to in Appendix A.

After taking into account information provided by submitters, the staff have updated their recommendations. The most significant change to the recommendations presented in the Application is a new proposal to retain approvals of substances containing DCOIT. This change is based on a revised environmental risk assessment, which predicts the risks to be considerably lower than what were modelled in the Application. Taking this into account, the staff now propose that of the 60 approvals included in this reassessment:

- 37 are retained;
- Eight are revoked;
- Eleven are approved for a four-year period; and
- Four are approved for a ten-year period.

This document also addresses some smaller changes, such as clarification of several controls and adding references which were missing from the Application.

Overview of the reassessment process

Grounds Application – Grounds approved 23/9/11

Grounds must be established in order for an application for a reassessment to be lodged. An application for grounds is lodged with the EPA and is heard by an independent decision-making committee established under HSNO.

Reassessment Application – Notified for public consultation 23/1/13 – 7/3/13

Once grounds have been established, an application for a reassessment is received and notified for public consultation.

Evaluation and Review Report – Circulated 3/5/13

After receipt of submissions on the Application, EPA Staff prepare an evaluation and review report taking into account information that has been submitted. This will be considered by the decision-making committee.

This document is the Evaluation and Review Report.

Public Hearing – 21/5/13–22/5/13

Once the staff have evaluated the submissions a public hearing is held, where submitters can speak to the decision-making committee.

Decision

After consideration of the application, the decision-making committee will issue its final decision.

Table of Contents

Part 1: Introduction

Part 1 explains the purpose and layout of this Evaluation and Review report.

Background

Under the Hazardous Substances and New Organisms Act 1996 (HSNO) the Chief Executive of the Environmental Protection Authority (EPA) can request previously approved substances be reassessed.

On 23 January 2013, an Application[1] to reassess antifouling paints under HSNO was publically notified and submissions were requested. Those submissions have been evaluated by the staff and the response to them, as well as the revised recommendations, can be found in this document. Throughout this process the applicant is the Chief Executive of the EPA.

Antifouling paints are slow release, surface-acting pesticides applied to prevent biofouling on submerged surfaces such as the hulls of vessels, nets and wharves. Antifouling paints come in liquid form. Most of the substances have physical hazards and all are toxic and ecotoxic. Almost all the substances being reassessed are skin sensitisers and/or eye irritants or corrosives. The formulations covered by this reassessment along with their approval numbers and hazard classifications are listed in Part 3.

The scope of this reassessment is restricted to a review of antifouling paints. The risk assessment methodology we have employed requires that emphasis be placed on the active ingredients, as they are the major contributors to the hazard profile of these substances. The effects of other components contained in antifouling paints (e.g. solvents) are not being reassessed. Antifouling paints that have been applied to vessels overseas and subsequently brought to New Zealand on the vessel are also not included in the scope of this reassessment.

Throughout the Application and this document, antifouling paints have been divided into groups according to the active ingredients they contain. For risk assessment purposes, the formulations which contain the same active ingredients are much more similar to one another than they are to any formulation containing a different active ingredient. As such, they have been grouped together and assessed in these groups. To clarify, although the active ingredients are often mentioned, this reassessment is only concerned with the formulations of antifouling paints containing them.

One proposal that staff have made for some of the substances being reassessed is that they should be given a time-limited approval, which will expire at a certain point in time. This is to allow for the consumer reliance on these substances to be phased out over a period of time, and so throughout this document these limited approval periods have been referred to as ‘phase-outs’.

[1] In order to distinguish between the two uses of the word “application” (i.e. when referring to the application document and references to the application of paints), the application document will be identified as “the Application”.

The staff have evaluated the active ingredients and formulations included in the Application, and propose to retain (with controls) or revoke these approvals. The Application included an explanation of the reassessment process and the methodology used to analyse the risks and benefits of the antifouling paints. Proposals for additional controls to mitigate adverse effects were also included, and recommendations were made to help inform decision makers. Submissions on the Application have now been received by the EPA.

This evaluation and review report includes the updated recommendations of the staff after taking into account the submissions received.

It is important to note that the recommendations of the staff may or may not be supported by the decision-making committee for this Application. The decision-making committee can choose to accept, reject or modify the recommendations.

This report contains:

1. A summary of new information received in the submissions which has led to the staff revising their recommendations and controls
2. Updated recommendations and controls
3. An appendix summarising the submissions that were received in response to the Application.

Part 2: Updates

This section contains a summary of the new information received from submitters which has led the staff to re-evaluate their recommendations made in the Application. It also highlights recommended changes to the HSNO classifications for antifouling paint formulations.

Submissions

This application was open for submissions from 23 January 2013 to 7 March 2013 and 30 submissions were received. Staff responses to each of the key comments and issues raised by submitters can be found in the Summary of Submissions (Appendix A).

In this section, the key comments raised by submitters are addressed. Some of these comments have resulted in the risk assessment being refined, while others have helped to point out areas of ambiguity which have been clarified in this document. See Part 3 of this document for the revised recommendations which have taken these comments into account.

Benefits and economic analysis

Submissions were received which commented on perceived inaccuracies of the economic analysis (the Covec report). There were also submissions made which emphasised the importance of antifouling paints to the biosecurity of New Zealand.

The generic benefits of antifouling paints were established as being high in the Application. It is because of these benefits that the staff have proposed the retention of some approvals even when significant risks exist. No additional information was provided to indicate that specific additional benefits exist for any of the individual approvals which the staff have proposed be phased out, so the analysis of benefits has not been altered from that presented in the Application.

Comments on the benefits and economic analysis have been addressed in Appendix A.

Controls

Following the public notification of the Application, the staff have considered submitters' comments on the proposed controls and recommendations. These are discussed in the sections below. The updated recommendations can be found in Part 3 of this document.

Guidance material

Submissions confirmed that users would benefit from guidance material regarding safe use of antifouling paints being made available. In addition to controls, the staff consider that providing information to users of the substances is critical to ensuring that they are aware of the risks and handling measures required to minimise adverse effects resulting from the use of antifouling paints. The staff consider guidance material should include information on how to comply with the HSNO obligations and safe handling of antifouling paints, including a description of the level of personal protective equipment (PPE) and respiratory protective equipment (RPE) required. It should also include information about the precautions necessary to ensure that the application and removal of antifouling paints from hulls of boats and other submerged surfaces does not result in environmental exposure.

Comments on proposed controls

Enclosed area

Submitters were unsure about the intent and meaning of the enclosed area control proposed for antifouling paints in the Application. There was concern that this would mandate the complete enclosure of vessels during the spray application of antifouling paints. Submitters felt full enclosure was unnecessary as many boat maintenance facilities have systems in place to prevent the off-target deposition of antifouling paint during spray application. They explained that preventing discharge of contaminants from spray is already a requirement of air discharge consents that are monitored by respective regional councils. If full enclosure of vessels during spray operation was the intent of this control, then submitters suggested this would be impractical and impose a significant cost on these operations.

EPA staff response

The intent of this control is to protect sensitive areas from spraydrift that occurs during the application of the antifouling paint with spray techniques. The staff note that the prevention of discharge of antifouling paints is not a requirement of all regional councils plans, and that establishing a standard for all antifouling paint application is an objective of the reassessment. The level of enclosure should be sufficient to ensure the off-target deposition of the substance is avoided. The staff consider that many marinas and commercial operators already have systems in place that would meet this requirement. However, to avoid further confusion the staff propose an amendment to the wording of this control as outlined in Table 1 below.

Table 1: Updated recommendations on the R2 control. Changes to recommendations are highlighted in yellow.

Control code	Intent of control	Proposed wording
R-2	**Controlled work area and signage** To protect sensitive areas from exposure arising from spraydrift of the substance, the application of the substance by spray techniques is permitted provided that it is done in a controlled work area. The extent of the controlled area should be sufficient to ensure that off-target deposition of the substance is avoided. Additionally, this will also protect bystanders from involuntary exposure to antifouling paints during application. In order to inform people that spray painting activity is being undertaken, the staff consider that signage should be	**Control** **Controlled work area** 1. Any person applying the substance must ensure that application of the substance is carried out in a **controlled work area**. 2. The **controlled work area**, as referred to in subclause (1) is a designated area in which antifouling paints are applied, using a method and located such that off-target deposition of the substance, including onto bystanders, is prevented.

	placed at the entrance of the controlled work area.	**Signage** 3. The person in charge of the application of the substance must ensure that signs are placed at every point of entrance into the controlled work area. Signs must be posted from the start of application, until the end of the application. 4. Signs erected in accordance with (2) must— a. warn that an application is being carried out using a substance that is toxic to humans; and b. state that entry into the controlled work area is not permitted unless personal protective equipment (PPE) is worn by the person entering the controlled work area, as if the person is carrying out the application. 5. Signs erected in accordance with subclauses (3) and (4) must— a. comply with regulation 34(1), (2), and (4) and regulation 35(1), (3), and (5) of the Hazardous Substances (Identification) Regulations 2001, but as if the distances referred to in regulation 35(3) were a distance of not less than 10 metres; and b. identify the person in charge of the application.

This amendment should provide greater clarity regarding the intent of this control. This is a performance-based measure and is designed to ensure the off-target deposition of antifouling substances does not occur onto bystanders or in sensitive areas, such as the aquatic environment.

Compliance with this control may be achieved in a number of ways, which will be appropriate to the circumstances in which the substance is being used (such as location, equipment and application method, mitigation measures, etc).

Collection of substance from maintenance activities

The waste collection and disposal control was generally supported. Submitters emphasised that many marinas already have waste collection facilities as part of their resource consent obligations under the Resource Management Act (RMA) 1991. Marina operators stressed that these facilities should be permitted to continue, particularly if they are operating with resource consent.

EPA staff response

The intent of this control is to ensure that people undertaking antifouling maintenance will collect their wastes and dispose of them in a manner which complies with the Hazardous Substances Disposal Regulations. The staff recognise that many marinas have existing waste management facilities appropriate for disposal of hazardous wastes. The staff note that, if the proposed controls are imposed, the facilities would need to be appropriate for disposal of used antifouling paint waste if they are used for that purpose (i.e. in accordance with the Hazardous Substances (Disposal) Regulations 2001).

To provide greater clarity the staff consider that the proposed wording for this control should be amended as outlined in Table 2.

Table 2: Updated recommendations on the R2 control.

Control code	Intent of control	Proposed wording
R-3	**Collection of substances from maintenance activities** Boat maintenance activities remove the antifouling substance, biofouling waste and other contaminants from the hull of a boat. Used antifouling paints removed from the hull of boats during maintenance present a risk to the terrestrial and aquatic environments. Collecting used antifouling paints generated from maintenance activities will reduce this risk to an acceptable level. It is intended that this control should apply to all antifouling paint waste so that it is a requirement to collect waste for any antifouling paint removed from a vessel's hull. The staff consider that this can be achieved by applying this control to each antifouling paint approval. The staff acknowledge that the time	**Control** 1. Any person who removes an antifouling paint coating from the hull of a boat during maintenance activities must ensure that ~~all~~ waste contaminated with antifouling paint residue is collected ; and 2. All collected waste, as referred to in subclause (1) must be disposed of in accordance with the Hazardous Substances (Disposal) Regulations 2001.

	period between application of the antifouling paint and subsequent removal of the used antifouling paint coating could be a number of years. By making this control a requirement for all antifouling paints (accompanied by appropriate label statements on antifouling paints as specified by control R-4), collection and proper disposal of all antifouling paint waste will become mandatory.	

Risk assessment

Human health risk assessment

Several submissions were received which commented on the staff's human health risk assessment. Most of these were requesting clarification of definitions and modelling assumptions. These have been addressed in Appendix A.

In the Application, the EPA asked specifically for any data on the dermal absorption of ziram to be provided. One submitter provided data on the dermal toxicity of ziram. While helpful, this information did not enable us to address the dermal absorption data gap and so default values must continue to be used in the modelling.

These submissions have not resulted in any significant changes to the risk assessment for human health.

Environmental risk assessment

Several submissions were received with general comments about the staff's environmental risk assessment. The staff have reviewed these, and have addressed them in Appendix A.

There were two submissions relating to specific changes in the environmental risk assessment. One submission addressed an assumption identified in the Application about the rejection of the proposal to apply a reduction factor to the calculated leaching rates. The other submission provided clarification around concerns that the EPA had identified with a previously submitted supporting data package.

Assumption around leaching rate (pages 96-97 of the Application)

In response to the EPA's 'Call for Information' document, a request was made that the EPA should apply a reduction factor (2.9) as discussed in Finnie (2006) to all the ISO 10890:2010 calculated leaching rates. After a thorough consideration of that request and submissions received on the Application, the staff have not applied this factor to the calculated leaching rates used in the risk assessment. Presented here is a summary of that consideration.

This approach was presented in a document to the International Maritime Organisation's Marine Environment Protection Committee (IMO-MEPC 60 (2010)). The Committee accepted the approach and formally noted that the mass-balance calculation method (used in the EPA's risk assessment), when used in conjunction with suitable conservative default correction factors, is the most appropriate route to generate representative biocide release rate estimates for antifouling paints.

In December 2011 the OECD Task Force on Biocides reviewed the various leaching rate methods and published a document titled 'Possible approach for developing data to estimate leaching rates of biocidal active substances from antifouling coating films' in March 2012[2]. This document concluded that before agreeing on recommended methods, more data needed to be reviewed. The staff note the comment in the foreword that this should be treated as a living document, which will be reviewed as new data becomes available. The staff agree with this comment and would like to point out that if further information becomes available in the future to support the use of a reduction factor of 2.9, then future risk assessments of antifouling paints conducted by the EPA will reconsider the application of this factor.

To date, only Norway has used this factor to adjust a leaching rate (in the Competent Authority Report on DCOIT) and that is still in a draft version.

The staff have concluded that the data which this proposal is based on are insufficient to apply a reduction factor.

The paper by Finnie (2006) provides a thorough review of the problems associated with the estimation of copper release rates from antifouling paints. However, the recommendation that a correction factor is to be applied to the ISO-calculation for regulatory use appears to be premature, based on the following reasons:

- The small number of vessels examined (n = 5)
- A lack of knowledge of the maintenance history, level of fouling and the voyage history of the vessels examined.

The discussion provided by the submission of Finnie (2013) (as an attachment to Submission 102707), although providing valuable insight, does not allay our concerns around the above critical information gaps.

The staff would like to make it clear that the recommendations made by this reassessment would not have been any different if the 2.9 reduction factor had been applied. This is because based on the staff's risk assessment, only zineb and dichlofluanid posed risks below the level of concern (LOC). All other substances which the staff have recommended be retained pose non-negligible risks to the environment. It is only because they possess benefits which outweigh these risks that staff recommend they be approved. This weighing of risks and benefits is qualitative, and was conducted by looking at the substances relative to each other. If the reduction factor was applied, then the Risk Quotients (RQs) for copper pyrithione, ziram and DCOIT would also fall below the level of concern.

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[2] http://search.oecd.org/officialdocuments/displaydocumentpdf/?cote=ENV/JM/MONO(2012)6&doclanguage=en

This would have no effect on the recommendations as the staff have already proposed to retain copper pyrithione and DCOIT approvals, while ziram is being approved on a time-limited basis because of the risks it poses to human health. All of the remaining substances would still have RQs greater than one. Meaning that they would still be subject to the same weighing up of relative risks and benefits.

Revised environmental modelling summary (pages 27-29 of the Application)

The staff had identified concerns with some aspects of a supporting data package which had been submitted during the preliminary risk assessment phase. The submitter provided clarification on a number of issues and this has enabled the staff to adjust the modelling for DCOIT, and the results of that are presented below.

The tables below show a revised summary of the environmental risk assessment, displaying the RQs for the four exposure scenarios modelled.

Table 3: Risk quotients for all active ingredients in four different exposure scenarios on the basis of "Average" predicted environmental concentrations (PECs)

Active ingredient	Half Moon Bay marina	Lyttelton Harbour	Kinloch marina	OECD marina
Chlorothalonil	100	23	30	24
Copper	3.3	0.6	7.5	0.33
DCOIT[3]	~~(10)~~ 0.62	~~(2.8)~~ 0.18	~~(6)~~ 1.8	~~(3.9)~~ 0.24
Dichlofluanid	0.71	0.29	0.17	0.99
Diuron	15	3.1	4.7	2.9
Irgarol*	240	49	150	46
Mancozeb*	2	0.6	4.9	1
Octhilinone	8.6	1.8	2.8	1.6
Pyrithione (Copper)	2.3	0.59	2.4	0.93
Pyrithione (Zinc)	4.1	1.1	4.4	1.7

[3] These RQs have been revised since the original application, as the result of a refined predicted non effective concentration (PNEC) value.

Thiram	**2.7**	**0.65**	**7.6**	**0.74**
Tolyfluanid*	**4.5**	**1.7**	**1.1**	**5.1**
Zineb	**0.27**	**0.12**	**0.063**	**0.46**
Ziram	**0.97**	**0.31**	**2.2**	**0.74**

* The leaching rate used to estimate PECs for these active ingredients was based on the highest for biocides (excluding copper), as no specific data were available to allow us to calculate the leaching rate. All other values are based on average PECs derived using average leaching rates.

According to our risk assessment, only two biocides used in antifouling paints - dichlofluanid and zineb - pose environmental risks below the level of concern.

All of the other active ingredients pose risks to the environment that are of concern. The active ingredients appear in Table 4 in the order of their environmental risk, based on the worst-case RQ.

Table 4: Worst-case scenarios for environmental RQs

Active ingredient	Worst-case RQ
Irgarol	**240**
Chlorothalonil	**100**
Diuron	**15**
Octhilinone	**8.6**
Thiram	**7.6**
Copper	**7.5**
Mancozeb	**4.9**
Tolyfluanid	**4.5**
Pyrithione (Zinc)	**4.4**
Pyrithione (Copper)	**2.4**
Ziram	**2.2**
DCOIT[4]	**~~(6)~~ 1.8**
Dichlofluanid	**0.71**
Zineb	**0.27**

[4] This RQ has been revised since the original application, as the result of a refined PNEC value.

Derivation of PNEC values for DCOIT (page 118 of the Application)

A new PNEC value has been calculated for DCOIT. The explanation of that derivation is below.

A species sensitivity distribution (SSD) was calculated from the following chronic no observed effect concentration (NOEC) data. This resulted in an HC5 value of 0.22 µg/L.

Table 5: The database of NOEC values used in the generation of an SSD for DCOIT

Species	Media	Test duration	Endpoint	Value (µg/L)	Reference
Oncorhynchus mykiss	Fresh water	97 day	$NOEC_{growth}$	0.56	Rhodes (2002)
Cyprinodon variegatus	Salt water	35 day	$NOEC_{survival}$	6.0	Ward and Boeri (1990)
Daphnia magna	Fresh water	21 day	NOEC	0.63	Brown (2002)
Americamysis bahia	Salt water	28 day	NOEC	0.63	Ward and Boeri (2000)
Chironomus riparius	Fresh water/sediment	28 day	10 d NOEC	9.5 (porewater)	Aufderheide (2002)
Crassostrea virginica	Saltwater	48 hour	NOEC (larval development)	18	Roberts, Delisle and Vogelbein (1990)
Mytilus edulis	Saltwater	48 hour	EC10	2.2	Bellas (2006)
Ciona intestinalis	Saltwater	48 hour	Ec10	10.5	Bellas (2006)
Paracentrotus lividus	Saltwater	48 hour	EC10	0.55	Bellas (2006)
Navicula pelliculosa	Fresh water	96 hour	24 h NOErC	0.34	Sinderman, Kendall, Krueger (2007a)
Skeletonema costatum	Saltwater	120 hour	24 h NOErC	0.48	Sinderman, Kendall, Krueger (2007b)
Selenastrum capriconutum	Fresh water	96 hour	NOErC	7.8	Hughes, C.
Anabaena flos-aquae	Fresh water	96 hour	NOErC	1.5	Hughes, C.
Scenedesmus vacuolatus	Fresh water	24 hour	24 h NOEC	27.1	Arrhenius (2006)
Lemna gibba	Fresh water	7 day	3 d NOEC	4.5	Rhodes (2001)

Species	Media	Test duration	Endpoint	Value (µg/L)	Reference
Fucus serratus Linnaeus	Saltwater	72 hour	24 h NOEC	2.5	Braithwaite (2005)

The next step in generating a PNEC value is to decide on an appropriate assessment factor to apply to the HC5 value (PNEC = HC5/assessment factor). The following points were considered:

- No species has a NOEC below the HC5 value of 0.22 µg/L, with the lowest NOEC (0.34 µg/L) being 1.5 times higher than the HC5.
- The database (see table 5) contained two fish species, two crustaceans, an insect, five algal species, two higher plant species, two mollusc species, a sea squirt and an echinoderm. This covers a large variety of taxa.
- An independent microcosm study[5] determined a NOEC of 2.82 µg/L, while a study on a periphyton community indicated a No Effect Concentration of 50.2 µg/L. Both of these studies indicate that the HC5 value (0.22 µg/L) would be protective at the population level.

The database used to derive the HC5 value fulfills the requirements as described in the European Commission's Technical Guidance Document on Risk Assessment (TGD)[6]. It also includes marine-specific species, though it is recognized that the mollusc and echinoderm data do not include long-term growth data. Although the NOEC data on the development at a sensitive life-stage can be used instead of long-term growth data, it cannot be considered a true chronic endpoint.

In conclusion, it is considered that an assessment factor of 2 is appropriate.

PNEC = 0.22 µg/L / 2

$PNEC_{marine}$=0.11 µg/L

$PNEC_{freshwater}$=0.11 µg/L

Environmental risks for all exposure scenarios

Table 6: Tier I PEC values and risk quotients for DCOIT according to the different exposure scenarios selected for the maximum leaching rate

PEC (µg/L)	Half Moon Bay marina	Lyttelton harbour	Kinloch marina
Maximum	0.13	0.033	0.4
95% concentration	0.13	0.031	0.4

[5] Larson et al. 2003

[6] http://ihcp.jrc.ec.europa.eu/our_activities/public-health/risk_assessment_of_Biocides/doc/tgd

Average	0.082	0.022	0.24
Median	0.078	0.024	0.23
Minimum	0.029	0.0036	0.087
RQ=PEC/PNEC	**$PNEC_{marine}$=0.11 µg/L**		**$PNEC_{freshwater}$=0.11 µg/L**
Maximum	1.2	0.3	3.6
95% concentration	1.2	0.29	3.6
Average	0.74	0.2	2.2
Median	0.71	0.22	2.1
Minimum	0.27	0.033	0.79

Table 7: Tier II PEC values and risk quotients for DCOIT according to the different exposure scenarios selected for the average leaching rate

PEC (µg/L)	Half Moon Bay marina	Lyttelton harbour	Kinloch marina
Maximum	0.11	0.028	0.34
95% concentration	0.11	0.026	0.34
Average	0.069	0.019	0.2
Median	0.066	0.02	0.19
Minimum	0.025	0.003	0.073
RQ=PEC/PNEC	**$PNEC_{marine}$=0.11 µg/L**		**$PNEC_{freshwater}$=0.11 µg/L**
Maximum	0.98	0.25	3.1
95% concentration	0.98	0.24	3.1
Average	**0.62**	**0.17**	**1.9**
Median	0.6	0.18	1.8
Minimum	0.22	0.027	0.66

Concerns raised by Māori

Te Rūnanga o Ngāi Tahu and the Ngātiwai Trust Board made submissions raising matters of cultural concern relating to the use and management of antifouling paints. These were largely based around the lack of New Zealand specific data in the staff's risk assessment, the need to better provide for 'active protection' under the principles of the Treaty of Waitangi, and concerns relating to compliance. The staff assessment is based on all the available information, and many of the species used in the risk assessment are found in New Zealand. In terms of concerns relating to use, management, compliance and data gaps - a number of additional controls, phase-out periods and the revocation of approvals have been suggested to address these concerns. The staff also consider that the application of these additional controls and recommendations improve the overall provision for ‘active protection’ by reducing or removing the potential for effects to occur.

The staff note that one of the key reasons that grounds for this reassessment were established, was that there was significant Māori concern. This level of concern does not appear to be represented in the number of submissions that were received. The staff consider that this is because of the consultative work done throughout the reassessment process, and feel that the active dialogue between the EPA and Māori has helped to ease a lot of concerns.

Other issues

Submitters commented on a number of issues that were not directly discussed in the Application. These included concerns that the EPA could not ensure the compliance of international shipping and that the regulatory process might be an impediment to the development of new technologies. The staff note that this reassessment only applies to antifouling paint applied in New Zealand and so any vessels painted overseas will not face any changes as a result of this reassessment. The full staff responses to these comments can be found in Appendix A.

Changes to HSNO classifications

The staff proposed revised classifications for most approvals, after reviewing the classifications for all antifouling paint formulations covered by this reassessment. The classification review took into account the following matters:

- changes in the classification of the components of the mixture, including antifouling paint active ingredients, that may have occurred since the original classification was carried out;
- the use of summation rules in place of additivity for derivation of ecotoxicity classifications for mixtures; and
- in the absence of formulation data, the use of mixture rules to determine irritancy/corrosivity classifications.

The EPA sought comments on the proposed revisions and several importers/manufacturers provided some comment on approvals which they had information about.

The staff have been working with those companies to address the specific concerns raised. The staff have updated their proposed classifications based on confidential information provided and the revised classifications can be found in Part 3 of this report.

For point of clarification, the staff have identified a number of substances that should be classified as being acutely toxic via aspiration. This classification has been identified on the basis that:

- the concentration of hydrocarbons in the formulation is > 10 %
- the hydrocarbon component(s) have a kinematic viscosity of ≤20.5 mm^2/s measured at 40°C
- the formulation has a kinematic viscosity of ≤20.5 mm^2/s measured at 40°C.

A formulation is classified as an aspiration hazard when the criteria above are met. A formulated product should be labelled accordingly to identify those hazards in line with the default controls. Where the acute toxicity classification is denoted with a superscript 'A' (e.g. $6.1D^A$), if the kinematic viscosity is ≥ 20.5 mm^2/s measured at 40°C, then the substance is not considered to be an aspiration hazard.

Corrections to the EPA Application

The changes mentioned below do not have any effect on the risk assessment conducted by the staff for the Application. They are included here solely for accuracy's sake.

International regulatory actions

Copper pyrithione (page 64 of the Application)

Jurisdiction	Regulatory actions/Conclusions	Update
USEPA (Federal)	Not registered yet. Currently being assessed for registration as a new active ingredient in an antifouling formulation.	This is incorrect, the USEPA do have a registration for an antifouling paint containing copper pyrithione.

Copper (page 65 of the Application)

Jurisdiction	Regulatory actions/Conclusions	Update
California EPA (May 2011)	No antifouling paint containing copper will be allowed to be manufactured, sold and distributed from 2015 onwards.	California will no longer be implementing the ban from 2015 onwards, and they are now considering other options to protect their marine environment.

References

It was noted during the submission period that two arguments had been misattributed in the Application. They have been revised below.

The following paragraph is from page 96 of the Application:

"*As for point (b), Howell notes that "the release rate would be expected to vary from sampling locations on the vessel hull because of the differing local hydrodynamic conditions as well as differing biological conditions (e.g. type and degree of biofilm growth)." This generates an uncertainty around the effectiveness of the coating at the specific point of their service life when the measurements took place. In addition, the author notes that "the environmental release rate data referenced in this study* *have been generated from vessels at pier-side without specific knowledge of the activity patterns of those vessels". There is therefore uncertainty around the second bullet point of (b) above*."

The quotation about sampling locations comes from IMO, 2010 and not from Howell. The quotation about knowledge of vessel activity patterns should be attributed to Finnie, 2006.

It was also noted that the following references were inadvertently omitted from the original reference section (page 151-155 of the Application). A revised reference list can be found in Appendix C.

Finnie, A. A. (2006). Improved estimates of environmental copper release rates from antifouling products, Biofouling, 22(5), 279-291.

Howell D. 2010. Testing the impact of biofilms on the performance of marine antifouling coatings. In: Hellio, C., Yebra, D.M. (Eds.), Advances in Marine Antifouling Coatings and Technologies. Woodhead Publishing Ltd, Oxford, UK, pp. 422-442.

IMO Marine Environmental Protection Committee. 2010. 60th Session, 22-26 March 2010, Document MEPC 60/13, Harmful Anti-fouling Systems for Ships – The generation of biocide leaching rate estimates for anti-fouling coatings and their use in the development of proposals to amend annex 1 of the AFS Convention, submitted by the International Paint and Printing Ink Council.

Preiser RS, Bohlander GS and Cologer CP. 1977. Fouling Control Means Fuel Savings for the US Navy. STAR Symposium, pp. 499-516.

Seligman PF, Neumeister JW inventors, 1983. The United States of America as represented by the Secretary of the Navy, assignee. In situ leach measuring system. US Patent 4375451.

Valkirs AO, Davison BM, Kear LL, Fransham RL, Zirino AR, Grovhoug JG. 1994.Environmental effects from in-water cleaning of ablative copper antifouling coatings. NavalCommand Control and Ocean Surveillance Center RDT&E Division San Diego, Technical Document 2662. 82 p. Available from US Department of Commerce NationalTechnical Information Service, Springfield, VA 22161.

Valkirs AO, Seligman PF, Haslbeck E, Caso JS. 2003. Measurement of copper release rates from antifouling paint under laboratory and in situ conditions: implications for loading estimation to marine water bodies. Mar Pollut Bull 46: pp.763-779.

The staff would like to sincerely thank all those submitters who pointed out errors and omissions in the Application.

Part 3: Revised recommendations

This section contains updated recommendations and controls and explains how they differ from the recommendations and controls in the Application.

Updated formulation recommendations

The following recommendations differ from those proposed in the Application, as they incorporate new information received from submitters. The most significant change to the staff recommendations presented in the Application is that the staff now propose to retain approvals of substances containing DCOIT. This change is based on a revised environmental risk assessment, which predicts the risks to be considerably lower than what were modelled in the Application. Taking this into account, the staff now propose that of the 60 approvals included in this reassessment:

- 37 are retained
- Eight are revoked
- Eleven are approved for a four-year period
- Four are approved for a ten-year period.

Overall assessment of risks and benefits

The staff are satisfied that antifouling paints possess generic benefits sufficient to outweigh some level of risk of adverse effects. These generic benefits are combined with the specific benefits of individual antifouling paint active ingredients to produce a total benefit for each substance. It should be noted that the only antifouling active ingredient considered by staff to possess any specific benefits is copper. Copper is used as the principal biocidal component in all antifouling paints. This means there would be no antifouling paints available if copper was not approved for use in these products. This represents a significant specific benefit for copper, as the use of copper is necessary for the provision of all of the generic benefits of antifouling paints.

In order to recommend retaining an existing approval, the staff must be satisfied that the substance either:

a) poses risks to human health and the environment which are negligible, or

b) possesses benefits which outweigh any un-mitigated risks posed to human health or the environment.

For substances with non-negligible risks, controls are applied in an attempt to mitigate the risks. If the risks are still non-negligible, then they must be weighed against the benefits of the substance. If the benefits outweigh the risks (with appropriate controls in place), the staff recommend the substances are retained.

For substances where the risks cannot be adequately mitigated, and their use and effect outweigh their benefits, the staff recommend their approvals are revoked. The staff consider that on this basis the approvals for antifouling paints containing irgarol and chlorothalonil should be revoked. The risks associated with these substances are greater than the benefits they provide. Disposal of any residual stocks of irgarol or chlorothalonil-containing antifouling paints should be by use in accordance with the label.

There are also a group of substances which, according to the staff, possess levels of risk which are finely balanced with their current levels of benefit. This balance only exists because currently there is a relatively large dependence on these substances by users, which generates a specific benefit for them. Were the substances to be made unavailable, this could result in users struggling with the difficulty of purchasing different paints and opting instead to delay repainting their boats with antifouling paints. The staff consider this may be a risk because users can have quite strong brand loyalty (as pointed out in submissions), and when this is combined with an increase in cost, the act of finding a new paint and purchasing it may not be easy or desirable for some users.

If users delay repainting their boats, this could create a risk to New Zealand's biosecurity which is currently being mitigated (albeit in an indirect way) by the current HSNO approvals for these substances.

While there is currently a fine balance between the benefits and the risks for these substances, after a suitable period of time (during which industry will need to stop using these active ingredients in their products, and users will need to change their purchasing habits), the staff expect this balance will shift and the risks will subsequently outweigh the benefits.

The staff recommend that these substances are approved for a fixed timeframe as detailed below. During this time it is expected that the specific benefits currently possessed by these substances will decline, leaving only the generic benefits. At this point the risks will outweigh the benefits and the formulations should not continue to be approved.

The following recommendations are made for antifouling paints as a result of the updated risk and benefit assessment:

Table 8: Updated recommendations for antifouling paint approvals

Updated Recommendation	Active Ingredient substance
Retain approvals, with additional controls	All antifouling paints containing one or more of the following as active ingredients: • Copper* • Copper pyrithione • DCOIT • Dichlofluanid • Mancozeb • Tolyfluanid • Zineb • Zinc pyrithione
Time limited approvals	All antifouling paints containing one or more of the following: • Diuron (4 years) • Octhilinone (4 years) • Thiram (10 years)

	• Ziram (4 years)
Revoke approvals	All antifouling paints containing either of the following: • Chlorothalonil • Irgarol 1051

The recommendation for substances containing DCOIT has been changed. In the Application, the environmental risk assessment predicted risks which exceeded the level of generic benefit possessed by these substances. Further information was provided as a submission, and the risk assessment was refined (see the 'Revised environmental modelling summary' section earlier in this document). This resulted in the modelled risks now being less than the level of generic benefits, so the staff now propose to retain approvals for DCOIT-containing substances.

The staff note, despite the recommendation to retain antifouling paints containing mancozeb, the only approved antifouling paints that contain mancozeb also contain chlorothalonil. Given that the risks associated with chlorothalonil-based antifouling paints are considered to outweigh the benefits, those approvals for antifouling paints containing mancozeb and chlorothalonil should be revoked as a result of the recommendations for chlorothalonil-containing antifouling paints.

The staff also note that a submission has suggested that manufacture of dichlofluanid-containing antifouling paints will cease at the end of 2013. While staff do not consider that this directly effects the recommendation to retain dichlofluanid approvals, decision makers should consider this when determining if the phase-out periods proposed for other substances are appropriate. As the generic benefits of antifouling paints are only fully attained if sufficient numbers of antifouling paints are still being used, it is important to consider potential supply issues when determining which high-risk substances can be revoked.

The recommendations above do not apply to the approvals for the active ingredients themselves, but only to the approvals for the formulations where the active ingredients are used in antifouling paints. The specific HSNO approvals that the recommendations apply to are detailed below.

The staff note that antifouling paints have biocidal properties which give rise to the potential for cultural risk. These risks include the deterioration of the mauri of taonga flora and fauna species, the environment and the general health and well-being of individuals and the community. The staff consider that recommendations proposed in this document will sufficiently manage the potential adverse effects to the relationship between Māori and the environment. Further, the additional level of biosecurity to the marine environment that antifouling paints provide will aid Māori to fulfil their role as kaitiaki. Therefore it is considered that the EPA is meeting all its obligations, including those to Māori interests and the principles of Te Tiriti o Waitangi/the Treaty of Waitangi.

Updated control recommendations

The staff consider that antifouling paints containing only the following active ingredients should be retained as they either pose negligible risks (dichlofluanid and zineb) or they pose risks which are considered less than the level of benefits that they possess. These additional controls ensure that residual risks are managed. Note that these additional controls now also apply to substances containing DCOIT, in line with the revised recommendation.

Table 9: Recommended additional controls that apply to antifouling paints containing only active ingredients that are proposed to be retained.

Active ingredient	Additional controls
Copper Copper pyrithione Dichlofluanid DCOIT Mancozeb Tolyfluanid Zinc pyrithione Zineb	R-1: PERSONAL PROTECTIVE EQUIPMENT CONTROL VARIATION (immediate implementation)
	R-2: CONTROLLED WORK AREA AND SIGNAGE (2 year phase-in)
	R-3: COLLECTION OF SUBSTANCES FROM MAINTENANCE ACTIVITIES (2 year phase-in)
	R-4: ADDITIONAL LABELLING REQUIREMENTS (2 year phase-in)
	R-5: SAFETY DATA SHEETS MODIFICATION (6 month phase-in)

The staff consider that antifouling paints containing the following active ingredients should have time-limited approvals due to their high risks to human health and/or the environment which are currently being finely balanced with specific benefits. During the specified phase-out period, the additional controls and variations in

Table 10 should apply, to ensure that risks are minimised during the continued use of these high-risk substances.

Table 10: Recommended additional controls that apply to antifouling paints containing active ingredients that are proposed to be revoked.

Active ingredient	Additional Controls
DiuronOcthilinone Thiram Ziram	R-1: PERSONAL PROTECTIVE EQUIPMENT CONTROL VARIATION (immediate implementation)
	R-2: CONTROLLED WORK AREA AND SIGNAGE (2 year phase-in)
	R-3: COLLECTION OF SUBSTANCES FROM MAINTENANCE ACTIVITIES (2 year phase-in)
	R-4: ADDITIONAL LABELLING REQUIREMENTS (2 year phase-in)

Active ingredient	Additional Controls
	R-5: SAFETY DATA SHEETS MODIFICATION (6 month phase-in)

The staff consider that providing user information for the safe use of antifouling paints and good practice guidance for maintenance and disposal activities will be critical in allowing professional and non-professional users determine what PPE should be employed when applying antifouling paints. Raising awareness of these requirements will provide greater assurance to the EPA and enforcement agencies that users, in particular the non-professionals, know their obligations in terms of preventing human and environmental exposure.

Table 11 is provided to help with the cross-referencing of product names, the biocidal active ingredients and the HSNO approval number that covers the product.

Table 11: Cross-reference of antifouling paint products with HSNO approvals

Trade name	Biocidal active ingredients	HSNO approval number
271 Longlife Antifouling black	Chlorothalonil, Copper (I) Oxide	HSR000912
271 Longlife Antifouling blue	Chlorothalonil, Copper (I) Oxide	HSR000912
271 Longlife Antifouling red	Chlorothalonil, Copper (I) Oxide	HSR000912
ABC #3 Antifouling	Ziram, Copper (I) Oxide	HSR007897
ABC7 ANTIFOULING	3(2H)-Isothiazolone, 4,5-dichloro-2-octyl-, Copper (I) Oxide	HSR001748
Ablative A Antifouling Range	Thiram, Copper (I) Oxide	HSR000035
Ablative A1 Antifouling Range	Irgarol 1051, Tolylfluanid, Zinc pyrithione, Octhilinone, Copper (I) oxide, Copper Pyrithione	HSR000036
Ablative B Antifouling Range	Irgarol 1051, Copper (I) oxide	HSR000037
AF1000	Thiram, Copper (I) Oxide	To be assigned (from HSR000035)
AF500 Cleanship Antifouling black	Chlorothalonil, Mancozeb, Copper (I) Oxide	HSR000914
AF500 Cleanship Antifouling blue	Chlorothalonil, Mancozeb, Copper (I) Oxide	HSR000914
AF500 Cleanship Antifouling green	Chlorothalonil, Mancozeb, Copper (I) Oxide	HSR000914
AF500 Cleanship Antifouling red	Chlorothalonil, Mancozeb, Copper (I) Oxide	HSR000914
Alloy Antifouling Range	Diuron, Copper Thiocyanate	HSR000038
Alloy B Antifouling Range	Zinc Pyrithione, Copper	HSR000951

Trade name	Biocidal active ingredients	HSNO approval number
	Thiocyanate	
Alloy C Antifouling Range	Tolyfluanid, Copper Thiocyanate	HSR000952
Antifouling paint containing 640-655g/L cuprous oxide	Copper (I) Oxide	HSR100080
Antifouling Seaguardian	Copper (I) Oxide	HSR000931
Antifouling Seaquantum Classic	Copper (I) Oxide, Copper Pyrithione	To be assigned (from HSR000036)
Antifouling SeaQuantum Ultra	Copper (I) Oxide, Copper Pyrithione	To be assigned (from HSR000036)
Antifouling Seasafe	Zineb, Copper Thiocyanate	HSR000918
Antifouling Seavictor 40	Copper (I) Oxide	HSR000930
Antifouling Seavictor 50	3(2H)-Isothiazolone, 4,5-dichloro-2-octyl-, Copper (I) Oxide	to be assigned (from HSR000931)
Awlcraft No.5	Thiram, Copper (I) Oxide	HSR000035
Coastal Copper Antifouling	Thiram, Copper (I) Oxide	HSR000035
Coppercoat Extra	Diuron, Copper (I) Oxide	To be assigned (from HSR000924)
Cruiser Superior (White, Scarlet, Blue & Black)	Diuron, Copper Thiocyanate	HSR000916
Flexgard VI	Copper (I) Oxide	HSR000919
Gemcoat AB	Thiram, Copper (I) Oxide	HSR000928
Hard A Antifouling Range	Irgarol 1051, Copper (I) oxide	HSR000039
Hard B Antifouling Range	Octhilinone, Tolylfluanid, Copper (I) Oxide	HSR000040
Hempel’s A/F Globic NCT 8190M	Copper (I) Oxide, Copper Pyrithione	To be assigned (from HSR000036)
Hempel’s A/F Globic NCT 8195M	Copper (I) Oxide, Copper Pyrithione	To be assigned (from HSR000036)
Hempel’s Antifouling Nautic	Diuron, Copper (I) Oxide	HSR000926
Hempels Antifouling 7177	Copper (I) Oxide	HSR000921
Hempel's Antifouling Globic	3(2H)-Isothiazolone, 4,5-dichloro-2-octyl-, Copper (I) Oxide	HSR000112
Hempel's Antifouling Olympic 86901 colour range	Copper (I) Oxide	HSR002484
Hempel's Antifouling Olympic 86951 colour range	Copper (I) Oxide	HSR002698
Intercleane 165 BWA 900 Bright Red	Diuron, Copper (I) Oxide	HSR000924
Intersmooth Ecoloflex 360	Zinc Pyrithione, Copper (I) Oxide	HSR000932

Trade name	Biocidal active ingredients	HSNO approval number
Intersmooth Ecoloflex 460	Zinc Pyrithione, Copper (I) Oxide	HSR000932
Interspeed 642 BQA 405 Dark Red	Diuron, Copper (I) Oxide	HSR000924
Interspeed 642 BQA 407 Red/BQA 412 Blue	Diuron, Copper (I) Oxide	HSR000924
Interspeed BRA 240 RED	Zineb, Copper (I) Oxide	HSR000933
Longlife (Black, Blue & White)	Diuron, Copper (I) Oxide	To be assigned (from HSR000924)
Longlife Extra (Blue, Red & Black)	Diuron, Copper (I) Oxide	To be assigned (from HSR000924)
Micron 66 (Red, Black or Blue)	Zinc Pyrithione, Copper (I) Oxide	HSR000932
Micron 77 Black	Copper (I) Oxide, Copper Pyrithione	HSR100059
Micron 77 Blue	Copper (I) Oxide, Copper Pyrithione	HSR100058
Micron 77 Navy	Copper (I) Oxide, Copper Pyrithione	HSR100060
Micron 77 Red	Copper (I) Oxide, Copper Pyrithione	HSR100057
Micron CSC (Black, Blue, Burgundy & White)	Diuron, Copper (I) Oxide	To be assigned (from HSR000924)
Micron Extra	Diuron, Copper (I) Oxide	HSR000924
Micron Extra Dover White	Diuron, Copper (I) Oxide	To be assigned (from HSR000924)
Mille Dynamic 7170	Diuron, Copper (I) Oxide	HSR000925
Norimp 2000	Copper (I) Oxide	HSR000920
Optima Activator (Black)	Zinc Pyrithione	HSR000103
Optima Activator (Blue)	Zinc Pyrithione	HSR000104
Optima Activator (Red)	Zinc Pyrithione	HSR000105
Optima Activator (White)	Zinc Pyrithione	HSR000106
Reduced Copper Antifouling Range (Range C)	Thiram, Copper (I) Oxide	To be assigned (from HSR002484)
Reduced Copper Antifouling Range (Range D)	Octhilinone, Copper (I) Oxide	HSR007955
Sea Hawk Biocop TF Black Antifouling Paint	Zinc Pyrithione, Copper (I) Oxide	To be assigned (from HSR000932)
SeaForce 60	Zineb, Copper (I) Oxide, Copper Pyrithione	HSR100411
SeaForce 90	Zineb, Copper (I) Oxide, Copper Pyrithione	HSR100412
Seahorse Formula 1000 (Corroless Heavy Duty Copper Antifouling)	Irgarol 1051, Copper (I) oxide	HSR000927
Seahorse propulsion	Irgarol 1051, Copper Thiocyanate	HSR000917

Trade name	Biocidal active ingredients	HSNO approval number
SeaSafe Ultra	3(2H)-Isothiazolone, 4,5-dichloro-2-octyl-, Copper Thiocyanate	HSR100427
Transocean Cleanship 200 Antifouling 2.74	Chlorothalonil, Copper (I) Oxide	HSR000913
Transocean Longlife Tin-free Antifouling 2.71	Chlorothalonil, Copper (I) Oxide	HSR000913
Trilux	Dichlofluanid, Copper Thiocyanate	HSR000889
Trilux 33 White	Zinc Pyrithione, Copper Thiocyanate	HSR000121
Ultra (Black, Red, Blue)	Dichlofluanid, Copper (I) Oxide	HSR000923
Ultra Dover White	Dichlofluanid, Copper (I) Oxide	HSR000923
VC Offshore Extra (Part A)	Diuron	HSR000934
VC Offshore Extra (Part B)	Copper (I) Oxide	HSR000922
Warpaint Marine Fouling Inhibitor	Copper (I) Oxide	HSR000929
Waterbased Antifouling Range	Copper (I) Oxide	HSR000041

The staff have proposed regulatory outcomes for antifouling paint approvals, which are that the approval is either retained with additional controls, or that the approval is revoked. Where new controls are imposed on a substance, the revised controls will come into effect after a transition period in order to allow for compliance with the revised controls to be arranged. For approvals for substances that are to be phased out, a period of time is established during which manufacture and importation of the substance can continue. This is to allow for a gradual shift away from highly popular products which present high risks to human health or the environment. After the phase-out period has elapsed, the approval for the substance will no longer be a valid approval and the substance may no longer be present in New Zealand under that approval.

Any changes in the description of proposed controls are highlighted in table 12 below.

Table 12: Updated additional controls to mitigate risks of antifouling paints

Control Code	Intent of control	Proposed wording
R-1	**Personal protective equipment** Control T5 (refers to Reg. 8 of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001) requires that people handling antifouling paints use protective clothing or equipment that prevents them from coming into contact with the substance, either via skin contact or through inhalation. The staff consider that this control should apply to any person using antifouling paints, including use of antifouling paints in locations that are not designated as workplaces. For clarity around situations where no workplace exposure standards exist for the relevant components of an antifouling paint, a variation is proposed to the default control T5 (use of PPE) that specifies when subclause (1)(b) applies.	**Control** Subclause (1) of Reg. 8 of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001 should be replaced by the following: 1. A person who handles the substance must use protective clothing or equipment that is designed, constructed, and operated to ensure that the person— a. does not come into contact with or inhale, the substance; and b. is not exposed to a concentration of the substance that exceeds the workplace exposure standard (WES) for that substance, if a WES for that substance exists.
R-2	**Controlled work area and signage** To protect sensitive areas from exposure arising from spraydrift of the substance, the application of the substance by spray techniques is permitted provided that it is done in a	**Control** **Controlled work area** 6. Any person applying the substance must ensure that

	controlled work area. The extent of the controlled area should be sufficient to ensure that off-target deposition of the substance is avoided. Additionally, this will also protect bystanders from involuntary exposure to antifouling paints during application. In order to inform people that spray painting activity is being undertaken, the staff consider that signage should be placed at the entrance of the controlled work area.	application of the substance is carried out in a **controlled work area**. 7. The **controlled work area**, as referred to in subclause (1) is a designated area in which antifouling paints are applied, using a method and located such that off-target deposition of the substance, including onto bystanders, is prevented. **Signage** 8. The person in charge of the application of the substance must ensure that signs are placed at every point of entrance into the controlled work area. Signs must be posted from the start of application, until the end of the application. 9. Signs erected in accordance with (2) must— a. warn that an application is being carried out using a substance that is toxic to humans; and b. state that entry into the controlled work area is not permitted unless personal protective equipment (PPE) is worn by the person entering the controlled work area, as if the person is carrying out the application. 10. Signs erected in accordance with subclauses (3) and (4) must— a. comply with regulation 34(1), (2), and (4) and regulation 35(1), (3), and (5) of the Hazardous Substances (Identification) Regulations 2001, but as if the distances referred to in regulation 35(3) were a distance of not less than 10 metres; and b. identify the person in charge of the application.
R-3	**Collection of substances from maintenance activities** Boat maintenance activities remove the antifouling substance, biofouling waste and other contaminants from the	**Control** 1. Any person who removes an antifouling paint coating from the hull of a boat during maintenance activities must ensure that waste

	hull of a boat. Used antifouling paints removed from the hull of boats during maintenance present a risk to the terrestrial and aquatic environments. Collecting used antifouling paints generated from maintenance activities will reduce this risk to an acceptable level. It is intended that this control should apply to all antifouling paint waste so that it is a requirement to collect waste for any antifouling paint removed from a vessel's hull. The staff consider that this can be achieved by applying this control to each antifouling paint approval. The staff acknowledge that the time period between application of the antifouling paint and subsequent removal of the used antifouling paint coating could be a number of years. By making this control a requirement for all antifouling paints (accompanied by appropriate label statements on antifouling paints as specified by control R-4), collection of all antifouling paint waste will become mandatory.	contaminated with antifouling paint residue is collected ; and 2. All collected waste, as referred to in subclause (1) must be disposed of in accordance with the Hazardous Substances (Disposal) Regulations 2001.
R-4	**Additional labelling requirements** In order to mitigate risks to both people and the environment, statements must be provided on product labels that are supplementary to those specified by the relevant default controls. The staff consider that the product label provides a key mechanism to ensure that the relevant information is made available to the end-user, and that a number of the proposed additional controls should be stated on the label. Subclause (2)(a) relates to Control R-2. Subclause (2)(b) relates to Control R-3.	**Control** For formulated antifouling substances: 1. A person must not supply a hazardous substance to any other person unless the substance label clearly states the additional controls that apply to a substance throughout the lifecycle of the substance. 2. Labels must include the following statements (or similar): a. When applying this substance by spraying, you must sufficiently enclose the area to ensure that the substance is not deposited on off-target sites and has no adverse effects on bystanders. b. You must ensure that waste generated from maintenance activities does not enter the environment. 3. The supplier of the hazardous substance must ensure that the substance label shows the information required by (1) and (2).
R-5	**Safety data sheets (SDS)** The regulations are performance based and require relevant	**Control** 1. A person, when selling or supplying this substance at any quantity

"documentation" to be provided when selling or supplying substances to places of work. This control modification will require 16-header SDS to be provided for antifouling paints rather than the more generic "documentation" requirements. This will standardise the presentation and format of safety information accompanying the substance.

We propose that this control modification replace regs 37 – 50 of the identification regulations, regs 16-18 of the emergency management regulations and reg 13 of the disposal regulations.

shall provide a safety data sheet for the substance to the recipient if—

a. the substance is likely to be used in a place of work; and
b. they have not previously supplied a safety data sheet for that substance to the recipient.

2. In each place of work where the substance is manufactured, stored or used, the person in charge of the place must ensure that every person handling the substance has access to a safety data sheet for that substance.
3. The safety data sheet must be available to a person handling the substance within 10 minutes, and be readily understandable by any fully trained persons required to have access to it.
4. A person who manufactures or supplies a substance in New Zealand, or imports a substance into New Zealand must, if asked to do so by any person in charge of a place of work where a substance is stored or used, give that person the required safety data sheet.
5. Information required on a safety data sheet must be provided under the following 16 general headings in the order listed below, and must include the information referred to under those headings:

Section 1 - Identification of the substance and supplier—
i. product name
ii. recommended uses
iii. name of the supplier, New Zealand contact details including an emergency contact.

Section 2 - Hazards identification—
i. a description of the hazards of the substance, which may include its HSNO hazard classification
ii. hazard information, including signal words, hazard statement(s) and precautionary statement(s).

Section 3 - Composition/information on ingredients—
i. in the case of single component substances, their chemical identity, including common names and synonyms, CAS number and any impurities that are themselves hazardous
ii. in the case of substances that are mixtures, the chemical identity of each hazardous ingredient, their CAS number and their concentration ranges.

Section 4 - First aid measures—
i. first aid instructions according to each relevant route of exposure
ii. whether medical attention is required, and its urgency
iii. information on the most important symptoms and effects, acute and delayed, from exposure.

Section 5 - Fire fighting measures—
i. information on the appropriate type of extinguishers or fire-fighting agents, including extinguishers that may not be appropriate for a particular situation
ii. any advice on hazards that may arise from combustion products
iii. precautions for fire fighters and protective clothing requirements.

Section 6 - Accidental release measures—
i. advice on protective clothing requirements and emergency procedures
ii. any environmental precautions from accidental spills and releaseiii. advice on how to contain and clean up a spill or release;

Section 7 - Handling and storage—
i. precautions for safe handling
ii. conditions for safe storage, including any incompatibilities.

Section 8 - Exposure controls/personal protection—
i. exposure limits set for the substance or any of its components, or in their absence, relevant overseas exposure limits
ii. engineering controls
iii. individual protection measures, including personal protective equipment.

Section 9 - Physical and chemical properties—
i. a description of relevant physical and chemical properties for the substance, including units of measurement and reference conditions where appropriate
ii. where necessary for interpretation of data reported, the method of determination.

Section 10 - Stability and reactivity—
i. an indication of the chemical stability of the substance under normal and anticipated storage and handling conditions
ii. a list of conditions to avoid to prevent a hazardous situation; and
iii. information on incompatible substances or materials.

Section 11 - Toxicological information—
i. a full description of the toxicological (health) effects, including the symptoms or signs of injury or ill health associated with each likely route of exposure
ii. the dose, concentration or conditions of exposure likely to cause injury or ill health
iii. a summary of the data used to identify the health effects.

Section 12 - Ecological information—
i. ecotoxicity
ii. persistence and degradability
iii. mobility.

Section 13 - Disposal considerations—
i. disposal methods, including disposal of packaging
ii. special precautions to be taken during disposal
iii. any method of disposal that should not be used.

Section 14 - Transport information—
If relevant,
i. the UN number
ii. the proper shipping name
iii. the UN Dangerous Goods class and subsidiary risk
iv. the UN Packing Group.

		Section 15 - Regulatory information— i. HSNO approval number and/or title of the Group Standard ii. information on the conditions of the Group Standard, and any other regulatory requirements. Section 16 - Other information— i. date of preparation or revision of the safety data sheet ii. a key/legend to abbreviations and acronyms used. 6. Where a substance is being transported, a safety data sheet is not required if— a. there is in the vehicle concerned documentation complying with the Land Transport Rule whilst being transported by land b. there is in the ship concerned documentation complying with the Maritime Rule whilst being transported by sea c. there is in the aircraft concerned documentation complying with the Civil Aviation Rule whilst being transported by air.

The following tables contain a revised summary of the proposed recommendations for antifouling paint approvals and the associated formulations.

3(2H)-Isothiazolone, 4,5-dichloro-2-octyl-, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications[7][8]	Variation to Default Controls	Additional controls and recommendation[9]
Hempel's Antifouling Globic	HSR000112	Current 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A Proposed 3.1C, 6.3B, 6.4A, 6.5B, 6.6A, 6.8B, 6.9B, 9.1A	Remove: I20, I30	Add: R-1, R-2, R-3, R-4, R-5 ~~Phase-out: 4 years~~ Retain approval
ABC7 ANTIFOULING	HSR001748	Current 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3C Proposed 3.1C, 6.1D, 6.3A, 8.3A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3C	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 ~~Phase-out: 4 years~~ Retain approval
Antifouling Seavictor 50 *(from HSR000931)*	*To be assigned*	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 ~~Phase-out: 4 years~~

[7] Where the acute toxicity classification is denoted with a superscript 'A' (e.g. 6.1DA), if the kinematic viscosity is ≥ 20.5 mm2/s measured at 40°C, then the substance is not considered to be an aspiration hazard.

[8] Shaded classifications have been revised.

[9] Recommendations proposed in the application which have changed are struck through.

		Proposed: 3.1C, 6.1D, **6.3A**, 6.4A, 6.5B, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B		Retain approval

3(2H)-Isothiazolone, 4,5-dichloro-2-octyl-, Copper Thiocyanate

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
SeaSafe Ultra	HSR100427	Current: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3C Proposed: 3.1C, **6.1D**[A], 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3C	No change	Add: R-1, R-2, R-3, R-4, R-5 ~~Phase-out: 4 years~~ Retain approval

Chlorothalonil, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing 138 g/L chlorothalonil and 722 g/L cuprous oxide 271 Longlife Antifouling black 271 Longlife Antifouling blue 271 Longlife Antifouling red	HSR000912	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.7B, 6.9B, 9.1A, **9.2C**, 9.3B Proposed: 3.1C, **6.1D**[A], 6.3B, 6.4A, 6.5B, 6.7B, 6.9B, 9.1A, 9.3B	No change	Revoke approval
Antifouling paint containing 84- 138 g/L chlorothalonil and 517-690 g/L	HSR000913	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, **9.2C**, 9.3B	No change	Revoke approval

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
cuprous oxide Transocean Longlife Tin-free Antifouling 2.71 Transocean Cleanship 200 Antifouling 2.74		Proposed: 3.1C, 6.1D, **6.3A**, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3B		

Chlorothalonil, Mancozeb, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing chlorothalonil 62 g/L and 518 g/L cuprous oxide and 82 g/L mancozeb AF500 Cleanship Antifouling red AF500 Cleanship Antifouling black AF500 Cleanship Antifouling blue AF500 Cleanship Antifouling green	HSR000914	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.7B, 6.8A, 6.9B, 9.1A, **9.2C**, 9.3B Proposed: 3.1C, **6.1D**[A], 6.3B, 6.4A, 6.5B, 6.7B, 6.8A, 6.9B, 9.1A, 9.3B	No change	Revoke approval

Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Waterbased Antifouling Range	HSR000041	Current: 6.1D, 6.3B, 6.4A, 6.8A, 6.9B, 9.1A, 9.3C Proposed: 6.1D, 6.3B, 6.4A, 6.8A, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling paint containing 195 g/litre cuprous oxide Flexgard VI	HSR000919	Current / proposed: 6.1E, 6.4A, 6.9B, 9.1A, 9.3C	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling paint containing 245 g/litre cuprous oxide Norimp 2000	HSR000920	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3C Proposed: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3C	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling paint containing 521 g/litre cuprous oxide Hempels Antifouling 7177	HSR000921	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D[A], 6.3B, 6.4A, 6.5B, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling paint containing 1000	HSR000922	Current / proposed: 6.1D, 6.4A, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
g/kg cuprous oxide (Part B) VC Offshore Extra (Part B)				Retain approval
Antifouling paint containing 754 g/litre cuprous oxide and 550 g/litre zinc oxide Warpaint Marine Fouling Inhibitor	HSR000929	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, **6.1D**[A], 6.3B, 6.4A, 6.5B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling paint containing 780 g/litre cuprous oxide and 220 g/litre zinc oxide Antifouling Seavictor 40	HSR000930	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D, **6.3A**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling paint containing 840 g/litre cuprous oxide and 350 g/litre zinc oxide Antifouling Seaguardian	HSR000931	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D, **6.3A**, 6.4A, 6.5B, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Hempel's Antifouling Olympic	HSR002484	Current:	No change	Add:

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
86901 colour range		3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3B		R-1, R-2, R-3, R-4, R-5 Retain approval
Hempel's Antifouling Olympic 86951 colour range	HSR002698	Current / proposed: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling paint containing 640-655g/L cuprous oxide	HSR100080	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, **6.1D**[A], 6.3B, 6.4A, 6.5B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Copper (I) Oxide, Copper Pyrithione

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Micron 77 Red	HSR100057	Current / proposed: 3.1C, 6.1D, 6.3A, 6.7B, 6.8B, 6.8C, 6.9B, 8.3A, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Micron 77 Blue	HSR100058	Current / proposed: 3.1C, 6.1D, 6.3A, 6.7B, 6.8B, 6.8C, 6.9B, 8.3A, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Micron 77 Black	HSR100059	Current / proposed: 3.1C, 6.1D, 6.3A, 6.7B, 6.8B, 6.8C, 6.9B, 8.3A, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Micron 77 Navy	HSR100060	Current / proposed: 3.1C, 6.1D, 6.3A, 6.7B, 6.8B, 6.8C, 6.9B, 8.3A, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Hempel's A/F Globic NCT *(from HSR000036)* Hempel's A/F Globic NCT 8190M Hempel's A/F Globic NCT 8195M	*To be assigned*	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D, 6.3A, 8.3A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3B	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling SeaQuantum Ultra *(from HSR000036)*	*To be assigned*	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
		Proposed: 3.1C, 6.1D, 6.3A, 8.3A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B		Retain approval
Antifouling Seaquantum Classic *(from HSR000036)*	*To be assigned*	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Dichlofluanid, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing 408 - 494 g/litre cuprous oxide and 34 - 42 g/litre dichlofluanid Ultra (Black, Red, Blue) Ultra Dover White	HSR000923	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, **6.1D**[A], 6.3B, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Dichlofluanid, Copper Thiocyanate

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing 215 g/litre copper thiocyanate and 36 g/litre dichlofluanid Trilux	HSR000889	Current: 3.1C, **6.1D**, 6.3B, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, **9.3C** Proposed: 3.1C, **6.1E**[A], 6.3B, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A	Remove: I20	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Diuron

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing 20 g/litre diuron (Part A) VC Offshore Extra (Part A)	HSR000934	Current: 3.1C, 6.1E, **6.3B**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.2B, 9.3C Proposed: 3.1C, **6.1D**, **6.3A**, 6.4A, 6.5B, **6.7B**, 6.8B, 6.9B, 9.1A, 9.2B, 9.3C	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years

Diuron, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing 450 - 849 g/litre cuprous oxide and 40 - 70 g/litre diuron Interspeed 642 BQA 407 Red/BQA 412 Blue Micron Extra Intercleane 165 BWA 900 Bright Red Interspeed 642 BQA 405 Dark Red	HSR000924	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B Proposed: 3.1C, 6.1D, **6.3A**, 6.4A, 6.5B, **6.7B**, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years
Antifouling paint containing 450 - 849 g/litre cuprous oxide and 40 - 70 g/litre diuron (aspiration hazard) (Substance A) *(from HSR000924)* Micron CSC (Black, Blue, Burgundy & White) Longlife (Black, Blue	*To be assigned*	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B Proposed: 3.1C, **6.1D**[A], **6.3A**, 6.4A, 6.5B, **6.7B**, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
& White)				
Antifouling paint containing 450 - 849 g/litre cuprous oxide and 40 - 70 g/litre diuron (aspiration hazard) (Substance B) *(from HSR000924)* Coppercoat Extra Longlife Extra (Blue, Red & Black) Micron Extra Dover White	*To be assigned*	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B Proposed: 3.1C, **6.1D**[A], 6.3B, 6.4A, 6.5B, **6.7B**, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years
Antifouling paint containing 580 g/litre cuprous oxide, 65 g/litre diuron and 320 g/litre zinc oxide Mille Dynamic 7170	HSR000925	Current: 3.1C, 6.1D, 6.4A, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B Proposed: 3.1C, 6.1D, 6.4A, **6.7B**, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years
Antifouling paint containing 760 g/litre cuprous oxide, 62 g/litre diuron and 165	HSR000926	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.2A, 9.3B Proposed: 3.1C, 6.1D, **6.3A**, 6.4A, 6.5B, **6.7B**, 6.8B,	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
g/litre zinc oxide Hempel's Antifouling Nautic		6.9B, 9.1A, 9.2A, 9.3B		

Diuron, Copper Thiocyanate

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Alloy Antifouling Range	HSR000038	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, 6.8B, **6.9A**, 9.1A, 9.3C Proposed: 3.1C, 6.1D, **6.3A**, **8.3A**, 6.5B, **6.7B**, 6.8B, **6.9B**, 9.1A, **9.2A**, 9.3C	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years
Antifouling paint containing 230 g/litre copper thiocyanate and 40 g/litre diuron Cruiser Superior (White, Scarlet, Blue & Black)	HSR000916	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.2A, 9.3C Proposed: 3.1C, **6.1D**[A], **6.3A**, 6.4A, 6.5B, **6.7B**, 6.8B, 6.9B, 9.1A, 9.2A, 9.3C	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years

Irgarol 1051, Copper (I) oxide

Substance Description	HSNO Approval	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation

	Number			
Ablative B Antifouling Range	HSR000037	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, 6.9B, 9.1A, **9.3C** Proposed: 3.1C, 6.1D, **6.3A**, **8.3A**, 6.5B, **6.8B**, 6.9B, 9.1A, **9.3B**	Add: EM2, I2, I10, I22, P14	Revoke approval
Hard A Antifouling Range	HSR000039	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.8A, 6.9B, 9.1A, **9.3C** Proposed: 3.1C, 6.1D, 6.4A, 6.5B, 6.8A, 6.9B, 9.1A, **9.3B**	No change	Revoke approval
Antifouling paint containing 570 g/litre cuprous oxide and 20 g/litre irgarol Seahorse Formula 1000 (Corroless Heavy Duty Copper Antifouling)	HSR000927	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, **6.1D**[A], 6.3B, 6.4A, 6.5B, 6.9B, 9.1A, 9.3B	No change	Revoke approval

Irgarol 1051, Copper Thiocyanate

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation

Antifouling paint containing 220 g/litre copper thiocyanate and 20 g/litre irgarol Seahorse propulsion	HSR000917	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, **6.9B**, 9.1A, 9.3C Proposed: 3.1C, **6.1D**[A], 6.3B, 6.5B, 9.1A, 9.3C	No change	Revoke approval

Irgarol 1051, Tolylfluanid, Zinc pyrithione, Octhilinone, Copper (I) oxide, Copper Pyrithione

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Ablative A1 Antifouling Range **Trade Names** Ablative A1 Antifouling Range	HSR000036	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D, **6.3A**, **8.3A**, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B	Add: EM2, I2, I10, I22, P14	Revoke approval

Octhilinone, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Reduced Copper Antifouling Range (Range D)	HSR007955	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, **6.1D**[A], **6.3A**, 6.4A, 6.5B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years

Octhilinone, Tolylfluanid, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Hard B Antifouling Range	HSR000040	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, **6.8A**, 6.9B, 9.1A, **9.3C** Proposed: 3.1C, **6.1D**[A], **6.3A**, **8.3A**, 6.5B, **6.8B**, 6.9B, 9.1A, **9.3B**	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years

Thiram, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Ablative A Antifouling Range Coastal Copper Antifouling Awlcraft No.5	HSR000035	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, **6.6B**, 6.8B, 6.9B, 9.1A, **9.3C** Proposed: 3.1C, 6.1D, **6.3A**, **8.3A**, 6.5B, 6.8B, 6.9B, 9.1A, **9.3B**	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 10 years
AF1000 *(from HSR000035)*	*To be assigned*	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.5B, **6.6B**, 6.8B, 6.9B, 9.1A, **9.3C** Proposed: 3.1C, 6.1D, **6.3A**, **8.3A**, 6.5B, 6.8B, 6.9B, 9.1A, 9.3C	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 10 years
Antifouling paint containing 750 g/litre cuprous oxide, 50 g/litre thiram and 260 g/litre zinc oxide Gemcoat AB	HSR000928	Current / proposed: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 10 years
Reduced Copper Antifouling Range (Range C) *(from HSR002484)*	*To be assigned*	Current: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, **6.8C**, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 10 years

Tolyfluanid, Copper Thiocyanate

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Alloy C Antifouling Range	HSR000952	Current: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, **6.7B**, 6.8A, 6.9B, 9.1A, 9.2B, 9.3C Proposed: 3.1C, 6.1D, 6.3B, 6.4A, 6.5B, 6.8A, 6.9B, 9.1A, 9.2B, 9.3C	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Zinc Pyrithione

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Optima Activator (Black)	HSR000103	Current: 6.1C, **6.3A**, 6.8B, 6.9A, 8.3A, 9.1A, **9.3B** Proposed: 6.1C, 6.8B, 6.9A, 8.3A, 9.1A, **9.3C**	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Optima Activator (Blue)	HSR000104	Current: 6.1C, **6.3A**, 6.8B, 6.9A, 8.3A, 9.1A, **9.3B** Proposed: 6.1C, 6.8B, 6.9A, 8.3A, 9.1A, **9.3C**	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Optima Activator (Red)	HSR000105	Current: 6.1C, **6.3A**, **6.5B**, 6.8B, 6.9A, 8.3A, 9.1A, **9.3B** Proposed: 6.1C, **6.3B**, 8.3A, 6.8B, 6.9A, 9.1A, **9.3C**	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Optima Activator (White)	HSR000106	Current: 6.1C, **6.3A**, 6.8B, 6.9A, 8.3A, 9.1A, **9.3B** Proposed: 6.1C, 6.8B, 6.9A, 8.3A, 9.1A, **9.3C**	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Zinc Pyrithione, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing 640 g/litre cuprous oxide and 60 g/litre zinc pyrithione Intersmooth Ecoloflex 360 Intersmooth Ecoloflex 460 Micron 66 (Red, Black or Blue)	HSR000932	Current: 3.1C, 6.1D, **6.3B**, **6.4A**, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B Proposed: 3.1C, 6.1D, **6.3A, 8.3A**, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Antifouling paint containing cuprous oxide and zinc pyrithione *(from HSR000932)* Sea Hawk Biocop TF Black Antifouling Paint	*To be assigned*	Proposed: 3.1C, **6.1D**[A], **6.3B**, **8.3A**, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3B	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Zinc Pyrithione, Copper Thiocyanate

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Trilux 33 White	HSR000121	Current: 3.1C, 6.1D, 6.3B, **6.4A**, 6.5B, 6.8B, 6.9B, 9.1A, 9.3C Proposed: 3.1C, **6.1D**[A], 6.3B, **8.3A**, 6.5B, 6.8B, 6.9B, 9.1A, 9.3C	Add: EM2, I2, I10, I22, P14	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
Alloy B Antifouling Range	HSR000951	Current: 3.1C, 6.1D, 6.3B, **6.4A**, 6.5B, 6.8A, 6.9B, 9.1A, 9.2B, 9.3C Proposed: 3.1C, **6.1D**, 6.3B, ~~**8.3A**~~ 6.4A, 6.5B, 6.8A, 6.9B, 9.1A, 9.2B, 9.3C	~~Add:~~ ~~EM2, I2, I10, I22, P14~~ No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Zineb, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing 648 g/litre cuprous oxide and 70 g/litre zineb Interspeed BRA 240 RED	HSR000933	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, **9.2D**, 9.3B Proposed: 3.1C, 6.1D, **6.3A**, 6.4A, 6.5B, 6.8B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Zineb, Copper (I) Oxide, Copper Pyrithione

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
SeaForce 60	HSR100411	Current / proposed: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval
SeaForce 90	HSR100412	Current / proposed: 3.1C, 6.1D, 6.3A, 6.4A, 6.5B, 6.7B, 6.8B, 6.9B, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Zineb, Copper Thiocyanate

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
Antifouling paint containing 290 g/litre copper thiocyanate, 220 g/litre zinc oxide and 55 g/litre zineb Antifouling Seasafe	HSR000918	Current: 3.1C, 6.1D, **6.3B**, 6.4A, 6.5B, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3C Proposed: 3.1C, **6.1D**[A], **6.3A**, 6.4A, 6.5B, 6.7B, 6.8B, 6.8C, 6.9B, 9.1A, 9.3C	No change	Add: R-1, R-2, R-3, R-4, R-5 Retain approval

Ziram, Copper (I) Oxide

Substance Description	HSNO Approval Number	Hazard Classifications	Variation to Default Controls	Additional controls and recommendation
ABC #3 Antifouling	HSR007897	Current / proposed: 3.1C, 6.1D, 6.3A, 6.5B, 6.8B, 6.9B, 8.3A, 9.1A, 9.3B	No change	Add: R-1, R-2, R-3, R-4, R-5 Phase-out: 4 years

Appendix A: Summary of submissions

Submitter key

Code	Submitter	Organisation	Submission number	Wishes to be heard?	Overall view
S1	Marius Rademaker	Waikato Hospital	102686	No	Neutral
S2	Larry and Gail Phillips	-	102687	No	Support
S3	Brett Colby	Half Moon Bay Marina	102694	No	Support
S4	Peter Lawless	Top of the South Marine Biosecurity Partnership	102695	Yes	Oppose
S5	David Abercrombie	Yachting New Zealand	102696	Yes	Support
S6	Stacey Hunter	NZ Marine	102697	Yes	Support
S7	David Hollingsworth	Westpark Marina	102698	Yes	Support
S8	Mike Henwood	Metachem Ltd	102699	Yes	Support
S9	Shayne Akari	Bay of Plenty Regional Council	102700	No	Support
S10	Bernard Rhodes	-	102701	No	Neutral
S11	Richard Foster	-	102702	Yes	Support
S12	Elya Ameriks	Te Rūnanga o Ngāi Tahu	102703	Yes	Neutral
S13	Darryl Smith	Whitianga Marina Society	102704	No	Neutral

S14	Neil Debenham	Altex Coatings	102705	Yes	Neutral
S15	Keith Ingram	Maritime Industry Advocate NZ Marine Transport Association NZ Recreational Fishing Council Bucklands Beach Yacht Club	102706	Yes	Oppose
S16	Catherine McGurk	Akzo Nobel	102707	No	Oppose
S17	Alison Undorf-Lay	Sanford Limited	102708	Yes	Neutral
S18	Rodolphe Querou	Dow Microbial Control	102709	No	Oppose
S19	Neal Blossom	American Chemet Corporation	102710	No	Neutral
S20	Nicola de Wit	Environmental Defence Society	102711	No	Support
S21	Fiona Black	Real Journeys Ltd	102712	No	Neutral
S22	David Hollingsworth	New Zealand Marina Operators Association	102713	Yes	Support
S23	Donna Vincent	New Zealand Paint Manufacturers Association	102714	No	Support
S24	Kevin Long	EU Antifouling Copper Task Force	102715	No	Neutral
S25	Don MacLeod	-	102718	Yes	Neutral
S26	Eugene Georgiades	Ministry for Primary Industries	102719	Yes	Support
S27	Alan Boyd	-	102720	Yes	Neutral
S28	K Wishart	New Zealand Defence Force	102730	No	Neutral
S29	Brett Colby	New Zealand Clean Marina Programme	102735	No	Support

S30	Clive Stone	Ngatiwai Trust Board	102784	No	Neutral

Submissions on the benefits and economic costs

Number	Submitters	Comment	EPA Response
B1	S15, S14	Domestic fleets must operate on a compatible footing with the international fleet in maintaining biosecurity protection. They should not be penalised by added costs before international fleets adjust or even comply.	Noted. The staff recommend that many antifouling paints maintain their approvals and note that many of the products being revoked have already been banned overseas. While the EPA cannot control which paints are used on international vessels travelling through New Zealand, the Ministry for Primary Industries does have new biofouling requirements for vessels arriving in New Zealand, aimed at supporting biosecurity.
B2	S15	There are concerns about the economic implications of proposed regulations for local ownership of pleasure craft and commercial shipping. Cost increases could prohibit the right to own a boat and enjoy water activities, as well as driving away boat building, refit and maintenance business opportunities for the marine industry.	Noted. The proposed controls were recommended to mitigate risks and we consider that there will be cost-effective methods of achieving compliance.
B3	S4	The EPA has not fully taken into account the benefits of antifouling paints in lessening the introduction of invasive species that can damage delicate ecosystems.	The staff consider biosecurity as the most important reason for maintaining the use of antifouling paints, and have factored this in when assessing the benefits of antifouling paints. It is because of these benefits that a number of antifouling paint approvals will be retained, even when possessing risks above the level of concern.
B4	S23	There are concerns about the adverse effects of antifouling paint application to society and communities. It is suggested the EPA should ensure costs that mitigate these effects are apportioned fairly.	Our assessment considered both the adverse effects and benefits of antifouling paints. In general, costs to limit risks to human health and the environment will be borne by the user.
B5	S23, S14	There are beneficial effects of antifouling paint to society and communities. These include protecting against the transfer of organisms that may have major negative impacts on maritime farms, seafood production, marine parks and world heritage sites, and restricting trade. These negative impacts of invasive species have knock-on effects within	The staff agree with these comments and the benefits of antifouling paints have been factored into the risk/benefit analysis.

		the marine industry, and to people and families associated with it. Damage to the marine industry affects the whole community.	
B6	S23	The Covec Economic Report didn't show the full scope of the maritime industry. There are concerns that the cost implications would be dramatically higher than suggested, especially in the first year.	The Covec report focussed on the pleasure boat market. This is because it is the environmental risks associated with moored vessels in marinas which are of greatest concern. The proposed controls are performance-based and less prescriptive than those described in the Covec report (for example approved handler and hard stands). Staff consider there will be cost-effective means of meeting these controls.
B7	S23	There are concerns about the manufacturing and producing aspect of the reassessment, and ensuring that antifouling paint manufacturers stay in New Zealand.	Antifouling paint manufacturers were consulted in this reassessment, and their input was included in the reports. During conversations with staff, manufacturers have indicated that they will be able to change which active ingredients are being used in their paints if required. This suggests that New Zealand is unlikely to lose any significant number of manufacturers as a result of the recommendations proposed by the staff.
B8	S21	There are concerns that COVEC's "Economic Analysis to Support the reassessment of Antifouling" may only focus on the implications for Picton northwards. Have the implications for southern New Zealand vessel operations been adequately addressed?	Noted. The greatest contributor to the benefits of these substances is their use in biosecurity. The staff consider this benefit to apply across the country. Although limited economic analysis was conducted on southern New Zealand, staff do not believe this has affected the recommendations in any significant way. It is noted that no new information was presented during submissions which would have allowed further economic analysis to take place for southern New Zealand operations.
B9	S21	COVEC is being overly optimistic when suggesting that the cost of new paints will only be 5-10% higher than now. Paint companies will need to invest more in research and development. These costs will then need to be passed on to the consumer.	Figures provided in the Covec report are estimates. Cost and sales information from paint manufacturers have been included in Covec's calculations.
B10	S21	COVEC's economic analysis is extremely flawed regarding the costs of facility improvements and its impacts on users. There will need to be considerable investment in facilities to allow for the collection and disposal of contaminants at vessel slipways. There are major concerns that the costs of providing these facilities will be passed on solely to the	The control is unlikely to place an additional burden on slipway users. Discharge of contaminants into the environment is regulated under the RMA also. This control aligns with the RMA and manages HSNO risks to the environment.

		users, and in southern New Zealand there are far fewer vessels and accordingly large costs are likely to be passed on to a relatively small group of vessel owners	
B11	S21	Introduction of some sort of a financial subsidy should be available for the upgrade of vessel maintenance facilities so that costs do not become more crippling.	There is no funding mechanism under HSNO for such an arrangement.
B12	S14	The caption for Figure 1.2 in the Covec report is incorrect. The figure actually shows the effect of postponing the re-applying of antifouling paint on vessels, past its period of effectiveness.	Noted. This discrepancy will be pointed out to the decision makers.
B13	S14	More stringent controls result in an increase in costs, which lead to vessel owners further postponing re-coating. This pushes the effectiveness of their antifouling coating to its limit. This will lead to vessel damage as shown in Figure 1.2.	This is a risk that has been factored into our assessment. It contributes to the specific benefits of antifouling paints with large market shares at the moment, which we anticipate to reduce over time. It is because of this risk (and the benefits associated with mitigating it) that some paints which possess high levels of risk, have been recommended to be phased out, rather than revoked immediately.
B14	S14	Regarding Clause 2.1.1. A typical small boat of 12 metre length should only require 10-12 litres for 2 coats at the manufacturers recommended film build.	Covec identified that Figure 2.1.1. shows the range of estimates of paint required. 12 litres was represented near the top of the scale.
B15	S14	There were queries about the total volume of antifouling coating quoted within Clause 2.2.1. There were suggestions that the calculations are inaccurate and that, based on the information presented in the COVEC analysis, the total antifouling paint consumption per annum within New Zealand is 168,960 litres for the pleasure market vessel market, and 98,328 litres for the commercial vessel market. This would then make the split 63:37 in favour of the pleasure vessel market, rather than the 60:40 split in favour of the commercial market reported by Covec.	The figures in the Covec report came from a confidential survey of paint manufacturers. They reflect the actual quantities of paint sold in 2011. Covec calculated the quantity of paint distributed between commercial and pleasure craft based on the brand of paint, and whether or not it was sold through a retail outlet. Covec made the assumption that paint sold through retail outlets is used for pleasure craft.
B16	S14, S18	There was comment about the statement in Clause 3.2.1: “if all paints as hazardous as Sea Nine (DCOIT) were banned, Sea Safe would be the only commercial paint available for use with aluminium vessels”. Altex	The staff thank the submitters for this new information. The statement quoted no longer applies as the risk assessment of DCOIT has been refined thanks to other new information, and the risks are considerably

		Coatings Ltd is manufacturing and supplying a product (Pettit Vivid) that contains Zinc Pyrithione as the co-biocide and has been designed specifically for the aluminium vessel market.	lower than first modelled.
B17	S14	There was comment about the statement [in the Covec report] “Similarly if Octhilinone was also banned, Pettit Hydrocoat would have a monopoly amongst ablative paints”. This is incorrect as Altex Coatings Ltd manufactures and markets their AYB No.5, Sea~Barrier 1000 and Sea~Barrier 3000 products as ablative antifoulings.	The staff thank the submitter for this new information. This has not changed our risk/benefits assessment and our proposals remain the same.
B18	S14	Clause 3.2.3. of the Covec report is incorrect. Altex Coatings Ltd actually manufactures the AYB No.5 in New Zealand.	The staff thank the submitter for this new information.
B19	S14	Suggests the analysis infers the price of the antifouling paint is impacted by the price of the biocide. That the cheaper co-biocides make for cheaper antifouling coatings. There is a generalisation that the effective life of the antifouling coatings with cheaper co-biocides is shorter than with higher priced co-biocides. Also inferred is the number of coats applied is directly proportional to its effective life. There is a considerable balancing act undertaken by the vessel owner in respect to choosing an antifouling coating i.e. how many coats, how long do they want it to last, the cost of the antifouling paint, vessel preparation and paint application.	This inference was not intentional. The staff recognise the difficulty in balancing costs and effectiveness of antifouling paint. No assumptions were made in the risk/benefits analysis based on the price of the co-biocide. Only prices for formulated products were used.
B20	S14	Questions were raised regarding the fairness of including advertised discounts for card holders. It would be considered more scientific to compare listed retail pricings (or trade pricings) for all the antifouling coatings being compared in Table 4.	Noted. The report notes that the prices were a snapshot at the time of writing and comment is made on the changeability of the prices.
B21	S14	The submitter considered that the suggested cost increases [in the Covec report] to the DIY boat owners of $14 to $27 per boat painted, are significantly underestimated, and that the actual figure is likely to be nearer three times that at $50 to $75 per boat.	This calculation was based on the assumptions of use described in the Covec analysis. Sufficient information has not been submitted to enable a review of these figures.
B22	S14	There is no provision in the analysis for the costs associated with enclosing a large vessel for spray application of antifouling paint. There	As a result of submitter comments the staff have provided further clarification of this control. Total enclosure for spray application of

		is a suggestion that these costs would be extremely high and would prevent spray application.	antifouling paint of large vessels may not be necessary. We have proposed that when antifouling paints are being applied, the work is carried out in a controlled work area that is sufficiently enclosed to prevent the off-target deposition of antifouling substances.
B23	S14	Expresses concern with the ability of marina owners to levy individual berth holders to cover any additional costs associated with meeting the proposed controls.	We consider controls are required to manage the risks. Because these controls are performance-based, this allows for the most cost-effective method of compliance to be implemented.
B24	S14	The requirement to use hardstands would result in a significant reduction in the facilities that allow the application of antifouling paint (especially in more remote areas). As a result the vessels will be required to have their painting undertaken at more central, larger operations in the main centres, leading to additional transport costs as well as causing congestion in these facilities.	The control for hardstands was not included in the application. Performance-based controls have been proposed to allow users to determine the most appropriate method to allow compliant use of antifouling paints.
B25	S14	Disagreement with the cost analysis of the approved handler requirement. There is a specified duration of 5 years for an Approved Handler Certificate, so there will be an on-going cost to maintain these approvals. The issuing of an Approved Handler Certification is an open market issue, with individual Test Certifiers charging against their own scale of costs, not taking into account actual training costs.	The control for approved handler was not included in the application. Performance-based controls have been proposed to allow users to determine the most appropriate method to allow compliant use of antifouling paints.
B26	S14	There is no difference in the PPE that is available to the DIY user and that which is available to the ‘professional applicator’. Many of the larger operations will most likely also consider the cheaper PPE options if they are available.	The obligations under the controls are the same for DIY users as for commercial applicators. The PPE worn, must be sufficient to prevent exposure relevant to the substance being handled and the method of application. For example we would expect that increased levels of protection would be required during spray application (e.g. a respirator) compared to brush and roller application.
B27	S14	The costs of hardstands will not be passed on in marina fees. If Clause 4.1 was implemented, then this would deny the vessel operator the opportunity to choose who and where they would haul their boat, and also potentially lead to the facility operator penalising vessels from	The requirement for hardstands is no longer being proposed. See Part 3 of this document for the controls which are being proposed.

		outside their catchment area.	
B28	S14	Concerns were raised by the statement in Clause 6.3: “the requirement for approved handlers could have a significant impact on activity if it effectively stopped DIY painting”. If yards need to have an approved handler on site with a large number of DIY users they would not be adequately supervised. Also the approved handlers would need to be present at all times and would cost a significant amount of money. They will not actually achieve what is required to protect the safety of people and the environment.	The approved handler control is no longer proposed as part of the reassessment (see staff response to B25).
B29	S14, S24	Copper is the primary biocide within antifouling coatings to stop the growth of hard organisms as opposed to soft organisms. It is the most effective tool currently available in the control of NIS. Support is shown for the continued use of copper.	Noted. The staff agree that copper has substantial specific benefits and that these outweigh the risks associated with it. As such, staff are recommending that copper is retained for use in antifouling paints.
B30	S14	Diuron-based antifouling coatings are at the lower end of the cost spectrum, and do work. A lot of commercial vessels like this technology because of this low-cost factor and that it does meet their longevity requirements.	The specific benefits of diuron generated by its low cost and consumers reliance on it are acknowledged. It is because of these market-dependant benefits that staff believe there is a fine balance existing between the benefits and the risks (which are high). As a result, a phase out period of four years is proposed.
B31	S11, S14, S26	Noted the role of antifouling paints in biosecurity.	Noted. The staff have identified biosecurity as one of the important generic benefits provided by antifouling paints and this has been factored heavily into our risk/benefit analysis.
B32	S16	Banning individual biocides rather than determining safe products affects the Industry’s ability to formulate these products.	The active ingredient approvals are not affected by this reassessment. Anyone wishing to import or manufacture new substances containing any antifouling biocide would need to make an application for approval under part 5 of the HSNO Act. This would assess the risks and benefits associated with that substance.
B33	S16	There have not been any recorded cases of resistance in populations of fouling organisms through the use of antifouling paints. Such effects are unlikely to be observed due to the broad spectrum of algal and animal	Noted. The staff accept this argument, and as such have not factored the risk of resistance into our risk/benefit analysis.

		species controlled by these products and the general nature of the mode of action of active substances used, such as general metabolic inhibition.	
B34	S16	The decision-making committee need to be made aware that the biocide dichlofluanid (Preventol A4S from Lanxess) is not going to be available to purchase after the end of 2013 and therefore a natural phase-out of products containing this biocide will follow. The impact of this is important because a key part of the economic analysis was looking at retail prices of paints, and three out of eight analysed contained dichlofluanid (see Table 4 of Economic Analysis Report). Users will not be able to switch to dichlofluanid based products to replace the Diuron ones lost. The four year phase out period is therefore paramount to allow new products to be developed and brought to the New Zealand market.	As mentioned in the staff response to B30 above, a fine balance currently exists between the risks and benefits for antifouling paints containing diuron. This submission supports the staff's recommendation that four years will be enough time for a market shift away from diuron to occur. Once this has occurred, the risks will outweigh the benefits and so the substance should no longer continue to be approved. This is why a four-year phase-out period has been proposed.
B35	S25	List of reasons for which antifouling paints is used on boats.	Additional benefits in keeping navigation aids free from fouling and hull surfaces safe for swimmers and divers were identified. These are not considered to significantly the benefits assessment.
B36	S28	The RNZN use a soft antifoul, which is different to the standard commercial hard antifoul. Antifouling paints which require continual friction/abrasion of water over hulls are unsuitable for navy vessels.	Noted. All current approvals for antifouling paints have been included in this reassessment.
B37	S28	The RNZN have expressed concern that timelines and routines would be at risk if copper or zinc pyrithione were to be banned. If they were to be banned, the RNZN have requested a five-year phase-out period.	The staff recommend that the approvals for these substances be retained as the benefits of using these substances outweigh the risks that they pose to human health and the environment.
B38	S12, S20	The argument for stronger antifouling products is flawed. Evidence provided states to prevent biofouling you need to stop microorganisms developing biofilms that enable successional development of more complex macrofaunal communities. Microorganisms form biofilms that withstand both chemical and physical stressors is well established, and is the subject of intense research activity. It is unlikely that stronger biocides will provide a long term solution to the problem without inherent activity against non-target species. Alternatives that involve novel	The staff agree that stronger biocides are not the only way forward and have recommended that approvals for the highest risk substances are revoked. Staff consider that there are many factors which contribute to the effectiveness of antifouling paints, including mode of action, method of release and formulation types.

		materials based around physical processes offer a potential solution to this problem.	
B39	S18	Provides additional information on the mode of action of DCOIT, including a reference paper.	The staff note the unique mode of action of DCOIT. The risk assessment has been refined to incorporate new information, and the benefits now outweigh the risks.
B40	S18	Provide a breakdown of the chemistry of each of the co-biocides the EPA have proposed to keep, highlighting that of the 6 retained, there are only 3 chemical families. Raises concern over lack of diversity.	Noted. See B33 where other stakeholders have noted that there is no evidence for resistance becoming an issue for antifouling paints. Staff have accepted this point, and have not factored the risk of resistance into the risk/benefits analysis.
B41	S18	A summary of the environmental fate profile of DCOIT, highlighting how quickly it degrades.	The environmental fate profile of each active ingredient was taken into account in our risk assessment, as environmental fate is a key factor in the model that we used to predict antifouling paint concentrations.
B42	S8	The EPA application report, as well as the Covec Economic Analysis, does not appear to have taken into account any impacts of the withdrawal of the actives on the importers/distributors of these materials, and the extended economic effects.	The staff have factored market shifts into our recommendations, and endeavour to reduce the economic impact of any regulatory changes. This is reflected in phase-out periods being proposed for several substances, which should allow for markets to adapt to a different range of products being available.
B43	S8	The removal of copper-based antifouling paints from the range of products manufactured and sold by local manufacturers could possibly also result in the closure of some of these manufacturers.	The staff have recommended that the approvals for many copper-based products be retained (see staff response to B29).
B44	S14	The claim that Altex No.5 is the third cheapest product available is incorrect. It only has the largest market share in the pleasure marine sector, and is not as proportionately large as reported due to a market size error made by Covec.	Noted. Sufficient information has not been made available to reassess the market share of this formulation.

Submissions on the proposed controls

Number	Submitters	Comment	EPA Response

C1	S15	What is the justification for banning all the toxins in known use, including copper, as listed in the executive summary of the reassessment on page 3?	The staff have never proposed to 'ban all the named recognised and accepted toxins in known use'.
C2	S15	There are some environmental risks associated with the use of antifouling paints, and we agree with attempts to control their unintended leaching into the environment. By this, we assume the EPA is talking about the control, collection and disposal of hull cleaning residue, sandings and scrapings.	The staff consider that revoking the approvals of the most dangerous antifouling paints, will limit potential adverse environmental effects. The controlled-area control applies to antifouling paints when they are applied by spray techniques. It has a dual effect of protecting bystanders and the environment by preventing the unintended spread of antifouling paints into non-target areas. The control around the collection and disposal of antifouling paint waste also prevents these toxic chemicals from entering the environment.
C3	S15	Introducing a blanket ban on all products is not a good way of dealing with exposures resulting from smaller haul-out facilities.	The staff have undertaken a risk assessment and propose to phase out only those antifouling paints that present an unmanageable risk to people and the environment. Where the risks associated with the use of certain antifouling substances can be managed, the staff have recommended their approvals be retained. Our modelling was based on reasonably-sized marinas.
C4	S15, S22	Marina and hardstand facilities are not disproportionately responsible for environmental risks, when the EPA cannot effect compliance over the greater marine coastal space for which it remains responsible for.	There is evidence that shows there is a high level of contamination around marinas. For example it was noted in Auckland Council Technical report TR2012/033 that in many marinas, copper concentrations exceed water quality guidelines.
C5	S3, S15, S22, S29	Marinas should not be responsible for ensuring compliance, particularly with regards to PPE.	Under HSNO, compliance with PPE controls is the responsibility of the person handling the substance. Enforcement of HSNO requirements lies with the relevant HSNO enforcement agency e.g. Ministry of Business Innovation and Employment (in a workplace) or the local Territorial Authority. It should be noted that HSE requirements apply to all workplaces and those in charge of marinas will need to ensure they are complying with their HSE obligations.

C6	S15	The NIWA assessment of copper levels in Fiordland is incorrect. The EPA should not use Fiordland as any sort of justification for this application.	There is no reference to Fiordland in the application and it has not been used as a justification for the reassessment. The media attention on Fiordland and the NIWA report had no bearing or influence on the preparation of this reassessment. Most importantly, our modelling is not based on Fiordland as it was considered that Milford Sound did not represent other New Zealand ports or marinas (since it is a small berthage area for tourist vessels). The justification for the selected environments is described in the Application.
C7	S15	Biocides should not be phased out until alternatives are available.	Of the 60 antifouling paint approvals being reassessed, only eight are proposed to be revoked immediately. With another eleven recommended to be phased out in four years, and a further four approvals being phased out in ten years. The staff have recommended phase out for these approvals in order to ensure there are enough viable antifouling paints available to users. These periods provide industry with a transitional period to develop new technologies, and provide users with enough time to gradually change their purchasing habits.
C8	S15	It is important that boat owners be able to carry out their own annual removal and maintenance of antifouling paints.	Boat owners will still be able to undertake their own boat maintenance activities. Compliance with the controls should be able to be achieved by DIY boat owners.
C9	S15	All careening grids should be banned for fouling removal, bottom paint preparation and antifouling paint application. These grids should not be removed by force or law as they are an important facility for urgent hull fitment, propeller and rudder repairs.	The proposed controls to reduce environmental contamination when undertaking boat maintenance activities are ‘controlled work area’ and ‘collection of waste’. If these controls cannot be met using a careening grid, then a careening grid should not be used.
C10	S11, S15	There is opposition to any suggestion of banning or placing prescriptive controls on DIY boat owners. There is also objection to the idea of restricting cost-effective antifouling paints to licensed applicators only.	The staff’s recommendations do not discriminate in any way between a DIY user and a professional user. All users must comply fully with any controls set on an antifouling paint.

C11	S15	There is confusion over what additional controls are.	When a substance is approved under HSNO, default controls are automatically assigned to it based on its classifications, in accordance with the regulations. If there are risks which are not sufficiently mitigated by these default controls, in order to approve the substance, the EPA has the ability to add additional controls. The staff are not satisfied that default controls will manage the risks that antifouling paints pose, so the staff have recommended additional controls to mitigate these risks. These additional controls are referred to in Table 9 of the application document (p.45). The full wording for these additional controls is available in Part 3 of this document.
C12	S15	There is no need for prescriptive rules for the DIY user using brush and roller predominantly in the open air. Any DIY user must already comply with the yards local rules, and they must be responsible for his or her own actions and safety.	The controls do not differentiate between DIY users and professional users. All people applying antifouling paint by brush and roller will be required to wear PPE that protects them from direct contact with antifouling paints. All users will be required to collect wastes contaminated with antifouling paints, and to dispose of it in accordance with the HSNO disposal regulations.
C13	S14, S15, S23	Copper should not be banned, as non-copper containing formulations are in their infancy and far from a commercial reality.	The staff are proposing to retain copper in antifouling paint formulations, see staff response to B29.
C14	S15	There should be a minimum phase-in of at least 10 years for all controls.	The staff do not consider phase-in periods of ten years to be appropriate across the board, as some of the additional controls simply provide clarification over what is expected already.
C15	S15	Hull protection and fuel efficiencies for international shipping will dictate what protects the hulls of ships in the future, not this reassessment. The EPA should wait and see what develops before making any costly decisions.	The decision made on this application does not impact on any person's ability to make a new application for an antifouling paint substance. Where unacceptable risk currently exists, the EPA must either impose further controls to mitigate those risks, or revoke the approval.
C16	S23	Imported products should meet the same standards as NZ produced product (e.g. labelling, compliance, regulations).	Imported substances are required to adhere to the controls imposed by HSNO approvals for New Zealand produced antifouling paints.

C17	S21	There are few antifouling paints effective for use on vessels cruising between 8 and 12 knots. No restrictions should be put in place until reliable proven alternative products are readily available on the New Zealand market.	Recommendations for phasing out certain antifouling paints were made based on the risk assessment. The staff consider that the phase-out periods proposed will enable industry to develop suitable alternatives.
C18	S21	When a vessel hull paint system is changed the hull needs to be stripped back to bare metal or timber before the new paint can be applied. This process is expensive and time consuming, and means that some companies will take years to swap the antifouling paint used on their fleet.	The controls do not require boats that are coated in revoked antifouling paints to be stripped and/or repainted. The outcomes of this reassessment apply to the import and manufacture of antifouling paint.
C19	S3, S5, S6, S9, S13, S22, S28, S29	Support for PPE requirements.	Noted. PPE is required under HSNO for all these substances.
C20	S3, S5, S6, S9, S13, S22, S29	Support for the enclosed work area control.	Noted. We have proposed that when antifouling paints are being applied, the work is carried out in a controlled work area that is sufficiently enclosed to prevent the off-target deposition of antifouling substances.
C21	S3, S5, S6, S22, S29	Waste collection and disposal controls are fully supported. There are many marinas which already have waste collection facilities. These should be permitted to continue, particularly if they are currently operating with a resource consent.	These existing facilities are not subject to reassessment. It is intended that disposal facilities that accept antifouling paint waste allow users to meet the requirements set out in the HS disposal regulations.
C22	S3, S5, S6, S13, S22, S29, S9	Support for labelling requirements, but they may have little effect as labels will not be present during maintenance and removal activities.	Noted. Staff consider that provision of guidance material on safe practices to users of antifouling paints will reduce risks and increase compliance.
C23	S7	How will amateur users know how to dispose of waste? Facilities may need to have an antifouling paint disposal facility.	Staff consider that provision of guidance material on appropriate disposal procedures will reduce risks and increase compliance. The EPA encourage the use of approved facilities for the disposal of antifouling paints.

C24	S10,S11, S28	Restricting the application of antifouling paints to hardstand areas is likely to be impractical for many boat owners.	We have proposed that when antifouling paints are being applied, the work is carried out in a controlled work area that is sufficiently enclosed to prevent the off-target deposition of antifouling substances. Use of hard-stands could be one way to achieve this. It should be noted that this is a performance-driven objective to allow people to comply in a manner that is convenient for them. The risk assessment has identified high risks to the aquatic environment and therefore it is necessary to better manage the use of antifouling paints in both the commercial and non-commercial sectors. Restricting use to scenarios where off-target deposition is prevented will better protect the environment, and this may require boat owners to use facilities that enable these requirements to be met.
C25	S10	Antifouling and maintenance activities on tidal grids have no significant effects on the environment. So application via brush or roller to vessels on tidal grids and suitable areas of beach should be permitted.	Antifouling paint application and removal must not contaminate the environment. The controls proposed require sufficient containment to prevent contamination of the marine environment from application or maintenance of antifouling paint.
C26	S14	With reference to Covec analysis Clause 3.3.3, most haul-out operations (either travelift or conventional cradles on trolleys on concrete ramps), are required to have detritus traps of some description in order to operate legally under the Resource Management Act. So why is the EPA looking to introduce additional controls?	Controls will be imposed under HSNO to ensure people dispose of waste in accordance with the HS disposal regulations, which will manage the risks to the aquatic environment. Many marinas are already doing this. We are no longer specifying controls as written in clause 3.3.3 of the Covec analysis.
C27	S14	Disagreement with the blanket requirement for the containment of wastewater on hardstands through collection by drainage and sealing.	The EPA require those doing antifouling paint maintenance to collect all their waste contaminated with antifouling paint and dispose of it in compliance with the HSNO disposal regulations. We are not suggesting controls that require marinas to install specific treatment facilities.
C28	S14, S25	Questions around whether the approved handler certificate would be an effective control.	See staff response to B25.

C29	S14	With regards to the phase-out periods proposed for thiram and diuron, there was appreciation for the extended phase-out periods given to these substances (though longer, would be even better). The phase-in periods for labelling and documentation should not cause concern as long as the exact PPE requirements needing to be displayed on the label can be agreed upon.	The staff consider that the proposed phase-out periods should provide adequate time and incentive for industry to identify and source alternatives.
C30	S14	Support for the proposal to retain copper pyrithione.	Noted.
C31	S14	Support for the proposal to retain dichlofluanid.	Noted.
C32	S14	Support for the proposal to retain mancozeb.	Noted. The current antifouling paint approvals which contain mancozeb, also contain chlorothalonil. Based on the risk assessment of chlorothalonil, these approvals are proposed to be revoked.
C33	S14	Support for the proposal to retain tolyfluanid.	Noted.
C34	S14	Support for the proposal to retain zinc pyrithione.	Noted.
C35	S14	Support for the proposal to retain zineb.	Noted.
C36	S9, S14	Support for the proposal to phase out chlorothalonil in 6 months.	Noted.
C37	S9, S14	Support for the proposal to phase out irgarol in 6 months.	Noted.
C38	S9, S14	Support for the proposal to phase out DCOIT in 4 years.	The staff note that the risk assessment of DCOIT has been refined due to new information, and the calculated risks are considerably lower than first modelled. This has resulted in the benefits now outweighing the risks, so staff have proposed to retain approvals for DCOIT.
C39	S9, S14	Reluctant support for the proposal to phase out diuron in four years, with some preferring a shorter phase-out period and others a ten year phase-out period.	See B30 and B34 for the justification of the phase-out period for diuron.
C40	S9, S14	Reluctant support for the proposal to phase out octhilinone in four years, with some preferring a shorter phase-out period and others a ten year phase-out period.	Based on the results of our risk assessment, a four-year phase-out period has been proposed for octhilinone to ensure sufficient alternatives are available in the medium term.

C41	S14	Reluctant support for the proposal to phase out thiram in 10 years, and would prefer 15 year phase out period.	A fine balance currently exists between the risks and benefits for antifouling paints containing thiram. This active is the most widely used co-biocide in antifouling paints for pleasure craft. It presents lower risks than other widely used co-biocides, for example diuron. The additional benefits provided by thiram have led to a recommendation for a longer phase-out period. The staff consider that ten years will be enough time for a market shift away from thiram to occur and/or alternatives to be developed. Once this has occurred, the risks will outweigh the benefits and so the substance should no longer continue to be approved.
C42	S14	Support for the proposal to phase out ziram in 4 years.	Based on the results of our risk assessment, a four-year phase-out period has been proposed for ziram to ensure sufficient alternatives are available in the medium term.
C43	S14	Should the EPA be imposing controls on top of existing HSE legislation and WES standards?	HSNO is the primary legislation in NZ that sets controls on hazardous substances. It sets the baseline standards and considers risks to both people and the environment. HSE (Health and Safety Executive) sets generic requirements on workplaces based on taking all practicable steps to eliminate/manage risks to workers.
C44	S17	What is meant by enclosed work area?	The staff propose to modify the control to refer to a ‘controlled work area’ instead of an ‘enclosed work area’, in order to provide greater clarity regarding the intent of the control which is to prevent off-target deposition of antifouling paint.
C45	S17	What is the intent of the control for waste collection?	The intent of this control is to reduce the contamination around marinas, for example, caused by contaminated waste from boat maintenance activities.

C46	S18	There should be more detail around what the safety data sheet control covers.	The intent of this control modification is to provide greater clarity and consistency about how product and safety information for antifouling paint substances should be presented. The HSNO regulations are performance based, and refer to the need for "documentation" to be provided when selling or supplying substances to places of work. This control modification will require a 16-header SDS to be provided for antifouling paints rather than the more generic "documentation" requirements. This will standardise the presentation and format of safety information accompanying the substance.
C47	S3, S5, S6, S29	General support for the proposals, provided that paint manufacturers are comfortable with the phase-out periods and additional controls.	Noted.
C48	S3, S5, S6, S9, S13, S29	Support for the SDS control. A suggestion that SDSs be made available at the point of sale.	There is a control requiring that suppliers provide a SDS to the person buying the product if the substance is likely to be used in a place of work and they have not previously supplied that person with a SDS for that substance. There is also a control requiring that suppliers provide a SDS to anyone who requests one.
C49	S13	Proposals should apply to all users of antifouling paints including yacht clubs and boat yards.	The conditions of an antifouling paint approval will apply to all users.
C50	S6	NZ Marine is able and willing to introduce approved training/unit standards for the application of antifouling paints.	Noted. This is something the EPA can discuss with NZ Marine.
C51	S16	No opposition to the banning of diuron with a four-year phase-out period.	Noted.
C52	S27	Wet sanding is a viable option for the removal of antifouling paints. There should be a uniform standard established in NZ for the wet removal of antifouling paints.	This reassessment does not restrict wet-sanding, provided it is carried out in a manner which meets the proposed control for collection of substances from maintenance activities.

C53	S25	Concerns that the proposed controls will cause antifouling costs to increase, without making any difference to the risks.	The controls that have been proposed in this reassessment were based on a comprehensive assessment of the risks to both human health and the environment. It is therefore considered that there will be a reduction in adverse effects/risks through the application of these additional controls.
C54	S25	These proposals will not affect vessels painted overseas and subsequently visiting NZ with product in their paint lockers.	This is only partly correct. Boats painted overseas will not be affected, but they will not be allowed to bring in any antifouling paint in their paint lockers without a HSNO approval, because this is considered to be importation.
C55	S12	The question of disposal of water-blasting solids during antifouling paint removal needs to be addressed as part of ‘controls’. Incineration or secure burial in appropriate landfills is recommended.	The staff consider that those doing antifouling paint maintenance should collect their waste and dispose of it in a way that complies with the proposed control for collection of substances from maintenance activities. Disposal of collected waste must comply with the disposal regulations.
C55	S12	The EPA should require paint suppliers and applicators to provide educational material (more than just data sheets) to enable consumers to make an educated choice based on optimum performance and safety of antifouling paints rather than just price.	We support the provision of guidance information on antifouling paints being made available to all suppliers / users.
C56	S9, S12	The ten-year phase-out for thiram is too long given the high risks of the substance. New phase-outs of five and eight years are proposed.	See C41 for the justification for ten-year phase-out period for thiram.
C57	S9	Support for the proposal to phase out mancozeb in six months.	There is no proposal to phase out mancozeb-containing antifouling paints. Staff note however that current antifouling paint approvals which contain mancozeb also contain Chlorothalonil and based on the risk assessment of chlorothalonil, these approvals are proposed to be revoked.

C58	S9	The four-year phase-out period for ziram is too long, given the large human health risks. This should be reduced to two years.	The high risk quotients calculated for this substance may be an over-estimation of the actual risks. This is because in the absence of substance-specific data, conservative default values for dermal absorption were used in the exposure modelling. The staff maintain that the proposed phase-out period of four years is appropriate.
C59	S9	The EPA should provide adequate advance notice to Regional Councils of all antifouling paints to be de-registered and the timeframe for this.	The EPA will ensure all regional councils are advised of the outcome of this reassessment.
C60	S9	The EPA should introduce a control to prevent stockpiling of antifouling paints which are being phased out.	A HSNO approval is linked to import and manufacture. Under HSNO, we do not have the ability to restrict use if we do not decline an approval.
C61	S9	A phase-in period of two years for signage is too long, three months is suitable.	Because we introduced a number of new controls with associated compliance costs we have proposed a two-year phase-in period for all the controls. The reason that signage, a relatively cheap control to implement, is phased in over two years, is because it is the controlled areas which must have the signage. As these may not be established for two years, there is nowhere for the signage to be placed.
C62	S9	Additional labelling requirements are supported but this should have a one year phase-in period instead of the proposed two years.	Because we introduced a number of new controls with associated compliance costs we have proposed a two-year phase in period for all the controls. Industry are able to comply with the controls earlier.
C63	S9	Introduce an ‘approved handler’ requirement/control for the commercial applicators of antifouling paints, and for the purchase of commercial quantities of antifouling paints.	The HSNO Act does not differentiate between professional and non-professional applicators. In lieu of an approved handler control we have introduced other controls that are protective of human health and the environment.
C64	S9	Introduce a control that antifouling paints are to only be applied, or removed on hardstand areas, with the possible exception of paints containing dichlofluanid and zineb. This would significantly reduce the potential for contaminants to leach into ground/surface water.	The proposed ‘controlled work area’ control and the proposed ‘collection of substance from maintenance activities’ control adequately manage this risk.

C65	S9	There should be clarification and strengthening of the responsibilities and role of various government agencies in relation to dealing with non-compliance issues.	The EPA have recently developed a guide outlining the roles and responsibilities of the various enforcement agencies (http://www.epa.govt.nz/Publications/EA-roles-and-responsibilities.pdf).
C66	S16	There should be a consideration of enforcing maximum biocide concentrations instead of outright bans.	Consideration was given to this idea by the staff, but it was determined that in setting a maximum biocide concentration below the level of concern, fewer approvals may be retained.
C67	S14	There needs to be an effective border policing strategy, as many vessels that come across to New Zealand for re-fit and re-antifouling bring their own antifouling coatings for application here. There could be a strategy to ensure disclosure of what antifouling paints are on each vessel (local and visiting) and this needs to be available to an Inspectorate (similar to the IMO requirement for large vessels to have certification in place to show that their antifoul is tin free). These records should then be maintained.	Noted. This is something that needs to be discussed with Customs.
C68	S14	Preventing discharge of contaminants from spray is a requirement of air discharge consents that should be being constantly and consistently monitored by the respective Regional Councils, so why is the EPA looking to introduce additional controls on top of whatever is already in place?	HSNO is the primary legislation in New Zealand that sets controls on hazardous substances. It sets the baseline standards. Regional councils are able to set additional controls to cover off site specific risks.

Submissions on the risk assessment

Number	Submitters	Comment	EPA Response
R1	S15	The main influence on the reassessment is to keep up with overseas regulators.	Grounds for this reassessment were established not only to address the new information used by overseas regulators, but also to address Māori concerns around antifouling paints.
R2	S7, S11, S13, S14, S15, S22, S24, S25	There is no evidence for adverse (human health) effects of (specific) antifouling paints.	The application admitted there are no epidemiological data, or reports of adverse effects on human health from the use of antifouling paints. However, this does not mean harm does not occur, or that the risks don't exist. We modelled exposure scenarios based on actual use which

			showed a potential risk does exist.
R3	S7, S12, S15, S22	There is a lack of New Zealand specific / research data.	The staff acknowledge there is a lack of New Zealand-specific data. Consistent with our overseas counterparts, when these data gaps exist we apply best practice using modelling with established endpoints and uncertainty factors. In order to ensure our models are relevant to New Zealand scenarios, the EPA commissioned a report from NIWA to identify New Zealand appropriate parameters for inputting into the model scenarios. This resulted in data based on specific New Zealand marinas being used in the modelling scenarios.
R4	S7, S15, S22, S25	The EPA should have considered exposure during paint removal.	Exposure to paint may occur during the removal process, however exposure to the active itself (considering the remaining concentration of the active) is considered to be far less than during application. The staff agree with the comments of several submitters that PPE should be worn during both application and removal, and is one of the default controls of these approvals.
R5	S7, S15, S22	Diuron was not detected in studies of Westpark sediment. This raises questions about the validity of the models.	No modelling of sediment concentrations was presented in the application. The risk assessment was based on the total concentration in water.
R6	S14	Spray application can be completed in approximately one third of the time of brush/roller application, and this may be as low as one tenth of the time for the larger commercial vessels. Spray application significantly reduces the exposure time of the applicator to the products.	The staff agree spraying a boat will generally be faster than using a brush/roller, but note this does not necessarily mean less exposure time (and certainly not less exposure), as the applicator may simply paint more boats in the same amount of time. Staff also note that the potential routes of exposure from spraying include inhalation as well as skin contact.

R7	S14	Where do the percentages of active ingredients listed come from[10], and can there be some clarification in respect to copper content as to whether it is gross cuprous oxide, copper thiocyanate, or copper ion content? Additionally are these values on wet antifouling paint or dry antifouling films?	These percentages were selected as representative of currently approved antifouling paints. The copper content referred to is gross cuprous oxide/copper thiocyanate. These values are for formulated substances (wet paint) not the dry film.
R8	S14	There is some information pertaining to ziram dermal toxicology.[11]	The staff looked at the data summary for ziram provided by the submitter. The EPA's Substance Database has a similar finding result for ziram although it has been assigned a classification of ND (meaning insufficient data). Based on a review of the data identified by the submitter, the classification for ziram can be changed to 6.1 (dermal): No. The data are summarised below: SPECIES: Rabbit TYPE OF EXPOSURE: Occluded patch test TEST GUIDELINE: OECD No 402. DURATION: 24 hours (this is longer than the guideline) END POINT: LD50, signs of toxicity VALUE: LD50 >2000 mg/kg bw. No signs of significant toxicity at this limit dose. REFERENCE SOURCE: 1989: ECHA (accessed April 2013) (see footer) RELIABILITY (KLIMISCH SCORE): 1 CONCLUSION ON CLASSIFICATION: No classification for dermal toxicity should apply. Staff assumed these data were supplied in response to question 8.1 on page 26 of the Application. These data relate to the dermal toxicity, not

[10] Page 24, Clause 8.2

[11] http://apps.echa.europa.eu/registered/data/dossiers/DISS-9d8addc1-9f42-1b22-e044-00144f67d249/AGGR-f4263c09-148b-4d60-ab9d-b007e09f1dc0_DISS-9d8addc1-9f42-1b22-e044-00144f67d249.html#AGGR-f4263c09-148b-4d60-ab9d-b007e09f1dc0

			the information that was sought which was data on the dermal absorption, which is an input into the modelling. The reason that data was sought is that results for ziram indicate exposures above the level of concern and was based on a high dermal absorption value of 30%, which is much higher than for other actives. If data were supplied that scientifically supported use of a lower value this would reduce the risks. The above data do not provide information that enables such a revision.
R9	S14, S15, S22	The few human health issues that have been reported for antifouling paints have been related to the solvents that are used within the products, and the lack of appropriate PPE for handling a solvent-based product.	Solvents are taken into account during the classification of these substances. Default controls are applied specifically to deal with any risks the solvents contribute to the formulations. These controls include the need for appropriate PPE to be worn to prevent harmful exposure. In the case of a solvent-based paint the appropriate RPE would take into account the solvent and include an organic vapour or mist filter capacity.
R10	S1, S7, S13, S14, S15, S22, S25	There are other sources of these chemicals, contributing to marina contamination. Will they be phased out? If not, why not? The boating community is being singled out because they are visible.	The other sources of these chemicals are beyond the scope of this reassessment. The key difference between antifouling paints and other sources is that all other sources that have HSNO approvals (in particular the dispersive uses such as herbicidal uses in the agricultural and horticultural sector) have their own controls to limit the chance of the substance entering waterways (in particular a label statement that the substance is not to be applied into or onto water). Antifouling paints are intended specifically to be used on vessels and other articles used in the water, which means that the same level of risk mitigation cannot take place.
R11	S14	The duration of exposure (90 minutes) for brush/ roller application for the non-professional is more likely to be up to 180 minutes, but would only occur every 21 months (based on information indicated by the Cove report). This should be able to be managed as a Short Term Exposure Level (STEL) type value, rather than a Time Weighted Average (TWA) exposure type value.	The submission proposes the use of a longer period (180 minutes) for the DIY applicator. EPA staff note that a median value of 90 minutes is consistent with the modelling approaches taken in European assessment for brush and roller application by non-professionals. See UK Committee on Pesticides, October 2001. Evaluation on diuron (dichlorophenyl dimethyl urea) Use as a Booster Biocide in Antifouling Products (p63) – for application by brush and roller non-professional. [Note: Spray application is for 1 hour for non-professional for diuron and for zinc

			pyrithione [UK Committee on Pesticides, May 2003 Evaluation on zinc pyrithione (p52ff)]. Reference to a comparison against Workplace Exposure Standard (Short Term Exposure Limit) in comparison to a Time-Weighted Average (TWA) is not relevant in this context, as the assessment parameter is not a Workplace Exposure Standard (WES) or Threshold Limit Value. The assessment of both professional and DIY application has been carried out in comparison to the Acceptable Operator Exposure Limit (AOEL) for the relevant active ingredient. The AOEL is generally based on a three month (90 day) exposure period (in animal studies). Since the AOEL is an acceptable daily exposure, the EPA conceded that use of this form comparison for an exposure most likely to occur occasionally (approximately annually) as for a DIY applicator, is precautionary, assuming they have one vessel and it is treated seasonally. However, we note that there is the possibility that people helping each other carry out these tasks, so that one person may paint a number of vessels even as a DIY applicator. Reducing the exposure estimates to reflect assumptions about frequency of such activities is not consistent with the approach to such exposure risks used overseas.
R12	S14	The 180 minutes for mixing/loading activities, is a gross over-estimation, and 15 minutes is a more realistic timeframe, and could be considered as a STEL type value. The 180 minutes for the professional user to high pressure spray and brush/roller application is a suitable time frame, but this needs to be addressed more as a TWA type value as these types of users are likely to be undertaking this type of activity multiple times a week.	The staff note the comment on the 180 minutes for mixing/loading activities which is referred to on p76 (Appendix C). This duration reflects the value used by the European regulators for their assessment of antifouling paint substances. See UK Committee on Pesticides, October 2001. Evaluation on diuron (dichlorophenyl dimethyl urea) Use as a Booster Biocide in Antifouling Products (p56ff) and UK Committee on Pesticides, May 2003 Evaluation on zinc pyrithione (p52ff). The staff concede that it may appear surprising to use 180 minutes for both the application and the mixing/loading processes, but this is understood to be due to the parallel processing being undertaken for airless spray operations. The mixing/loading workers (“potmen”) are

			working to provide product that is being sprayed as it is used.
R13	S16	The models are too conservative. Are marina concentrations an appropriate protective goal? The importance of a future-proof model, which was suitable for new products, is emphasised.	Using marina concentrations is standard international best practice for antifouling paint modelling. The staff agree it is important our modelling can be used for future substances. However we do not share the submitter's concerns over the suitability of this risk assessment in the future. The submitter is concerned any future substances seeking approval will be assessed in a stand-alone fashion, and if the modelling shows risks above the LOC, they will not be approved. When providing advice to decision makers, staff regularly take past decisions into account when assessing the risk of a substance relative to currently approved substances. There is no reason to anticipate any change to this practice.
R14	S16	Safe use can be demonstrated for non-professional application by modification of the human risk assessment and in particular by use of dermal penetration data for biocidal antifoulings which can be provided confidentially. Where this data is available for individual products, it should be taken into account when assessing human risk and individual product risk assessment (via BPD TNsG methods), and should be considered when choosing to reject use of a given biocide.	The staff note while it is always preferable to have such formulation data, it would not influence the results of the current reassessment as the human health risks are generally already below the level of concern and so have not been major contributors to the risks. The only exceptions are antifouling paints containing ziram. The staff note for new active ingredients, this data would be appreciated during the assessment process.
R15	S16	The EPA should review the additional information supplied by Dr Finnie, and adopt the use of the 2.9 reduction factor as a Tier 2 assessment.	The staff would like to thank the submitter for providing this detailed submission. Staff have reviewed the arguments provided and although the information offered some insight into several of our concerns, we still believe that there are critical data gaps around the size of the original sample and the lack of knowledge about the maintenance history. Staff are not going to apply this reduction factor to the calculated leaching rates. Please see Part 2 of this document for a discussion around this reduction factor.
R16	S25	The EPA have not mentioned that DIY boat owners have a very low accumulated exposure.	The staff agree that DIY boat owners have low accumulated exposures. While this was not made explicitly clear, note on page 23 of the application it states 'Non-professionals are only likely to apply antifouling

			paints infrequently'.
R17	S25	Can the EPA determine if the total annual exposure is a significant risk to health or not? Also is the exposure risk greater for a professional or a DIY user?	Staff note that the duration of use by non-professional users is reduced in comparison to professional users (90 minutes rather than 180 minutes). The submitter is correct that the modelling approach does not take into account the frequency of use of antifouling paints as such (such as on an annual basis), and the comparison point for the professional and non-professional (the AOEL) is the same. The proportion of the year that application of antifouling paint is likely to be undertaken in is not taken into account, despite this being identified as being different on p23 of the Application (section 8.1). Staff note that this comparison with AOEL is consistent with what is done for other assessments (such as plant protection products) and while such a comparison with the AOEL is precautionary for the non-professional (who is likely to use antifouling paint less often than a professional), some additional level of precaution for the general population is considered reasonable.
R18	S1, S2, S13, S20, S22, S30	There are concerns around the use of some antifouling paints, and the proposed bans are supported in general. Cases of allergic contact dermatitis are attributed to all of the substances under review.	The staff have considered stakeholder concerns around antifouling paints, and these have formed a contributing factor in undertaking this reassessment (by being one of the reasons for establishing grounds to reassess). The staff are aware of the potential for triggering contact sensitisation by some active ingredients in antifouling paint formulations. The EPA addresses the risks by identifying the contact sensitisation hazard of the respective active ingredient and assigning a 6.5B classification to the formulated product (paint) when appropriate. This classification carries a set of controls that are designed to protect users by minimising exposure and as a result minimising risks from all adverse effects triggered by the formulated product. Risks to users of antifouling paints where the contact sensitisation hazard is triggered are addressed in this reassessment. There is a proposal to manage other potential risks to human health with prescriptive recommendations for protective personal equipment.
R19	S12	There should be monitoring of antifouling paint concentrations in New	Staff note while monitoring data may assist in refining models, it is

		Zealand marinas.	unlikely to be an economically viable option. The staff have confidence in our modelling, and believe this was conducted in line with international best practice.
R20	S12, S20	There should be further research into the use of antifouling paints on areas not covered by this application, namely aquaculture structures and nets and suggest tests be carried out on the food safety of fish produced from such treated cages.	It was assumed that risks to the environment and human health are unlikely to be significantly different for antifouling paints used on surfaces other than ship hulls. As such, although no specific models were used to measure the risks pertaining to aquaculture structures, the staff are confident that the modelled risks do present an accurate estimate of what these risks would be. The proposed controls will protect users and the environment from antifouling paint use on aquaculture structures. Any risks to food safety would arise as the result of residues, and these are managed by the Ministry for Primary Industries (MPI).
R21	S18	The SSD refinement for DCOIT should be used in determining a PNEC because: • EU CAR did not require SSD refinement to reach safe levels, which is why it wasn't used. • Although not all studies are GLP, those that aren't are considered reliable. • The endpoints have now been justified. Marine and freshwater sensitivity are likely to be similar, so the same PNEC is appropriate for both.	The staff have analysed and accepted the explanations given and will now use the SSD refinement in the calculation of a PNEC value for DCOIT. See pp14-18 for further information about revising the risk assessment for DCOIT.
R22	S18	Parts of this risk assessment should not apply to DCOIT because it is not intended for use on recreational vessels.	Unlike many overseas jurisdictions, the EPA has no power to restrict who may use a substance (or indeed the approval). As the EPA cannot restrict the use of a substance to a particular scenario (e.g. commercial vessels only), the risk/benefit analysis must take all possible scenarios into account.

R23	S24	The monitored concentrations are up to three times lower than the modelled concentrations[12].	The staff do not consider that the study referred to is robust enough to have any major effect on our risk assessment. The authors of the study note that overall, the predictions of the MAMPEC model (used for the environmental risk modelling) are considered to be close enough to the measured concentrations to support further use of this model to reflect marina concentrations, at least in the Auckland region.
R24	S15, S22	The APVMA reviewed the potential of diuron to contaminate marine environments through various sources, and concluded that diuron antifouling use patterns in Australia did not present risks to aquatic organisms.	The staff agree this to be true. The relevant conclusion from the study is: 'Although antifouling paints containing diuron are no longer permitted for use in the United Kingdom and Europe, the risk assessment approach undertaken in Australia (July 2011 environmental assessment), using a very conservative model, concluded that diuron antifouling use patterns in Australia did not present risks to aquatic organisms.' However, the same cannot be said based on the EPA's modelling of New Zealand use patterns, where significant risks were found. This is likely due to the particular physical characteristics of the New Zealand marinas and harbours used in the modelling.
R25	S12	The EPA's role must also include research on the impacts of leached contaminants on 'down-stream' taonga species and marine ecosystems, in a similar manner to that required for introduced bio-controls.	The EPA is not a research agency. If other data were available on marine ecosystems, then it would be taken into account in a risk assessment. The staff believe that by using marinas as a protective goal, we are able to effectively protect all other marine environments which have a much lower exposure to antifouling paints.

Submissions on the cultural assessment

Number	Submitters	Comment	EPA Response
M1	S12	The EPA should be more mindful of its responsibilities for 'active	The antifouling reassessment was initiated and driven from concerns

[12] http://www.aucklandcouncil.govt.nz/SiteCollectionDocuments/aboutcouncil/planspoliciespublications/technicalpublications/TR2012033Antifoulingbiocidesinmarinas.pdf

		protection' under Te Tiriti o Waitangi.	raised by Ngā Kaihautū Tikanga Taiao (Ngā Kaihautū) in a number of antifouling paint applications leading up to 2008 and through a specific request to include the reassessment of antifouling paints as a priority[13]. Ngā Kaihautū considered a reassessment would provide the opportunity to fulfil our Treaty responsibilities through the review and possible improvement of controls; revocation of the approvals for some of the substances; and restrictions on the uses for some of the substances. These measures in turn would lower any negative impacts current antifouling paints have on Māori interests. Given these points, staff consider the EPA is acting appropriately with regard to it responsibilities for "active protection".
M2	S12	The EPA must undertake more meaningful consultation with Māori in future applications of this magnitude and complexity. This could be for example by using the Māori National Network to a far greater extent.	The EPA (and previously ERMA) have been consulting and providing information about the antifouling situation to Māori groups including the Māori National Network since 2008. We also outlined the consultation process for this application in the Application Document itself, noting that a series of consultation hui specific to this reassessment were held in Northland, Auckland, Central North Island, Tauranga and Top of the South Island. We also held workshop discussions at two Māori National Networks in 2012.

Other submissions on the assessment

Number	Submitters	Comment	EPA Response
O1	S15	The information relied on is flawed and unsubstantive. There should be an independent review to investigate how robust the research forming the basis of the EPA's recommendations is.	The staff consider that the information used in this reassessment is robust and accurate. The EPA do not plan to initiate any reviews of the research relied upon.
O2	S11, S15, S22	Visiting ships will expose our waters to higher levels of toxins than domestic ships, and there is no way of knowing what substances have	The EPA cannot control what antifouling paints are applied to vessels overseas. The EPA is able to apply restrictions that limit which

[13] Ngā Kaihautū is the EPA's statutory Māori Advisory Committee

		been used on these boats. How will the EPA effect compliance for international ships?	substances are available for application within New Zealand territory, and this offers some protection to New Zealand aquatic environments.
O3	S15, S25	If restrictions were imposed to limit the antifouling paints available to DIY users, this would lead to backyard production of paints. It could also lead to a black market for the banned paints.	While always possible, the staff have not found any evidence to confirm this as being likely.
O4	S15	If international ship owners are forced to paint their craft with safe paints, then tankers will be diverted elsewhere.	Only paints applied in New Zealand will be affected by this reassessment. Any vessels which have been painted overseas with antifouling paints not approved in New Zealand are still able to enter New Zealand waters.
O5	S15	If visiting ships do not have to comply with the same rules as local ships, then the EPA and Government is leaving itself open to legal challenge.	The resulting approvals and controls will affect the application of paints onto any vessel while it is in New Zealand.
O6	S14, S17, S23	There needs to be a timely and cost-effective processing system for applications for replacement paints which isn't too strict, to ensure manufacturers can supply product to customers. A group standard would be supported.	New antifouling paints will be put through the same risk assessment process as all hazardous substances, with the risks of the substance being weighed up against the benefits it offers. This assessment will generally take place within the existing statutory timeframes.
O7	S14	Can the EPA provide a legal and enforceable definition of who constitutes a professional user?	The staff note that the 'professional user' was a term required during the risk assessment and is used for practicality. Data for this group came directly from studies of workers as opposed to studies on the general population which supported the 'DIY user' assessment. As the staff have not proposed any controls restricting use to a particular group, a legal definition has not been provided.

Submissions on corrections and clarification

Number	Submitters	Comment	EPA Response
F1	S19	California will no longer be introducing a ban on copper in antifouling paints from 2015 onwards and now are considering other options.	Thank you, this is correct and the table is updated in this report.
F2	S19	The Washington ban on copper in antifouling paints for recreational vessels was brought about because boatyards were forced into supporting the ban in order to avoid lawsuits from environmental	Noted.

		organisations.	
F3	S16	The references on pages 96 and 97 of APP201051 need correcting.	The staff would like to thank the submitter for pointing this out and these errors have been corrected in this report.
F4	S16	The USEPA (Federal) regulatory conclusions are incorrect for copper pyrithione, which has been registered for nearly a year.	Thank you, this is correct and the table is updated in this report.
F5	S16	Can the deposition rates and effectiveness of PPE for nonprofessional and professional applicators be explained more clearly? There appears to be an inconsistency between what is written on p75 and what is presented in the table on p76.	Staff note that the non-professional exposure values are based on 75th percentiles from one dataset[14] in contrast to the 90th percentiles for another dataset[15] derived for professionals. Staff do not have access to the original data so cannot derive the 75th percentile from the Links et al, 2007 data. If this 75th percentile value becomes available, stagg would use this value for further assessments in this area. When PPE is used, exposure is (not surprisingly) significantly lower than when it is not. So even though the exposure values with no PPE are higher for professionals than for non-professionals, once PPE is factored into the equation exposure is significantly lower for professionals than for the non-professional with no PPE. Staff consider this to be the most relevant comparison. Overall the conclusion is that use of these exposure paramaters is scientifically sound and appears consistent with overseas regulatory approaches.
F6	S16	What level of protection is afforded by use (only) of a short-sleeved shirt and shorts with or without gloves?	Staff consider that this is what is assumed in the non-professional brush and roller applicator, as the dermal body product deposition (with no PPE) is the appropriate value. The use of gloves is the only relevant PPE

[14] Technical Guidance Document (TNG) from Consumer Product Painting Model 4

[15] A submission from Dow with measurements based on a paper – Links et al 2007

			applied to the non-professional, and no separate protection factor for short-sleeved shirt and shorts in comparison to other clothing is provided for in the case of the non-professional.
F7	S16	The ISO leaching rates calculated by the EPA cannot be replicated. Can the EPA clarify how the ISO method was applied so that the calculations can be replicated.	The staff will contact this submitter to determine the source of the discrepancy. The formula used by the EPA is: Mean biocide release rate over the lifetime of the paint $R=0.0329*m_{rel}/t$ Where: • t is the lifetime of the antifouling paint, in months • m_{rel} = La x α x wa x ρ x DFT/NV*V* • L_a is the percentage of biocide that is released from the paint film during the lifetime of the paintα is the mass fraction of biocide in the biocidal ingredient • wa is the content of biocidal ingredient in the paint formulation as manufactured, in % by mass • ρ is the density of the paint as manufactured, in kg.dm-3 (g.cm-3) • DFT is the dry-film thickness specified for the lifetime of the paint, in μm • NV*V* is the non-volatile-matter content (volume solids content) of the paint, in % by volume

Appendix B: References

Several references were inadvertently omitted from the original reference section (page 151-155 of the Application). Those references which have been added to the original list are marked with *.

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Appendix C: Explanation of HSNO Classification Codes

HSNO Classification Code	Explanation
3.1C	Flammable liquid – Medium hazard
6.1C	Substances that are acutely toxic - Toxic
6.1D	Substances that are acutely toxic - Harmful
6.1E	Substances that are acutely toxic – May be harmful, aspiration hazard
6.3A	Substances that are irritating to the skin
6.3B	Substances that are mildly irritating to the skin
6.4A	Substances that are irritating to the eye
6.5B	Substances that are contact sensitisers
6.7B	Substances that are suspected human carcinogens
6.8A	Substances that are known or presumed human reproductive or developmental toxicants
6.8B	Substances that are suspected human reproductive or developmental toxicants
6.8C	Substances that produce toxic human reproductive or developmental effects on or via lactation
6.9A	Substances that are toxic to human target organs or systems
6.9B	Substances that are harmful to human target organs or systems
8.3A	Substances that are corrosive to ocular tissue
9.1A	Substances that are very ecotoxic in the aquatic environment
9.2A	Substances that are very ecotoxic in the soil environment
9.2B	Substances that are ecotoxic in the soil environment

9.2C	Substances that are harmful in the soil environment
9.2D	Substances that are slightly harmful to the soil environment
9.3B	Substances that are ecotoxic to terrestrial vertebrates
9.3C	Substances that are harmful to terrestrial vertebrates

Appendix D: Explanation of HSNO Control Codes

Identification	Identification Regulations	Description
I1	Regs 6, 7, 32–35, 36(1) – (7)	Identification requirements, duties of persons in charge, accessibility, comprehensibility, clarity and durability
I2	Reg 8	Priority identifiers for corrosive substances
I3	Reg 9	Priority identifiers for ecotoxic substances
I4	Reg 10	Priority identifiers for explosive substances
I5	Reg 11	Priority identifiers for flammable substances
I6	Reg 12	Priority identifiers for organic peroxides
I7	Reg 13	Priority identifiers for oxidising substances
I8	Reg 14	Priority identifiers for toxic substances
I9	Reg 18	Secondary identifiers for all hazardous substances
I10	Reg 19	Secondary identifiers for corrosive substances
I11	Reg 20	Secondary identifiers for ecotoxic substances
I12	Reg 21	Secondary identifiers for explosive substances
I13	Reg 22	Secondary identifiers for flammable substances
I14	Reg 23	Secondary identifiers for organic peroxides

I15	Reg 24	Secondary identifiers for oxidising substances
I16	Reg 25	Secondary identifiers for toxic substances
I17	Reg 26	Use of generic names
I18	Reg 27	Requirements for using concentration ranges
I19	Regs 29 – 31	Additional information requirements, including situations where substances are in multiple packaging
I20	Reg 36(8)	Durability of information for class 6.1 substances
I21	Regs 37-39, 47-50	General documentation requirements
I22	Reg 40	Specific documentation requirements for corrosive substances
I23	Reg 41	Specific documentation requirements for ecotoxic substances
I24	Reg 42	Specific documentation requirements for explosive substances
I25	Reg 43	Specific documentation requirements for flammable substances
I26	Reg 44	Specific documentation requirements for organic peroxides
I27	Reg 45	Specific documentation requirements for oxidising substances
I28	Reg 46	Specific documentation requirements for toxic substances
I29	Regs 51, 52	Signage requirements

Packaging	Packaging Regulations	Description
P1	Regs 5, 6, 7(1), 8	General packaging requirements
P2	Regs 7(2), (3)	Specific criteria for class 4.1.2 and 5.2 substances
P3	Reg 9	Criteria that allow substances to be packaged to a standard not meeting Packing Group I, II or III criteria
P4	Reg 10	Packaging requirements for explosive substances
P5	Reg 11	Packaging requirements for flammable liquids
P6	Reg 12	Packaging requirements for liquid desensitised explosives
P7	Reg 13	Packaging requirements for flammable solids
P8	Reg 14	Packaging requirements for self-reactive flammable substances
P9	Reg 15	Packaging requirements for substances liable to spontaneous combustion
P10	Reg 16	Packaging requirements for substances that emit flammable gases when in contact with water
P11	Reg 17	Packaging requirements for oxidising substances
P12	Reg 18	Packaging requirements for organic peroxides
P13	Reg 19	Packaging requirements for toxic substances
P14	Reg 20	Packaging requirements for corrosive substances
P15	Reg 21	Packaging requirements for ecotoxic substances

PG1	Schedule 1	Packaging requirements equivalent to UN Packing Group I
PG2	Schedule 2	Packaging requirements equivalent to UN Packing Group II
PG3	Schedule 3	Packaging requirements equivalent to UN Packing Group III
PS4	Schedule 4	Packaging requirements as specified in Schedule 4

Emergency Management	Emergency Management Regulations	Description
EM1	Regs 6, 7, 9 – 11	Level 1 information requirements for suppliers and persons in charge
EM2	Reg 8(a)	Information requirements for corrosive substances
EM3	Reg 8(b)	Information requirements for explosive substances
EM4	Reg 8(c)	Information requirements for flammable substances
EM5	Reg 8(d)	Information requirements for oxidising substances and organic peroxides
EM6	Reg 8(e)	Information requirements for toxic substances
EM7	Reg 8(f)	Information requirements for ecotoxic substances
EM8	Regs 12-16, 18-20	Level 2 information requirements for suppliers and persons in charge
EM9	Reg 17	Additional information requirements for flammable and oxidising substances and organic peroxides
EM10	Regs 21 – 24	Fire extinguisher requirements

EM11	Regs 25 – 34	Level 3 emergency management requirements: duties of person in charge, emergency response plans
EM12	Regs 35 – 41	Level 3 emergency management requirements: secondary containment
EM13	Reg 42	Level 3 emergency management requirements: signage

Appendix D: Glossary of terms

Term	Definition
Acute	Adverse effect that occurs after a single exposure which usually lasts for a short time.
AOEL	The Acceptable Operator Exposure Level is the internal dose of a substance that an operator (worker) may be exposed to on a daily basis without the likelihood of an adverse toxicological effect.
Approved Handler	A person who holds a current test certificate certifying that the person has met the requirements of Hazardous Substances and New Organisms (Personnel Qualifications) Regulations 2001 in relation to an approved handler for one or more hazard classifications or hazardous substances.
Benefit	The value of a positive effect expressed either in monetary or non-monetary terms.
Biocide	A substance that is solely designed for biocidal action as defined in Schedule 6 (1) of the Hazardous Substances (Minimum Degrees of Hazard) Regulations 2001.
Chronic	Adverse effect that occurs after a repeated exposure and which usually is long lasting and recurring.
Cost	The value of an adverse effect expressed either in monetary or non-monetary terms.
DT_{50}	Period required for 50% dissipation of a substance.
Endpoint	Toxicological or ecotoxilogical value used in the risk assessment
Exposure	Human or environmental organism contact with a substance.
HSNO	The Hazardous Substances and New Organisms Act 1996.
K_{ow}	Partition coefficient between n-octanol and water. Measures the difference in solubility of a substance in water or alcohol reflecting its tendency to bind to organic material and particulates rather than stay dissolved in water.
LC_{50}	The median lethal concentration, being a statistically derived single concentration of a substance that can be expected to cause death in 50% of animals.

Term	Definition
LD_{50}	The median lethal dose, being a statistically derived single dose of a substance that can be expected to cause death in 50% of animals.
Likelihood	The probability of an effect occurring.
LOAEL	Lowest Observable Adverse Effect Level.
LOC	The Level of Concern is a point above which there is a risk of an adverse effect occurring. For this reassessment the LOC is equivalent to a risk quotient of 1.
LOEL	Lowest Observable Effect Level.
Magnitude	Expected level of effect.
Mesocosm	A mesocosm is an experimental tool that brings a small part of the natural environment under controlled conditions. Mesocosms can be used to evaluate how organisms or communities might react to environmental change.
MSDS	Material Safety Data Sheets contain data regarding the properties of a substance and procedures for handling or working with that substance.
NOAEL	No Observed Adverse Effect Level.
NOEC	No Observed Effect Concentration.
PEC	Predicted Environmental Concentration is the calculated value of a chemical in the environment based on exposure models.
Phase-out period	A period following a decision to approve a substance for a limited time only. This allows time to reduce risks which may exist if the substance was revoked immediately, including disposal of existing stock, and market disruptions.
PNEC	Predicted Non Effective Concentration is the calculated concentration of a chemical that could be safely present in the environment, with no species being affected.
PPE	Personal Protective Equipment including any item of equipment used to protect a person from hazards e.g. safety helmet, goggles, gloves, boots, respirator.

Term	Definition
REI	A Restricted Entry Interval is the time which must elapse after application of a substance before entry into the treated area is permitted without use of PPE or RPE.
RPE	Respiratory Protective Equipment (a type of PPE).
Risk	The combination of the magnitude of an adverse effect and the probability of its occurrence.
RQ	Risk quotient is the ratio of predicted exposure concentration to predicted no effect concentration.

Marine Invasive Species and Shipping

Whitman Miller, Gregory Ruiz, *Ian Davidson
Smithsonian Environmental Research Center
and *Portland State University

National Paint and Coatings International Marine and Offshore Coatings Conference (June 20, 2007)

SERC
Marine Invasions Research Laboratory

Invasion Ecology and Patterns	Transfer Mechanisms & Pathways	National Ballast Info. Clearinghouse

Definitions

- Non-Native = Non-Indigenous = Exotic = Introduced = Alien = Invader

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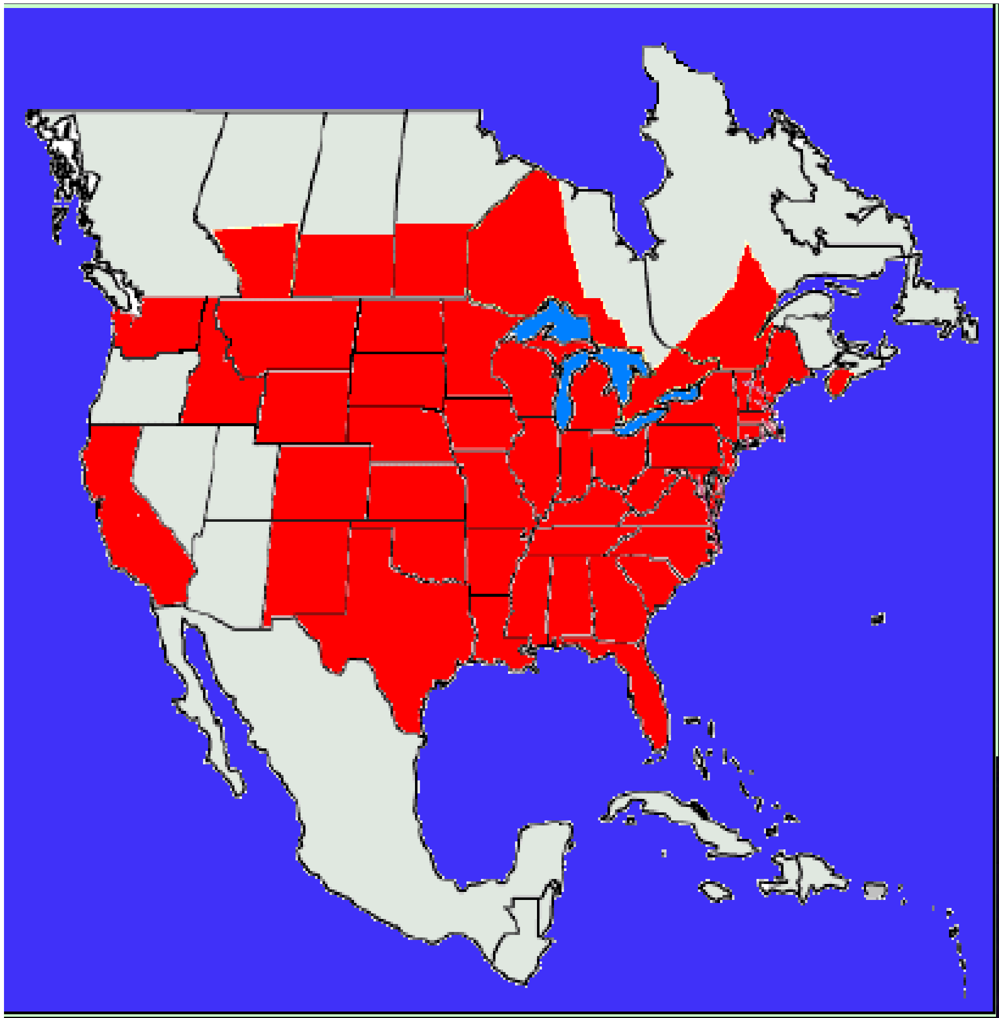
- Non-Native = Non-Indigenous = Exotic = Introduced = Alien = Invader
- "Invasive" describes the rate and extent of invasion – so not all invaders are invasive!
- Vector = Pathway: The mechanism by which Non-native species are introduced to new habitats.



WEST NILE VIRUS SPREADS ACROSS NATION

INVASION SEQUENCE:

Species Pool

⇩

Entrainment

⇩

Arrival / Release

<u>Transfer</u>

⇩

Colonization

⇩

Reproduction

⇩

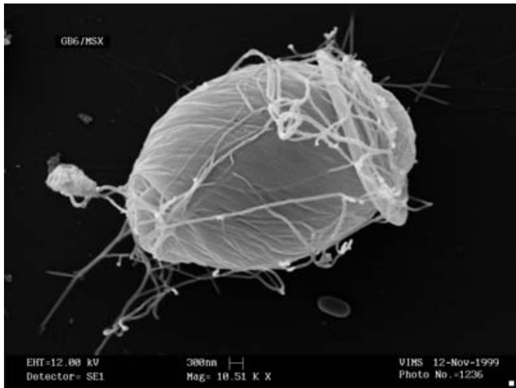
<u>Establishment</u> (Invasion)

⇩

Geographic Spread (Invasive)

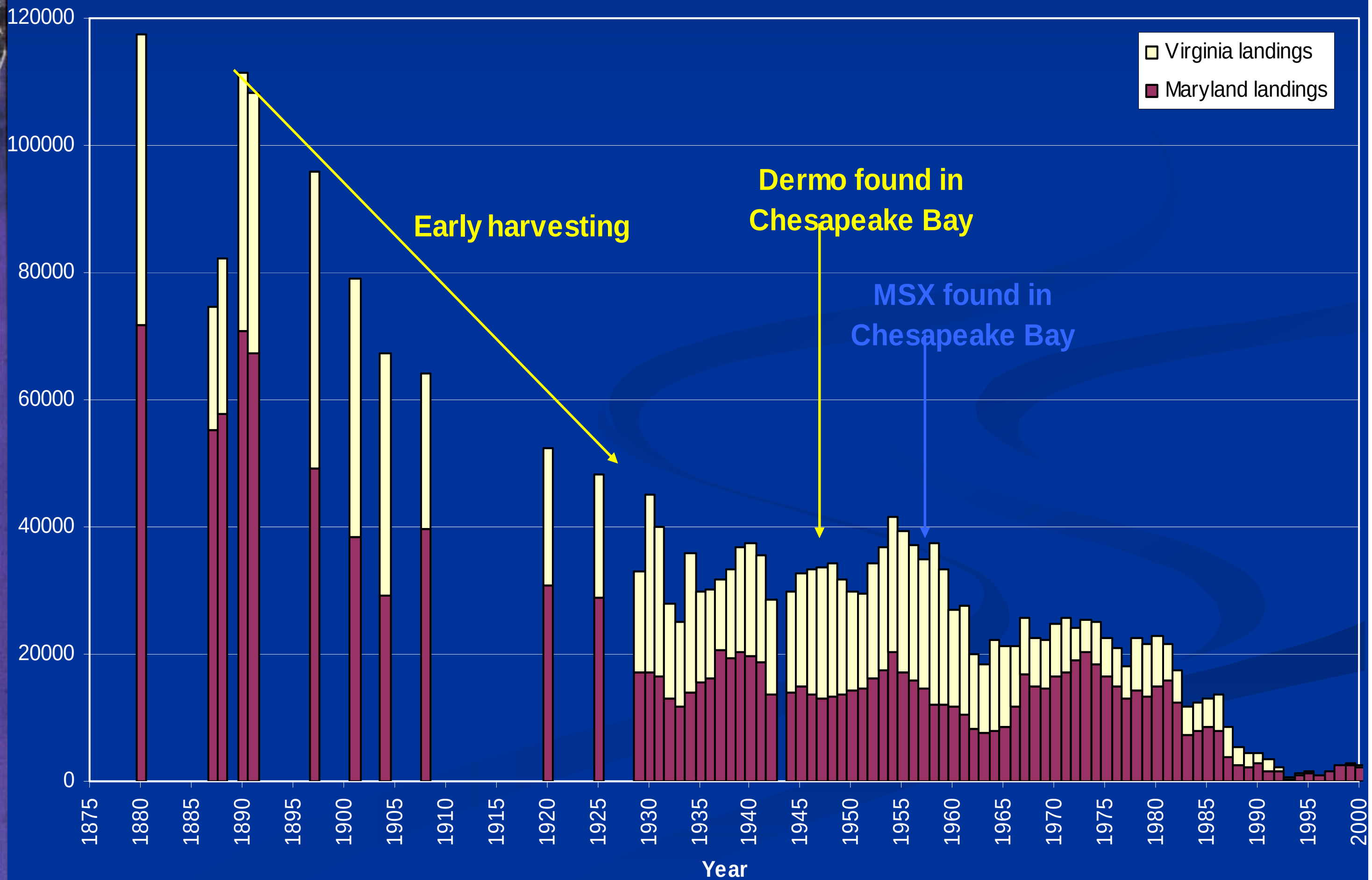
⇩

High Impact (Nuisance / Pest)



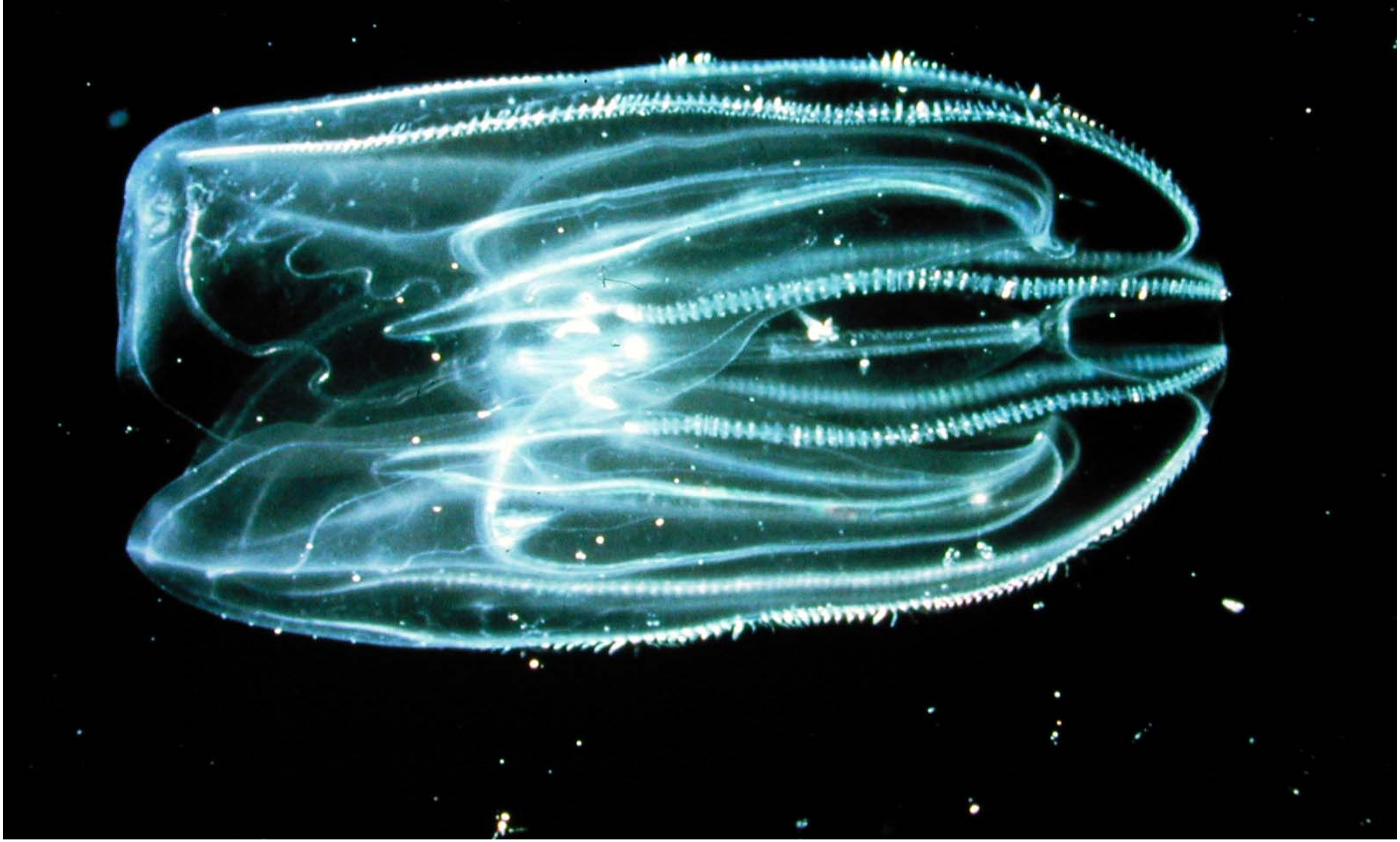
MSX CONTRIBUTES TO OYSTER FISHERY COLLAPSE

History of commercial oyster landings in Chesapeake Bay



ded by: National Research Council

Mnemiopsis leidyi – ctenophore (comb jelly)
Introduced to the Black Sea in 1980s



Effects of Invasive Species

- Invasions by nonindigenous species (NIS) are a major force of global change, resulting in significant ecological, economic, and human health impacts

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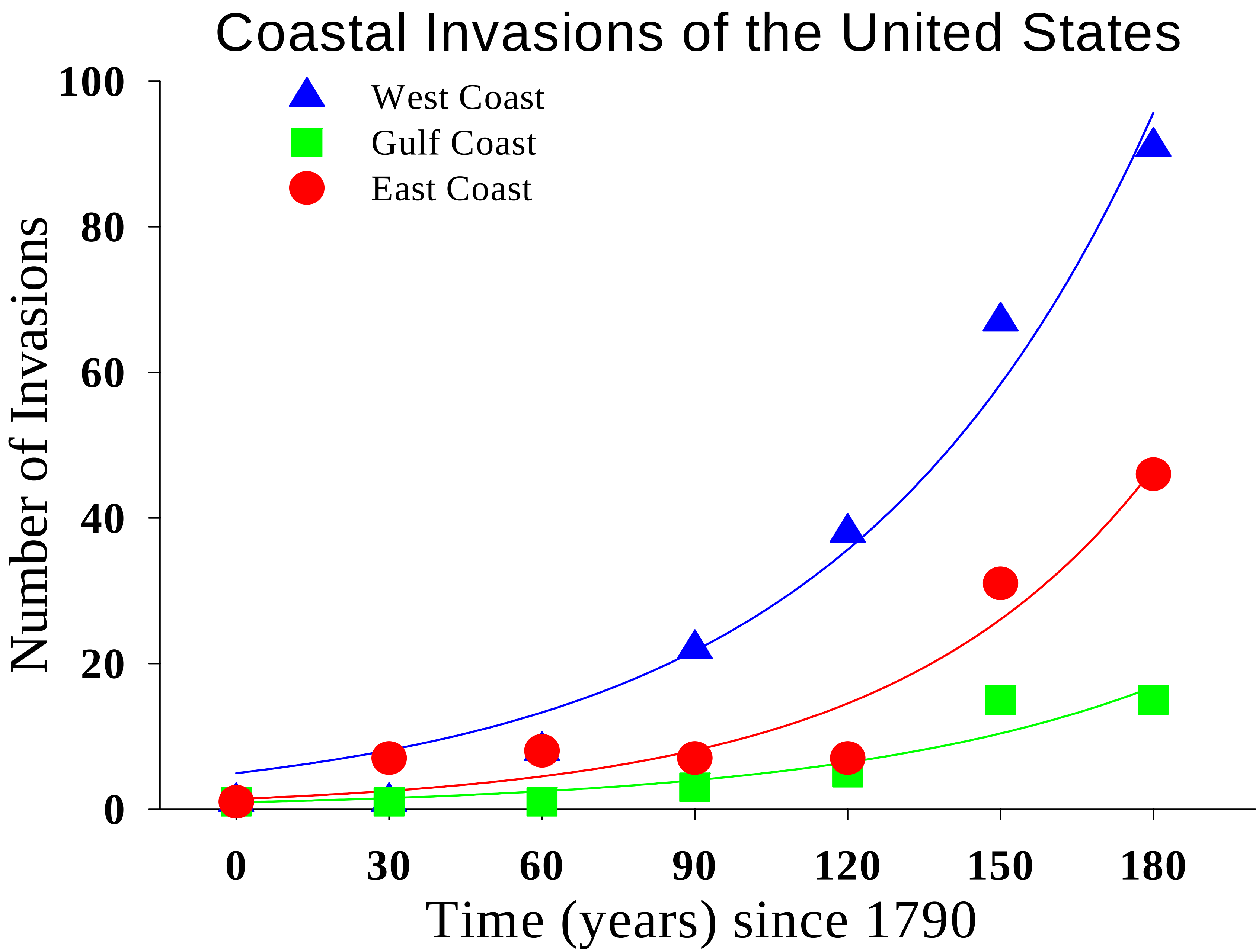
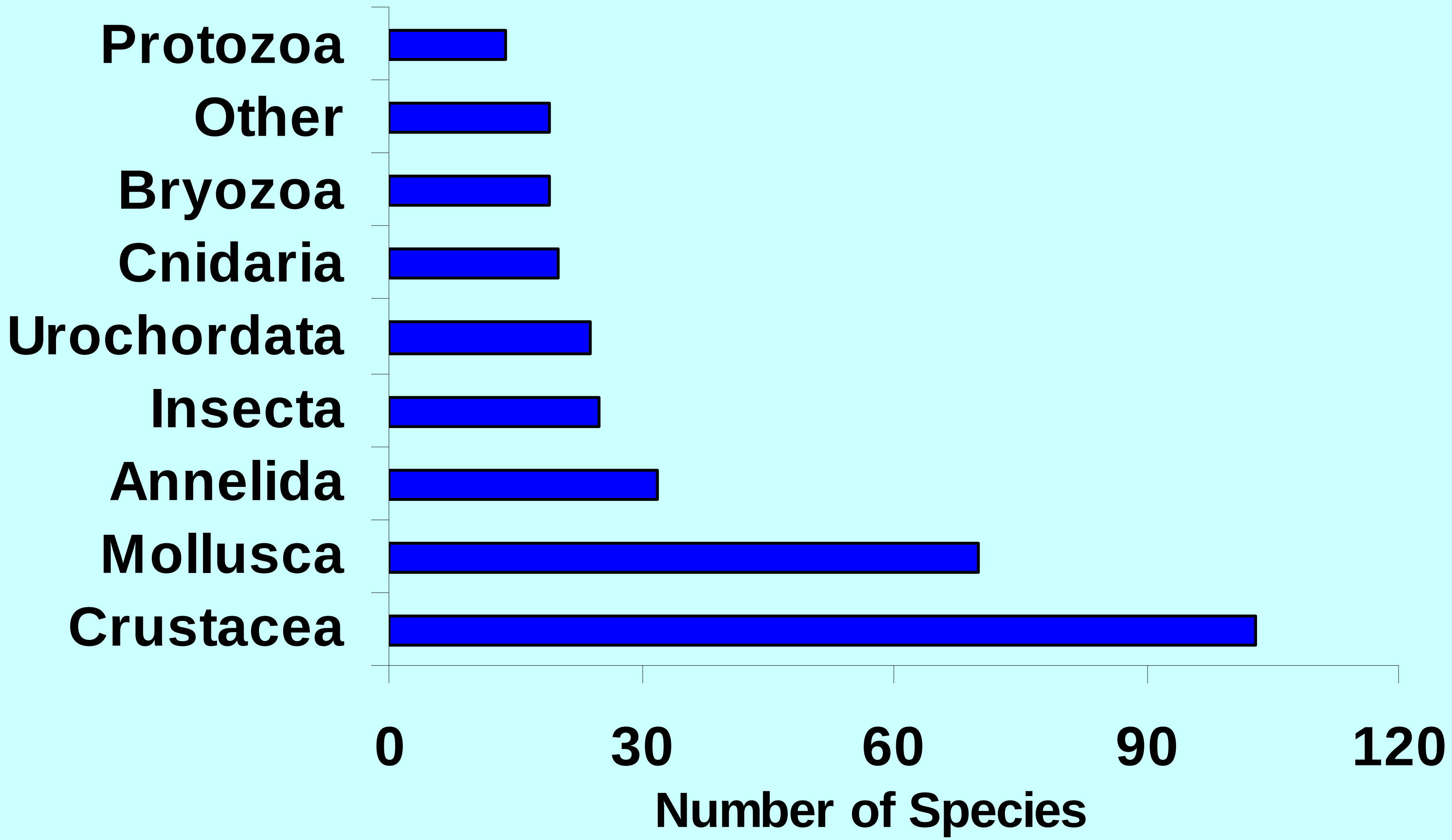
- Economic cost in U.S. of aquatic invasions >$10 billion / year (Pimentel 2003)

Effects of Invasive Species

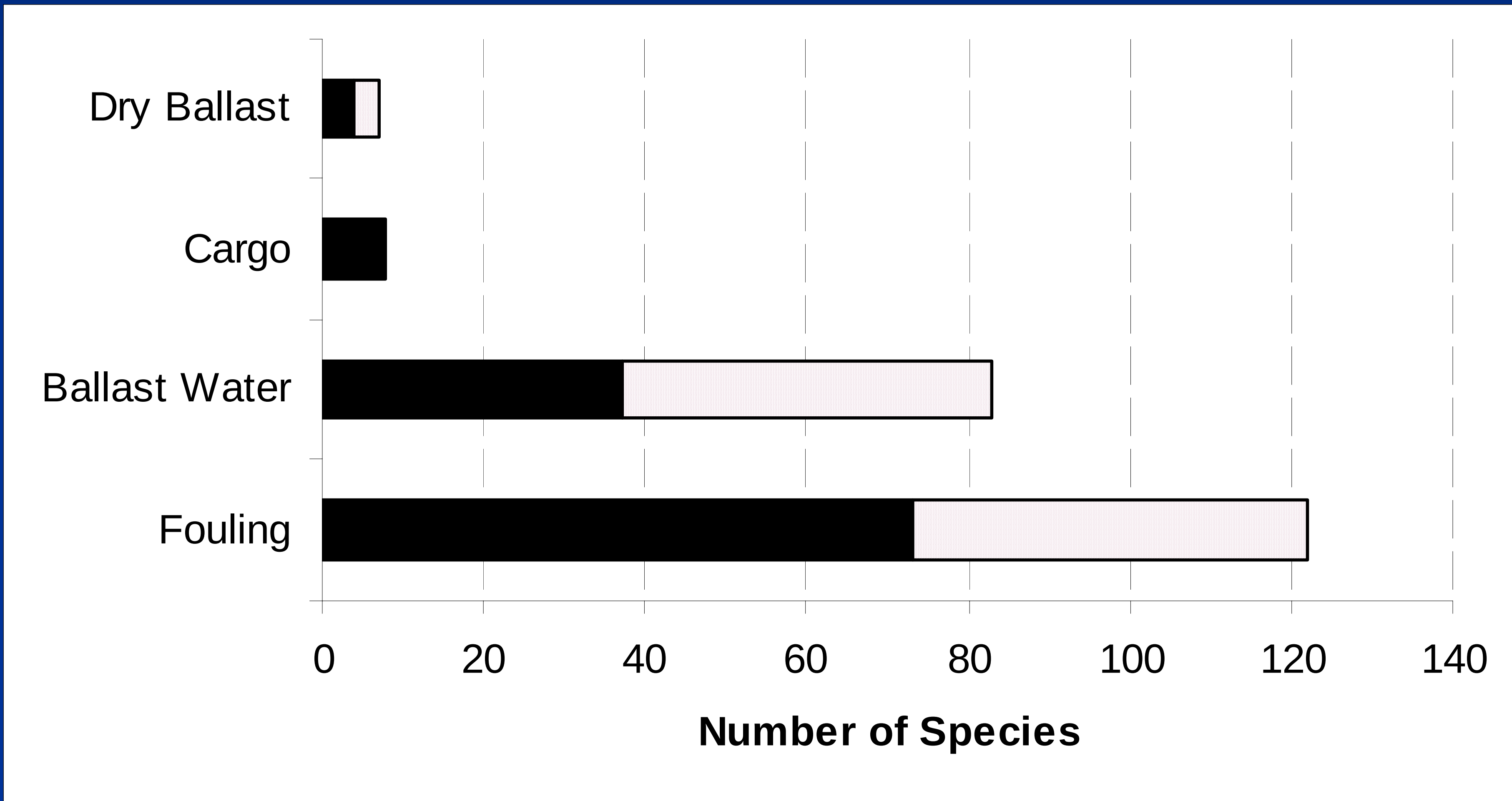
- Invasions by nonindigenous species (NIS) are a major force of global change, resulting in significant ecological, economic, and human health impacts
- Economic cost in U.S. of aquatic invasions >$10 billion / year (Pimentel 2003)
- Transfers of NIS by human activities have increased dramatically over the past century and continue to do so

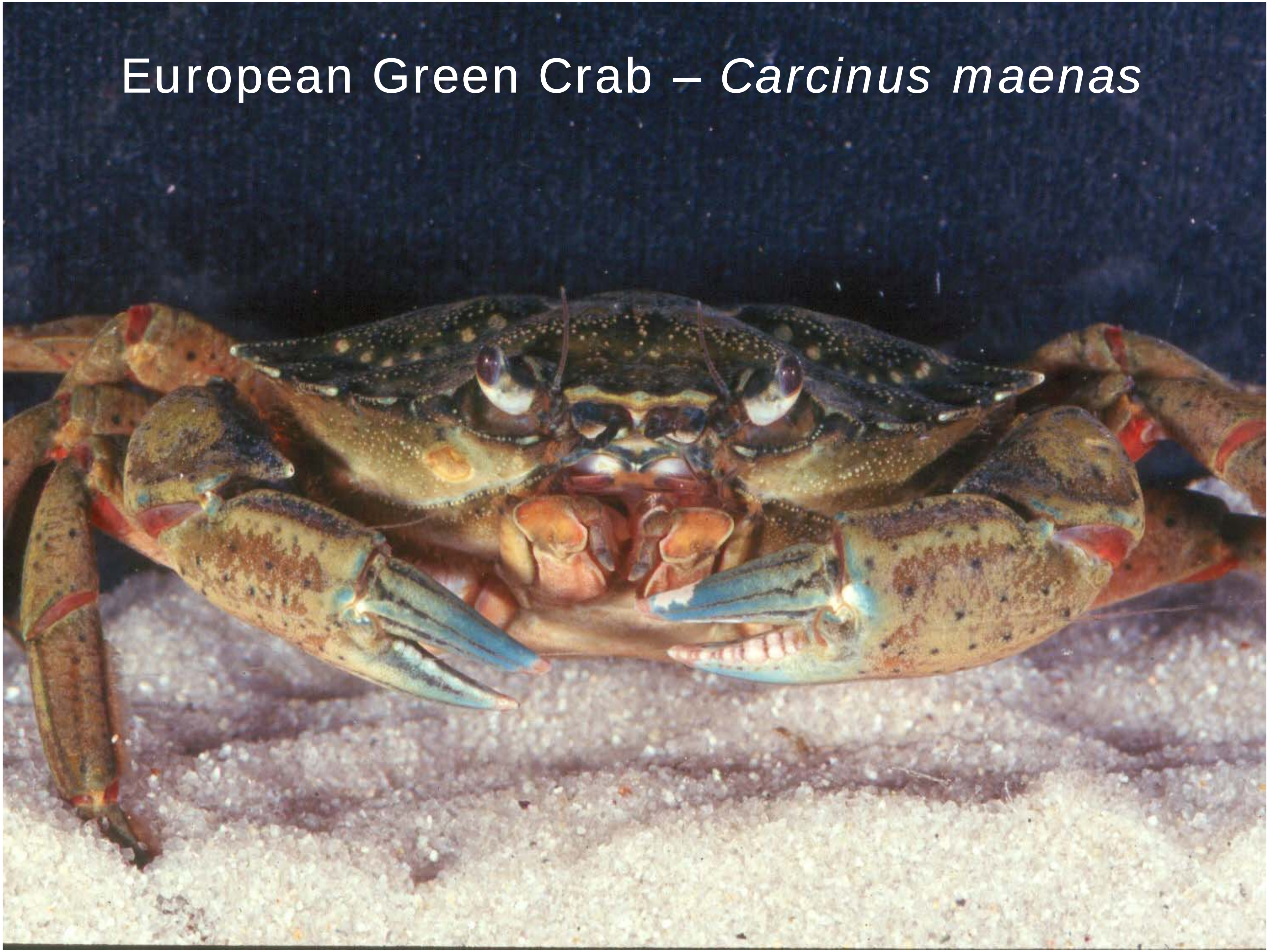

Coastal Invasions of the United States
West Coast
Gulf Coast
East Coast
Number of Invasions
0
20
40
60
80
100
0
30
60
90
120
150
180
Time (years) since 1790

Non-native invertebrate taxa reported in coastal waters of continental U.S. (n=326)



Possible vector for coastal NIS introduced to North America by shipping (n=171)

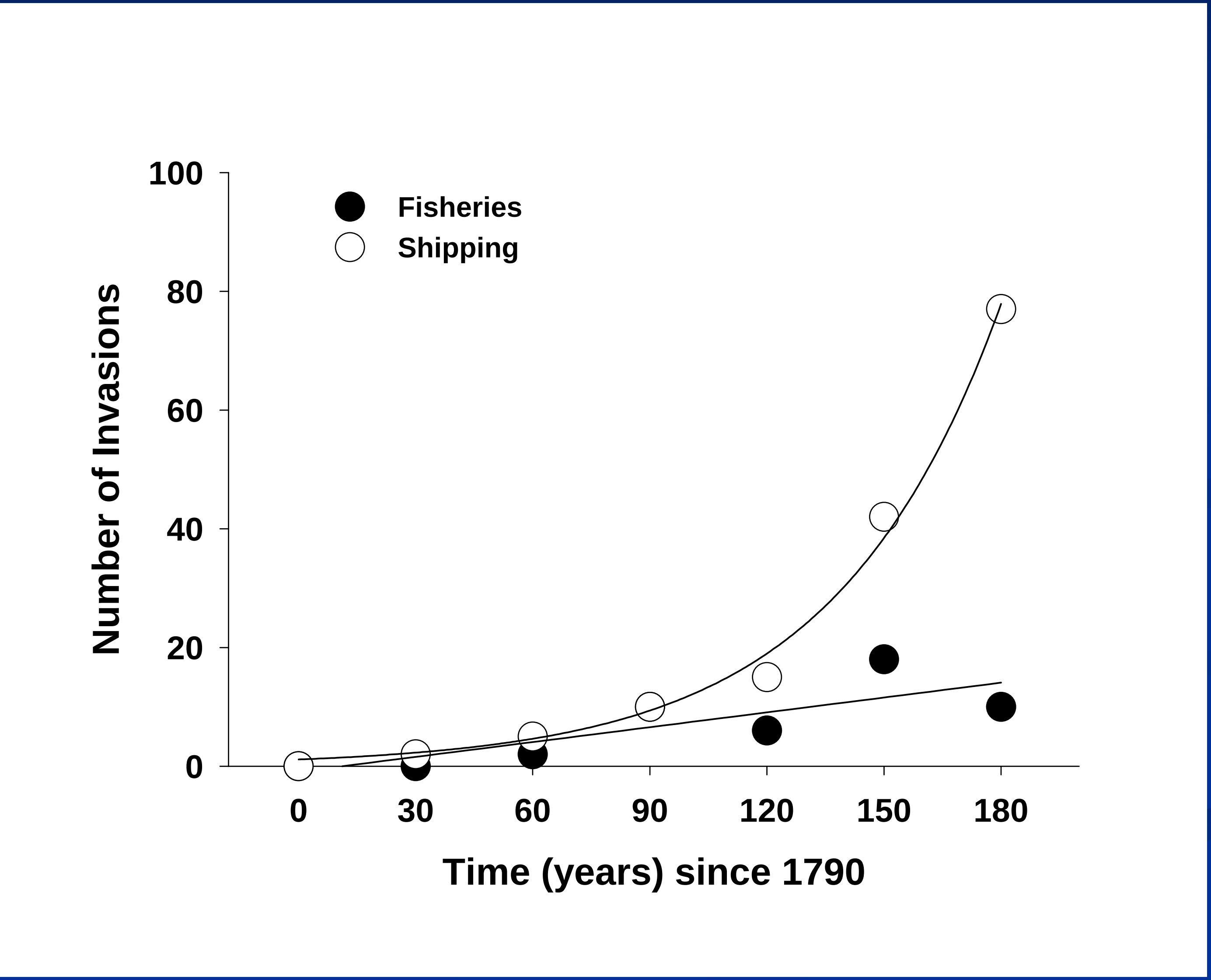



European Green Crab – *Carcinus maenas*

GREEN CRABS IMPACT SHELLFISH & COASTAL COMMUNITIES

Chinese Mitten Crab (*Eriocheir sinensis*)
Chesapeake and Delaware Bays (2006 & 2007)

Rate of coastal invasions detected in North America according to vector




~110,000 Arrivals to US Ports and Places Annually
(Overseas + Domestic)

Modes of Introduction via the Shipping Vector

- Ballast Water:

  water that is pumped or gravitated into BW tanks or holds to stabilize ship for proper trim and stability

Modes of Introduction via the Shipping Vector

- Ballast Water:

  water that is pumped or gravitated into BW tanks or holds to stabilize ship for proper trim and stability.
- Hull Fouling

Vector ecology

species pool
↓
entrainment
↓
arrival / release
↓
colonization
↓
reproduction
↓
establishment
↓
spread

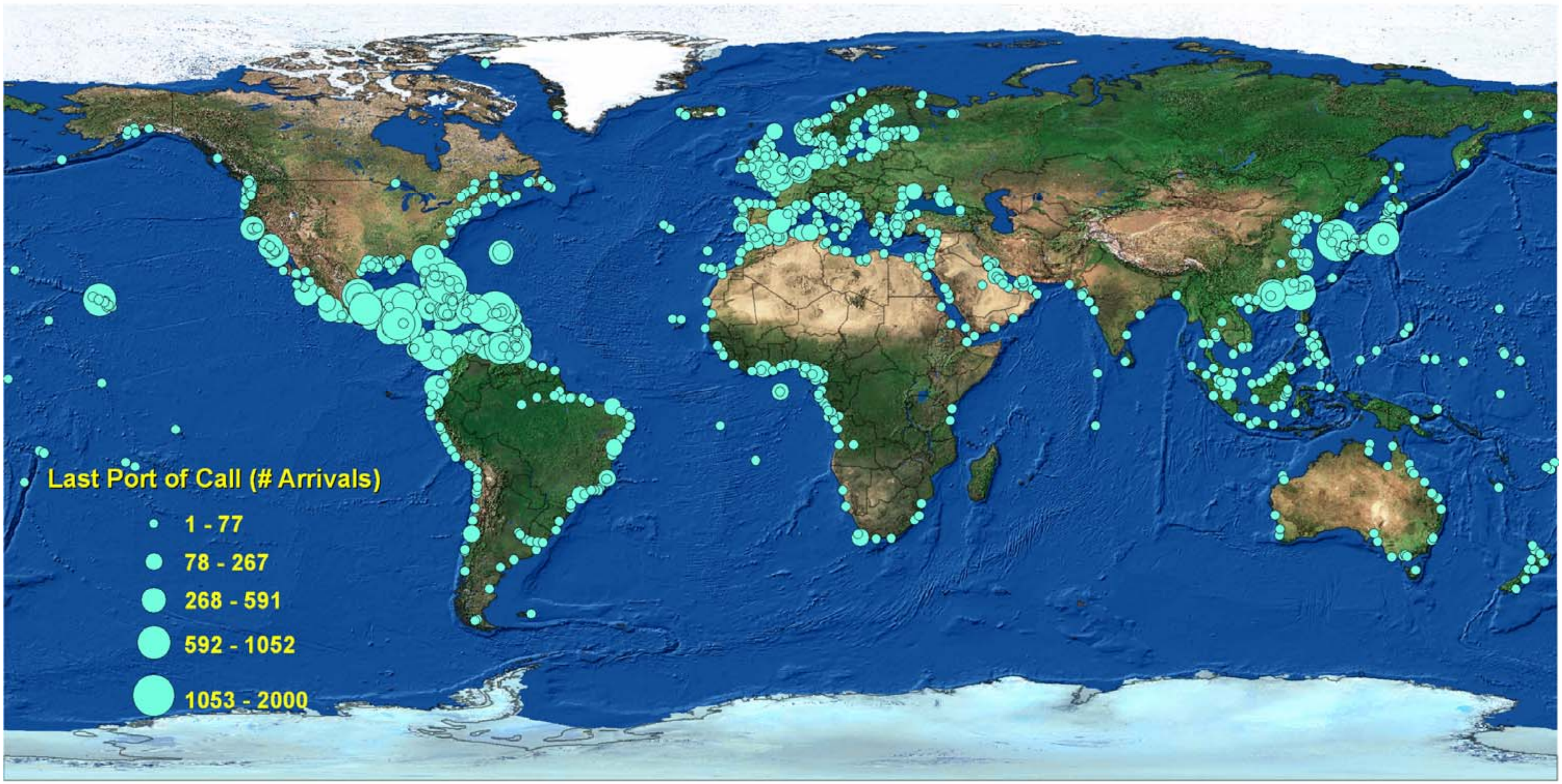
transfer

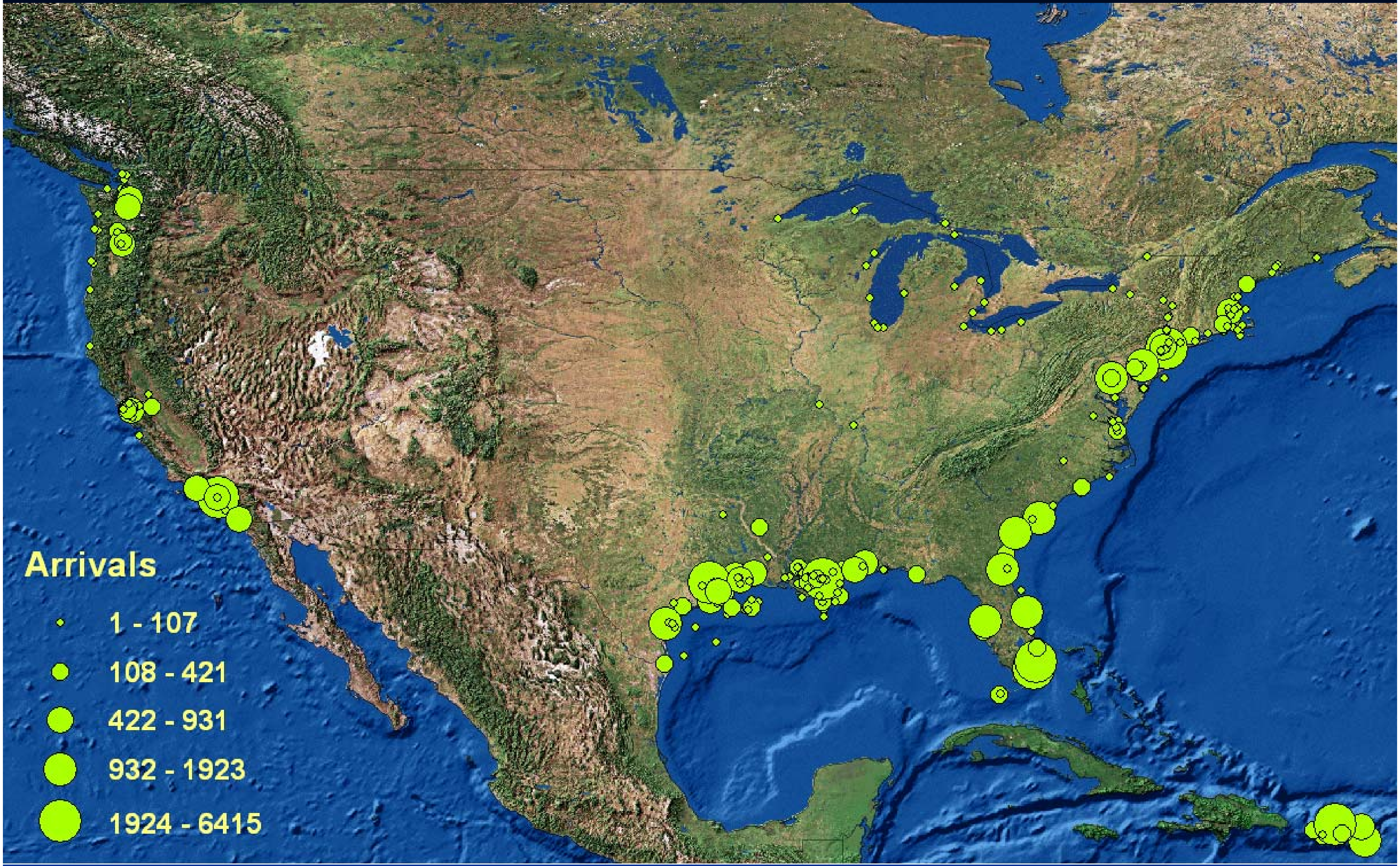
variability of transfers

- number
- source regions
- recipient regions
- magnitude
- frequency
- duration
- density
- diversity

Ruiz & Carlton (2003)

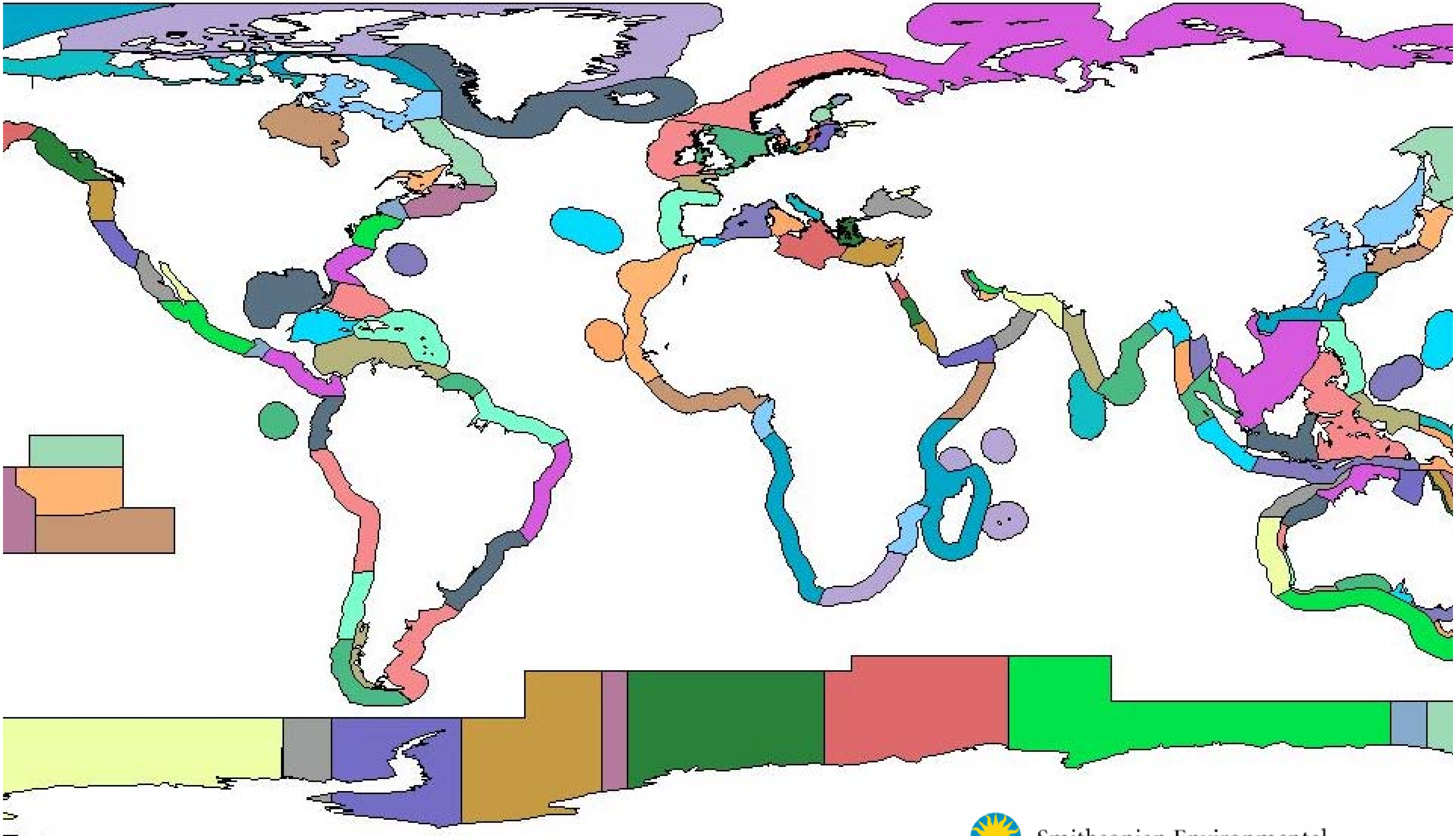
Last Ports of Call to US Ports and Places (Jan 2004 – Dec 2005)





Overseas Ship Arrivals (Jan 2004 – Dec 2005)

IUCN Marine Bioregions



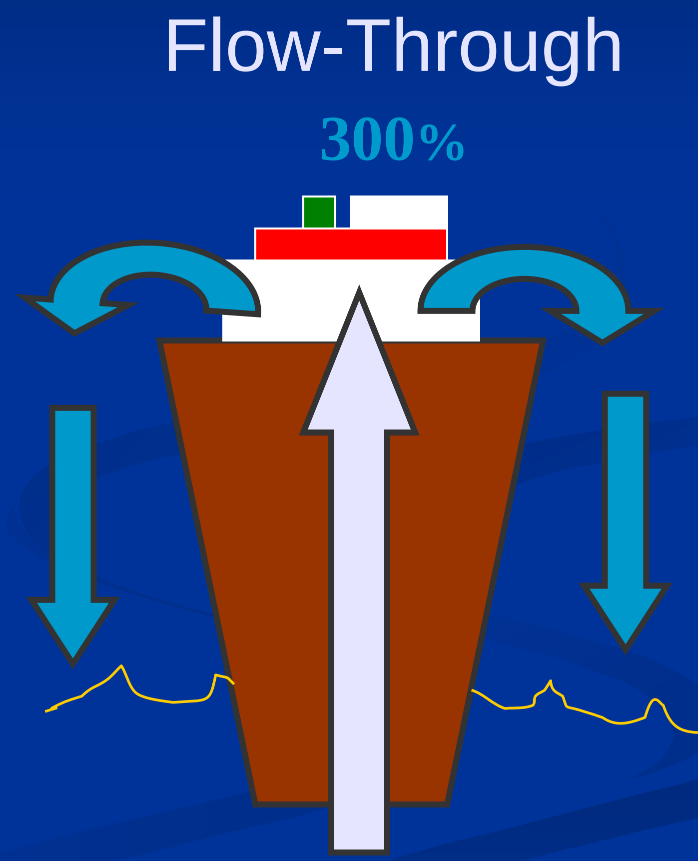
Smithsonian Environmental
Research Center

SERC Ballast Water Ecology Program:

Over 400 vessels boarded to date:

- Biological Sampling
- BW Exchange Experiments

Mid-ocean ballast water exchange



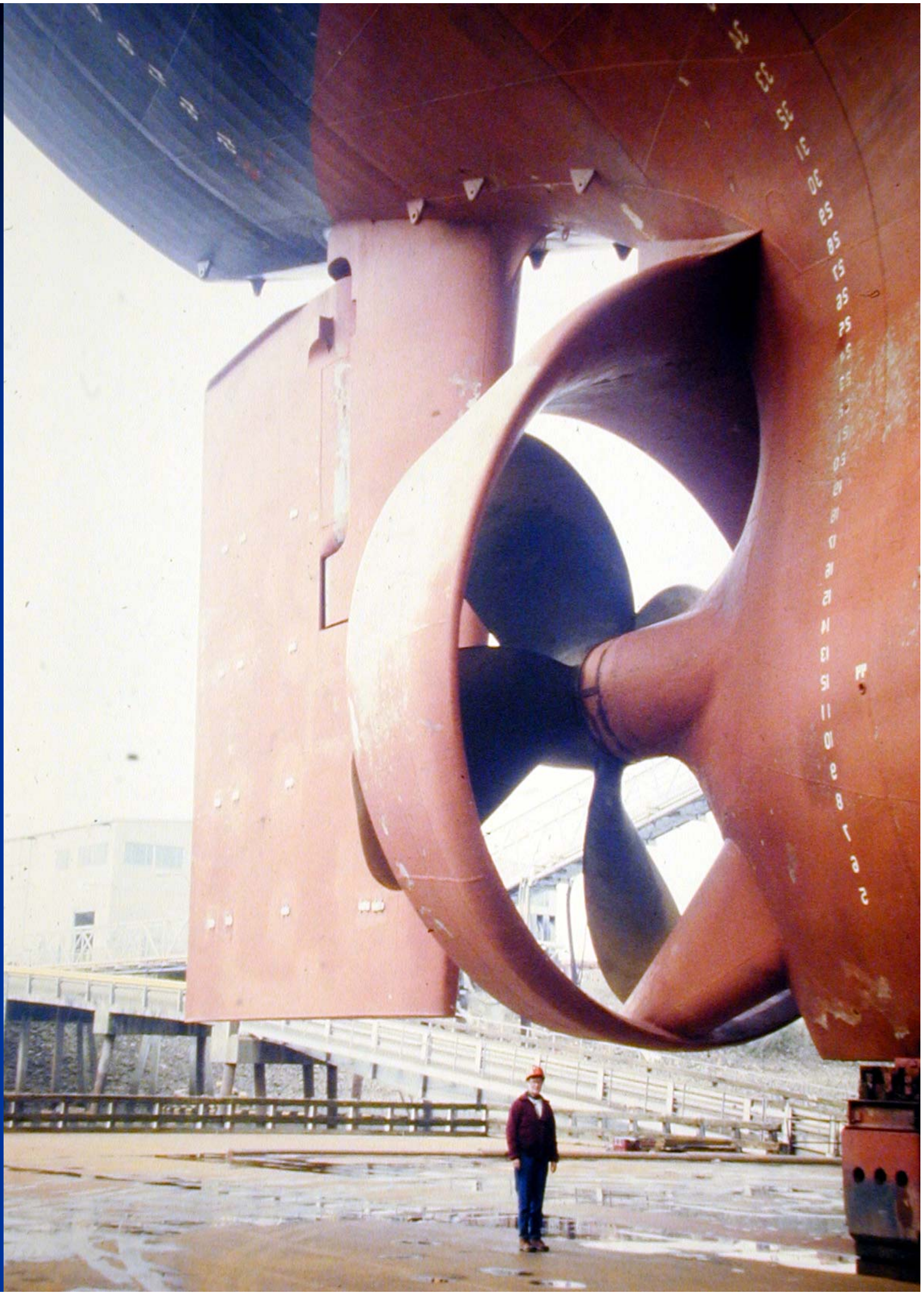
Hull Fouling

- Important Historically

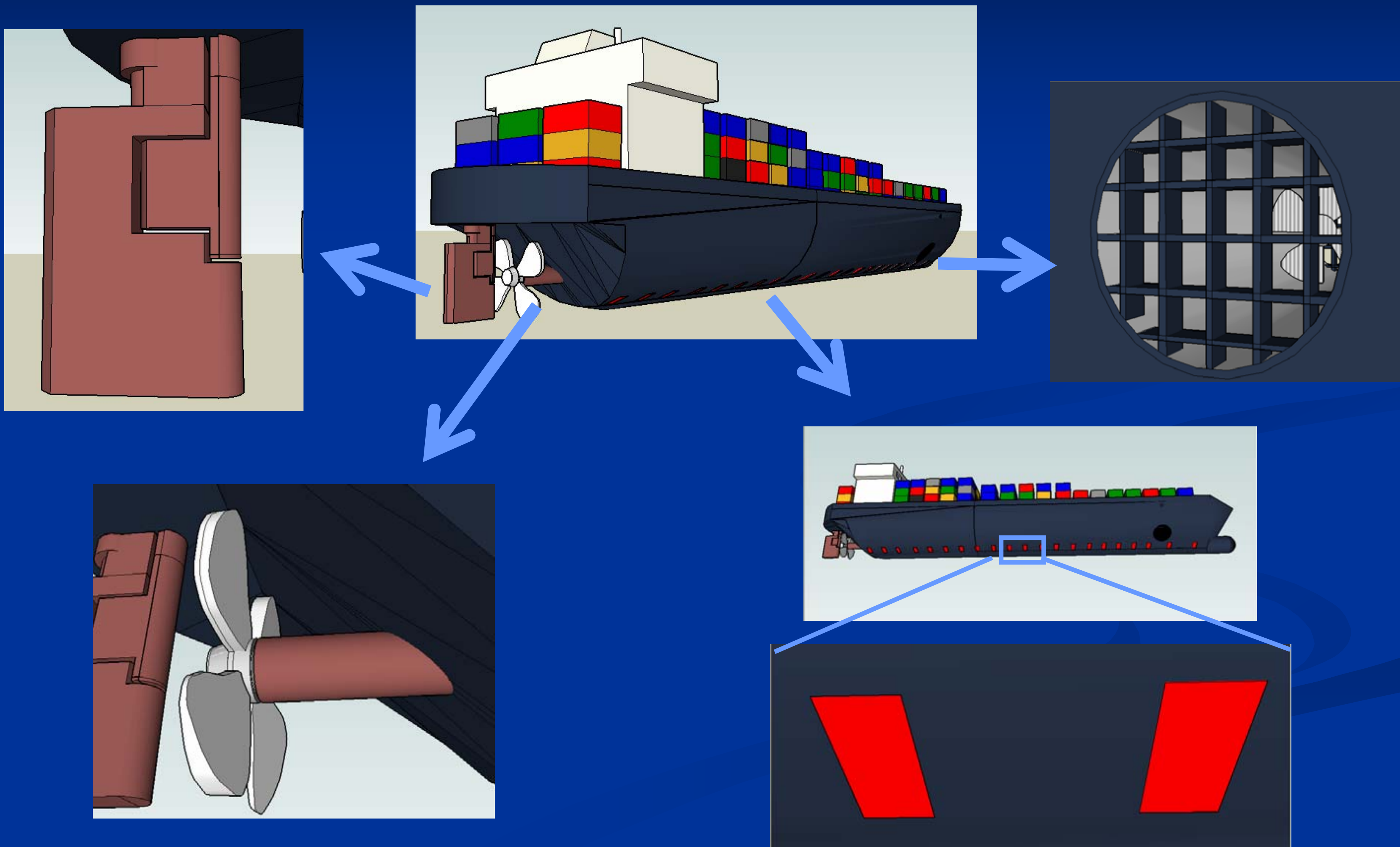
Hull Fouling

Important Today:

- bigger ships
- travel farther, faster
- TBT phase out



Differential Fouling

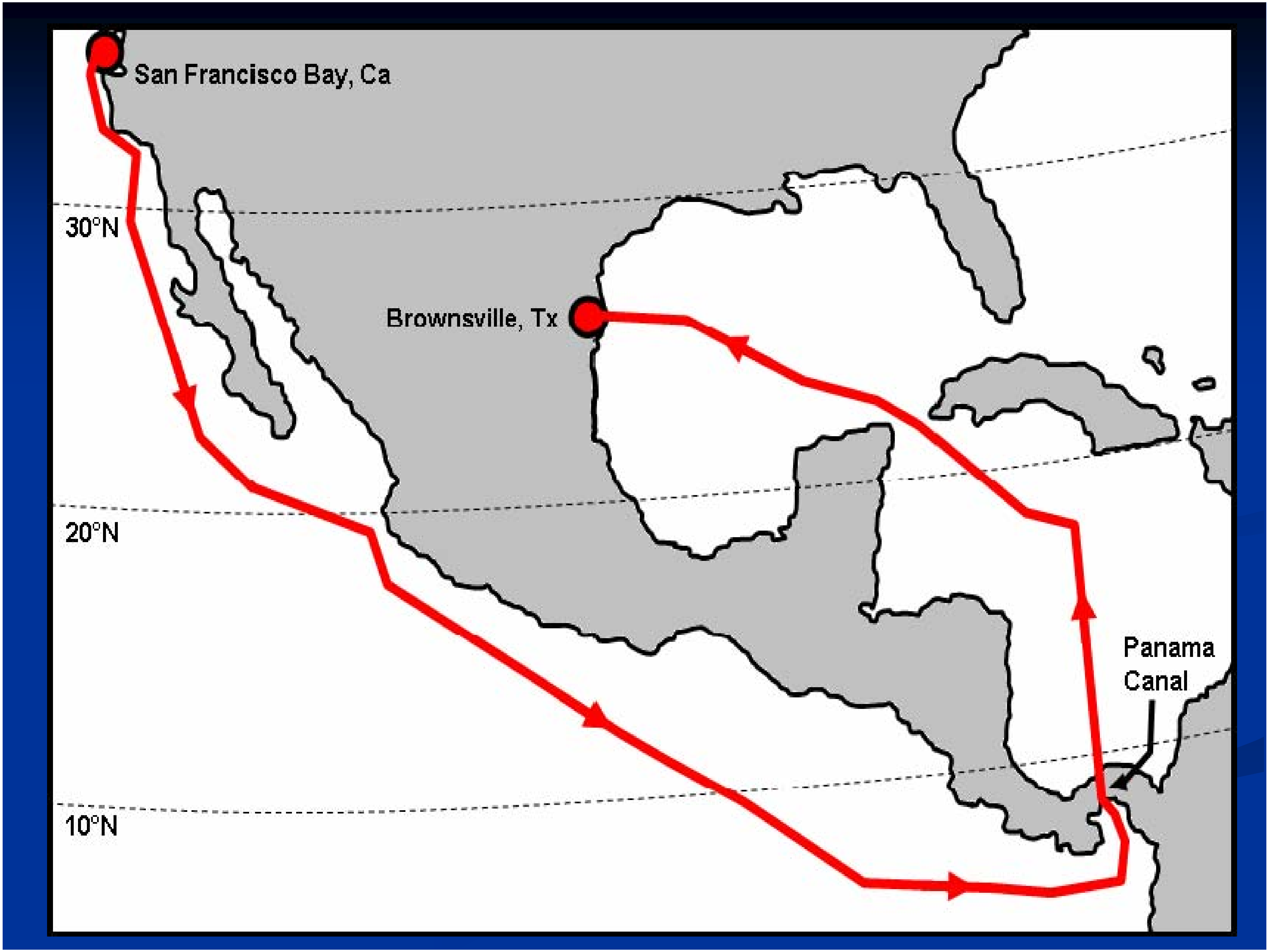


Factors Likely to Affect Biofouling Accumulation

- harbor residence time
- vessel speed
- voyage duration
- surface area & complexity
- voyage routes & geography
- environmental factors (salinity, temperature)
- season
- hull husbandry schedule
- antifouling regime

Source regions

obsolete ships

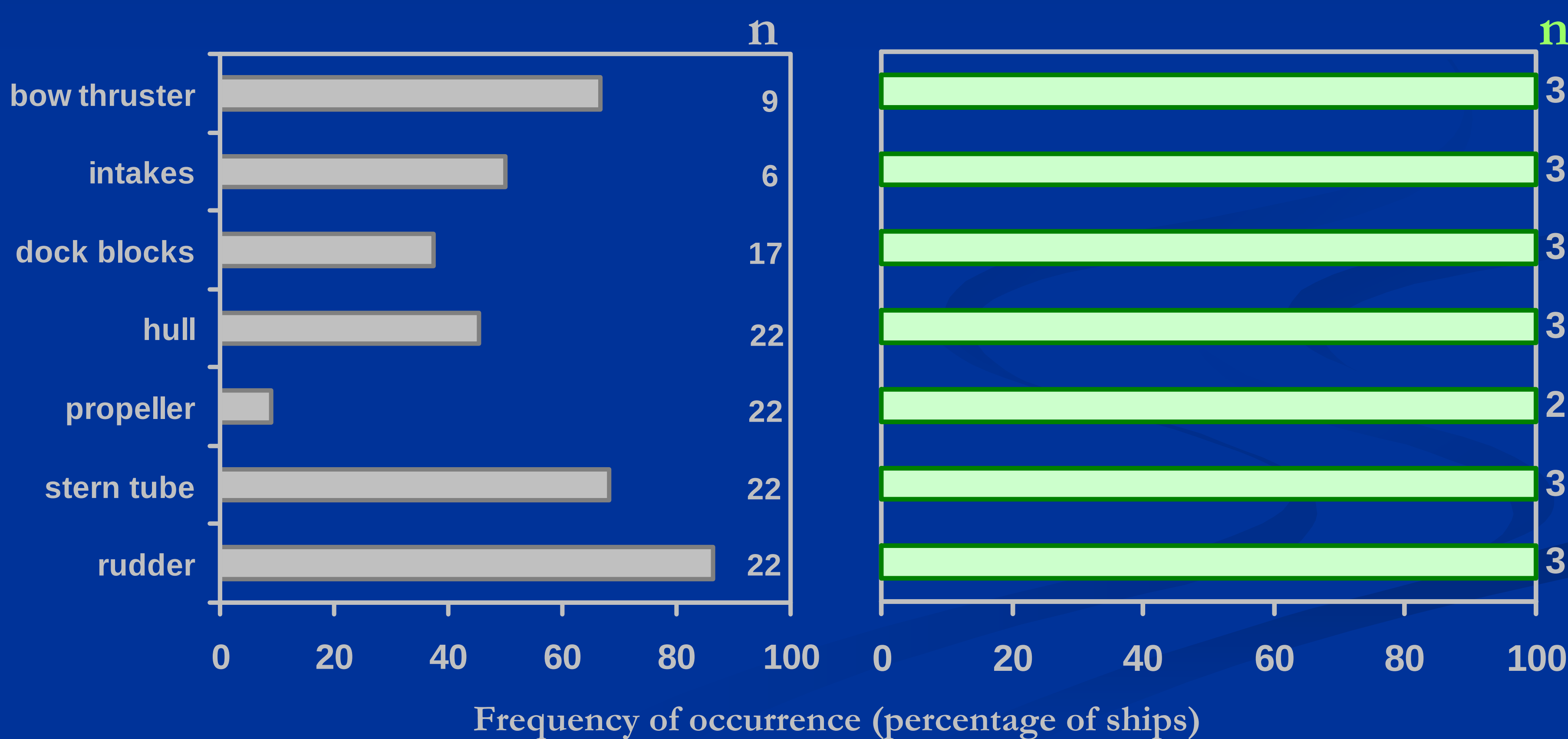

San Francisco Bay, Ca
Brownsville, Tx
30°N
20°N
10°N
Panama
Canal

Density & Diversity

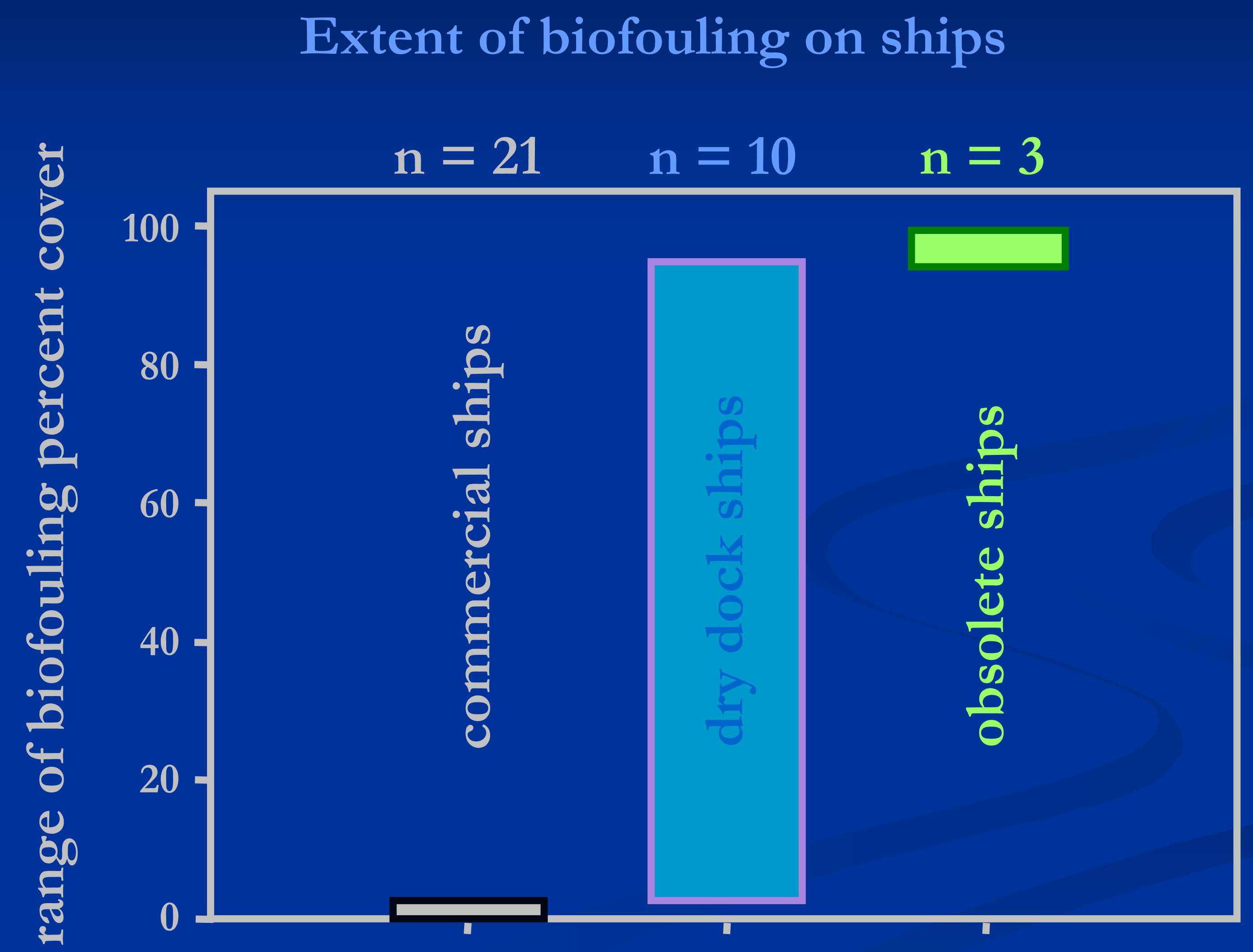
commercial ships

obsolete ships

underwater vessel locations and biofouling occurrence



Density & Diversity

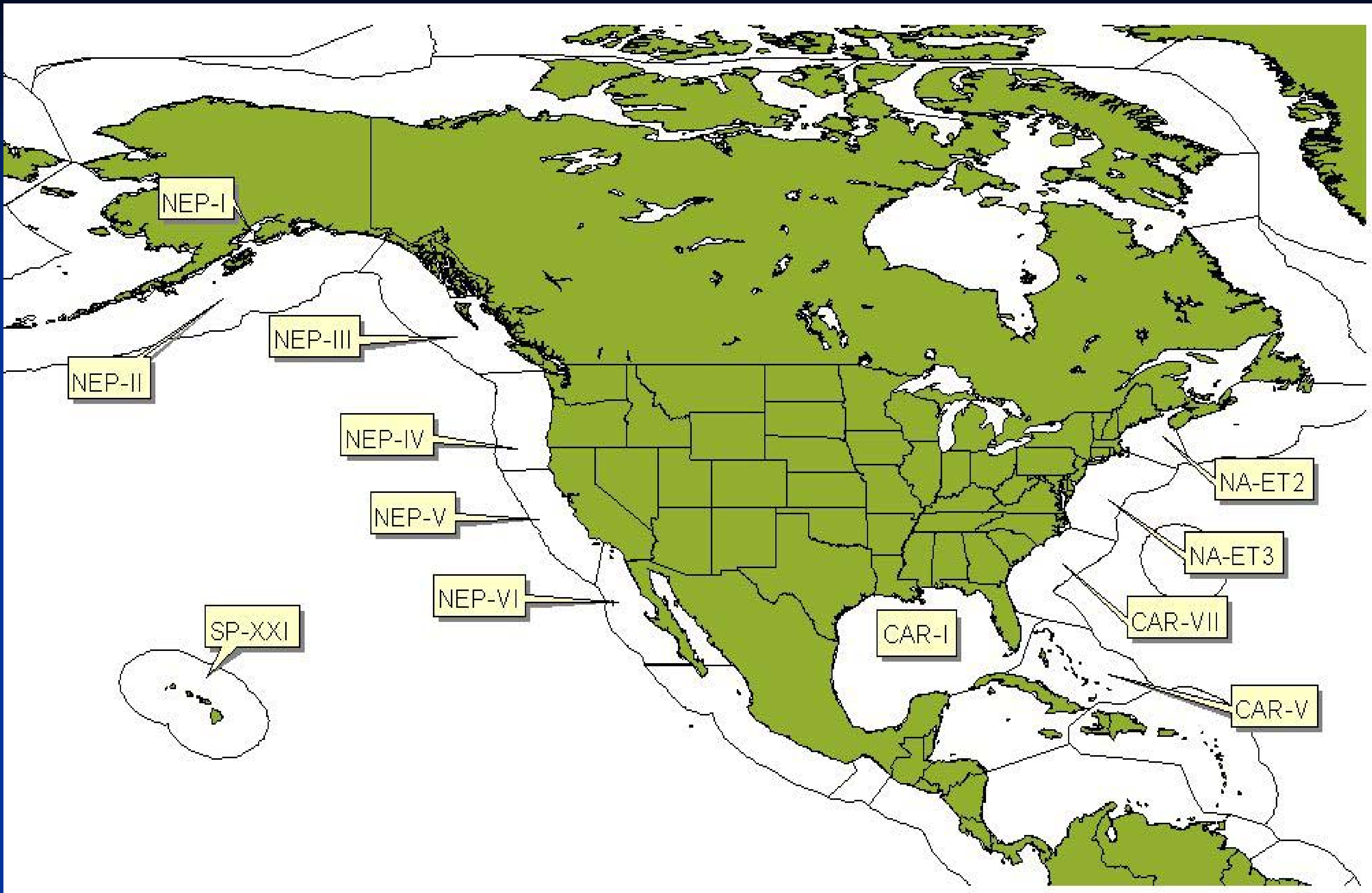


Estimating Total Wetted Surface Area from NRT

- WSA is a function of:
  - Length
  - Beam
  - Draft
  - Vessel Class Blocking Coefficient

1. WSA Calculated for 6-10,000 Lloyd's Reg. Entries/Class
2. Regression:

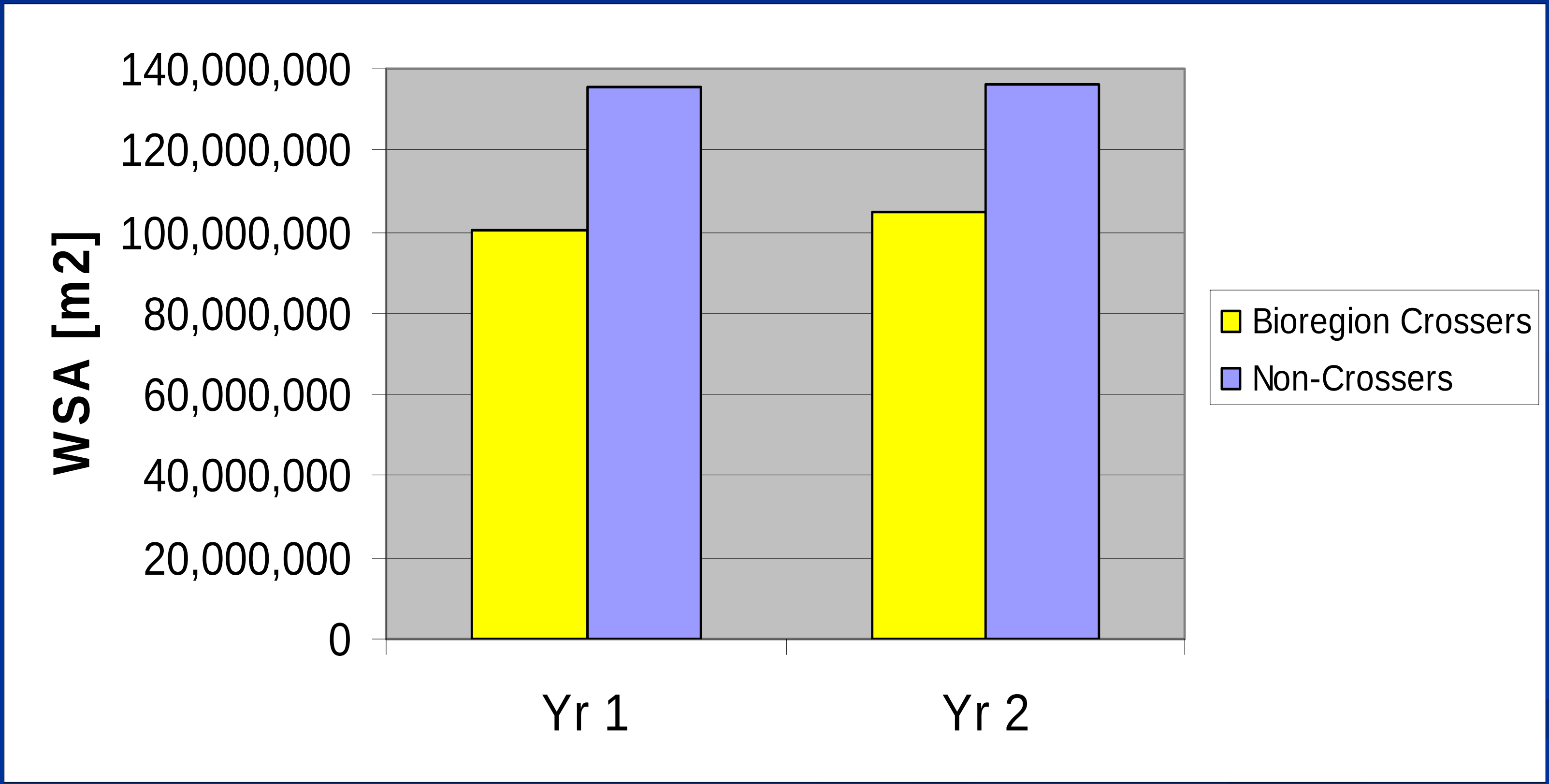
   (NRT x WSA)
3. $r^2 = 0.70 - 0.93$
4. MARAD Arrivals Binned by Vessel Class and NRT
5. WSA = f (NRT)
6. Divide WSA into Bioregion Crossers and Non-Crossers


NEP-I
NEP-II
NEP-III
NEP-IV
NEP-V
NEP-VI
SP-XXI
CAR-I
NA-ET2
NA-ET3
CAR-VII
CAR-V

Wetted Surface Area [x 10^6 m^2] arriving to U.S. Bioregions from other Global Regions

	AF	AO	AS	AU	EU	EU-AS	HS	IO	NA	PO	SA	Total
CAR-I	5.88	0.19	8.82	0.38	12.08	0.78	4.69	0.00	94.25	0.06	20.95	**148.08**
CAR-IV	1.15	0.00	3.06	0.02	1.92	0.08	0.01	0.02	28.56	0.02	4.15	**39.00**
CAR-VII	0.28	0.02	4.00	0.06	3.69	0.16	0.04	0.06	17.92	0.03	3.00	**29.26**
GL-I	0.01	0.00	0.02	0.04	0.14	0.01	0.00	0.00	0.01	0.00	0.03	**0.25**
GL-II	0.08	0.00	0.04	0.01	0.41	0.02	0.00	0.00	0.04	0.00	0.02	**0.62**
GL-III	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	**0.02**
NA-ET2	0.13	0.03	0.03	0.03	2.14	0.01	0.01	0.00	0.56	0.00	0.97	**3.90**
NA-ET3	5.39	1.28	3.18	0.33	17.87	0.59	0.07	0.00	10.14	0.01	9.42	**48.27**
NEP-II	0.00	0.00	1.16	0.00	0.03	0.02	0.18	0.00	0.07	0.03	0.08	**1.58**
NEP-III	0.01	0.00	8.47	0.34	0.01	0.04	0.00	0.00	0.26	0.08	0.16	**9.38**
NEP-IV	0.01	0.00	5.69	0.24	0.03	0.01	0.00	0.00	0.50	0.01	0.18	**6.67**
NEP-V	0.05	0.02	2.81	0.23	0.10	0.02	0.37	0.00	1.65	0.54	0.75	**6.54**
NEP-VI	0.03	0.00	22.05	0.34	0.31	0.01	0.22	0.00	13.29	0.35	1.99	**38.59**
SP-XXI	0.00	0.00	1.68	0.16	0.00	0.00	0.14	0.02	0.97	0.29	0.02	**3.29**
Total	**13.02**	**1.54**	**61.02**	**2.18**	**38.75**	**1.75**	**5.72**	**0.10**	**168.22**	**1.41**	**41.72**	**335.44**

Wetted Surface Area [m^2]
Domestic Arrivals (MARAD 1999-2001)



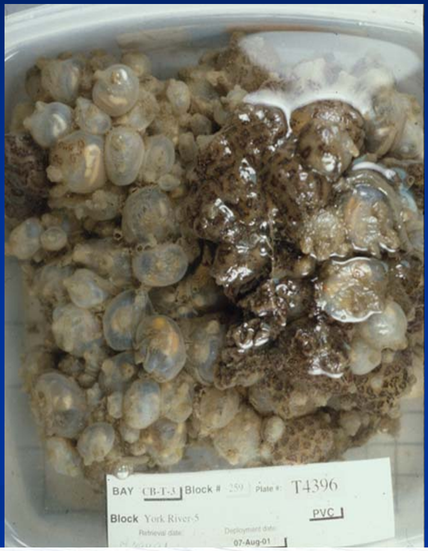
SERC National Fouling Survey

PVC and wood panels sample species that settle on hard surfaces or bore into wooden structures

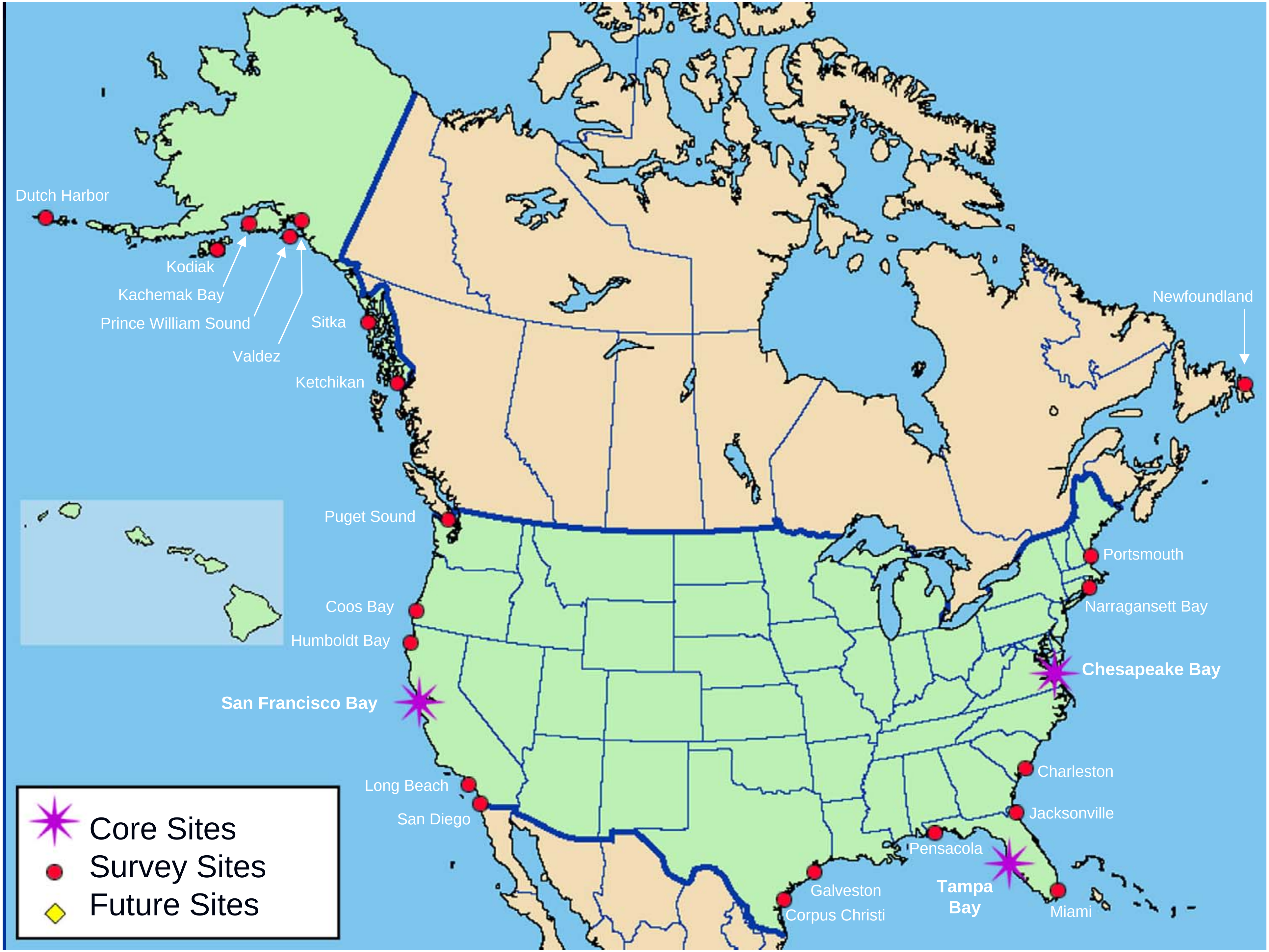
200 PVC panels and 20 wood blocks are deployed per embayment

Conducting the Survey: Methods

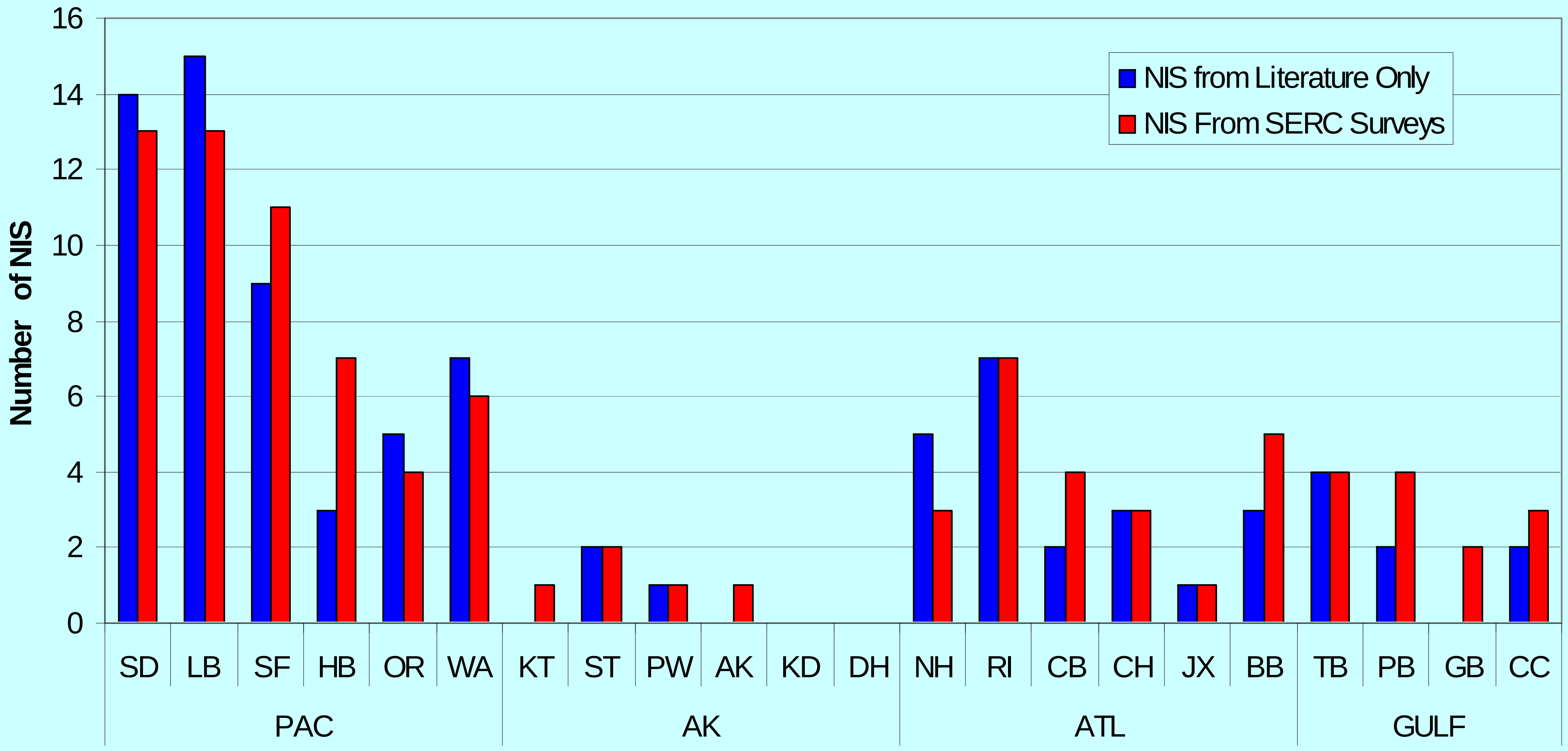
Panels are hung off fixed structures, 1m below mean low tide mark and retrieved after 3 months



Perna viridis and *Styela plicata*


Dutch Harbor
Kodiak
Kachemak Bay
Prince William Sound
Valdez
Sitka
Ketchikan
Newfoundland
Puget Sound
Portsmouth
Narragansett Bay
Coos Bay
Humboldt Bay
Chesapeake Bay
San Francisco Bay
Charleston
Jacksonville
Long Beach
San Diego
Pensacola
Galveston
Corpus Christi
Tampa Bay
Miami
Core Sites
Survey Sites
Future Sites

Fouling Survey Results



Summary: Hull Fouling

- **Commercial shipping provides at least 2 important modes of introduction for marine organisms: ballasted materials and hull fouling.**
- **Relative importance of these modes is not resolved.**
- **~800 million m^2 of inter-bioregional hull area arrives into U.S. bioregions per year (i.e., ~40 billion 6” x 6” setting plates).**
- **Best-maintained vessels have 5% WSA fouled???**

Summary: Present State of Knowledge

<u>Knowns</u>:

•Variation in magnitude & frequency of commercial vessel arrivals (WSA)

- by ship type - by port

<u>Unknowns:</u>

•Traffic flux measures for recreational, fishing, & barge traffic

•Extent and composition of biofouling assemblages on commercial ships (& other vessel types)

•Effect of vessel behavior (route, husbandry, etc) & ship type on biota

•How does hull assemblage relate to probability of NIS establishment?

Components of Vector Management

Vector Strength
(Invasion Patterns)

Vector Operation
(Transfer Mechanisms &
Propagule Supply)

Prevention Measures
(Vector Interruption)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

May 19, 2010

MEMORANDUM

SUBJECT: **Addendum to the 2009 Revised Coppers Reregistration Eligibility Decision (RED): Antimicrobial Uses of Copper Oxides**
Case Nos. 4025, 4026
PC Codes: 025601, 022501, 042401 (Case 4025); 039105, 024409 (Case 4026)

FROM: K. Avivah Jakob, Chemical Review Manager
Regulatory Management Branch II
Antimicrobials Division (7510P)

THROUGH: Lance Wormell, Team Leader
Regulatory Management Branch II
Antimicrobials Division (7510P)

TO: Mark Hartman, Chief
Regulatory Management Branch II
Antimicrobials Division (7510P)

Attached please find an addendum to the revised "Reregistration Eligibility Decision for Coppers," dated May 26, 2009. The ecological risk assessment for the Coppers RED addressed only the agricultural uses of copper and did not assess possible environmental exposure and risk resulting from the antimicrobial uses of copper. The Agency has conducted a screening level exposure assessment to address the antimicrobial uses of copper, which were not included in the Coppers RED.

The antimicrobial uses of copper were included in the human health exposure and risk assessment and Coppers RED. For further information regarding the coppers human health exposure and risk assessment please refer to the revised "Reregistration Eligibility Decision (RED) for Coppers," dated May 26, 2009.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

May 19, 2010

Dear Registrant:

This document presents the US Environmental Protection Agency's ("EPA" or "the Agency") Reregistration Eligibility Decision (RED) for the antimicrobial uses of copper. EPA completed a RED document for agricultural uses of coppers (Reregistration Case numbers 0636, 0649, 4025 and 4026) on July 11, 2006. An amendment to the 2006 Coppers RED was completed on May 26, 2009. The Agency is issuing this document because the ecological risk assessment supporting the 2006 Coppers RED addressed only the agricultural uses of copper and did not include the antimicrobial uses of copper. (The antimicrobial uses of copper were included in the human health exposure and risk assessment supporting the 2006 Coppers RED.) For further information regarding the 2006 risk assessments please refer to the revised "Reregistration Eligibility Decision (RED) for Coppers," dated May 26, 2009.

Copper is registered as an antimicrobial pesticide for use as materials preservatives, wood preservatives, antifoulants and for water treatment. The copper oxides and copper salts (Case Numbers: 4025, 4026; PC Codes: 025601, 022501, 042401, 039105, 024409) will be referred to as "copper" or "coppers" within this document. The Agency has conducted screening level ecological exposure assessments for the following antimicrobial copper use scenarios which were not included in the 2006 Coppers RED: preserved wood in a housing community (wood decks, wood fences, etc.), roofing shingles in a housing community and antifoulant paints in a commercial marina (applied to ships and other recreational water vehicles). The risk quotients (RQs) and estimated environmental concentrations (EECs) identified within these screening level exposure assessments were based on conservative assumptions that may overestimate possible exposure resulting from antimicrobial copper use. The calculated exposures and risk are within the range of those identified in the ecological assessment for the agricultural uses of copper.

Copper-based pesticides play a significant role in the building materials, wood preservation and antifoulant markets. Copper-based wood preservatives dominate the marketplace for residential products that are exposed to the elements including decking, playground equipment and fencing; filling the role previously held by CCA which was voluntarily cancelled for these uses effective December 31, 2003 based on potential human health exposures to arsenic and chromium. Most non-copper preservatives are limited to use where treated wood is protected from exposure to moisture due to differing pest pressures and product efficacy. Copper-based antifoulants provided the main alternatives to the previously dominant tributyltin compound (TBT) based systems which have been phased out internationally based on ecological concerns. While these benefits of copper-based antimicrobial products have not been quantified at this time, the Agency recognizes the potentially significant benefits derived from their use in these areas. These benefits, together with the magnitude of the calculated risk levels and the uncertainties within the risk assessments enable the Agency to conclude that no risk mitigation measures are necessary at this time in order for these products to be eligible for reregistration.

Determination of Reregistration Eligibility

Section 4(g)(2)(A) of FIFRA calls for the Agency to determine, after submission of relevant data concerning an active ingredient, whether or not products containing the active ingredient are eligible for reregistration. The Agency has determined that the data are sufficient to support reregistration of the antimicrobial uses of copper.

The Agency has completed its screening level ecological exposure assessment for the antimicrobial uses of copper. This assessment supplements the Coppers RED previously completed in 2006 and revised in 2009. The Agency has determined that copper containing antimicrobial products are eligible for reregistration. Appendix A summarizes the uses of copper that are eligible for reregistration.

Environmental Exposure Assessment

EPA completed screening level environmental exposure assessments for the registered antimicrobial uses of copper. For further information regarding these screening level assessments please refer to the documents titled, "BLM Model Results for the Antimicrobials Uses of Copper," dated February 18, 2010 and "Estimated Environmental Concentrations (EECs) for Antifoulant Use of Copper," dated February 18, 2010.

Methodology

The Biotic Ligand Model (BLM) was used to estimate exposure from wood preservative and roofing shingle uses. The MAM-PEC Model (version 2) was used to estimate the concentrations of copper in water and sediments resulting from the use of antifoulant paints applied to ships and other water recreational vehicles. The Agency modeled wood preservative, roofing shingle and antifoulant paint uses because these uses represent reasonable worst-case antimicrobial use scenarios for estimating potential environmental exposure.

The Agency has limited environmental exposure data for the antimicrobial uses of copper (such as leaching data). Given this lack of data, the Agency made conservative assumptions when estimating exposure. The BLM model conservatively assumed that there were four houses per acre and each of these homes had copper treated shingles, copper treated wood decks and copper treated wood fences. In addition, in the absence of leaching and other environmental fate data, it was assumed that 100% of copper leached from the treated roofs, wood decks and fences into water bodies. The Agency believes that the assumptions and described scenarios do not reflect real-life conditions in which antimicrobial products are used and, thus, the results from the BLM model may over-estimate the potential levels of copper in the environment and risk quotients for non-target species.

The MAM-PEC Model (version 2) was used to develop estimated environmental concentrations (EECs) for the use of copper as an antifoulant. Conservative assumptions were also used to assess the use of copper as an antifoulant as a result of limited data. For this screening level exposure assessment the use of copper as an antifoulant in commercial marinas was assessed. The commercial harbor scenario used for this screening level exposure assessment relied on the conservative assumptions that: (1) all ships were treated with copper and (2) copper would leach at the highest possible rate. The Agency also notes that the number of ships in the harbor may be lower than what was used in the assessment scenario according to the season and that water temperature and salinity may vary according to the environmental conditions, which could affect the copper concentration in water. Considering these conservative assumptions, it is believed that the results from the MAMPEC model may overestimate the potential levels of copper in the environment.

Listed Species Considerations

Section 7 of the Endangered Species Act, 16 U.S.C. Section 1536(a)(2), requires all federal agencies to consult with the National Marine Fisheries Service (NMFS) for marine and anadromous listed species, or the United States Fish and Wildlife Services (FWS) for listed wildlife and freshwater organisms, if they are proposing an "action" that may affect listed species or their designated habitat. Each federal agency is required under the Act to insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. To jeopardize the continued existence of a listed species means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species." 50 C.F.R. ' 402.02.

To facilitate compliance with the requirements of the Endangered Species Act subsection (a)(2) the Environmental Protection Agency, Office of Pesticide Programs has established procedures to evaluate whether a proposed registration action may directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of any listed species (U.S. EPA 2004). After the Agency's screening-level risk assessment is performed, if any of the Agency's Listed Species LOC Criteria are exceeded for either direct or indirect effects, a determination is made to identify if any listed or candidate species may co-occur in the area of the proposed pesticide use. If determined that listed or candidate species may be present in the proposed use areas, further biological assessment is undertaken. The extent to which listed species may be at risk then determines the need for the development of a more comprehensive consultation package as required by the Endangered Species Act.

For certain use categories, the Agency assumes there will be minimal environmental exposure, and only a minimal toxicity data set is required (Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs U.S. Environmental Protection Agency - Endangered and Threatened Species Effects Determinations, 1/23/04, Appendix A, Section IIB, pg.81). Chemicals in these categories such as material preservatives do not typically undergo a full screening-level risk assessment. However, certain antimicrobial use patterns have potential for environmental exposure. Considering current registered antimicrobial uses of copper, this preliminary review has modeled wood preservative, roofing shingle, and antifoulant paint uses as maximum exposure scenarios.

If it is determined that there is potential for antimicrobial copper uses to overlap with listed species and that a more refined assessment is warranted, to include direct, indirect and habitat effects, the refined assessment should involve clear delineation of the action area associated with antimicrobial copper uses and best available information on the temporal and spatial co-location of listed species with respect to the action area. This analysis has not been conducted for this assessment. An endangered species effect determination will not be made at this time.

Labeling for Antimicrobial Copper Products

At this time, labeling changes are not needed to support the registered antimicrobial uses of copper products.

Required Confirmatory Data

At this time, confirmatory data are not needed to support the registered antimicrobials uses copper. Although the Agency is not requiring confirmatory data at this time in support of the reregistration of antimicrobial copper-based pesticide products, additional data may be needed in the future per registration review to support an endangered species assessment. These data could also be used to refine the conservative assessments for non-listed species. However, the need for further data to support an endangered species assessment will be determined when the coppers undergo registration review. The registration review process for these chemicals is scheduled to begin September 2010.

Further Information

If you have questions on the reregistration eligibility decision for the antimicrobial uses of copper, please contact the Chemical Review Manager, Avivah Jakob, at (703) 305-1328. For questions about product reregistration please contact the Product Manager, Marshall Swindell, at (703) 308-6341.

Sincerely,

Joan Harrigan-Farrelly

Joan Harrigan-Farrelly
Director, Antimicrobials Division
Office of Pesticide Programs
Environmental Protection Agency

Appendix A. Antimicrobial Uses of Copper Eligible for Reregistration

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	10250-54	Ready-to-use solution	48.79 (43.07 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat.
025601	10250-55	Ready-to-use solution	37.00 (33.40 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat.
025601	10250-55	Ready-to-use solution	37.00 (33.40 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat.
025601	10250-55	Ready-to-use solution	37.00 (33.40 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat.
025601	10250-55	Ready-to-use solution	37.00 (33.40 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat. Hull must be primed.
025601	10250-56	Ready-to-use solution	36.1 (33.40 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat.
025601	10250-56	Ready-to-use solution	36.1 (33.40 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat.
025601	10250-56	Ready-to-use solution	36.1 (33.40 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat.
025601	10250-56	Ready-to-use solution	36.1 (33.40 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	10 hours between coats	Temperature range: 68° F 12 hour minimum launch time after last coat. Hull must be primed.
025601	10350-57	granules	6.0	Materials Preservatives	Coatings, Industrial	Roof Shingles	Incorporation	Mix with standard roofing granules at a rate of 5-10% by weight and processed normally during manufacture of the shingles.	

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	10350-63	granules	3.28	Materials Preservatives	Coatings, Industrial	Roof Shingles	Incorporation	Mix with standard roofing granules at a rate of 5-10% by weight and processed normally during manufacture of the shingles.	
42401	10465-28	Soluble Concentrate	11.40	Wood Preservatives	Seasoned Wood Pressure/Thermal Treatment	Lumber and Timber for Salt Water Use Only (C2). Piles (C3). Poles (C4), Plywood (C9), Wood for Highway Construction (C14), Round,	Pressure Treatment	0.5 to 10% by weight in a water solution	
025601	10465-42	Technical chemical	97.5 (78.0 copper as metallic)			Technical chemical for formulation into wood preservative products.			
025601	1719-24	Ready-to-use solution	66.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	4 hour minimum launch time after last coat. 8 hour minimum in high humidity or low temperatures
025601	1719-24	Ready-to-use solution	66.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	4 hour minimum launch time after last coat. 8 hour minimum in high humidity or low temperatures
025601	1719-24	Ready-to-use solution	66.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	4 hour minimum launch time after last coat. 8 hour minimum in high humidity or low temperatures
025601	1719-34	Ready-to-use solution	56.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	4 hour minimum launch time after last coat. 8 hour minimum in high humidity or low temperatures
025601	1719-34	Ready-to-use solution	56.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	4 hour minimum launch time after last coat. 8 hour minimum in high humidity or low temperatures
025601	1719-34	Ready-to-use solution	56.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	4 hour minimum launch time after last coat. 8 hour minimum in high humidity or low temperatures
025601	23566-10	Ready-to-use solution	45	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat. Do not use on aluminum
025601	23566-10	Ready-to-use solution	45	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	23566-10	Ready-to-use solution	45	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-18	Ready-to-use solution	67	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat. Do not use on aluminum
025601	23566-18	Ready-to-use solution	67	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-18	Ready-to-use solution	67	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-19	Ready-to-use solution	43	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-19	Ready-to-use solution	43	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-19	Ready-to-use solution	43	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-20	Ready-to-use solution	55	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-20	Ready-to-use solution	55	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-20	Ready-to-use solution	55	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	23566-6	Ready-to-use solution	25.0 (22.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats.	Temperature range: 73° F 16 hour minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	23566-6	Ready-to-use solution	25.0 (22.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats.	Temperature range: 73° F 16 hour minimum launch time after last coat.
025601	23566-6	Ready-to-use solution	25.0 (22.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats.	Temperature range: 73° F 16 hour minimum launch time after last coat.
025601	2568-102	Ready-to-use solution	31.94	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	4 hours between coats, two coats	Temperature range and relative humidity range: 70° F / R.H 50% 8 hour minimum launch time after last coat.
025601	2568-93	Ready-to-use solution	44.59	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	4 hours between coats, two coats	Temperature range and relative humidity range: 70° F / R.H 50% 8 hour minimum launch time after last coat.
025601	2568-99	Ready-to-use solution	39.59	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	4 hours between coats, two coats	Temperature range and relative humidity range: 70° F / R.H 50% 8 hour minimum launch time after last coat.
025601	26883-10	Intermediate Forumlation	93.0 (88.0 copper as metallic)			Technical chemical for formulation into antifouling coatings, wood preservative products and roofing materials			
025601	26883-20	Powder	57.8 (50.0 copper as metallic)	Argicultural Use	Vegetable, fruit and nut crops.	Almonds, Apples, Apricots Avocados, Bananas, Blueberries, Caneberries (blackberries, youngberries, loganberries, red & black	Spray	0.25-5.0 lbs./100 gal of water.	See agricultural use label for use details on specific crops
025601	26883-22	Intermediate Forumlation	75.0 (71.0 copper as metallic)			Technical chemical for formulation into antifouling coatings, wood preservative products and roofing materials			
025601	26883-7	Technical chemical	95.0 (88.0 copper as metallic)			Technical chemical for formulation into antifouling coatings, wood preservative products and roofing materials			
025601	2693-107	Ready-to-use solution	42.75 (37.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F minimum 12 hour minimum launch time after last coat.
025601	2693-107	Ready-to-use solution	42.75 (37.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Apply first coat thinnned 10% Temperature range: 73° F minimum 12 hour minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	2693-107	Ready-to-use solution	42.75 (37.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F minimum 12 hour minimum launch time after last coat.
025601	2693-11	Ready-to-use solution	23.1	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Unreadable Label	2 hour minimum launch time after last coat.
025601	2693-11	Ready-to-use solution	23.1	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Unreadable Label	2 hour minimum launch time after last coat.
025601	2693-11	Ready-to-use solution	23.1	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Unreadable Label	2 hour minimum launch time after last coat.
025601	2693-119	Ready-to-use solution	57.00 (50.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	2693-119	Ready-to-use solution	57.00 (50.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply Three coats over bare wood. Overnight dry between coats.	Apply first coat thinnned up to 10%. Overnight minimum launch time after last coat.
025601	2693-119	Ready-to-use solution	57.00 (50.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	2693-12	Ready-to-use solution	42.75	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats, 16 hours between coats	Temperature range: 50° F minimum 16 hour minimum, 48 hour maximum launch time after last coat.
025601	2693-12	Ready-to-use solution	42.75	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats, 16 hours between coats	Temperature range: 50° F minimum Apply first coat thinnned 10%. Apply 2nd and 3rd coats unthinned. 16 hour minimum, 48 hour maximum launch time after last coat.
025601	2693-12	Ready-to-use solution	42.75	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats, 16 hours between coats	Temperature range: 50° F minimum 16 hour minimum, 48 hour maximum launch time after last coat.
025601	2693-121	Ready-to-use solution	57.00 (50.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats, 5 hours between coats	Overnight minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	2693-121	Ready-to-use solution	57.00 (50.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply Three coats over bare wood. 5 hours between coats	Apply first coat thinnned up to 10%. Overnight minimum launch time after last coat.
025601	2693-121	Ready-to-use solution	57.00 (50.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats, 5 hours between coats	Overnight minimum launch time after last coat.
025601	2693-132	Ready-to-use solution	37.20 (32.90 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Apply first coat thinnned 10% Temperature range: 77° F 16 hour minimum launch time after last coat. Do not apply over soft antifouling paints
025601	2693-132	Ready-to-use solution	37.20 (32.90 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Do not apply over soft antifouling paints
025601	2693-132	Ready-to-use solution	37.20 (32.90 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Do not apply over soft antifouling paints
025601	2693-135	Ready-to-use solution	66.50 (58.36 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 50° F minimum 16 hour minimum launch time after last coat. Do not apply over soft antifouling paints
025601	2693-135	Ready-to-use solution	66.50 (58.36 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Apply first coat thinnned 10% (15% for brush and roller applications) Temperature range: 50° F minimum 16 hour minimum launch time after last coat. Do not apply over soft antifouling paints
025601	2693-135	Ready-to-use solution	66.50 (58.36 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 50° F minimum 16 hour minimum launch time after last coat. Do not apply over soft antifouling paints
025601	2693-142	Ready-to-use solution	41.97 (37.11 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 73° F 24 hour minimum launch time after last coat. Do not apply over soft antifouling paints
025601	2693-142	Ready-to-use solution	41.97 (37.11 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Apply first coat thinnned 10% (15% for brush and roller applications) Temperature range: 73° F 24 hour minimum launch time after last coat.
025601	2693-142	Ready-to-use solution	41.97 (37.11 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 73° F 24 hour minimum launch time after last coat. Do not apply over soft antifouling paints. Contact mfr. for information for use.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
	2693-143	Ready-to-use solution	72.25 (64.10 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 50° F minimum 12 hour minimum launch time after last coat.
025601	2693-143	Ready-to-use solution	72.25 (64.10 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Apply first coat thinnned up to 10%. Temperature range: 50° F minimum 12 hour minimum launch time after last coat.
025601	2693-143	Ready-to-use solution	72.25 (64.10 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 50° F minimum 12 hour minimum launch time after last coat.
025601	2693-144	Ready-to-use solution	76.00 (67.40 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 50° F 16 hours minimum launch time after last coat.
025601	2693-144	Ready-to-use solution	76.00 (67.40 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Apply first coat thinnned up to 10%. Temperature range: 50° F 16 hours minimum launch time after last coat.
025601	2693-144	Ready-to-use solution	76.00 (67.40 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 50° F 16 hours minimum launch time after last coat.
025601	2693-146	Ready-to-use solution	35.3 (31.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	6 hour minimum launch time after last coat.
025601	2693-146	Ready-to-use solution	35.3 (31.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	6 hour minimum launch time after last coat.
025601	2693-146	Ready-to-use solution	35.3 (31.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	6 hour minimum launch time after last coat.
025601	2693-146	Ready-to-use solution	35.3 (31.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	6 hour minimum launch time after last coat.
025601	2693-147	Ready-to-use solution	35.1 (31.04 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 8 hours between coats	Temperature range: 73° F 18 hours minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	2693-147	Ready-to-use solution	35.1 (31.04 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 8 hours between coats	Apply first coat thinnned up to 10%. Temperature range: 73° F 18 hours minimum launch time after last coat.
025601	2693-147	Ready-to-use solution	35.1 (31.04 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 8 hours between coats	Temperature range: 73° F 18 hours minimum launch time after last coat.
025601	2693-148	Ready-to-use solution	41.15 (37.25 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 10 hours between coats	Temperature range: 77° F 10 hours minimum launch time after last coat.
025601	2693-148	Ready-to-use solution	41.15 (37.25 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 10 hours between coats	Apply first coat thinnned up to 10%. Temperature range: 77° F 10 hours minimum launch time after last coat.
025601	2693-148	Ready-to-use solution	41.15 (37.25 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 10 hours between coats	Temperature range: 77° F 10 hours minimum launch time after last coat.
025601	2693-165	Ready-to-use solution	35.00 (31.7 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-165	Ready-to-use solution	35.00 (31.7 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-165	Ready-to-use solution	35.00 (31.7 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-166	Ready-to-use solution	48.02 (43.47 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-166	Ready-to-use solution	48.02 (43.47 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-166	Ready-to-use solution	48.02 (43.47 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	2693-167	Ready-to-use solution	20.21 (18.29 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-167	Ready-to-use solution	20.21 (18.29 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-167	Ready-to-use solution	20.21 (18.29 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-167	Ready-to-use solution	20.21 (18.29 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum 6 hours between coats	Temperature range: 60° F 6 hours minimum launch time after last coat. 24 hours maximum
025601	2693-168	Ready-to-use solution	49.24 (44.57 xopper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats one hour between coats	4 hour minimum launch time after last coat. Apply first coat thinned up to 10%.
025601	2693-168	Ready-to-use solution	49.24 (44.57 xopper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats one hour between coats	4 hour minimum launch time after last coat.
025601	2693-168	Ready-to-use solution	49.24 (44.57 xopper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats one hour between coats	4 hour minimum launch time after last coat.
025601	2693-168	Ready-to-use solution	49.24 (44.57 xopper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats one hour between coats	4 hour minimum launch time after last coat.
025601	2693-169	Ready-to-use solution	22.8 (20.5 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 60° F 6 hour minimum launch time after last coat.
025601	2693-169	Ready-to-use solution	22.8 (20.5 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 60° F 6 hour minimum launch time after last coat.
025601	2693-169	Ready-to-use solution	22.8 (20.5 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 60° F 6 hour minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	2693-169	Ready-to-use solution	22.8 (20.5 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 60° F 6 hour minimum launch time after last coat.
025601	2693-170	Ready-to-use solution	42.75 (37.93 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Temperature range: 75° F 8 hour minimum launch time after last coat. Apply first coat thinnned 10%
025601	2693-170	Ready-to-use solution	42.75 (37.93 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	Temperature range: 75° F 8 hour minimum launch time after last coat.
025601	2693-170	Ready-to-use solution	42.75 (37.93 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	Temperature range: 75° F 8 hour minimum launch time after last coat. Do not use on aluminum. Consult manufacturer before use.
025601	2693-171	Ready-to-use solution	19.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum 6 hours between coats, three coats for new work.	6 hours maximum before launch
025601	2693-172	Ready-to-use solution	46.45 (37.9 elemental copper	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	Temperature range: 50° F 36 hour minimum launch time after last coat. Do not use on aluminum. Consult manufacturer before use.
025601	2693-172	Ready-to-use solution	46.45 (37.9 elemental copper	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	Temperature range: 50° F 36 hour minimum launch time after last coat.
025601	2693-172	Ready-to-use solution	46.45 (37.9 elemental copper	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 6 hours between coats	Apply first coat thinnned 10% Temperature range: 50° F 36 hour minimum launch time after last coat.
025601	2693-175	Ready-to-use solution	48.8 (44.17)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	Temperature range: 50° F 48 hour minimum launch time after last coat. Do not use on aluminum. Consult manufacturer before use.
025601	2693-175	Ready-to-use solution	48.8 (44.17)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats	Temperature range: 50° F 48 hour minimum launch time after last coat.
025601	2693-175	Ready-to-use solution	48.8 (44.17)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 6 hours between coats	Apply first coat thinnned 10% Temperature range: 50° F 48 hour minimum launch time after last coat.

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025601	2693-176	Ready-to-use solution	21.31 (18.93 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 8 hours between coats	Temperature range: 50° F 16 hour minimum launch time after last coat.
025601	2693-177	Ready-to-use solution	27.73 (38.30 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 8 hours between coats	Temperature range: 50° F 16 hour minimum launch time after last coat.
025601	2693-178	Ready-to-use solution	38.19 (34.57 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (airless spray preferred)	2.0 mils per dry coat, two coats 3 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat.
025601	2693-178	Ready-to-use solution	38.19 (34.57 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (airless spray preferred)	2.0 mils per dry coat, two coats 3 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat.
025601	2693-178	Ready-to-use solution	38.19 (34.57 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (airless spray preferred)	2.0 mils per dry coat, two coats 3 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat.
025601	2693-179	Ready-to-use solution	28.32 metallic copper	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	1.0 mils per dry coat, two coats 2 hours between coats	Temperature range: 77° F 8 hour minimum launch time after last coat.
022501	2693-179	Ready-to-use solution	28.32 metallic copper	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	1.0 mils per dry coat, two coats 2 hours between coats	Temperature range: 77° F 8 hour minimum launch time after last coat.
022501	2693-179	Ready-to-use solution	28.32 metallic copper	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	1.0 mils per dry coat, three coats 2 hours between coats	Apply first coat thinnned 10% Temperature range: 77° F 8 hour minimum launch time after last coat.
025601	2693-18	Ready-to-use solution	35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Apply first coat thinnned 10%. Apply 2nd and 3rd coats unthinned. 6 hour minimum, 12 hour maximum launch time after last coat.
025601	2693-18	Ready-to-use solution	35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 50° F minimum 6 hour minimum, 12 hour maximum launch time after last coat.
025601	2693-180	Ready-to-use solution	38.63 (34.94 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3.0 mils per dry coat, 2-3 coats 12 hours between coats	Temperature range: 73° F 24 hour minimum launch time after last coat.

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025601	2693-183	Ready-to-use solution	29.73 (26.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-183	Ready-to-use solution	29.73 (26.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Apply first coat thinnned 10% Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-183	Ready-to-use solution	29.73 (26.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Do not use on aluminum
025601	2693-187	Ready-to-use solution	40.41 (35.89 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Airless spray	4.9 mils dry coat total, two coats 6 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat.
025601	2693-187	Ready-to-use solution	40.41 (35.89 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Airless spray	4.9 mils dry coat total, three coats 6 hours between coats	Apply first coat thinnned 10% Temperature range: 77° F 12 hour minimum launch time after last coat.
025601	2693-187	Ready-to-use solution	40.41 (35.89 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Airless spray	4.9 mils dry coat total, two coats 6 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat. Consult manufacturer before use.
025601	2693-187	Ready-to-use solution	40.41 (35.89 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Airless spray	4.9 mils dry coat total, two coats 6 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat. Consult manufacturer before use.
025601	2693-188	Ready-to-use solution	42.69 (38.63 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Airless spray	3.0-6.0 mils dry total, two coats 4 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat.
025601	2693-188	Ready-to-use solution	42.69 (38.63 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Airless spray	3.0-6.0 mils dry total, two coats 4 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat.
025601	2693-188	Ready-to-use solution	42.69 (38.63 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Airless spray	3.0-6.0 mils dry total, two coats 4 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat.
025601	2693-19	Ready-to-use solution	42.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F minimum 12 hour minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	2693-19	Ready-to-use solution	42.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Apply first coat thinnned 10%. Apply 2nd and 3rd coats unthinned. 6 hour minimum, 12 hour maximum launch time after last coat.
025601	2693-19	Ready-to-use solution	42.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F minimum 12 hour minimum launch time after last coat.
025601	2693-190	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-190	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Apply first coat thinnned 10% Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-190	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-192	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	Temperature range: 77° F 8 hour minimum launch time after last coat.
025601	2693-192	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 2 hours between coats	Apply first coat thinnned 10% Temperature range: 77° F 8 hour minimum launch time after last coat.
025601	2693-192	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	Temperature range: 77° F 8 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-193	Ready-to-use solution	28.45 (25.74 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	1.2 mils per dry coat, two coats 4 hours between coats	Mix 7 parts end use product with 1 part Zinc pyrithione activator (EPA Reg. No. 2693-194) Temperature range: 75° F 7 hour minimum launch time after last coat.
025601	2693-193	Ready-to-use solution	28.45 (25.74 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	1.2 mils per dry coat, three coats 4 hours between coats	Mix 7 parts end use product with 1 part Zinc pyrithione activator (EPA Reg. No. 2693-194) Apply first coat thinnned 10% Temperature range: 75° F
025601	2693-193	Ready-to-use solution	28.45 (25.74 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	1.2 mils per dry coat, two coats 4 hours between coats	Mix 7 parts end use product with 1 part Zinc pyrithione activator (EPA Reg. No. 2693-194) Temperature range: 75° F 7 hour minimum launch time after last coat.

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022501	2693-195	Ready-to-use solution	99.00 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Three coats 10 minutes between coats	Mix end use product with EPA Reg. No. 2693-198 before use 20 minute minimum launch time after last coat.
022501	2693-195	Ready-to-use solution	99.00 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Three coats 10 minutes between coats	Mix end use product with EPA Reg. No. 2693-198 before use Apply first coat thinnned 10% 20 minute minimum launch time after last coat.
022501	2693-195	Ready-to-use solution	99.00 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Three coats 10 minutes between coats	Mix end use product with EPA Reg. No. 2693-198 before use 20 minute minimum launch time after last coat. Do not use on aluminum
022501	2693-196	Ready-to-use solution	84.00 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Three coats 10 minutes between coats	Mix end use product with EPA Reg. No. 2693-198 before use 20 minute minimum launch time after last coat.
022501	2693-196	Ready-to-use solution	84.00 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Three coats 10 minutes between coats	Mix end use product with EPA Reg. No. 2693-198 before use Apply first coat thinnned 10% 20 minute minimum launch time after last coat.
022501	2693-196	Ready-to-use solution	84.00 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Three coats 10 minutes between coats	Mix end use product with EPA Reg. No. 2693-198 before use 20 minute minimum launch time after last coat. Do not use on aluminum
025601	2693-200	Ready-to-use solution	34.34 (30.50 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 75° F 12 hour minimum launch time after last coat.
025601	2693-200	Ready-to-use solution	34.34 (30.50 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 12 hours between coats	Temperature range: 75° F Apply first coat thinnned 10% 12 hour minimum launch time after last coat.
025601	2693-200	Ready-to-use solution	34.34 (30.50 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 75° F 12 hour minimum launch time after last coat. Consult manufacturer before use.
025601	2693-201	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-201	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 16 hour minimum launch time after last coat.

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025601	2693-201	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-202	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-202	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 16 hour minimum launch time after last coat.
025601	2693-202	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-204	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-204	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 16 hour minimum launch time after last coat.
025601	2693-204	Ready-to-use solution	38.62 (34.03 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-205	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-205	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 16 hour minimum launch time after last coat.
025601	2693-205	Ready-to-use solution	66.65 (59.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-208	Ready-to-use solution	42.75 (37.93 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat.

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025601	2693-208	Ready-to-use solution	42.75 (37.93 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 12 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 12 hour minimum launch time after last coat.
025601	2693-208	Ready-to-use solution	42.75 (37.93 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-209	Ready-to-use solution	41.97 (37.24 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat.
025601	2693-209	Ready-to-use solution	41.97 (37.24 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 12 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 12 hour minimum launch time after last coat.
025601	2693-209	Ready-to-use solution	41.97 (37.24 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-212	Ready-to-use solution	55.00 (48.80 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	Temperature range: 77° F 8 hour minimum launch time after last coat.
025601	2693-212	Ready-to-use solution	55.00 (48.80 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 2 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 8 hour minimum launch time after last coat.
025601	2693-212	Ready-to-use solution	55.00 (48.80 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	Temperature range: 77° F 8 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-213	Ready-to-use solution	66.00 (58.56 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-213	Ready-to-use solution	66.00 (58.56 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Temperature range: 77° F Apply first coat thinnned 15% 16 hour minimum launch time after last coat.
025601	2693-213	Ready-to-use solution	66.00 (58.56 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum

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025601	2693-214	Ready-to-use solution	38.62 (34.30 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-214	Ready-to-use solution	38.62 (34.30 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 16 hour minimum launch time after last coat.
025601	2693-214	Ready-to-use solution	38.62 (34.30 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-215	Ready-to-use solution	64.65 (57.42 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	Temperature range: 77° F 8 hour minimum launch time after last coat.
025601	2693-215	Ready-to-use solution	64.65 (57.42 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 2 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 8 hour minimum launch time after last coat.
025601	2693-215	Ready-to-use solution	64.65 (57.42 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	Temperature range: 77° F 8 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-217	Ready-to-use solution	45.48 (40.39 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	1.25 mils per dry coat 4 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-218	Ready-to-use solution	41.97 (37.24 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat.
025601	2693-218	Ready-to-use solution	41.97 (37.24 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 12 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 12 hour minimum launch time after last coat.
025601	2693-218	Ready-to-use solution	41.97 (37.24 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-219	Ready-to-use solution	66.00 (58.56 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.

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025601	2693-219	Ready-to-use solution	66.00 (58.56 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 16 hour minimum launch time after last coat.
025601	2693-219	Ready-to-use solution	66.00 (58.56 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-224	Ready-to-use solution	34.76 (30.87 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat.
025601	2693-224	Ready-to-use solution	34.76 (30.87 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 16 hour minimum launch time after last coat.
025601	2693-224	Ready-to-use solution	34.76 (30.87 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats	Temperature range: 77° F 16 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-225	Ready-to-use solution	33.40 (29.66 copper as metallic	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 75° F 8 hour minimum launch time after last coat.
025601	2693-225	Ready-to-use solution	33.40 (29.66 copper as metallic	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats	Temperature range: 75° F Apply first coat thinnned 10% 8 hour minimum launch time after last coat.
025601	2693-225	Ready-to-use solution	33.40 (29.66 copper as metallic	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 75° F 8 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-227	Ready-to-use solution	29.73 (26.40 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat.
025601	2693-227	Ready-to-use solution	29.73 (26.40 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 12 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 12 hour minimum launch time after last coat.
025601	2693-227	Ready-to-use solution	29.73 (26.40 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 12 hours between coats	Temperature range: 77° F 12 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum

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025601	2693-228	Ready-to-use solution	25.00 (22.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 75° F 8 hour minimum launch time after last coat.
025601	2693-228	Ready-to-use solution	25.00 (22.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats	Temperature range: 75° F Apply first coat thinnned 10% 8 hour minimum launch time after last coat.
025601	2693-228	Ready-to-use solution	25.00 (22.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 75° F 8 hour minimum launch time after last coat. Consult manufacturer before use. Do not use on aluminum
025601	2693-33	Ready-to-use solution	43.5 (38.3 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per coat, two coats 8 hours between coats	Temperature range: 73° F 8 hour minimum launch time after last coat. May be thinned up to 10%.
025601	2693-33	Ready-to-use solution	43.5 (38.3 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per coat, two coats 8 hours between coats	Temperature range: 73° F 8 hour minimum launch time after last coat.
025601	2693-33	Ready-to-use solution	43.5 (38.3 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per coat, two coats 8 hours between coats	Temperature range: 73° F 8 hour minimum launch time after last coat.
025601	2693-46	Ready-to-use solution	66.8 (58.45 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 8 hours between coats	Temperature range: 73° F minimum 24 hour minimum launch time after last coat.
025601	2693-54	Ready-to-use solution	21.8	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F minimum 4 hour minimum launch time after last coat. For wood and non-ferrous surfaces consult Navy specifications
025601	2693-56	Ready-to-use solution	55.6	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 8 hours between coats	Temperature range: 73° F minimum 24 hour minimum launch time after last coat. For wood and non-ferrous surfaces consult manufacturer
025601	2693-58	Ready-to-use solution	43.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 5 hours between coats	Launch within 24 hours after application of final coat.
025601	2693-58	Ready-to-use solution	43.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 5 hours between coats	Apply first coat thinnned 10%. Launch within 24 hours after application of final coat.

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025601	2693-58	Ready-to-use solution	43.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 5 hours between coats	Launch within 24 hours after application of final coat.
025601	2693-59	Ready-to-use solution	43.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 5 hours between coats	Launch within 24 hours after application of final coat.
025601	2693-59	Ready-to-use solution	43.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 5 hours between coats	Apply first coat thinnned 10%. Launch within 24 hours after application of final coat.
025601	2693-59	Ready-to-use solution	43.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 5 hours between coats	Launch within 24 hours after application of final coat.
025601	2693-60	Ready-to-use solution	42.75	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F minimum 6 hour minimum launch time after last coat.
025601	2693-60	Ready-to-use solution	42.75	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Apply first coat thinnned up to 10%. Temperature range: 73° F minimum 6 hour minimum launch time after last coat.
025601	2693-60	Ready-to-use solution	42.75	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Brush, Roller or Spray (conventional or airless) spray preferred	Temperature range: 73° F minimum 6 hour minimum launch time after last coat.
025601	2693-61	Ready-to-use solution	42.7 (38.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats Allow overnight drying time between coats.	Launch within 72 hours of final coat.
025601	2693-61	Ready-to-use solution	42.7 (38.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats Allow overnight drying time between coats.	Apply first coat thinnned up to 10%. Allow overnight drying time between coats. Launch within 72 hours of final coat.
025601	2693-61	Ready-to-use solution	42.7 (38.6 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats Allow overnight drying time between coats.	Launch within 72 hours of final coat.
025601	2693-62	Ready-to-use solution	42.75 (37.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 50° F minimum 12 hour minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	2693-62	Ready-to-use solution	42.75 (37.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Apply first coat thinnned up to 10%. Temperature range: 50° F minimum 12 hour minimum launch time after last coat.
025601	2693-62	Ready-to-use solution	42.75 (37.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 50° F minimum 12 hour minimum launch time after last coat.
025601	2693-64	Ready-to-use solution	20.90 (18.50 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats Overnight between coats	Temperature range: 77° F Overnight minimum launch time after last coat.
025601	2693-64	Ready-to-use solution	20.90 (18.50 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats Overnight between coats	Apply first coat thinnned up to 10%. Temperature range: 77° F Overnight minimum launch time after last coat.
025601	2693-64	Ready-to-use solution	20.90 (18.50 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats Overnight between coats	Temperature range: 77° F Overnight minimum launch time after last coat.
025601	2693-70	Ready-to-use solution	33.40 (29.66 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Apply first coat thinnned up to 10%. Temperature range: 50° F minimum 12 hour minimum launch time after last coat.
025601	2693-70	Ready-to-use solution	33.40 (29.66 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 50° F minimum 12 hour minimum launch time after last coat.
025601	2693-84	Ready-to-use solution	21.3 (18.8 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats	Allow overnight drying time between coats.
025601	2693-84	Ready-to-use solution	21.3 (18.8 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats	Apply first coat thinnned up to 10%. Allow overnight drying time between coats.
025601	2693-84	Ready-to-use solution	21.3 (18.8 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats	Allow overnight drying time between coats.
025601	2693-90	Ready-to-use solution	20.9 (5.0 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F minimum 12 hour minimum launch time after last coat.

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025601	2693-90	Ready-to-use solution	20.9 (5.0 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Apply first coat thinnned 10% Temperature range: 73° F minimum 12 hour minimum launch time after last coat.
025601	2693-90	Ready-to-use solution	20.9 (5.0 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F minimum 12 hour minimum launch time after last coat.
025601	2693-97	Ready-to-use solution	23.6 (20.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Overnight dry between coats.	Launch within 72 hours after application of final coat.
025601	2693-97	Ready-to-use solution	23.6 (20.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply Three coats over bare wood. Overnight dry between coats.	Launch within 72 hours after application of final coat.
025601	2693-97	Ready-to-use solution	23.6 (20.9 elemental copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Overnight dry between coats.	Launch within 72 hours after application of final coat.
025601	3008-100	Soluble Concentrate	66.64 (59.0 copper as metalic)	Wood Preservatives	Seasoned Wood Pressure/Thermal Treatment	Not listed	Pressure Treatment	0.10 to 10.53 gal per 1000 gallons of end use solution	None listed.
042401	3008-17	Soluble Concentrate	24.5 (15.9 copper as metallic)	Wood Preservatives	Posts	*Posts, round, 1/2 and 1/4 round for highway construction (including guide, sign and sight). *Fence (farm). *Posts, round,	Pressure Treatment	None listed.	None listed.
042401	3008-17	Soluble Concentrate	24.5 (15.9 copper as metallic)	Wood Preservatives	Poles	*Utility poles (including laminated). *Poles for highway and agricultural construction, lighting, building structural use.	Pressure Treatment	None listed.	None listed.
042401	3008-17	Soluble Concentrate	24.5 (15.9 copper as metallic)	Wood Preservatives	Round Timber Piling	*Foundation and fresh water piles	Pressure Treatment	None listed.	None listed.
042401	3008-17	Soluble Concentrate	24.5 (15.9 copper as metallic)	Wood Preservatives	Sawn Products	*Guardrails for highway construction, including for golf course bridges meeting highway construction standards. *Shakes and	Pressure Treatment	None listed.	None listed.
042401	3008-17	Soluble Concentrate	24.5 (15.9 copper as metallic)	Wood Preservatives	Wood Composites	*Composite lumber for structural uses. *Glue- or nail-laminated members. *Plywood for agriculture, farms, roof sheathing,	Pressure Treatment	None listed.	None listed.

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042401	3008-17	Soluble Concentrate	24.5 (15.9 copper as metallic)	Wood Preservatives	Marine Applications	*Bulkhead sheathing. *Lumber/timbers use, including use in aqua/mariculture, timbers and cross bracing, highway	Pressure Treatment	None listed.	None listed.
042401	3008-34	Soluble Concentrate	10.5	Wood Preservatives	Posts	*Posts, round, 1/2 and 1/4 round for highway construction (including guide, sign and sight). *Fence (farm). *Posts, round,	Pressure Treatment	None listed.	None listed.
042401	3008-34	Soluble Concentrate	10.5	Wood Preservatives	Poles	*Utility poles (including laminated). *Poles for highway and agricultural construction, lighting, building structural use.	Pressure Treatment	None listed.	None listed.
042401	3008-34	Soluble Concentrate	10.5	Wood Preservatives	Round Timber Piling	*Foundation and fresh water piles	Pressure Treatment	None listed.	None listed.
042401	3008-34	Soluble Concentrate	10.5	Wood Preservatives	Sawn Products	*Guardrails for highway construction, including for golf course bridges meeting highway construction standards. *Shakes and	Pressure Treatment	None listed.	None listed.
042401	3008-34	Soluble Concentrate	10.5	Wood Preservatives	Wood Composites	*Composite lumber for structural uses. *Glue- or nail-laminated members. *Plywood for agriculture, farms, roof sheathing,	Pressure Treatment	None listed.	None listed.
042401	3008-34	Soluble Concentrate	10.5	Wood Preservatives	Marine Applications	*Bulkhead sheathing. *Lumber/timbers use, including use in aqua/mariculture, timbers and cross bracing, highway	Pressure Treatment	None listed.	None listed.
042401	3008-60	Soluble Concentrate	14.07 (11.31 copper as metallic)	Wood Preservatives	Posts	*Posts, round, 1/2 and 1/4 round for highway construction (including guide, sign and sight). *Fence (farm). *Posts, round,	Pressure Treatment	None listed.	None listed.
042401	3008-60	Soluble Concentrate	14.07 (11.31 copper as metallic)	Wood Preservatives	Poles	*Utility poles (including laminated). *Poles for highway and agricultural construction, lighting, building structural use.	Pressure Treatment	None listed.	None listed.
042401	3008-60	Soluble Concentrate	14.07 (11.31 copper as metallic)	Wood Preservatives	Round Timber Piling	*Foundation and fresh water piles	Pressure Treatment	None listed.	None listed.
042401	3008-60	Soluble Concentrate	14.07 (11.31 copper as metallic)	Wood Preservatives	Sawn Products	*Guardrails for highway construction, including for golf course bridges meeting highway construction standards. *Shakes and	Pressure Treatment	None listed.	None listed.

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042401	3008-60	Soluble Concentrate	14.07 (11.31 copper as metallic)	Wood Preservatives	Wood Composites	*Composite lumber for structural uses. *Glue- or nail-laminated members. *Plywood for agriculture, farms, roof sheathing,	Pressure Treatment	None listed.	None listed.
042401	3008-60	Soluble Concentrate	14.07 (11.31 copper as metallic)	Wood Preservatives	Marine Applications	*Bulkhead sheathing. *Lumber/timbers use, including use in aqua/mariculture, timbers and cross bracing, highway	Pressure Treatment	None listed.	None listed.
042401	3008-76	Pending	98.0 (78.0 copper as metallic	Technical	Technical	Technical	None listed.	None listed.	None listed.
042401	35896-21	Technical chemical	97.6 (78.0 copper as metallic)			Technical chemical for formulation into wood preservatives, roofing materials formulations, and copper-based pesticide			
042401	35896-24	Intermediate Forumlation	85.7 (68.5 copper as metallic)			Technical chemical for formulation into wood preservatives, roofing materials formulations, and copper-based pesticide			
025601	41750-1	Ready-to-use solution	40.36 (36.92)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F 24 hour minimum launch time after last coat. Do not use on aluminum
025601	41750-1	Ready-to-use solution	40.36 (36.92)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 24 hour minimum launch time after last coat.
025601	41750-1	Ready-to-use solution	40.36 (36.92)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F 24 hour minimum launch time after last coat.
025601	41750-2	Ready-to-use solution	44.15 (40.39 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F 24 hour minimum launch time after last coat. Do not use on aluminum
025601	41750-2	Ready-to-use solution	44.15 (40.39 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 24 hour minimum launch time after last coat.
025601	41750-2	Ready-to-use solution	44.15 (40.39 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F 24 hour minimum launch time after last coat.

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025601	41750-3	Ready-to-use solution	17.09 (15.63 metallic copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F 24 hour minimum launch time after last coat. Do not use on aluminum
025601	41750-3	Ready-to-use solution	17.09 (15.63 metallic copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F Apply first coat thinnned 10% 24 hour minimum launch time after last coat.
025601	41750-3	Ready-to-use solution	17.09 (15.63 metallic copper)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	Temperature range: 77° F 24 hour minimum launch time after last coat.
025601	44428-3	Ready-to-use solution	27.45	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats one hour between coats	No mimimum launch time.
025601	44428-3	Ready-to-use solution	27.45	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats one hour between coats	No mimimum launch time.
025601	44428-3	Ready-to-use solution	27.45	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats one hour between coats	No mimimum launch time.
025601	44891-10	Ready-to-use solution	75.8 (67.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3.0 mils per dry coat, two coats on hull, three below water line. two hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10% Do not use on aluminum
025601	44891-10	Ready-to-use solution	75.8 (67.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3.0 mils per dry coat, two coats on hull, three below water line. two hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%
025601	44891-10	Ready-to-use solution	75.8 (67.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	3.0 mils per dry coat, two coats on hull, three below water line. two hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat.
025601	44891-11	Ready-to-use solution	45.2 (42.21 copper as metallic)	Antifoulant Coatings	Crab, lobster and bass pots	Wire Crab and lobster pots	Brush, Roller or Spray (conventional or airless) spray preferred	3.1 mils per dry coat, two coats on hull, three below water line. two hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%
025601	44891-11	Ready-to-use solution	45.2 (42.21 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3.1 mils per dry coat, two coats on hull, three below water line. two hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%

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025601	44891-11	Ready-to-use solution	45.2 (42.21 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	3.1 mils per dry coat, two coats on hull, three below water line. two hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%
025601	44891-12	Ready-to-use solution	33.6	Jacket	Crab, lobster and bass pots	Wire Crab and lobster pots	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum	12 hour minimum launch time after last coat.
025601	44891-12	Ready-to-use solution	33.6	Jacket	Boats/ships Hulls/Bottoms	Ships, boats, barges and running gear	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum	12 hour minimum launch time after last coat.
025601	44891-12	Ready-to-use solution	33.6	Jacket	Boats/ships Hulls/Bottoms	Fish nets, traps, lines, docks, walls,	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum	12 hour minimum launch time after last coat.
025601	44891-13	Ready-to-use solution	73.75	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Ships, boats, barges and running gear	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum	May be thinned up to 10%. 12 hour minimum launch time after last coat. temperature must be at least 50' F (10' C) above dew point.
025601	44891-14	Ready-to-use solution	47.57	Jacket	Boats/ships Hulls/Bottoms	Ships, boats, barges and running gear	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum	May be thinned up to 10%. 12 hour minimum launch time after last coat. temperature must be at least 50' F (10' C) above dew point.
025601	44891-15	Ready-to-use solution	38.06	Jacket	Boats/ships Hulls/Bottoms	Ships, boats, barges and running gear	Brush, Roller or Spray (conventional or airless) spray preferred	3.1 mils per coat, two coats one hour between coats	Temperature range: 73° F May be thinned up to 10%. 12 hour minimum launch time after last coat.
025601	44891-7	Ready-to-use solution	47.57 (42.21 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.7 mils per dry coat, two coats one hour between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%
025601	44891-7	Ready-to-use solution	47.57 (42.21 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.7 mils per dry coat, two coats one hour between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%
025601	44891-7	Ready-to-use solution	47.57 (42.21 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.7 mils per dry coat, two coats one hour between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%
025601	44891-9	Ready-to-use solution	54.67 (51.76 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.2 mils per dry coat, two coats on hull, three below water line. one hour between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10% Do not use on aluminum

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025601	44891-9	Ready-to-use solution	54.67 (51.76 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.2 mils per dry coat, two coats on hull, three below water line. one hour between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%
025601	44891-9	Ready-to-use solution	54.67 (51.76 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.2 mils per dry coat, two coats on hull, three below water line. one hour between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. May be thinned up to 10%
022501	45168-1	Ready-to-use solution	14	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Roller or Spray (conventional or airless) spray preferred	two coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-1	Ready-to-use solution	14	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Roller or Spray (conventional or airless) spray preferred	two coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-1	Ready-to-use solution	14	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Roller or Spray (conventional or airless) spray preferred	two coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-5	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-5	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-5	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-6	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-6	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-6	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.

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022501	45168-7	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-7	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-7	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-8	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-8	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
022501	45168-8	Ready-to-use solution	20.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Roller or airless spray	2-3 coats 10 minutes between coats	three minute minimum launch time after last coat.
025601	48142-2	Technical chemical	97.0 (86.0 copper as metallic)			Technical chemical for formulation into antifouling coatings			
025601	48142-8	Technical chemical	94.0 (86.0 copper as metallic)			Technical chemical for formulation into antifoulant coatings, as a fungicide in wood preservatives, and as an algicide/ mildeweide in roofing materials.			
025601	48302-11	Ready-to-use solution	45.56	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3.0-6.0 mils per dry coat, two coats 5 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%
025601	48302-11	Ready-to-use solution	45.56	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3.0-6.0 mils per dry coat, two coats 5 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	48302-11	Ready-to-use solution	45.56	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	3.0-6.0 mils per dry coat, two coats 5 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%
025601	48302-13	Ready-to-use solution	72.6	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3.0-6.0 mils per dry coat, two coats 5 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%
025601	48302-13	Ready-to-use solution	72.6	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3.0-6.0 mils per dry coat, two coats 5 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%
025601	48302-13	Ready-to-use solution	72.6	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	3.0-6.0 mils per dry coat, two coats 5 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%
025601	48302-4	Ready-to-use solution	33.3	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Roller or airless spray	two coats minimum	
025601	48302-4	Ready-to-use solution	33.3	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Roller or airless spray	two coats minimum	
025601	48302-4	Ready-to-use solution	33.3	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Roller or airless spray	two coats minimum	
025601	48302-4	Ready-to-use solution	33.3	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Roller or airless spray	two coats minimum	
025601	48302-7	Ready-to-use solution	49	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-3.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%
025601	48302-7	Ready-to-use solution	49	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-3.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%
025601	48302-7	Ready-to-use solution	49	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-3.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%

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025601	48302-7	Ready-to-use solution	49	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-3.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces May be thinned up to 5%
025601	48302-8	Ready-to-use solution	49	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces
025601	48302-8	Ready-to-use solution	49	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces
025601	48302-8	Ready-to-use solution	49	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats minimum	Temperature range: 73° F 12 hour minimum launch time after last coat. Use on properly primed surfaces
42401	56248-1	Technical chemical	98.9 (79.0 copper as metallic)			Technical chemical for formulating wood preservative products.			
025601	577-549	Ready-to-use solution	51.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time
025601	577-549	Ready-to-use solution	51.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. Apply first coat thinnned 30%. Apply second coat thinned up to 5% if
025601	577-549	Ready-to-use solution	51.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Gelcoat	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time
025601	577-549	Ready-to-use solution	51.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	not for use on aluminum unless a minimum of 15 dry mils of epoxy primer is used and a proper amount of zinc anodes. Contact mfr. for information
025601	577-550	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time

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025601	577-550	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. Apply first coat thinnned 30%. Apply second coat thinned up to 5% if
025601	577-550	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Gelcoat	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time
025601	577-550	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	not for use on aluminum unless a minimum of 15 dry mils of epoxy primer is used and a proper amount of zinc anodes. Contact mfr. for information
025601	577-550	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Military Uses	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	not for use on aluminum unless a primer is used. On wood, apply first coat thinned at one quart per gallon, Apply second coat unthinned. Do not apply over vinyl antifouling paints
025601	577-551	Ready-to-use solution	55.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time
025601	577-551	Ready-to-use solution	55.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. Apply first coat thinnned
025601	577-551	Ready-to-use solution	55.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Gelcoat	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	Temperature range and relative humidity range: 40° F / R.H 50% Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time
025601	577-551	Ready-to-use solution	55.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray	not for use on aluminum unless a minimum of 15 dry mils of epoxy primer is used and a proper amount of zinc anodes. Contact mfr. for information
025601	577-551	Ready-to-use solution	55.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Military Uses	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats	not for use on aluminum unless a primer is used. On wood, apply first coat thinned at one quart per gallon, Apply second coat unthinned. Don not apply over vinyl antifouling paints
025601	577-552	Ready-to-use solution	63.6	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats	4 hour minimum launch time after last coat.
025601	577-552	Ready-to-use solution	63.6	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats	Apply first coat thinnned up to one quart per gallon of antifoulant 4 hour minimum launch time after last coat.

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025601	577-552	Ready-to-use solution	63.6	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats	4 hour minimum launch time after last coat.. Do not use on aluminum
025601	577-553	Ready-to-use solution	70.6 (IN OPPIN) 66.9 (ON LABEL)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	4 hour minimum launch time after last coat.
025601	577-553	Ready-to-use solution	70.6 (IN OPPIN) 66.9 (ON LABEL)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	4 hour minimum launch time after last coat.
025601	577-553	Ready-to-use solution	70.6 (IN OPPIN) 66.9 (ON LABEL)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats	4 hour minimum launch time after last coat.
042401 022501 025601	577-554	Ready-to-use solution	022501, 27.6 025601, 34.4 042401, 0.6 (025601, 55.6 on LABEL)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	None listed.	None listed.
042401 022501 025601	577-554	Ready-to-use solution	022501, 27.6 025601, 34.4 042401, 0.6 (025601, 55.6 on LABEL)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	None listed.	None listed.
042401 022501 025601	577-554	Ready-to-use solution	022501, 27.6 025601, 34.4 042401, 0.6 (025601, 55.6 on LABEL)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	None listed.	None listed.
025601	577-555	Ready-to-use solution	40.3	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Ships, boats, barges and running gear	None listed.	None listed.	
025601	577-556	Ready-to-use solution	23	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	6 hour minimum launch time after last coat.
025601	577-558	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Vinyl antifoulant coated surfaces	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time after last coat.
025601	577-558	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time after last coat.

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025601	577-558	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. Apply first coat thinnned 20%. Apply 2nd and 3rd coat thinned up to 5% if needed. 4 hour minimum launch time
025601	577-558	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time after last coat.
025601	577-559	Ready-to-use solution	55.7 (49.47 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Vinyl antifoulant coated surfaces	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time after last coat.
025601	577-559	Ready-to-use solution	55.7 (49.47 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time after last coat.
025601	577-559	Ready-to-use solution	55.7 (49.47 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. Apply first coat thinnned 20%. Apply 2nd and 3rd coat thinned up to 5% if needed. 4 hour minimum launch time
025601	577-559	Ready-to-use solution	55.7 (49.47 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time after last coat.
025601	577-560	Ready-to-use solution	51.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Vinyl antifoulant coated surfaces	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time after last coat.
025601	577-560	Ready-to-use solution	51.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Do not apply over soft sloughing type anti-fouling paints. 4 hour minimum launch time after last coat.
025601	577-560	Ready-to-use solution	51.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F Apply first coat thinnned 20%. Apply 2nd and 3rd coat thinned up to 5% if needed. 4 hour minimum launch time after last coat.
025601	577-560	Ready-to-use solution	51.35	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	3-5 mils dry 2 hours between coats with spray, 4 hours otherwise	Temperature range: 50° F-100° F 4 hour minimum launch time after last coat.
025601	577-561	Ready-to-use solution	69.69	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Vinyl antifoulant coated surfaces	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils dry per coat 2 hours between coats	Temperature range: 40° F-100° F 4 hour minimum launch time after last coat.

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025601	577-561	Ready-to-use solution	69.69	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils dry per coat 2 hours between coats	Temperature range: 40° F-100° F 4 hour minimum launch time after last coat.
025601	577-561	Ready-to-use solution	69.69	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils dry per coat 2 hours between coats	Temperature range: 40° F-100° F Apply first coat thinnned 20%. Apply 2nd and 3rd coat thinned up to 5% if needed. 4 hour minimum launch time after last coat.
025601	577-561	Ready-to-use solution	69.69	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils dry per coat 2 hours between coats	Temperature range: 40° F-100° F 4 hour minimum launch time after last coat.
025601	577-562	Ready-to-use solution	57	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Vinyl antifoulant coated surfaces	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils dry per coat 2 hours between coats	Temperature range: 40° F-100° F 4 hour minimum launch time after last coat.
025601	577-562	Ready-to-use solution	57	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils dry per coat 2 hours between coats	Temperature range: 40° F-100° F 4 hour minimum launch time after last coat.
025601	577-562	Ready-to-use solution	57	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils dry per coat 2 hours between coats	Temperature range: 40° F-100° F Apply first coat thinnned 20%. Apply 2nd and 3rd coat thinned up to 5% if needed. 4 hour minimum launch time after last coat.
025601	577-562	Ready-to-use solution	57	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils dry per coat 2 hours between coats	Temperature range: 40° F-100° F 4 hour minimum launch time after last coat.
025601	577-563	Ready-to-use solution	27.76 (24.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-563	Ready-to-use solution	27.76 (24.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-563	Ready-to-use solution	27.76 (24.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-563	Ready-to-use solution	27.76 (24.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.

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025601	577-564	Ready-to-use solution	24.53 (21.73 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-564	Ready-to-use solution	24.53 (21.73 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-564	Ready-to-use solution	24.53 (21.73 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-564	Ready-to-use solution	24.53 (21.73 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-565	Ready-to-use solution	10.79 (9.59 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-565	Ready-to-use solution	10.79 (9.59 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-565	Ready-to-use solution	10.79 (9.59 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-565	Ready-to-use solution	10.79 (9.59 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-566	Ready-to-use solution	10.87 (9.63 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-566	Ready-to-use solution	10.87 (9.63 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-566	Ready-to-use solution	10.87 (9.63 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	577-566	Ready-to-use solution	10.87 (9.63 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-567	Ready-to-use solution	75.4 (67.05 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-567	Ready-to-use solution	75.4 (67.05 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-567	Ready-to-use solution	75.4 (67.05 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-567	Ready-to-use solution	75.4 (67.05 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	577-568	Ready-to-use solution	59.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-2.5 mils per dry coat 4 hours between coats	Temperature range: 50° F-110° F 8 hour minimum launch time after last coat.
025601	577-568	Ready-to-use solution	59.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-2.5 mils per dry coat 4 hours between coats	Temperature range: 50° F-110° F Apply first coat thinnned 20%. Apply 2nd and 3rd coat thinned up to 5% if needed. 8 hour minimum launch time after last coat.
025601	577-568	Ready-to-use solution	59.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-2.5 mils per dry coat 4 hours between coats	Temperature range: 50° F-110° F 8 hour minimum launch time after last coat.
025601	577-569	Ready-to-use solution	44.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Vinyl antifoulant coated surfaces	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-2.5 mils per dry coat 4 hours between coats	Temperature range: 50° F-110° F 8 hour minimum launch time after last coat.
025601	577-569	Ready-to-use solution	44.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-2.5 mils per dry coat 4 hours between coats	Temperature range: 50° F-110° F 8 hour minimum launch time after last coat.
025601	577-569	Ready-to-use solution	44.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-2.5 mils per dry coat 4 hours between coats	Temperature range: 50° F-110° F Apply first coat thinnned 20%. Apply 2nd and 3rd coat thinned up to 5% if needed. 8 hour minimum launch time after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	577-569	Ready-to-use solution	44.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0-2.5 mils per dry coat 4 hours between coats	Temperature range: 50° F-110° F 8 hour minimum launch time after last coat.
025601	60061-10	Ready-to-use solution	65.8	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-10	Ready-to-use solution	65.8	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-10	Ready-to-use solution	65.8	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-101	Ready-to-use solution	47.5 (42.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-101	Ready-to-use solution	47.5 (42.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 5% and allow to dry overnight
025601	60061-101	Ready-to-use solution	47.5 (42.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-11	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-11	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-11	Ready-to-use solution	66.9	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
022501	60061-111	Powder	84.67 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	0.25 mils per dry coat, three coats 10 minutes between coats.	Product is part of a two component system. Ready-to-Use contains 21.00 metallic copper Temperature range: 70° F 1 hour minimum launch time after last coat.

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022501	60061-111	Powder	84.67 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	0.25 mils per dry coat, three coats 10 minutes between coats.	Product is part of a two component system. Ready-to-Use contains 21.00 metallic copper Temperature range: 70° F 1 hour minimum launch time after last coat.
022501	60061-111	Powder	84.67 copper powder	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	0.25 mils per dry coat, three coats 10 minutes between coats.	Product is part of a two component system. Ready-to-Use contains 21.00 metallic copper Temperature range: 70° F 1 hour minimum launch time after last coat.
025601	60061-117	Ready-to-use solution	40.0 (35.52 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-117	Ready-to-use solution	40.0 (35.52 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-117	Ready-to-use solution	40.0 (35.52 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-12	Ready-to-use solution	55.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-12	Ready-to-use solution	55.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-12	Ready-to-use solution	55.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-125	Ready-to-use solution	40.43	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 6 hours between coats	Temperature range: 70° F 16 hour minimum launch time after last coat. May be thinned up to 10%.
025601	60061-125	Ready-to-use solution	40.43	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 6 hours between coats	Temperature range: 70° F 16 hour minimum launch time after last coat. May be thinned up to 10%.
025601	60061-125	Ready-to-use solution	40.43	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 6 hours between coats	Temperature range: 70° F 16 hour minimum launch time after last coat. May be thinned up to 10%.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	60061-129	Ready-to-use solution	28.86 (20.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-129	Ready-to-use solution	28.86 (20.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-129	Ready-to-use solution	28.86 (20.20 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-132	Ready-to-use solution	23.7 (21.05 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat.
025601	60061-132	Ready-to-use solution	23.7 (21.05 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-132	Ready-to-use solution	23.7 (21.05 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat.
025601	60061-14	Ready-to-use solution	40.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-14	Ready-to-use solution	40.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-14	Ready-to-use solution	40.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-15	Ready-to-use solution	40.9 (37.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-15	Ready-to-use solution	40.9 (37.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight

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025601	60061-15	Ready-to-use solution	40.9 (37.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-31	Ready-to-use solution	24.5 (21.8 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat.
025601	60061-31	Ready-to-use solution	24.5 (21.8 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-31	Ready-to-use solution	24.5 (21.8 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat.
025601	60061-33	Ready-to-use solution	52	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	four coats 4 hours between coats.	Apply first coat thinnned up to 10%. Allow overnight drying time between coats.
025601	60061-33	Ready-to-use solution	52	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-33	Ready-to-use solution	52	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-33	Ready-to-use solution	52	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-34	Ready-to-use solution	42	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	four coats 4 hours between coats.	Apply first coat thinnned up to 10%. Allow overnight drying time between coats.
025601	60061-34	Ready-to-use solution	42	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-34	Ready-to-use solution	42	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.

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025601	60061-34	Ready-to-use solution	42	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-35	Ready-to-use solution	42	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	four coats 4 hours between coats.	Apply first coat thinnned up to 10%. Allow overnight drying time between coats.
025601	60061-35	Ready-to-use solution	42	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-35	Ready-to-use solution	42	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-35	Ready-to-use solution	42	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-43	Ready-to-use solution	35 (31.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 70° F 6 hour minimum launch time after last coat. May be thinned up to 5%.
025601	60061-43	Ready-to-use solution	35 (31.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 70° F 6 hour minimum launch time after last coat. May be thinned up to 5%.
025601	60061-43	Ready-to-use solution	35 (31.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 6 hours between coats	Temperature range: 70° F 6 hour minimum launch time after last coat. May be thinned up to 5%.
025601	60061-44	Ready-to-use solution	25 (22.2 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats.	Temperature range: 70° F 12 hour minimum launch time after last coat.
025601	60061-44	Ready-to-use solution	25 (22.2 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 16 hours between coats.	Temperature range: 70° F 12 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-44	Ready-to-use solution	25 (22.2 copper as elemental)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 16 hours between coats.	Temperature range: 70° F 12 hour minimum launch time after last coat.

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025601	60061-49	Ready-to-use solution	65 (57.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-49	Ready-to-use solution	65 (57.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-49	Ready-to-use solution	65 (57.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-5	Ready-to-use solution	31.4	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 2 hours between coats.	Temperature range: 70° F Apply first coat thinnned up to 10%. 6 hour minimum launch time after last coat.
025601	60061-5	Ready-to-use solution	31.4	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat.
025601	60061-5	Ready-to-use solution	31.4	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats.	Temperature range: 70° F 6 hour minimum launch time after last coat. Do not use on aluminum
025601	60061-50	Ready-to-use solution	75.8 (67.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-50	Ready-to-use solution	75.8 (67.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-50	Ready-to-use solution	75.8 (67.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-51	Ready-to-use solution	46	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Apply first coat thinnned up to 10%. Allow overnight drying time between coats.
025601	60061-51	Ready-to-use solution	46	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Apply first coat thinnned up to 10%. Allow overnight drying time between coats.

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025601	60061-51	Ready-to-use solution	46	Antifoulant Coatings	Keels, centerboards and underwater fittings	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-54	Ready-to-use solution	49.5 (43.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 8 hours between coats.	Temperature range: 40-90° F Overnight minimum launch time after last coat.
025601	60061-54	Ready-to-use solution	49.5 (43.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 8 hours between coats.	Temperature range: 40-90° F Overnight minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-54	Ready-to-use solution	49.5 (43.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 8 hours between coats.	Temperature range: 40-90° F Overnight minimum launch time after last coat.
025601	60061-57	Ready-to-use solution	60.9 (54.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-57	Ready-to-use solution	60.9 (54.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-57	Ready-to-use solution	60.9 (54.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-58	Ready-to-use solution	52.6 (46.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-58	Ready-to-use solution	52.6 (46.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-58	Ready-to-use solution	52.6 (46.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-63	Ready-to-use solution	45.7 (40.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.

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025601	60061-63	Ready-to-use solution	45.7 (40.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-63	Ready-to-use solution	45.7 (40.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-64	Ready-to-use solution	53.3 (47.4 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4hours between coats.	Temperature range: 40-90° F Overnight minimum launch time after last coat.
025601	60061-64	Ready-to-use solution	53.3 (47.4 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Temperature range: 40-90° F Overnight minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-64	Ready-to-use solution	53.3 (47.4 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	Temperature range: 40-90° F Overnight minimum launch time after last coat.
025601	60061-65	Ready-to-use solution	60.7 (54.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-65	Ready-to-use solution	60.7 (54.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-65	Ready-to-use solution	60.7 (54.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-66	Ready-to-use solution	55.6 (49.4 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-66	Ready-to-use solution	55.6 (49.4 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, three coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-66	Ready-to-use solution	55.6 (49.4 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.

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025601	60061-71	Ready-to-use solution	37.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat.
025601	60061-71	Ready-to-use solution	37.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-71	Ready-to-use solution	37.5	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 3 hours between coats.	Temperature range: 70° F 4 hour minimum launch time after last coat.
025601	60061-77	Ready-to-use solution	58.16	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Apply first coat thinnned up to 10%. Allow overnight drying time between coats.
025601	60061-77	Ready-to-use solution	58.16	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Apply first coat thinnned up to 10%. Allow overnight drying time between coats.
025601	60061-77	Ready-to-use solution	58.16	Antifoulant Coatings	Keels, centerboards and underwater fittings	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 4 hours between coats.	Allow overnight drying time between coats.
025601	60061-79	Ready-to-use solution	47.5 (42.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-79	Ready-to-use solution	47.5 (42.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight
025601	60061-79	Ready-to-use solution	47.5 (42.1 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-81	Ready-to-use solution	60.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-81	Ready-to-use solution	60.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 10% and allow to dry overnight

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025601	60061-81	Ready-to-use solution	60.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 6 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-86	Ready-to-use solution	33.26 (29.54 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-86	Ready-to-use solution	33.26 (29.54 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-86	Ready-to-use solution	33.26 (29.54 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 4 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-87	Ready-to-use solution	40.34	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-87	Ready-to-use solution	40.34	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-87	Ready-to-use solution	40.34	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats.	Temperature range: 70° F 16 hour minimum launch time after last coat.
025601	60061-94	Ready-to-use solution	60 (53.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 8 hours between coats.	Temperature range: 40-90° F 16 hour minimum launch time after last coat.
025601	60061-94	Ready-to-use solution	60 (53.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 8 hours between coats.	Temperature range: 40-90° F 16 hour minimum launch time after last coat. Apply first coat thinnned up to 25% and allow to dry overnight
025601	60061-94	Ready-to-use solution	60 (53.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 8 hours between coats.	Temperature range: 40-90° F 16 hour minimum launch time after last coat.
025601	60061-95	Ready-to-use solution	70 (62.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats.	Temperature range: 40-90° F 8 hour minimum launch time after last coat.

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025601	60061-95	Ready-to-use solution	70 (62.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	three coats 2 hours between coats.	Temperature range: 40-90° F 8 hour minimum launch time after last coat. Apply first coat thinnned up to 5% and allow to dry overnight
025601	60061-95	Ready-to-use solution	70 (62.2 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 2 hours between coats.	Temperature range: 40-90° F 8 hour minimum launch time after last coat.
042401	62190-13	Soluble Concentrate	98.6	Wood Preservatives	Seasoned Wood Pressure/Thermal Treatment	Manufacturing Use	Pressure Treatment	None listed	
042401	62190-14	Soluble Concentrate	28.5	Wood Preservatives	Seasoned Wood Pressure/Thermal Treatment	Lumber and Timber for mine ties and bridge ties, Lumber and Timber for salt water use (also includes brackish water) only (C2), Piles (C3);	Pressure Treatment	0.5 to 10% by weight in a water solution	
042401	62190-23	Soluble Concentrate	14.07	Wood Preservatives	Seasoned Wood Pressure/Thermal Treatment	This product may only be used for preservative treatment of the following categories of forest products and in accordance with the	Pressure Treatment	0.5 to 7% by weight in a water solution	
025601	62190-28	Powder	83	Wood Preservatives	Seasoned Wood Pressure/Thermal Treatment	Sold as a component to blend with other components used to formulate Chemonite wood treating solution intended for pressure	Pressure Treatment	Not listed	
042401	62190-8	Soluble Concentrate	13.32	Wood Preservatives	Seasoned Wood Pressure/Thermal Treatment	Lumber and Timber for mine ties and bridge ties, Lumber and Timber for salt water use (also includes brackish water) only (C2), Piles (C3);	Pressure Treatment	0.5 to 10% by weight in a water solution	
025601	63005-1	Technical chemical	97.15			Technical chemical for formulating copper based pesticide products.			
022501	63005-2	Technical chemical	99.75			Technical chemical for formulating of copper-based pesticide products, including marine paints, roofing granules and building and			
022501	63005-3	Technical chemical	98.75			Technical chemical for formulating of copper-based pesticide products, including marine paints, roofing granules and building and			
042401	65345-1	Technical chemical	98.6 (78.8 copper as metallic			Technical chemical for formulating wood preservative formulations.			

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025601	67543-7	Ready-to-use solution	70.2 (61.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Temperature range: 65° F Overnight minimum launch time after last coat.
025601	67543-7	Ready-to-use solution	70.2 (61.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Temperature range: 65° F Overnight minimum launch time after last coat.
025601	67543-7	Ready-to-use solution	70.2 (61.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply two coats. Overnight dry between coats.	Temperature range: 65° F Overnight minimum launch time after last coat. Do not use on aluminum
025601	70214-1	Ready-to-use solution	39.95	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats.	Temperature range: 70° F 8 hour minimum launch time after last coat.
025601	70214-1	Ready-to-use solution	39.95	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats.	Temperature range: 70° F 8 hour minimum launch time after last coat.
025601	70214-1	Ready-to-use solution	39.95	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats.	Temperature range: 70° F 8 hour minimum launch time after last coat.
025601	70214-1	Ready-to-use solution	39.95	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	2.0 mils per dry coat, two coats 2 hours between coats.	Temperature range: 70° F 8 hour minimum launch time after last coat.
022501	71227-7	Soluble Concentrate	6.1	Materials Preservatives	Plastics - including films, sheets, slabs, and molded plastic parts	Automobile Parts, Shower curtains, Mats, Protective Covers, Waste containers, Brush handles, Mops, Vacuum cleaner bags,	Incorporation	0.3 to 5.0% by weight	Do not use for any application involving direct or Indirect contact with food, drinking water, or packaging.
022501	71227-7	Soluble Concentrate	6.1	Materials Preservatives	Fibers — including cotton, rayon and synthetically derived fibers	Synthetic and Natural Fibers. Paper for gypsum board. Paper, paperboard, composite building materials	Incorporation	0.1 to 5.0% by weight	Do not use for any application involving direct or Indirect contact with food, drinking water, or packaging.
022501	71227-7	Soluble Concentrate	6.1	Materials Preservatives	Coatings, Films and Laminates	Building Materials (including gypsum board, insulation, cellulose or fiberglass ceiling tile, and polymer flooring.) Heating, Ventilation and Air	Incorporation	0.5 to 5.0% by weight	Do not use for any application involving direct or Indirect contact with food, drinking water, or packaging.
022501	71227-7	Soluble Concentrate	6.1	Materials Preservatives	Adhesives and Sealants	Adhesives, joint compound and grout for gypsum board, ceramic tile, wood, paper, cardboard, rubber and plastic.	Incorporation	0.5 to 5.0% by weight	Do not use for any application involving direct or Indirect contact with food, drinking water, or packaging.

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025601	72679-2	Ready-to-use solution	59.5 (52.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-2	Ready-to-use solution	59.5 (52.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-2	Ready-to-use solution	59.5 (52.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-2	Ready-to-use solution	59.5 (52.7 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-2	Ready-to-use solution	59.5 (52.7 copper as metallic)	Antifoulant Coatings	Crab, lobster and bass pots	Wire Crab and lobster pots	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-4	Ready-to-use solution	24.25 (21.73 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-4	Ready-to-use solution	24.25 (21.73 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-4	Ready-to-use solution	24.25 (21.73 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-4	Ready-to-use solution	24.25 (21.73 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-4	Ready-to-use solution	24.25 (21.73 copper as metallic)	Antifoulant Coatings	Crab, lobster and bass pots	Wire Crab and lobster pots	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-5	Ready-to-use solution	27.47 (24.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.

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025601	72679-5	Ready-to-use solution	27.47 (24.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-5	Ready-to-use solution	27.47 (24.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-5	Ready-to-use solution	27.47 (24.6 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	72679-5	Ready-to-use solution	27.47 (24.6 copper as metallic)	Antifoulant Coatings	Crab, lobster and bass pots	Wire Crab and lobster pots	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats.	2 hour minimum launch time after last coat.
025601	73092-1	Ready-to-use solution	18.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	2.4-6.0 mils per coat, two coats 30 minutes between coats	Temperature range: 68° F 6 hour minimum launch time after last coat.
025601	73092-1	Ready-to-use solution	18.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.4-6.0 mils per coat, two coats 30 minutes between coats	Temperature range: 68° F 6 hour minimum launch time after last coat.
025601	73092-1	Ready-to-use solution	18.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.4-6.0 mils per coat, two coats 30 minutes between coats	Temperature range: 68° F 6 hour minimum launch time after last coat.
025601	73092-1	Ready-to-use solution	18.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	2.4-6.0 mils per coat, two coats 30 minutes between coats	Temperature range: 68° F 6 hour minimum launch time after last coat.
025601	7313-11	Ready-to-use solution	55.2 (49.0 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Properly Primed Boat hulls below the water line	Brush, Roller or Spray (conventional or airless) spray preferred	4 hours between coats	Temperature range: 77° F 5 hour minimum launch time after last coat. Max one pint per gallon thinner.
025601	7313-12	Ready-to-use solution	29.2 (25.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Properly Primed Boat hulls below the water line	Brush, Roller or Spray (conventional or airless) spray preferred	4 hours between coats	Temperature range: 77° F 5 hour minimum launch time after last coat. Max one pint per gallon thinner.
025601	7313-13	Ready-to-use solution	38.46 (34.15 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Properly Primed Boat hulls below the water line	Brush, Roller or Spray (conventional or airless) spray preferred	4 hours between coats	Temperature range: 77° F 5 hour minimum launch time after last coat. Max one pint per gallon thinner.

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025601	7313-18	Ready-to-use solution	47.99 (42.3 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Properly Primed Boat hulls below the water line	Brush, Roller or Spray (conventional or airless) spray preferred	4 hours between coats	Temperature range: 77° F 5 hour minimum launch time after last coat. Max one pint per gallon thinner.
025601	7313-20	Ready-to-use solution	37.29 (33.12 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Properly Primed Boat hulls below the water line	Brush, Roller or Spray (conventional or airless) spray preferred	4 hours between coats	Temperature range: 77° F 5 hour minimum launch time after last coat. Max one pint per gallon thinner.
025601	7313-22	Ready-to-use solution	41.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.5-6.0 mils per coat, two coats 6 hours between coats	Temperature range: 68° F 8 hour minimum launch time after last coat.
025601	7313-22	Ready-to-use solution	41.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.5-6.0 mils per coat, two coats 6 hours between coats	Temperature range: 68° F 8 hour minimum launch time after last coat.
025601	7313-24	Ready-to-use solution	39	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	2.5-6.0 mils per coat, two coats 6 hours between coats	Temperature range: 68° F 8 hour minimum launch time after last coat.
025601	7313-24	Ready-to-use solution	39	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	2.5-6.0 mils per coat, two coats 6 hours between coats	Temperature range: 68° F 8 hour minimum launch time after last coat.
025601	73452-1	granules	5.3	Materials Preservatives	Coatings, Industrial	Roof Shingles	Incorporation	Mix with standard roofing granules at a rate of 10-20% by weight and processed normally during manufacture of the shingles.	
025601	73452-2	granules	3.6	Materials Preservatives	Coatings, Industrial	Roof Shingles	Incorporation	Mix with standard roofing granules at a rate of 10-20% by weight and processed normally during manufacture of the shingles.	
022501	73667-4	Soluble Concentrate	4.0	Materials Preservatives	Specialty Products	Water filters, media and components	None listed.	Product be used only for formulation into end-use antimicrobial pesticide for manufacturing or fabricating bacteriostatic water filter and	
025601	74681-1	Ready-to-use solution	67.00 (59.50 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	74681-1	Ready-to-use solution	67.00 (59.50 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller	Apply Three coats over bare wood. Overnight dry between coats.	Apply first coat thinnned up to 10%. Overnight minimum launch time after last coat.

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025601	74681-1	Ready-to-use solution	67.00 (59.50 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	74681-2	Ready-to-use solution	45.00 (39.97 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	74681-2	Ready-to-use solution	45.00 (39.97 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller	Apply Three coats over bare wood. Overnight dry between coats.	Apply first coat thinnned up to 10%. Overnight minimum launch time after last coat.
025601	74681-2	Ready-to-use solution	45.00 (39.97 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	74681-3	Ready-to-use solution	56.0	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	74681-3	Ready-to-use solution	56.0	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller	Apply Three coats over bare wood. Overnight dry between coats.	Apply first coat thinnned up to 10%. Overnight minimum launch time after last coat.
025601	74681-3	Ready-to-use solution	56.0	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	74681-4	Ready-to-use solution	67.00 (59.50 copper as metallic)	Antifoulant Coatings	Boats/Ships Hulls/Bottoms	Fiberglass	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	74681-4	Ready-to-use solution	67.00 (59.50 copper as metallic)	Antifoulant Coatings	Boats/Ships Hulls/Bottoms	Wood	Brush, Roller	Apply Three coats over bare wood. Overnight dry between coats.	Apply first coat thinnned up to 10%. Overnight minimum launch time after last coat.
025601	74681-4	Ready-to-use solution	67.00 (59.50 copper as metallic)	Antifoulant Coatings	Boats/Ships Hulls/Bottoms	Steel	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
025601	74681-6	Ready-to-use solution	45.00 (39.97 copper as metallic)	Antifoulant Coatings	Boats/Ships Hulls/Bottoms	Fiberglass	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.

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025601	74681-6	Ready-to-use solution	45.00 (39.97 copper as metallic)	Antifoulant Coatings	Boats/Ships Hulls/Bottoms	Wood	Brush, Roller	Apply Three coats over bare wood. Overnight dry between coats.	Apply first coat thinnned up to 10%. Overnight minimum launch time after last coat.
025601	74681-6	Ready-to-use solution	45.00 (39.97 copper as metallic)	Antifoulant Coatings	Boats/Ships Hulls/Bottoms	Steel	Brush, Roller	Apply three coats. Overnight dry between coats.	Overnight minimum launch time after last coat.
022501	75506-10	Ready-to-use solution	9.25	Wood Preservatives	Season Wood Pressure/Thermal Treatment	Wood	Pressure Treatment	0.1 to 3.0 % by weight in a water solution	
042401	75506-5	Ready-to-use solution	9.25	Wood Preservatives	Season Wood Pressure/Thermal Treatment	Wood	Pressure Treatment	0.1 to 5.0 % by weight in a water solution	
025601	75832-1	Soluble Concentrate	14.07 (11.31 Metallic Copper Equivalent)	Wood Preservatives	Season Wood Pressure/Thermal Treatment	Lumber and Timber for mine ties and bridge ties, Lumber and Timber for salt water use (also includes brackish water) only (C2), Piles (C3);	None listed.	0.5 to 7% by weight in a water solution	Dilution rate will vary based on wood species, treatment cycle and final retention.
025601	75832-3	Soluble Concentrate	14.07 (11.31 Metallic Copper Equivalent)	Wood Preservatives	Season Wood Pressure/Thermal Treatment	Lumber and Timber for mine ties and bridge ties, Lumber and Timber for salt water use (also includes brackish water) only (C2), Piles (C3);	None listed.	0.5 to 7% by weight in a water solution	Dilution rate will vary based on wood species, treatment cycle and final retention.
042401	79630-3	Soluble Concentrate	5.4 (4.3 Metallic Copper Equivalent)	Materials Preservatives	Specialty Products	Water filters, media and components	None listed.	Product be used only for formulation into end-use antimicrobial pesticide for manufacturing or fabricating bacteriostatic water filter and	
025601	81293-1	granules	4.37	Materials Preservatives	Coatings, Industrial	Roof Shingles	Incorporation	Mix with standard roofing granules at a rate of 2-10% by weight. For applications where algae growth is severe, uniformly blend with standard	
022501	82012-1	Impregnated Material	96.2	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-1	Impregnated Material	96.2	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-1	Impregnated Material	96.2	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.

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022501	82012-2	Impregnated Material	91.3	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-2	Impregnated Material	91.3	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-2	Impregnated Material	91.3	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-3	Impregnated Material	82.6	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-3	Impregnated Material	82.6	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-3	Impregnated Material	82.6	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-4	Impregnated Material	73.0	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-4	Impregnated Material	73.0	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-4	Impregnated Material	73.0	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-5	Impregnated Material	66.5	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-5	Impregnated Material	66.5	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.

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022501	82012-5	Impregnated Material	66.5	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-6	Impregnated Material	62.0	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-6	Impregnated Material	62.0	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	82012-6	Impregnated Material	62.0	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
025601	82133-1	Impregnated Material	9.49	Materials Preservatives	Boats/ships Hulls/Bottoms	Laminate moisture barrier for boat bottoms.	None listed.	None listed.	
022501	82415-1	Powder	6.1	Materials Preservatives	Fibers and textiles — polyester, polypropylene, nylon, polyethylene, acrylic and rayon	Home furnishings: mattress cover pads, sheets, blankets, quilt and pillow fiberfill, curtain and drapery, carpet and underlay, upholstery,	Incorporation	1.50% maximum by weight (0.75% for textile finishing and manufacturing)	
022501	82415-1	Powder	6.1	Materials Preservatives	Plastics - including films, sheets, slabs, and molded plastic parts	Gloves, shower curtains, cable wraps, protective covers, non-food contace foam containers, brush handles, sponges,	Incorporation	1.50% maximum by weight	
022501	82415-1	Powder	6.1	Materials Preservatives	Paper Coatings	Wallpaper, non-food wrap, wiping towels, book covers, corrugated paper filters	Incorporation	1.50% maximum by weight	
022501	82415-1	Powder	6.1	Materials Preservatives	Paint and dyes	Water and oil based paints for interior surfaces	Incorporation	1.50% maximum by weight (1.00% for dyestuffs and inks)	
022501	82415-1	Powder	6.1	Materials Preservatives	Adhesives and Sealants	Adhesivees for plywood, adhesives for cement tile and sealants.	Incorporation	2.0% maximum by weight	
025601	82481-1	Ready-to-use solution	32.5 (30.26 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Manufacturer specific spray equipment	Not listed	Coating is applied at 312° F

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025601	82481-1	Ready-to-use solution	32.5 (30.26 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Manufacturer specific spray equipment	Not listed	Coating is applied at 312° F
025601	82481-1	Ready-to-use solution	32.5 (30.26 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Manufacturer specific spray equipment	Not listed	Coating is applied at 312° F
025601	82481-1	Ready-to-use solution	32.5 (30.26 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Manufacturer specific spray equipment	Not listed	Coating is applied at 312° F
025601	82481-1	Ready-to-use solution	32.5 (30.26 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Concrete	Manufacturer specific spray equipment	Not listed	Coating is applied at 312° F
042401	84542-2	Intermediate Forumlation	98.6 (79.0 copper as metallic)	Materials Preservatives	Textile/Textiles Fibers-Making	Fibers, Floor coverings, Plastics, coatings, films and laminates, Adhesives and sealants	None listed.	0.2% - 4.0% product by weight.	
025601	84542-3	Intermediate Forumlation	97.15	Materials Preservatives	Textile/Textiles Fibers-Making	Fibers, Floor coverings, Plastics, coatings, films and laminates, Adhesives and sealants	None listed.	0.2% - 4.0% product by weight.	
022501	85290-1	Impregnated Material	97.6	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-1	Impregnated Material	97.6	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-1	Impregnated Material	97.6	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-2	Impregnated Material	91.2	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-2	Impregnated Material	91.2	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.

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022501	85290-2	Impregnated Material	91.2	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-3	Impregnated Material	91.2	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-3	Impregnated Material	91.2	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-3	Impregnated Material	91.2	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-4	Impregnated Material	82.6	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-4	Impregnated Material	82.6	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-4	Impregnated Material	82.6	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-5	Impregnated Material	99.5	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-5	Impregnated Material	99.5	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85290-5	Impregnated Material	99.5	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85341-1	Impregnated Material	97.6	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
022501	85341-1	Impregnated Material	97.6	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture) ; Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85341-1	Impregnated Material	97.6	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85341-2	Impregnated Material	73.1	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85341-2	Impregnated Material	73.1	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture) ; Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85341-2	Impregnated Material	73.1	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85346-1	Impregnated Material	73.1	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85346-1	Impregnated Material	73.1	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture) ; Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85346-1	Impregnated Material	73.1	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-1	Impregnated Material	66.5	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-1	Impregnated Material	66.5	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture) ; Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-1	Impregnated Material	66.5	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
022501	85353-2	Impregnated Material	73.0	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-2	Impregnated Material	73.0	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-2	Impregnated Material	73.0	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-3	Impregnated Material	82.6	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-3	Impregnated Material	82.6	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-3	Impregnated Material	82.6	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-4	Impregnated Material	97.6	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-4	Impregnated Material	97.6	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-4	Impregnated Material	97.6	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-5	Impregnated Material	91.3	Commercial, Institutional and Industrial premises and Equipment	Commercial, Institutional, Industrial Premises/Equipmet (Indoors);	Shopping cart handles, child seats, handrails. Cash registers: housing, keypads. ATM machines: keys, housing. Gym/Health club	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85353-5	Impregnated Material	91.3	Medical premises and Equipment	Hospital Noncritical Items (Bedpans/Furniture); Hospitals/Medical Institutions	Bedrails, footboards. Over-bed tables. Bed-side tables in hospitals (knobs, pulls, handles; hard non-porous surfaces). Handrails,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
022501	85353-5	Impregnated Material	91.3	Residential and Public Access Premises	Household/Domestic Dwellings Contents; Household/Domestic Dwellings Indoor	Kitchen surfaces (non-food contact only): table tops, counter tops, handles (microwave, refrigerator, stove), cabinet doors,	None listed.	None listed.	Product is a copper alloy surface treatment that imparts antimicribial properties to treatment site surface.
022501	85396-1	Powder	99.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	Apply four coats. one hour between coats.	Temperature range: 68° F 96 hour minimum launch time after last coat. May be thinned up to 10%.
022501	85396-1	Powder	99.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	Apply four coats. one hour between coats.	Temperature range: 68° F 96 hour minimum launch time after last coat. May be thinned up to 10%.
022501	85396-1	Powder	99.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	Apply four coats. one hour between coats.	Temperature range: 68° F 96 hour minimum launch time after last coat. May be thinned up to 10%.
022501	85396-1	Powder	99.7	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	Apply four coats. one hour between coats.	Temperature range: 68° F 96 hour minimum launch time after last coat. May be thinned up to 10%.
025601	9339-19	Ready-to-use solution	26.37 (22.68 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	24 hour minimum launch time after last coat. May be thinned with water.
025601	9339-20	Ready-to-use solution	24.7 (21.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	2 hour minimum launch time after last coat. Hull must be primed.
025601	9339-20	Ready-to-use solution	24.7 (21.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	9339-20	Ready-to-use solution	24.7 (21.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	9339-20	Ready-to-use solution	24.7 (21.9 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	2 hour minimum launch time after last coat. Hull must be primed.
025601	9339-21	Ready-to-use solution	3.69	Antifoulant Coatings	Crab, lobster and bass pots	Wire Crab and lobster pots	Brush or dipping	Two coats if brush. Three minutes contact time for dip. 6 hours between coats	Overnight minimum after last coat.

PC Code	EPA Reg Number used for Max. Appl. Rate	Formulation	% Active Ingredient in End Use Formulation	Use Category	Use Site	Treatment Site/Surfaces	Method of Application	Max Application/Use Rate	Use Limitations
025601	9339-22	Ready-to-use solution	3.88	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	4.0 mils per dry coat, two coats 4 hours between coats	24 hour minimum launch time after last coat.
025601	9339-23	Ready-to-use solution	1.94	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Outboard motors	Spray	Three coats two hours between coats.	Overnight minimum launch time after last coat.
025601	9339-24	Ready-to-use solution	18.00 (16.29 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Steel	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	2 hour minimum launch time after last coat. Hull must be primed.
025601	9339-24	Ready-to-use solution	18.00 (16.29 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Wood	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	9339-24	Ready-to-use solution	18.00 (16.29 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	2 hour minimum launch time after last coat.
025601	9339-24	Ready-to-use solution	18.00 (16.29 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	Aluminum	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	2 hour minimum launch time after last coat. Hull must be primed.
025601	ME940006 (9339-19)	Ready-to-use Solution	26.37 (22.68 copper as metallic)	Antifoulant Coatings	Boats/ships Hulls/Bottoms	New Fiberglass	Brush, Roller or Spray (conventional or airless) spray preferred	two coats 4 hours between coats	24 hour minimum launch time after last coat.

Washington State Invasive Species Council Strategic Plan Excerpts

Unwanted species enter the state in any number

of ways, along what are known as pathways, including: Hulls of boats, which often are encrusted with aquatic species. P. 6

Invasive Species Pathways

Transportation: Water/aquatic (boat hulls, ballast water) p. 14

RECOMMENDATION NO. 12

Conduct a gap analysis of entry pathways to identify those in need of greater protection.

Note: Invasive species arrive along pathways as diverse as ship ballast water, boat hulls, truck wheels and chassis, imported products, airplane holds, and recreational gear such as fishing waders.

Action 12.1 Work with partners to identify gaps in protection; close gaps in regulatory authority, funding, and other areas. P. 30

CASE STUDY IN REGULATORY CONTROL

The Tunicate, Didemnum sp. (A colonial sea squirt)

Background. The tunicate, Didemnum sp., is a sponge-like, invertebrate marine organism and prolific spawner. It lives in large, mat-like colonies and can rapidly invade new marine territories. Invasive tunicate colonies – comprising thousands of organisms – affix to underwater rock outcroppings, ship hulls and docks. Once established, invasive tunicates can displace most native organisms by out-competing them for food and space. Presently, seven non-native tunicate species, including Didemnum sp., have been identified and are established in Puget Sound. The Washington Department of Fish and Wildlife (WDFW) has identified three of the species as invasive. The remaining four non-native tunicates represent a lesser threat of becoming invasive. P.44

Industry Coordination

Because the increased introduction of new invasive species is mainly a human-made problem, a variety of industry sectors play an important role in preventing invasive species from entering Washington's ecosystems. The significance of industry lies in its role as a pathway for invading species to enter the state and to spread to new locations. Invasive species hitch a ride on the hulls of ships coming into Puget Sound and in their ballast water. They may hide in a beautiful ornamental bush purchased for a home garden or the bush itself may be invasive. Fortunately, many industries are working with state and federal agencies and non-governmental organizations to develop regulations, practices, and incentives that reduce their potential to be an invasive species carrier. P.46

Invaders at the Gate

Washington Invasive Species Council

2008 Strategic Plan

Washington pays a substantial price for co-existing with invasive species. We live, work, and recreate among marauding plants, animals ,and organisms that damage our waters, farms, forests, natural areas and fisheries.

PHOTOS ON COVER

Grass behind gate - *Phragmites australis* (Source: Washington Noxious Weed Control Board)

English Ivy - *Hedera helix L.*

Caterpillar - Asian Gypsy Moth, *Lymantria dispar* (Source: Washington Department of Agriculture, see sidebar on p. 23)

Nutria - (Source: Washington Department of Fish and Wildlife)

Zebra Mussel - (Source: Washington Department of Fish and Wildlife, see sidebar on p. 48)

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Acknowlegements

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"Critical Connection" Presentations at Council Meetings

Tom Fitzsimmons, Office of the Governor; Doug Sutherland, Commissioner of Public Lands; Washington Senator Ken Jacobsen; Joan Cabreza, Aquatic Nuisance Species Committee; Ron Shultz, Ballast Water Work Group; Dr. Brad White, Western Regional Plant Council; Lori Williams, National Invasive Species Council; Sara Crumb, representing Congressman Norm Dicks; Lynn Helbrecht, Biodiversity Council; Steve McGonigal, Washington Noxious Weed Control Board; John Mankowski, Office of the Governor; Kristin Rowe-Finkbeiner, Washington Invasive Species Coalition; Laura Johnson, Recreation and Conservation Office; Dr. Ron Sequeira, U.S. Department of Agriculture's Animal and Plant Health Inspection Service; Steven Phillips, 100th Meridian Initiative; Allen Pleus, Washington Department of Fish and Wildlife - Ballast Water Work Group and Columbia River Basin Zebra/Quagga Mussel Response Plan; William Brookreson, Washington Noxious Weed Funding Report; Amy Ferriter, Idaho Invasive Species Council; Mark Sytsma, Oregon Invasive Species Council.

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Executive Summary

Invaders at the Gate

Washington, the Evergreen State, is known for its lush, environmentally diverse landscapes. From the state's ocean beaches, to its forests, to its grassy prairies, Washington is home to thousands of different plant and animal species. Among the 50 states it ranks in the top 15 for diversity of native species plants, animals, and birds.[1]

Be it an orange-toothed rodent, a long-horned beetle, or a purple-flowered plant, invading species of all kinds cross state borders or expand their presence into Washington every day. They come as the result of migration, deliberate introduction, and, very often, by chance. When invaders do make it past the front gate, they can bring unintended consequences. They can decimate native species and quickly degrade ecosystems. Animal and plant invaders – those already past the front gate and others trying to get through – have the potential to change the face of Washington, forever.

Invasive species are a threat to Washington's environment and economy, exacting a high price for their presence. These biological invasions can produce serious, often irreversible effects on agriculture, recreation, and natural resources. While not all non-native species have aggressive traits, the sheer number of these species coming through our gates is increasing at an alarming rate. There are more than 650 non-native plant species documented in Washington.[2] This figure represents only a fraction of the total number of non-native species present in the state. Because of the devastating effect on Washington's plant, animal, and economy by some of these invaders, Washington citizens pay millions of dollars each year to prevent, control, and eradicate invasive species.

Washington has several programs that have received national recognition for combating the negative effects of invasive species. However, the state lacks fundamental information such as: important resources at risk, invasive species distribution, the extent of infestations, and the amount spent by agencies and programs. Furthermore, no comprehensive data have ever been compiled to present a broad picture of the invasive species problem or the degree to which the

[1] Bruce A. Stein. 2002. States of the Union: Ranking America's Biodiversity. Arlington, Virginia: NatureServe.
[2] Rice, P.M. INVADERS Database System (http://invader.dbs.umt.edu). Division of Biological Sciences, University of Montana, Missoula, MT 59812-4824.

state's current programs are managing the problem. To strengthen the state's invasive species efforts and make sound future decisions, we need this kind of fundamental information.

Call to Action

The Washington Invasive Species Council's mission is to provide policy direction, planning, and coordination to empower those entities engaged in the prevention, detection, and eradication of invasive species. The council developed the plan through a collaborative process involving five work groups composed of experts from around the state, an informal survey of organizations involved with invasive species programs, individual interviews, and comments from the public.

The plan presents 22 recommendations with specific action items covering the next 20 years. The five, short-term (3 years) priority recommendations for implementation are:

1. Compile existing information and conduct a baseline assessment of invasive species information and programs in Washington.
2. Develop a Web-based clearinghouse as the interchange for all existing invasive species information statewide.
3. Support targeted outreach campaigns to raise awareness of the potential damage caused by invasive species.
4. Facilitate and improve communication, accessibility of tools, and coordinated approaches across all organizations.
5. Improve agencies' access to emergency funding and develop an early detection and rapid response network.

The council recognizes that building and enhancing systems for interagency and partner coordination require time and money. Accordingly, the council crafted long-term recommendations for implementation during the next 20 years. Included among those recommendations are:

- Determine invasive species pathways (means of entry) that lack defenses and address the gaps.
- Assess current laws regarding invasive species and make recommendations for progressive legislation.
- Use risk analysis and economic models to prioritize the activities used for invasive species management.
- Improve efficiencies in spending on the control and eradication of invasive species across state, federal, and local agencies.

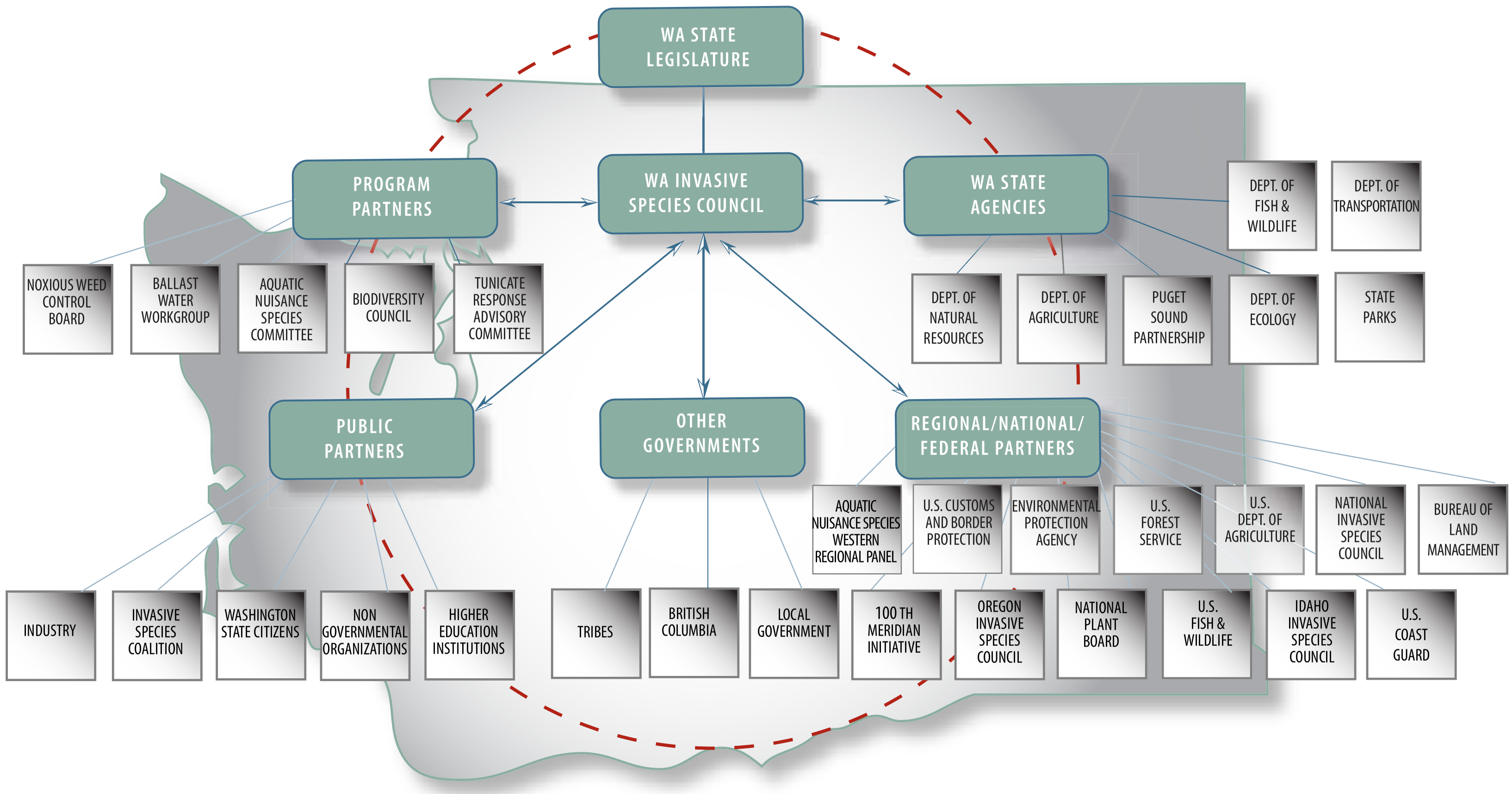
Future efforts related to quantifying and managing Washington's invasive species problem will be demanding. The council is developing a three-year work schedule that will focus on how it and its critical partners can implement the recommendations and actions.

It will not be possible to prevent all invasive species from entering Washington, nor to completely eradicate those already here. However, Washington can and must significantly decrease the myriad of economic, environmental, and human health impacts posed by invasive species.

The responsibility to prevent new introductions and control the spread of existing invaders does not belong to any one industry, organization, or person but rather to all residents of Washington. This statewide plan is just the beginning; the road to a strategic and unified approach to stopping these invaders at the gate lies ahead. The council's bold, yet achievable plan contains specific actions that will minimize the adverse effects of invasive species as they will help sustain Washington's human, plant, and animal communities as well as its thriving economy.

This statewide plan is just the beginning; the road to a strategic and unified approach to stopping these invaders at the gate lies ahead.

Fostering Cooperation



This is not a comprehensive list of entities for coordination, but lists examples of coordination opportunities and current efforts.

Invaders at the Gate: Understanding Washington State's Invasive Species Problem

In Washington, most people are completely unaware of the threat of invasive species. What they see are lush landscapes and abundant wildlife. They might not recognize as dangerous, the invading prolific plants, adaptable animals, and microscopic organisms that can transform the physical world, and put Washington's biological richness and diversity at risk.

Roughly 50,000 non-indigenous species in the United States cause major environmental damage and losses totaling about $137 billion each year.[3] Battling these invaders, Washington State spends, by conservative estimates, nearly $30 million every biennium to prevent or eliminate invading species.[4]

Jurisdictional boundaries do not stop invasive species from crossing the state's border or migrating from other countries. It's critical that the state's natural resources agencies and their partners act deliberately and cohesively to stem the threat of existing invaders, prevent the introduction of new invasive species, and ensure the viability of native species.

Purple Loosestrife

PHOTO COURTESY OF
NOXIOUS WEED CONTROL BOARD

Invasive Species Defined

The legislation establishing the Washington Invasive Species Council defines invasive species as "non-native organisms that cause economic or environmental harm and are capable of spreading to new areas of the state. Invasive species do not include domestic livestock, intentionally planted agronomic crops, or harmless exotic organisms."

Invaders at the gate

Purple loosestrife *(Lythrum salicaria)*, is a plant species that was deliberately introduced to the United States for its purported medicinal and ornamental value. Recognized today as a noxious weed, purple loosestrife invades Washington wetlands and quickly overtakes other species, such as cattail, that provide better food and nesting habitat for birds, bog turtles, mink, and muskrat.

A plant with purplish blossoms, this species probably was introduced to Grant County's Winchester Wasteway in the early 1960s. By 1989, it was estimated that purple loosestrife infested as much as 25,000 acres of the Winchester Wasteway. A coalition of agencies, including the U.S. Bureau of Reclamation, Washington Department of Fish and Wildlife, Washington Department of Agriculture, Washington State University, Grant County Noxious Weed Control Board, and others released three insect species on the Winchester Wasteway to biologically suppress purple loosestrife. Leaf-feeding beetles (*Galerucella calmariensis* and *G. pusilla*) decimated the population. Unfortunately, the eradication of one noxious weed left a void. A small population of an invasive strain of grass, known as *Phragmites australis*, spread rapidly. Today, several thousand acres of the Winchester Wasteway are infested by *Phragmites*.
(See page 60 for a case study on *Phragmites*.)

[3] David Pimentel, Lori Lach, Rodolfo Zuniga, and Doug Morrison BioScience, Vol. 50, No. 1 (Jan., 2000), pp. 53-65
[4] Washington Noxious Weed Funding Report, Washington Invasive Species Council, December 2007. Washington Invasive Species Council, Questionnaire Results, August, 2007.

Invaders come in all taxonomic kingdoms and include animals (mammals, reptiles, insects, and fish), plants, fungi, protista (molds, algae), and monera (bacteria and viruses). Upon its introduction to a new area, an invasive species may spread readily and rapidly if it lacks natural predators or grazers (in the case of plants) and if there are no competitive species or diseases to keep them in check.

In Harm's Way: The Economy, Environment, and Human Health

As several cases studies in this report show, established invasive species can and do harm the economy, environment, natural resources, and the health of humans and livestock. Across private and public sectors, scientists, government officials, industry leaders, and land managers now recognize the serious threat to the environment from invasive species. In the United States, about 400 of the 958 species listed under the Endangered Species Act as threatened or endangered are considered at risk primarily because of competition with and predation by non-indigenous species.[6]

Invaders at the gate

European crane fly

PHOTO COURTESY OF ERIC LAGASA, WASHINGTON DEPARTMENT OF AGRICULTURE, BUGWOOD.ORG

European crane fly or *Tipula paludosa* is a turf and pasture pest that as an adult looks much like an oversized mosquito. The larvae of this fly causes damage to native plants by feeding on roots of turf grass, seedlings, vegetables, and small fruit crops. The damage larvae does to grass, vegetables, and crops becomes apparent in the spring when larvae – 1.5 to 2 inch, worm-like creatures – feed on the host material. After the adults emerge, mate and lay eggs, the new larvae remains in a non-feeding pupae stage between June and August. Then, in the fall, eggs hatch and the larvae begin feeding, again.

In western Washington, the economic costs associated with controlling the crane fly by private homeowner-applied pesticides reached more than $12.8 million, according to a 1999 survey estimate; the cost to control the fly by commercial property landscape managers, golf courses, and others may be several times more.[1] In addition, the environmental effects from controlling crane fly using diazinon-based pesticide products contributed to urban stream contamination in the 1990s, making the chemical no longer usable. As private homeowners and lawns are concerned, spring is the best time for controlling the crane fly. Power raking or aerating the lawn has been shown to cut and destroy quite a few of these insects, and often eliminates the need for spraying.

[1] *Economic and Environmental Costs of Invasive Species in Washington State.* Washigton State Department of Agriculture, p. 24.

[6] David Pimentel, Lori Lach, Rodolfo Zuniga and Doug Morrison BioScience, Vol. 50, No. 1 (Jan., 2000), pp. 53-65.

For centuries, species too numerous to quantify have traveled with us to all parts of the globe. As our population has grown, become more mobile, and developed ever more sophisticated and rapid means of transportation, the rate of invasion by harmful species also has grown. Unwanted species enter the state in any number of ways, along what are known as pathways, including:

- Importation of seeds, plants, fruits, and vegetables.
- Ballast water discharged from ships.
- Soil brought in with nursery stock.
- Hulls of boats, which often are encrusted with aquatic species.
- Traveler's clothes or shoes.
- Cars and airplanes.
- Solid waste and soil dumped as fill into wetlands.
- People who abandon unwanted pets and ornamental plants. Owners of non-native species, such as exotic fish and snakes have been known to release them "into the wild."
- Internet sales of plants and animals.

Washington pays a substantial price for co-existing with invasive species. We live, work, and recreate among marauding plants, animals, and organisms that damage our waters, farms, forests, natural areas, and fisheries. Invasive species are found in every type of ecosystem. The damage they inflict can be measured in lost revenue to the state's economy, especially when a particular species problem is not immediately addressed. The costs also appear as degraded landscapes, less viable habitat for native plants and animals, and lost biological diversity as native species are pushed to the brink of extinction. Other costs include reduced accessibility to recreation

Brazilian elodea

PHOTO COURTESY OF
THE DEPARTMENT OF ECOLOGY

Invaders at the gate

Brazilian elodea, *Egeria densa*, is a freshwater perennial plant that looks like a larger, more robust version of its native relative, *Elodea canadensis* (waterweed). Brazilian elodea has green serrated leaves that grow in whorls with tiny white flowers that float on the water's surface. The plant, once commonly found in pet stores and nurseries, is no longer sold in Washington. The Department of Ecology suspects that most invasions have occurred after people dumped aquarium contents into lakes. Listed as a state noxious weed, the invasive characteristics of this plant allow it to rapidly overtake freshwater lakes and streams. Its dense growth interferes with recreation, navigation, fishing, and wildlife habitat.

Brazilian elodea has infested 27 western Washington lakes. It was introduced into the Duck Lake Waterways System in Ocean Shores sometime in the early 1990s. At that time, lake residents and the City of Ocean Shores adopted a non-chemical approach to weed management. The city focused its efforts on stocking infested waters with sterile (triploid) grass carp – a plant-eating fish. Over time, lake residents also pulled weeds by hand and even invested in building their own mechanical harvesting machine to reduce the noxious weed problem. Still, Brazilian elodea continued to thrive and colonize much of the shallow waterway system, making it less usable. In 2005, residents and city staff began to explore the idea of using aquatic herbicides to manage the rampant growth. While Brazilian elodea is notoriously difficult to eradicate, aquatic herbicides can effectively control this species (a removal rate of up to 99 percent). In early 2007, city officials treated Duck Lake using two herbicides and by summer, the lake and its waterways were relatively free of Brazilian elodea. With the infestation under control, lakeside residents and the public were able to enjoy the lake for boating, swimming, and other recreation. In the future, the grass carp present in the lake may be able to stem new growth of Brazilian elodea. If not, judicious herbicide treatments should keep Brazilian elodea populations under control.

activities such as boating and hiking, adversely affected water power production, lower property values, and more. Additionally, some of the smallest, often microscopic invaders jeopardize the health of plants, animals, and people.

The following is not a complete list of harmful outcomes due to invasive species but rather a summary of the most serious threats they pose to the state, namely the economy, the environment, and human health.

Economic Damage

Invasive species threaten Washington's economy because they can damage and hinder many of the state's key exports and local industries. Seafood, agriculture, timber, hydro-electricity, water supply, and recreational industries are highly susceptible to the effects of invasive species. Washington is the top producer in the nation of 11 crops, including apples, cherries, pears, red raspberries, and hops. The health of these and other agricultural products are especially important to the economic well-being of the state.

Invasive species also have the potential to undermine Washington's ranking as a top seafood producer.[7] Washington seafood farms produce about 12 million pounds of fresh finfish annually. The state's oyster harvest alone produces about 8 million pounds each year and routinely ranks first or second by volume in the nation. Washington is the leading producer of farmed bivalve shellfish in the United States, generating an estimated $77 million in sales and accounting for 86 percent of the West Coast's production in 2000.[8] Such species as tunicates, the European green crab, the Japanese oyster drill, and various pathogens and parasites represent an ongoing threat to the state's aquaculture industry.

Disease spread by non-native vectors also threatens the state's wild fisheries. Washington's commercial fishing industry harvests nearly 3 billion pounds of fish and shellfish annually, worth more than $1.6 billion wholesale. This sector provides for roughly 10,000 jobs in greater Seattle and accounts for gross annual sales of more than $3.5 billion.[9]

If that were not enough, invasive species can contribute to the decline in property values. For example, lakeside properties have been known to command a lesser price if the lake is infested with plants that interfere with boating and swimming.

Washington's timber industry also is vulnerable to invaders. For example, white pine blister rust, introduced in Washington around 1910, killed off most of the state's western white pine trees. Today the western white pine is not used in commercial forestry, in spite of its excellent qualities.[10]

7 Washington Sea Grant Web site: http://wsg.washington.edu/mas/resources/shellfish.html
8 Washington Center for Trade and Economic Development Web site: http://www.choosewashington.com/industries/detail.asp?i=3
9 Washington Center for Trade and Economic Development Web site: http://www.choosewashington.com/industries/detail.asp?i=3
10 Karen Ripley, Forest Health Department, Washington Department of Natural Resources, personal communication, April 1, 2008.

Environmental Harm

Washington is one of the most biologically diverse states in the nation. Its lands are home to many species that engender the vitality of several ecosystems, from estuaries to conifer forests to interior sand dunes and deep marine waters. Washington boasts 341 birds species, 140 mammals species, more than 3,300 plant species, and 470 fish species. Fifty-three of these species are found nowhere else on earth.[11]

Exacerbating the Problem: Climate Change

Climate change worldwide is affecting habitats and the movements of plants and animals, including Washington's native habitats and biological diversity. In the coming century scientists project average annual temperatures in Washington will rise at a rate of .01 to 0.6 degrees Celsius (0.2 and 1.0 degrees Fahrenheit) every decade. Researchers also project that Pacific Northwest winters will be wetter and summers drier.[1]

Globally, spring events such as flowering, mating, and migration are occurring earlier than in years past and at an average rate of 2.3 days earlier every decade. These changes have profound effects on ecological systems and the potential to alter habitats. For example, many species will be forced to move in response to climate change; many already have moved to higher elevations or pole-ward in latitude at rates that correspond to warming trends. As climate changes, species will move in response to temperature constraints and changes in habitat, food availability, movements of predators or competitors, and new diseases and parasites.[2] This movement likely will exacerbate the problems caused by invasive species here and worldwide.

In addition, the expected change in sea levels will alter Washington's coast. For example, by 2050, Tacoma's sea level is projected to rise by about 15 inches, flooding existing habitat. Warmer water will allow warm-water fish species to expand their range and force cool- and cold-water fish species to contract theirs. Such events, potentially, would increase competition between non-native fish, such as smallmouth bass, and native salmon and trout species. Warmer temperatures also can result in insect outbreaks, damaging timber, crops, and garden plants. Already, some insect pests are expanding their ranges and others have increased from a two- to a one-year life cycle, resulting in more pest populations.[3]

In response, Washington recently completed the Interim Climate Change Adaptation Strategy,[4] which recognizes the likely increase in invasive species problems with changing climatic regimes and recommended the following actions to address them:

- The efforts of the Invasive Species Council to establish a statewide strategic plan and invasive species baseline should be supported and used as a foundation for future efforts to monitor and control pests detrimental to public health, the environment, and the agricultural sector of the state. (*Recommendation 2.1*)

- Develop strategies to respond to potential increases in undesirable exotic and invasive species, including triage strategies and rapid response to emerging circumstances. (*Recommendation 5.5*)

[1] Lawler J.J. and M. Mathias. 2007. *Climate Change and the Future of Biodiversity in Washington*. Report prepared for the Washington Biodiversity Council.
[2] Lawler J.J. and M. Mathias. 2007. *Climate Change and the Future of Biodiversity in Washington*. Report prepared for the Washington Biodiversity Council.
[3] Lawler J.J. and M. Mathias. 2007. *Climate Change and the Future of Biodiversity in Washington*. Report prepared for the Washington Biodiversity Council.
[4] http://www.ecy.wa.gov/climatechange/InterimReport/climate_08-C-PAWG.pdf

[11] *Washington Biodiversity Conservation Strategy: Sustaining Our Natural Heritage for Future Generations*, Washington Biodiversity Council, December, 2007, p. 19.

Invaders at the gate

Giant hogweed, *Heracleum mantegazzianum*, is a biennial plant that grows up to 20 feet tall and invades disturbed areas across the Pacific Northwest and northeast United States. Giant hogweed, native to Europe and Asia, arrived in the U.S. in the early 1900s as an ornamental plant. The plant is designated as a federal and state noxious weed because it produces sap that causes skin sensitivity to ultraviolet radiation and leads to blistering and severe burns. The weed's large stem is hollow with purple blotches and the pointed leaves grow up to 5 feet in width. The umbrella-shaped, white flowers can grow up to 2.5 feet in diameter.

Giant Hogweed

PHOTO COURTESY OF THE NOXIOUS WEED CONTROL BOARD

Giant hogweed invades a variety of habitats but prefers moist, disturbed soils such as riverbanks, ditches, and railroad right-of-ways. It is found in many western Washington counties and is listed as a Class A noxious weed, meaning the law mandates its control and removal. Eliminating young plants and seedlings is a matter of pulling weeds out from moist soils. Mature plants can be dug out, but great care must be taken to avoid getting sap on the skin. Mowing is not effective for controlling mature plants. Herbicides are an option, but consult with the local weed control board for specific recommendations. The public can help stamp out giant hogweed by reporting the new local infestations to county noxious weed control boards.

Invasive species often have a detrimental impact on native species. In the past 100 years, Washington has witnessed a dramatic loss of its native species.[12] Non-native species have been identified as a principal risk to seven of Washington's nine eco-regions.[13] The rapid spread of invasive species poses a threat to an estimated 25 percent of Washington's plant species.[14] Some 40 animal species, including 15 fish species and 10 plant species in Washington, are in danger of extinction and listed under the federal Endangered Species Act.[15]

Whether introduced deliberately or inadvertently, the invaders may out-compete native species for resources, prey upon them, reduce the resiliency of ecosystems, and change the local habitat. When established, a new species can alter fundamentally the ecology of an area. For example, dense stands of highly flammable cheat grass mature in late spring and summer, usually before native species enter summer and fall dormancy. Cheat grass, then, alters the time and occurrence of large fires; this consequence can negatively effect other plant and animal species.[16]

In water ecosystems, invasive species crowd out native species, reduce open water habitat and oxygen levels, and impact flood patterns. Invasive aquatic species also alter fish habitat, disturb sediment levels from increased erosion, alter stream temperatures, and change nutrient levels.

Sometimes the control measure applied to an invasive species can adversely affect the state's natural resources. Thus, it is not just the invading animals, plants, and pathogens that degrade the environment, but also the control or eradication methods (pesticides and mechanical removal) used to stem an infestation.

[12] Biodiversity and Invasive Species in Washington State, Washington Biodiversity Council, 2007.
[13] *State of Washington Natural Heritage Plan*, Washington State Department of Natural Resources, 2003.
[14] *Washington Biodiversity Conservation Strategy: Sustaining Our Natural Heritage for Future Generations*, Washington Biodiversity Council, December, 2007, p. 29.
[15] *Washington Biodiversity Status and Threats*, Washington Biodiversity Council, January 2007, p. 16.
[16] U.S. Department of Agriculture. Plant Fact Sheet/Guide Coordination: http://plant-materials.nrcsusda.gov/intranet/pfs.html.

Public Health Endangered

Not only do invasive species pose a risk to the state's environment and economy, they also directly and indirectly endanger the health of Washington residents. Throughout history, animal-borne diseases have afflicted people. We've seen the incidence of diseases caused by pathogens such as: Severe Acute Respiratory Syndrome (SARS), "Bird Flu" and West Nile Virus - occuring in the United States, and even Washington. In recent years, concentrated agricultural production, and shrinking borders between houses and wildlife habitat have increased the likelihood of transmission. Rapid global transportation also increases the risk of transmitting such diseases around the world and compounds the effects of public health crises.

People experience other impacts, such as allergies and infections, from invasive species such as foxglove, giant hogweed, fire ants, and tansy ragwort, which are toxic.

While the Invasive Species Council recognizes the serious threat to public health, the council is not mandated to directly monitor invasive organisms that infect and affect humans. The Washington Department of Health is the lead agency, providing technical assistance to local health departments, veterinarians, and the public about diseases transmitted to humans from animals.

Control and Eradication Is Costly

It takes years of diligent efforts to eliminate harmful, aggressive non-native species. Additionally, invasive species management on private and public lands – detection, control, eradication, monitoring, and rehabilitation strategies – is expensive. Control and eradication costs are rarely a one-time expense. Management costs alone sometimes exceed the total budgets of managing agencies. Hence, affected land can and does go untreated or inadequately restored. In some cases, the high cost of managing infested public lands may be passed on to the public through higher fees and taxes.

A report and survey of state agencies and universities conducted by the Washington Invasive Species Council yielded preliminary data that begins to illuminate the financial burden caused by invasive species:

- Washington state government agencies and academic institutions spend an estimated $28 million every biennium to control and prevent the spread of invasive species.[17]
- Between 1998 and 2007, state and federal agencies provided more than $14 million in funding for cordgrass *(Spartina)* eradication programs in Washington.[18]
- Private and government sources spend about $1 million annually to control Washington's Eurasian watermilfoil (*Myriophyllum spicatum*).[1]

[17] Washington Noxious Weed Funding Report, Washington Invasive Species Council, December 2007. Washington Invasive Species Council Questionnaire Results, August, 2007.
[18] *Economic and Environmental Costs of Invasive Species in Washington State*, Washington Department of Agriculture, p.18.
[19] *Economic and Environmental Costs of Invasive Species in Washington State*, Washington Department of Agriculture, p.16.

CASE STUDY IN PREVENTION

Viral Hemorrhagic Septicemia Virus

Background: *Viral Hemorrhagic Septicemia* (VHS) is a deadly fish virus and aquatic invasive species that can enter Washington State through multiple pathways. The virus attacks and weakens the blood vessels of fish; vessel breakage and severe blood loss ultimately cause death. Worldwide, VHS is considered one of the worst and deadliest diseases for finfish. In 1988, scientists first reported the North American genotype of the VHS virus (IVa strain) in spawning salmon in the Pacific Northwest. The virus is pervasive in Pacific herring and cod populations off the coast of Alaska, Canada, and Washington. The World Organization for Animal Health lists VHS virus as a reportable disease in that it causes significant fish kills.

Situation: A new and particularly deadly strain of VHS IVb, was identified from an isolate obtained in 2003 from Lake Saint Clair, one of the smallest of the Great Lakes in the upper Midwest. In 2005, the virus was identified as the cause for a large die-off of freshwater drum and other species in Lake Ontario. Since then, the new strain has been killing off freshwater fish in other parts of the Great Lakes region. This highly contagious fish pathogen is expanding its range and the number of species it can infect. The Washington Department of Fish and Wildlife estimates 42 species, including salmonids and all major sport fish in the state, are susceptible to VHS IVb. Presently, this strain is found only in freshwater, but it may well be viable in saltwater. (Other VHS strains survive and spread in marine waters.)

The VHS IVb virus is treated as an aquatic invasive species primarily because of the many possible pathways of introduction. One pathway is infected live bait, such as leeches harvested in the Great Lakes region. The virus, could be contained in the standing raw water of transported watercraft – bait and fish wells and ballast tanks of wakeboard boats and could easily cross the Washington border. In Wisconsin, officials approached the problem (a likely introduction by watercraft) by making it illegal to transfer lake or river water, contained in various craft and vessels, from one water body to another. They also prohibited the transfer of live bait used in one lake for use in another lake.

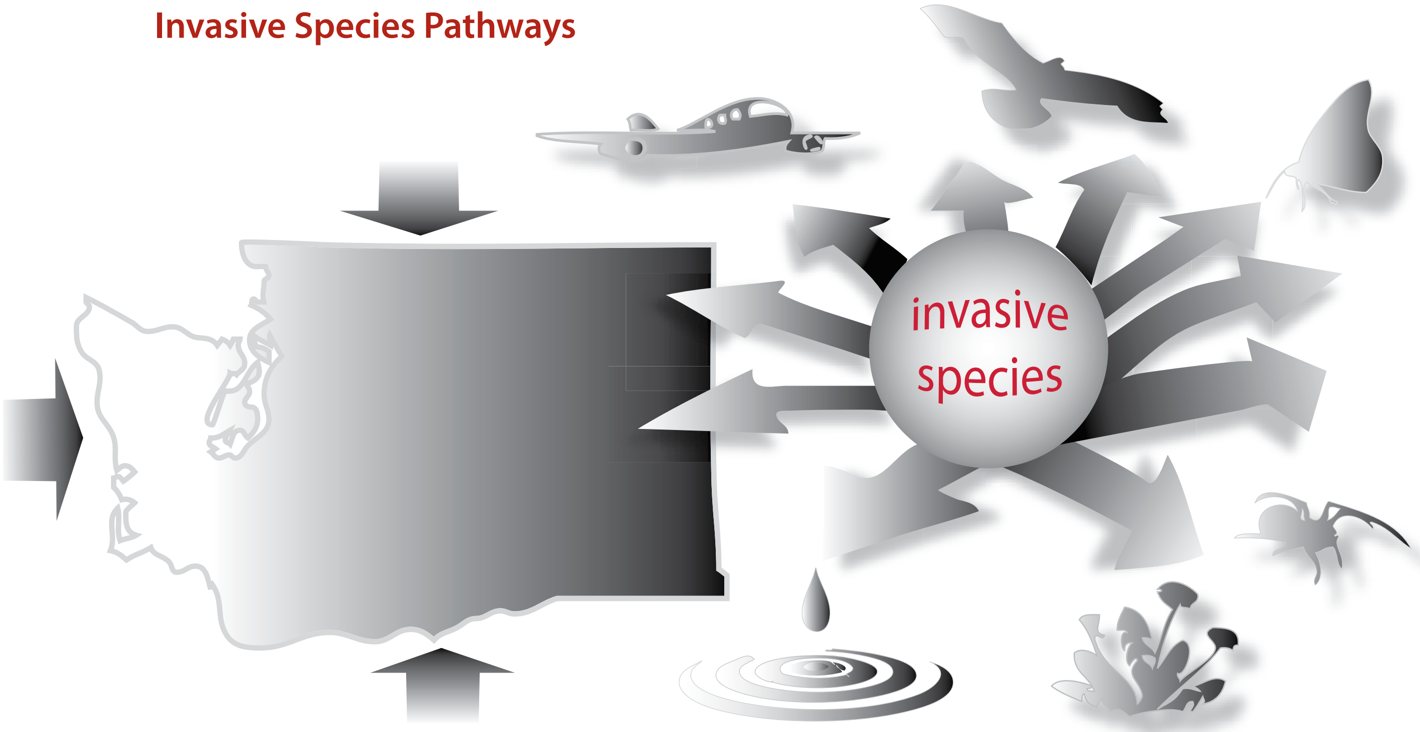
Conclusion: The new strain of VHS IVb is a resilient aquatic invasive species that causes disease in multiple species of fish, along with those fish from public and private aquaculture and hatcheries. Thwarting the pathogenic strain of this viral species – preventing its introduction to Washington – will require coordination across multiple disciplines. The Department of Fish and Wildlife has one of the best fish health systems in the nation. The agency already has instituted rigorous controls to keep the virus out of the state and private sector hatcheries. Additionally, the agency's recreational watercraft management plan monitors for the virus as part of the aquatic nuisance unit's prevention efforts against zebra and quagga mussel introductions. To get a better handle on the new strain of the virus, key regulatory agencies and partners need to further investigate bait pathway and other avenues of introduction. A coordination meeting (Fall 2008) is being planned between the state's Aquatic Nuisance Species Committee and the Pacific Northwest Fish Health Protection Committee.

PHOTO COURTESY OF JIM WINTON.

VHS virus attack on fish

PHOTO COURTESY OF GARTH TRAXLER.

Invasive Species Pathways



Transportation:
Air (planes, seaplanes, helicopters)
Water/aquatic (boat hulls, ballast water)
Land/terrestrial (cars, buses, ATVs, trains, subways, metros, monorails, construction and firefighting vehicles, hikers, horses, pets
Shipping (packing materials such as pallets and crates, containers interiors and exteriors, mail and internet)
Travel/Tourism/Recreation (humans, baggage/gear, pets, plants, food)

Living Industry Pathways:
Plants aquatic and terrestrial (importation of plants for research, includes seeds, bulbs, and roots, potting soils, plant trade such as agriculture, nursery and landscape)
Food (live seafood, plant and plant parts as food)
Non Food Animal Pathways (aquarium trade, animals for research, bait)
Nonliving animal and plant related pathways (frozen seafood, firewood, mulch, straw)

Miscellaneous Pathways:
Biocontrol (release of species to control another which then becomes invasive itself)
Interconnected waterways (freshwater canals, estuaries, domestic waste streams)
Natural Migration (ocean currents, wind patterns, migratory birds)
Ecosystem disturbance (logging, prescribed burning)
Garbage (landfill and transport of garbage)

Bolstering Washington's Defenses Against Invaders

The Washington Invasive Species Council's strategic plan is a vital first step towards a cohesive approach to managing the state's problem of invasive species. In 2006, the Legislature created the council through Engrossed Senate Substitute Bill 5385 and tasked it with improving statewide coordination to combat invasive species and the threat they represent to Washington's economy, environment, and natural resources.

The council's primary focus, and the purpose of this plan, is to foster strategic, unified, and coordinated approaches to minimize the detrimental effects of invasive species.

For resource agencies and their partners that already address the problem, the plan establishes clear priorities in coordination and information sharing; prevention, management, and eradication efforts; and education to increase awareness of the problem and its solutions. The plan defines actions intended to mend gaps in the state's defenses against invasive species. Interagency coordination, new partnerships, and opportunities to leverage existing revenue and secure new funds will help the council realize its overarching vision as stated in the following strategic goals:

1. **To foster cooperation, coordination, and communication among government agencies, stakeholders, land-managing agencies, private landowners, and tribes.**
2. **To prevent the introduction and establishment of invasive species and reduce their adverse impacts on Washington's environment, economy, and human health.**
3. **To refine and coordinate statewide capacity to identify, report, and respond to both newly discovered and existing invasive infestations.**
4. **To assist those who manage invasive species through containment, control, and eradication efforts.**
5. **To support the restoration and rehabilitation of key ecosystems adversely affected by invasive species.**

While the five goals embody the council's vision, the plan's recommendations and related actions describe the tools needed to bolster the state's current capabilities to control and manage invasive species. (Please note: Each goal is assigned a color and number. Each recommendation supports one or more goals, as indicated in the following pages.)

The recommendations represent short- and long-term initiatives and are a direct response to existing technical, funding, education, and regulatory obstacles that inhibit Washington's resource agencies from effectively battling a host of plant and animal invaders. The recommendations were developed in conjunction with a variety of organizations and industry sectors to address information voids, coordination gaps, funding issues, and technical constraints in this field of work. Feedback from stakeholder groups, a public comment process, and analyses by inter-agency work groups, enabled the council to craft nearly two dozen recommendations that will advance a cohesive, statewide strategy for managing invasive species.

Everyone living in Washington has a stake in reducing the harmful effects of invading plants and animals. Ultimately, the success of Washington's strategic plan to address this growing problem will hinge on the collaborative efforts of public agencies – and active participation by the public. The landowner, boater, gardener, consumer, traveler, and others all need to grasp the problem and support the necessary solutions to protect the state's valuable resources. The council realizes that education and outreach programs will become an important line of defense for invasive species prevention and control. Empowering individuals to assist resource agencies and conservationists may be the essential element in securing the passage of legislation and fighting invasive species on the ground.

Washington isn't starting from scratch. The council recognizes the significant work accomplished by both public and private agencies and organizations to minimize the effects of invasive species. For example, noxious weed control boards at the state and county level carry out programs that establish Washington as a national leader in the battle against invasive plants. Inter-agency committees and task forces routinely meet to address impending statewide threats as well as infestations of aquatic species, insects, and plants. By building on existing and successful models, the council and its partners hope to bolster the state's effectiveness in coping with invasive species.

To achieve the overarching goals, the council and its partners – by way of recommendations and related action items - have a clear road map to:

- Determine the breadth and depth of the invasive species threat in Washington.
- Establish clear, statewide priorities for the short- and long-term.
- Improve the state's capability to prevent new infestations and act quickly and decisively upon discovering new threats.
- Strengthen the state's overall control efforts for established species infestations.
- Communicate the gravity of invasive species and, in so doing change public opinion and behaviors, and alter the views of decision makers.

Recommendations

In the following section, 22 recommendations appear as short-and long-term initiatives. The short-term recommendations represent immediate priorities highlighted by council members and public participants. As budgets allow, the short-term recommendations will occur concurrently. The long-term recommendations and related actions cannot be accomplished in the next three years; however, the council expects progress will occur on several long-term measures.

Bullfrog *Rana catesbeiana* is native to central and eastern United States. This non-native frog was introduced to the western United States during trout stockings and also through the aquarium trade. Bullfrogs compete with and prey on native species.

PHOTO COURTESY OF THE NOXIOUS WEED CONTROL BOARD

Short-term Recommendations (0-3 years)

The council ranked the five short-term recommendations as its highest priorities. These recommendations, if implemented, would provide the foundation necessary for the council to meet its legislative mandate of facilitating more effective and efficient invasive species management in the state. Some short-term recommendations fit neatly with the council's legislative mandate. Other recommendations likely will be facilitated by the council with specific tasks (actions) accomplished by multiple partners. When the time comes to execute specific actions, the council and its partners will work closely to identify roles and responsibilities.

GOAL 3

To refine and coordinate statewide capacity to identify, report, and respond to both newly discovered and existing invasive infestations.

Problem Statement: Washington is fortunate to have programs in place to monitor and respond to many invasive species. However, there are many others for which there is little understanding of the nature and extent of the infestations and the necessary tools to address them. Without such knowledge it is difficult for the council, or others, to fully define the scope of the invasive species problem, as well as the state's capacity to measure its progress (through specifically implemented actions) to combat them. The council recommends compiling existing data on invasive species and programs into a geospatial data system. This kind of data system would pinpoint the location and spread of invasive species statewide, indicate those programs in place to address them, and inform decisions concerning new programs needed to combat problems. This information will provide the council, and others, with a statewide perspective on the nature and extent of the problem as well as a mechanism to measure progress in controlling them.

RECOMMENDATION NO. 1

Compile existing information and conduct a baseline assessment of invasive species information and programs in Washington. This baseline would serve as an initial step towards coordinating a statewide, strategic response to the threat of invasive species. The baseline will:

- ***Provide analysis of the worst invasive species in the state, the locations of the areas most affected, pathways, and resources most at risk.***
- ***Identify public and private efforts to prevent, control, or eradicate invasive species.***
- ***Inform public and private entities as it improves the state's ability to coordinate resources.***

Action 1.1 Develop council budget package, in coordination with partners, to compile existing information on species locations and programs in place.

Action 1.2 Work with partners to compile existing data.

Action 1.3 Perform functional gap analysis on state's capacity to address problem.

Action 1.4 Report back to council on necessary steps to address gaps.

Action 1.5 Develop a system and process to measure results of initial baseline assessment and update data to ensure invasive species programs and progress related to infestations can be analyzed.

GOAL 3

To refine and coordinate statewide capacity to identify, report, and respond to both newly discovered and existing invasive infestations.

Problem Statement: All too often, state agencies lack information to identify, respond to, or control invasive species infestations. While data and information exists on many Web sites and in agencies and universities, it is scattered as well as difficult to access or understand. The council recommends creating a Web-based clearinghouse to disseminate information on all aspects of invasive species management. As identified by many who commented during the council's public comment period, the clearinghouse would be an extremely useful tool for those involved in invasive species issues. The online clearinghouse would become a central hub of information including listings of known invasive species, potential funding sources, Web sites, risk assessments, control methods, and so forth all relating to invasive species work.

RECOMMENDATION NO. 2

Develop a Web-based information clearinghouse as the interchange for all existing invasive species information statewide.

Action 2.1 Develop a council budget package to support the development of the Web-based infrastructure necessary to house the clearinghouse.

Action 2.2 Form a team to implement consistent, basic reporting format and standards for data input and review all information for technical accuracy before launching the Web site.

Action 2.3 Working with partners, identify information and links to populate the clearinghouse.

Action 2.4 Create the framework for the Web site, including existing resource lists.

Action 2.5 Publicize clearinghouse and adaptively manage content.

GOAL 1

To foster cooperation, coordination, and communication among government agencies, stakeholders, land-managing agencies, private landowners, and tribes.

Problem Statement: Those on the front lines of invasive species battles realize bolstering public awareness of the problem and providing education will be the key in overcoming serious threats. Most people remain unaware of the effects of the state's invasive species. They do not realize that ordinary individuals play a role in the introduction and establishment of plant and animal invaders. But widespread knowledge and simple changes in behavior can prevent the spread of invasive species.

RECOMMENDATION NO. 3

Support targeted outreach campaigns to educate both public and private sectors on the damage caused by invasive species.

Action 3.1 Develop common message and speaking points for council members to use when discussing invasive species.

Action 3.2 Inventory and identify partners' most effective educational tools and dissemination tactics. Coordinate educational programs that are successful in the state and region.

Action 3.3 Encourage and leverage the participation of those in the private sector, academia, and the public to help with education.

Action 3.4 Coordinate with Oregon in interpreting results of Oregon Public Opinion Surveys and invasive species focus group work*.

* In a joint effort, Oregon Sea Grant, the Oregon Invasive Species Council, and Oregon Public Broadcasting conducted a statewide public opinion survey about invasive species and focus group interviews with boaters, hunters, gardeners, and others whose activities may put them in contact with plant or animal invaders.

GOAL 4

To assist those who manage invasive species through containment, control, and eradication efforts, and provide the necessary tools to respond.

Problem Statement: Managers need to respond quickly and efficiently to prevent the introduction and spread of invasive species. Precious time can be lost during the process of determining authority or funding, obtaining permits, and coordinating responses. In addition, managers may not have access to the tools needed to respond with the utmost effectiveness and least amount of environmental disturbance and cost. The council recommends enhancing communication channels to facilitate rapid responses, when needed, and better coordination.

RECOMMENDATION NO. 4

Increase and enhance communication across all entities to ensure coordinated approaches are supported and tools are accessible to address invasive species issues.

Action 4.1 Build capacity to address the threat of invasive species in the Puget Sound ecosystem by ensuring that the council's key strategies are integrated with the Puget Sound Partnership's 2020 Action Agenda[20] and into the science strategy that the Puget Sound Science Panel is developing.

Action 4.2 Ensure that new permits are available and processes expedited to enable quick responses for all likely control actions.

Action 4.3 Clarify jurisdiction and authority between federal, county, and state agencies to support coordination across boundaries.

Action 4.4 Bring together tribal and environmental protection entities, and state and local coordinators to develop a process for coordination.

[20] The Puget Sound Partnership is a community effort, engaging elected and public officials, tribal and business leaders, scientists, environmentalists, and, most importantly - citizens. The Action Agenda will be the roadmap to health for the Puget Sound. It will prioritize cleanup and improvement projects, coordinate federal, state, local, tribal, and private resources, and ensure that all entities are working cooperatively.

GOAL 2

To prevent the introduction and establishment of invasive species and reduce their adverse impacts on Washington's environment, economy, and human health through enhanced early detection and rapid response capabilities.

Problem Statement: Early action is critical to stop the introduction and spread of invasive species. Agency funds often are tied in statute to specific species and discretionary funds may be inadequate or limited in their use for early response. Limited communication also inhibits agencies from responding quickly.

RECOMMENDATION NO. 5

Enhance capacity to respond to invasive species by improving agencies' access to emergency funding and building on existing efforts to develop an interagency early detection and rapid response network.

Action 5.1 Establish a protocol and flowchart to support an early detection and rapid response network. Conduct tabletop exercises to enhance communications of the most efficient processes.

Action 5.2 Establish a state fund for emergency, rapid response.

Action 5.3 Identify existing emergency funds and enhance access to them.

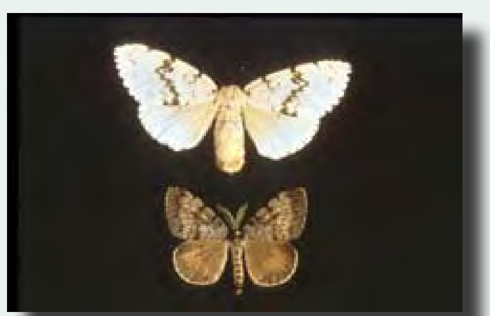
Action 5.4 Use existing early detection and rapid response network models to build a functioning, statewide system with enhanced capacity for detection, verification, assessment, planning, and response.

Long-term Recommendations (0-20 years)

The council intends to work concurrently on both short- and long-term recommendations in order to maximize the state's efforts to prevent, manage, and control invasive species. The council also recognizes that the complexity of the recommendations that follow will require more time to initiate and, ultimately, to accomplish. (Please note: The following recommendations are not listed in order of priority. Each goal is assigned a color and number. Each recommendation supports one or more goals as indicated in the following pages.)

The **Asian gypsy moth**, a relative of the European gypsy moth, entered the United States in 1992 in a shipment of grain. A massive effort by federal and state agencies apparently wiped most of them out. It is one of the most notorious pests of hardwood trees. Unlike its European cousin, the Asian gypsy moth (*Lymantria dispar*), defoliates conifers in addition to hardwoods, and spreads rapidly because the females can fly. The gypsy moth has established itself throughout the northeastern U.S. Small infestations occur sporadically in Utah, Oregon, Washington, California, and British Columbia. But when an infestation erupts, state and local agencies act and successfully eradicate the problem.

In the early 1990s, the United States Department of Agriculture estimated that if no suppression actions were taken, potential losses to recreation, tourism, and commercial forestry in western states could reach $3.5 billion dollars by 2040. The Washington Department of Agriculture spends between $900,000 and 1.2 million to survey and eradicate gypsy moth in Washington.



Gypsy Moth

PHOTOS COURTESY OF THE WASHINGTON DEPARTMENT OF AGRICULTURE

CASE STUDY

THE CASE FOR EARLY DETECTION AND RAPID RESPONSE

Cordgrass (*Spartina*)

Background: *Spartina alterniflora* is a fast-growing, rapidly-spreading perennial grass found in estuaries. Native to North America's Atlantic and Gulf coasts, the grass probably came to the West Coast in the late 19th century in shipments of oyster transplants that may have been packed in *Spartina*. Once established, *Spartina* or cordgrass is a strong competitor. The plants grow in tight clusters, or clones, that trap sediment and raise the elevation of the substrate. Left alone, *Spartina* clones eventually coalesce and grow together, forming a meadow of high marsh grass where once there were mud flats. The worst *Spartina* infestation is in Willapa Bay, arguably the most productive commercial oyster-producing area in Washington. Invasive cordgrass also has made inroads into Puget Sound, Grays Harbor, and rivers on the Olympic Peninsula. Uncontrolled, *Spartina* will crowd out native species, reduce biodiversity and alter wetland ecosystems. As a direct result of these events, invertebrates that live in mud flats disappear as their habitat is overgrown. In turn, food sources shrink for the birds that feed on invertebrates.

Situation: For decades, *Spartina* has threatened to overtake the inter-tidal mud flats and natural salt marshes of Willapa Bay. The bay provides habitat for thousands of shorebirds, waterfowl, and other animals. During spring and fall migrations, more than 100,000 shorebirds feed at Willapa, making the bay one of the top ten coastal habitats for shorebirds between Alaska and Mexico, according to The Nature Conservancy. In 1970, *Spartina* clearly had established itself in the bay and covered about 75 acres. By 1988, *Spartina* infested roughly 1,200 acres. In 2003, the peak of the infestation, more than 8,500 solid acres of *Spartina* covered 20,000-plus acres of the bay's intertidal zone.

The state and federal response to managing *Spartina* came slowly. Starting in the early 1990s – long after *Spartina* had been established – agencies began efforts to manage the noxious weed. Agencies (the state Departments of Natural Resources, Fish and Wildlife, Agriculture and the U.S. Fish and Wildlife Service) used mechanical, chemical, and biological techniques to control *Spartina*. Resource managers went forward without the certain knowledge of just how to kill the weed, let alone decimate more than 8,500 acres of cordgrass. In the early days, the control effort amounted to trial and error. In fact, techniques used to stem the

the invasion were inefficient and met with varying degrees of success. Some 15 years ago, field workers were applying herbicide (glyphosate) using small-scale tools, such as backpack sprayers; small crews of three to four people were using brush cutters to treat massive *Spartina* meadows. Boats were unable to travel across the mud flats so workers often were forced to walk great distances, in soupy mud, just to reach and treat *Spartina*.

Little by little, agencies developed more efficient and effective tools. They turned to airboats to traverse mud flats; high-pressure spray systems treated greater areas of infestation in a shorter amount of time; and a new herbicide, imazapyr, yielded better and more consistent results. With the new herbicide also came aerial (helicopter) treatment of huge *Spartina* meadows. For the first time, and in just one or two days, crews treated massive *Spartina* meadows in their entirety. After years of little progress, the control effort had begun to reduce the size of the infestation. Today the infestation totals about 1,000 acres of the 80,000-acre bay.

Conclusion: If state and federal agencies had begun treating *Spartina* in the 1970s when the grass covered a mere 75 acres of Willapa Bay, the cost of eradication would have been significantly less. And, if land managers had known then what they know today, field crews battling the infestation likely could have destroyed the noxious weed in a matter of weeks. Instead, stemming the *Spartina* problem took a full 10 years and a significant financial investment. To date, the price tag associated with eradicating *Spartina* from Willapa Bay is about $14 million. The lesson is clear: Despite agencies' lack of knowledge in how to best treat *Spartina* and inadequate early tools for stopping the infestation, a faster interagency response would have resulted in greater progress in less time and for less expense.

Cordgrass (*Spartina*)

PHOTO COURTESY OF WASHINGTON DEPARTMENT OF NATURAL RESOURCES

GOAL 2

To foster cooperation, coordination, and communication among government agencies, stakeholders, land-managing agencies, private land owners, and tribes.

Problem Statement: The council has observed a great willingness among agencies, stakeholders, and tribes to cooperate on invasive species management. Washington must take significant steps now to build upon this goodwill and ensure coordination occurs across larger biological, geographic, and political boundaries. The management of invasive species will be as effective as the combined and coordinated efforts of all responsible parties. Whether an invasive species has crossed a neighbor's fence, spread into the next watershed, or migrated to another county, solving the problem likely will involve coordination between land managers at the state, county, federal, and tribal government levels as well as private landowners.

RECOMMENDATION NO. 6

Coordinate with state and regional partners.

Action 6.1 Partner with Canada, Western Weed Coordinating Committee, [21] 100th Meridian Initiative, [22] vand the Western Regional Panel on Aquatic Nuisance Species. [23]

Action 6.2 Partner with Oregon and Idaho invasive species councils to share research results and leverage financial and staff resources.

Action 6.3 Work with state and regional partners, including the invasive species councils of Idaho and Oregon, to develop regional policy recommendations.

RECOMMENDATION NO. 7

Encourage and leverage the participation of those in business, academia, non-profit groups, and agencies who have invasive species expertise.

Action 7.1 Develop a structure for cooperative, shared resources, and joint responsibilities to initiate rapid response activities for specific invasive species and issues.

Action 7.2 Include and maintain stakeholder involvement when coordinating and prioritizing management efforts.

[21] The Western Weed Coordinating Committee is a voluntary organization designed to help coordinate noxious weed management programs and efforts among state and federal agencies.

[22] The 100th Meridian Initiative is a cooperative effort between state, provincial, and federal agencies to prevent the westward spread of zebra mussels and other aquatic nuisance species in North America.

[23] The Western Regional Panel on Aquatic Nuisance Species was formed in 1997 to help limit the introduction, spread and impacts of aquatic nuisance species into the western region of North America. This panel of public and private entities was formed by a provision in the National Invasive Species Act of 1996 (P.L. 101-636), the amendment to the 1990 Act.

Action 7.3 Encourage businesses to actively participate in invasive species prevention and detection.

Action 7.4 Support communications and coordination among land managers, researchers, and the Washington State University Cooperative Extension community; encourage a multi-disciplinary group to convene and discuss research needs and the development of new tools.

Action 7.5 Coordinate with the Washington Biodiversity Council, [24] Washington Aquatic Nuisance Species Committee, [25], and Washington Noxious Weed Control Board, [26] to ensure an efficient and effective approach to invasive species.

Action 7.6 Coordinate with the Puget Sound Partnership science panel [27] to help develop the capacity for invasive species monitoring and research in the Puget Sound region.

Action 7.7 Encourage strong working relationships with private landowners and organizations to form a voluntary program that leverages resources through grants as well as volunteer labor and expertise.

Action 7.8 Support research related to invasive species and climate change to better anticipate threats and strategically prevent their negative consequences.

RECOMMENDATION NO. 8

Build on existing efforts to develop, support, and implement an interagency, early detection and rapid response network that has the capacity to detect new infestations of invasive species, and rapidly contain or eradicate the infestations.

Action 8.1 Create a toll-free number and an electronic reporting system for people to report potential invasive species to the network.

Action 8.2 Establish an interagency task force to consolidate and coordinate resources to staff the network. Develop a memorandum of understanding that defines partners' roles and responsibilities and, in so doing, ensures successful responses to reported invasive species. Launch and publicize the network and conduct response test drills.

[24] Governor Chris Gregoire extended the Washington Biodiversity council until June 30, 2010 through Executive Order 08-02. The council is charged with coordinating implementation of early action items from the newly produced *Washington Biodiversity Conservation Strategy: Sustaining our Natural Heritage for Future Generations.*

[25] Created through Revised Code of Washington 77.60.130 the Aquatic Nuisance Species Committee fosters state, federal, tribal, and private cooperation on aquatic nuisance species issues.

[26] The Washington Noxious Weed Control Board advises the Washington Department of Agriculture about noxious weed control in Washington and serves as the state's noxious weed coordination center. Through its actions and policy decisions, it coordinates and supports the activities of the county noxious weed control boards and weed districts of Washington.

[27] The science panel's expertise and advice are critical to the Puget Sound Partnerships efforts to develop a comprehensive plan to restore Puget Sound.

Action 8.3 Increase the speed of notification to key resource agencies when a new invasive species is found. Create e-mail distribution lists to send notification of discoveries.

Action 8.4 Establish a group to develop rapid response authority for new threats from invasive species.

RECOMMENDATION NO. 9

Increase and enhance communication across all entities to ensure coordinated approaches are supported and tools are accessible to address invasive species issues.

Action 9.1 Support the development of new tools to manage invasive species, such as biological, cultural, chemical, and physical controls, through research and other means. Experiment with tools such as the Washington Biodiversity Council's Conservation Opportunity Framework[28] to determine their effectiveness.

Action 9.2 Have the Washington Invasive Species Council serve as the coordinating body on federal initiatives.

Action 9.3 Clarify tribal authority related to fee lands within reservations and boundary areas.

Action 9.4 Identify the council as the forum for voicing state preemption issues related to invasive species.

[28] The Washington Biodiversity Council invested in the development of a comprehensive set of maps, which assess the distribution of species, plant communities, ecological systems, and human population trends across the state, to identify regional opportunities for biodiversity conservation.

GOAL 2

To prevent new introductions, refine and coordinate statewide capacity to identify, report, and respond to both newly discovered and existing invasive species.

GOAL 5

To support the restoration and rehabilitation of key ecosystems adversely affected by invasive species.

Problem Statement: The state needs reliable information on emerging threats and new species arriving here, gathered through risk analyses. Without it, no intervention is likely to be either timely or successful. Early detection of new infestations requires vigilance and regular monitoring of managed areas and surrounding ecosystems. A prompt and coordinated response to a new species can reduce environmental and economic impacts at a lower financial cost, and result in less damage to the state's resources. Government agencies charged with protecting Washington's borders do an admirable job with the available resources. However, the state remains vulnerable to new threats. New invaders arrive and will continue to arrive in times of stagnating and fluctuating budgets. A cohesive, statewide strategy to identify new species and prevent their establishment will enhance the efforts of all groups and agencies working to maintain the biological health and richness of Washington. Stopping an invasive species – either before it reaches the state, or shortly after it arrives – is far less expensive than trying to remove the invader once it becomes established.

RECOMMENDATION NO. 10

Evaluate and recognize current methods for preventing the introduction and spread of invasive species.

Action 10.1 Encourage the use of invasive species management in habitat restoration projects.

Action 10.2 With partners, conduct analyses of current methods and practices for efficacy and cost-effectiveness. As necessary, strongly encourage the development and incorporation of new methods and practices to prevent the introduction of invasive species.

Action 10.3 Promote best management practices regarding the use of equipment and proper methods of decontamination when moving between sites.

RECOMMENDATION NO. 11

Compile and assess existing approaches to risk analysis and suggest a standard approach for use by state agencies. Expand the use of risk analyses to prepare for future threats.

Action 11.1 Convene scientific advisory panels to develop risk analyses for unexpected arrivals; expand the state risk analyses to include probable and potential changes in species and categories of organisms that enter the state, in part the result of global climate change.

Action 11.2 Recommend guidelines for state risk analysis documents.

Action 11.3 Make risk analyses from county, state, and regional partners available online (clearinghouse Web site, Recommendation No. 2).

RECOMMENDATION NO. 12

Conduct a gap analysis of entry pathways to identify those in need of greater protection.

Note: Invasive species arrive along pathways as diverse as ship ballast water, boat hulls, truck wheels and chassis, imported products, airplane holds, and recreational gear such as fishing waders.

Action 12.1 Work with partners to identify gaps in protection; close gaps in regulatory authority, funding, and other areas.

Action 12.2 Support the work of the U.S. Department of Agriculture's Animal and Plant Health Inspection Service, which conducts vital work related to importation pathways.

RECOMMENDATION NO. 13

Encourage the expansion of and emphasis on invasive species surveillance efforts.

Action 13.1 Conduct a gap analysis of existing surveillance efforts. Use the results from the pathway gap analysis (Recommendation No. 12) and the state risk analyses to focus surveillance efforts. Link results from all analyses to the clearinghouse Web site.

Action 13.2 Work with outdoor recreation groups to engage volunteers to detect invasive species. (The groups might include the Mountaineers, Audubon Society, and other associations.)

Action 13.3 Review successful models for ongoing surveillance, such as a natural history survey.

RECOMMENDATION NO. 14

Improve and expand diagnostic capabilities for specialists in the field including equipment.

Note: This is a universal issue for all specialties and levels of invasive species work.

Action 14.1 Build a database of taxonomic experts and make it available online. (Web clearinghouse, Recommendation No. 2).

Action 14.2 Train agency staff, volunteers, and private sector individuals associated with invasive species management programs to identify key species.

Action 14.3 Highlight the need for basic and applied research and support ongoing efforts through education and outreach.

RECOMMENDATION NO. 15

Use the concept of a scorecard to continue ongoing evaluations of management efforts. Such a scorecard would inform land and public resource managers and indicate the need for project enhancements to protect Washington from invasive species.

Action 15.1 In partnership with the Washington Biodiversity Council, develop a scorecard, start a peer review process to analyze the scorecard, and develop comprehensive biennial reports on the state's efforts to control, contain, and eradicate harmful invasive species.

Action 15.2 Monitor selected invasive species management projects to determine their effectiveness at reducing the size of infestations and the rate of spread.

Action 15.3 Assess all agency invasive species programs for effectiveness.

Action 15.4 Engage the research community to ensure ongoing research to support invasive species management efforts, based on gaps identified by the scorecard.

RECOMMENDATION NO. 16

Use risk analysis and economic models to prioritize the activities used for invasive species management.

Action 16.1 Conduct a comprehensive risk analysis for all invaders, based on existing information, and for the purpose of identifying priority species and focus areas.

Action 16.2 Research and develop appropriate economic models to inform prioritization actions.

RECOMMENDATION NO. 17

Consider the need for restoration in all invasive species management plans; take actions during project implementation to protect intact ecosystems and restore degraded ones.

Action 17.1 Build restoration funding into agency management plans and include long-term maintenance and monitoring activities, as appropriate.

Action 17.2 Compile information on restoration and rehabilitation efforts and build a history of successful restoration practices for placement on the council's clearinghouse Web site. (Recommendation No. 2)

Action 17.3 Partner with scientific organizations and academia to support and strengthen policies that incorporate the best available science for using native species in restoration. Topics for new and existing policies include establishment methods, species community relationships, genetic suitability, and site-specific information for proposed restoration plans.

Action 17.4 Encourage the development of state, county, or other municipality nurseries that specialize in wetland and native plants nurseries.

Yellow Starthistle

Centaurea solstitialis is a winter annual that can form dense impenetrable stands that displace desirable vegetation in natural areas, rangelands, and other places. Yellow starthistle interferes with livestock grazing and foraging in rangeland, pastures and grasslands. Dense infestations can displace native plants and animals, and threaten natural ecosystems.

PHOTO COURTESY OF THE NOXIOUS WEED CONTROL BOARD

GOAL 1

To foster cooperation, coordination, and communication among government agencies, stakeholders, land-managing agencies, private landowners, and tribes.

GOAL 5

To support the restoration and rehabilitation of key ecosystems adversely affected by invasive species.

Problem Statement: Public awareness and education is a large piece of the invasive species puzzle. As stated in the short-term recommendations, widespread public knowledge and simple changes in public behavior will help resource agencies and their partners control existing problems as well as prevent and stem new threats by invading plants and animals.

RECOMMENDATION NO. 18

Support educational and outreach materials that encourage the use of native species in restoration.

Action 18.1 Increase outreach to wholesale and retail nurseries on the need to promote desired native species and discourage the sale of non-native, invasive plants.

Action 18.2 Collaborate with groups such as native plant societies, master gardeners, state agencies, and universities to develop and distribute educational materials.

Action 18.3 Partner with state Department of Transportation and others to identify areas for viewing where landscape design and management techniques use native plants.

Action 18.4 Support research on native species suitable for restoration including plant species resistance to disease and insects, restoration and disturbance ecology, and behavior of intact and disturbed ecosystems.

RECOMMENDATION NO. 19

Support targeted outreach campaigns to educate both public and private sectors on the damage and potential harm caused by invasive species.

Action 19.1 Define user groups and enlist their help to identify specific targeted audiences for each user group (Examples of user groups include: pet and aquarium trade, plant importers, boaters, personal watercraft users, backcountry equestrians, all-terrain vehicle owners, etc.) Increase effectiveness by identifing potential educational overlaps between audiences and duplicative educational efforts.

Action 19.2 Coordinate a statewide, education outreach campaign with tools aimed at specified audiences. This will be a multifaceted education campaign that broadcasts clear and consistent messages related to invasive species work.

Action 19.3 Support the creation of a quarterly newsletter to provide managers and field staff with information on local and regional invasive species issues.

Butterfly Bush

Buddleia, a popular ornamental shrub with showy flowers, has more than 100 species and cultivars. It is widely established along roadsides (prolific along Interstate 5), natural areas and gardens throughout western Washington. The bush forms dense thickets, especially along river banks and river gravel bars, which then crowd out native vegetation.

PHOTO COURTESY OF TIM MILLER

GOAL 1 GOAL 4

To foster cooperation, coordination, and communication among government agencies, stakeholders, land-managing agencies, private landowners, and tribes.

To assist those who manage invasive species through containment, control, and eradication efforts.

Problem Statement: The state lacks adequate, stable funding on many invasive species fronts. More funding is needed for (1) early detection and rapid response; (2) programs to control and eradicate invasive plants and animals already in Washington; (3) monitoring, managing, and researching the problem at large; and (4) education and outreach efforts. The state also lacks dedicated, stable funding to enhance long-term invasive species programs.

RECOMMENDATION NO. 20

Develop consistent criteria to track invasive species funding and spending among state and local agencies and universities. Work with the Office of Financial Management and state agencies to track spending data to fully understand the amount of state revenue being spent to manage species threats; determine how the state and others spend existing invasive species funds; and inform future budget, planning, and implementation needs.

Action 20.1 Develop accurate and consistent language to define the project type (survey versus prevention or containment versus eradication) and clear, categorical definitions of invasive species work (such as vegetation management or invasive species control).

Action 20.2 Recommend an "invasive species control" budget line item for all land and resource management agencies. Encourage agency reporting on the use of this funding.

Action 20.3 Expand information on the state's spending related to invasive species and include federal, tribal, county, and non-governmental organizations. Use data from existing sources to track spending of non-state resources, such as federal and private grants.

RECOMMENDATION NO. 21

Improve efficiencies in spending across state, federal, and local agencies.

Action 21.1 Expand partnerships to control or manage invasive species across jurisdictional boundaries.

Action 21.2 Support the use of coordination success models such as coordinated weed management areas and regional coordination entities (For example, Western Regional Panel on Aquatic Nuisance Species, Western Weed Coordinating Committee, and the 100th Meridian Initiative.)

Action 21.3 Promote funding and legislative authority of the Washington Noxious Weed Control Board to help promote and enforce its programs.

Action 21.4 Encourage the development of an integrated, fiscal approach to invasive species management, one that seeks to link budgets across agencies responsible for managing invasive species.

Action 21.5 Encourage regional funding that targets specific invasive species.

Action 21.6 Increase funding and protect existing funding sources to state agencies for the prevention and control of invasive species.

Kudzu

Pueraria is the genus of more than 20 species of this high climbing, deciduous woody vine. In the southeastern United States, kudzu blankets forests, abandoned houses, and anything that might be in its path. Kudzu covers some 2 million acres across the southern United States alone. Kudzu was found in Washington's Clark County a few years ago; the county successfully eradicated the species, but it remains an impending threat to the state.

PHOTO COURTESY OF THE NOXIOUS WEED CONTROL BOARD

GOAL 1	**To foster cooperation, coordination, and communication among government agencies, stakeholders, land-managing agencies, private landowners, and tribes.**
GOAL 2	**To prevent new introductions and establishment of invasive species and reduce their adverse impacts on Washington's environment, economy, and human health.**
GOAL 3	**To refine and coordinate statement capacity to identify, report, and respond to both newly discovered and existing invasive infestations.**
GOAL 4	**To assist those who manage invasive species through containment, control, and eradication efforts.**

Problem Statement: Washington's invasive species regulations and management evolved during the past 125 years. Regulatory responsibility for invasive species management is assigned to agencies based on their legislative mandates. This fragmented approach to designating authority and assigning duties, ultimately, gave rise to a somewhat disjointed system for managing and funding invasive species. When a new invasive species arrives, it is sometimes unclear where the primary responsibility for response rests. Even when regulatory authority is clear, an agency poised to take action may lack flexible funding with which to tackle the problem.

In the past decade, the Legislature passed several bills to help agencies tackle invasive animals. However, funding occurs in a piecemeal fashion, and often is tied to commodity and pathway-based needs.[29] The state's management efforts, funding levels, and regulations for invasive animals still lag behind those for invasive plants. (The Washington Noxious Weed Board and numerous county weed boards and districts have long-time programs and regulations for managing invasive plants.)

The council has identified the following barriers to effectively manage invasive species:

- **Competing Priorities.** Agencies with legal authority to manage invasive species often have other funding mandates that hinder their ability to regulate or manage an infestation as needed.

- **After-the-fact regulations.** Regulations and specific control mechanisms tend to be introduced well after a species is established. Regulations are not being developed with the next crisis in mind.

[29] Pathway: The means by which species are transported from one location to another, National Invasive Species Council definition.

- **Regulatory obstacles.** Regulations pertaining to valuable natural resources encourage thoughtful and methodical planning before actions are taken. In the case of a new species threat, planning, and acting usually occur together. Environmental regulations tend to lack emergency clauses that would enable resource managers to swiftly address a new threat.
- **Species control versus pathway restrictions.** Usually, resource managers aim prevention and management efforts at controlling unwanted species rather than closing off particular pathways. Preventing the introduction of any number of species by managing the avenues by which they enter the state is far more desirable.

RECOMMENDATION NO. 22

Assess current invasive species laws and authorities. Recommend legislation to address gaps and overlaps, especially for non-plant species.

Action 22.1 Support and strengthen enforcement of state laws and quarantine lists.

Action 22.2 Strengthen current state regulations that safeguard against invasive species introductions and spread.

Hydrilla

Hydrilla verticillata is an aquatic plant found in freshwater habitats such as canals, springs, streams, ponds, lakes, and rivers. This underwater perennial spreads rapidly, displacing native species and interrupting patterns of natural water movement. A hydrilla infestation is an impending threat to Washington.

PHOTO COURTESY OF THE NOXIOUS WEED CONTROL BOARD

Assets to Build Upon

Washington has many organizations, both public and private, which are actively working to minimize the effects of invasive species. What follows is not a comprehensive analysis of current programs but highlights some of the activities occurring within the state.

Regulatory Efforts

State and federal agencies administer and enforce a growing body of laws to address the problem of invasive species. These laws primarily allow for management of existing populations of invasive species or seek to prevent species introduction through known pathways. The laws also establish regulatory structures and grant programs.

Regulatory agencies that manage invasive species have identification lists. For example, the Noxious Weed Control Board, the Department of Agriculture, and the Department of Fish and Wildlife have compiled lists of invasive weeds and animals that are regulated. The Aquatic Nuisance Species Committee has a list of invasive aquatic species that could pose problems in the state.[30] In addition, numerous statutes govern the management activities for controlling and eradicating invasive species. (The table in the appendix lists laws, statutes, agencies, and their roles, affected industry sectors, and species under each agency's jurisdiction.)

Local Weed Control

Washington is fortunate that its Legislature established model invasive species regulations decades ago for management of agricultural weeds. These laws set up a state noxious weed board, county noxious weed control boards, and local weed districts to deal with weeds. These laws also established a system for prioritizing resources by classifying weeds for management based on their distribution within the state. As a result, today's state and county weed jurisdictions have the regulations, infrastructure, and funding to deal with invasive plants.

Not all county weed boards are equal in terms of funding – some counties devote more resources to their local weed programs than others. Not surprisingly, well-funded local programs are more effective in ensuring landowner compliance with weed laws.

Many states consider Washington's weed laws as a model for the rest of the nation. During the past 25 years, the Noxious Weed Control Board has expanded its weed list to include not just weeds threatening agriculture, but weeds that affect all lands including, natural areas such as wetlands, lakes, stream banks, and forests. The Washington 2008 noxious weed list includes 135 weeds.

[30] Noxious Weed Lists are available at; http://www.nwcb.wa.gov/weed_list/weed_list.htm , Washington Department of Agriculture Plant Quarantine list: http://agr.wa.gov/PlantsInsects/PlantQuarantines/PlantQuarantines.htm, Washington Department of Fish and Wildlife prohibited species lists: http://wdfw.wa.gov/fish/ans/identify/index.htm, Washington Aquatic Nuisance Species Watch List: http://www.weedcenter.org/inv_plant_info/wa_aquatic_watch.pdf.

About the State Noxious Weed Control Board

Decades ago, Washington established invasive species regulations for the management of agricultural weeds. As a result, Washington has well designed and long-standing noxious weed control laws that are considered a very progressive approach to invasive plant control by others in the nation. During the past 25 years, the Noxious Weed Control Board (Weed Board) has expanded its weed list to include 135 weeds that primarily affect natural areas as well as those that harm agriculture. The Weed Board is responsible for overseeing Washington's noxious weed list (Revised Code of Washington 17.10) and also advises the Department of Agriculture regarding the state noxious weed program. It also coordinates and supports the 38 county weed boards and 11 weed districts that, in turn, enforce on-the-ground weed control. Additionally, the Weed Board promotes public awareness of noxious weeds and related laws through educational efforts

By definition, noxious weeds are invasive, non-native Washington species that are destructive to the state's agricultural and natural resources and difficult to control. The noxious weed list sets priorities for statewide weed management efforts by classifying weeds. Several western states have adopted Washington's weed classification system. There are three classes of noxious weeds:

Class A: Weeds of limited distribution in the state that are mandated for eradication (e.g. kudzu).

Class B: Weeds of limited distribution in some areas but of more widespread dispersal elsewhere in the state (e.g. Scotch broom). County boards or weed districts enforce landowners' weed management efforts. By law, landowners are required to prevent all seed set.

Class C: Weeds widespread throughout the state (e.g. English ivy). Although Class C weeds are too widespread to control at the state level, county boards have flexibility to select species for control. Many counties do not mandate control but do provide education on this class of noxious weeds and recommendations for control.

Each year, the weed board requests recommendations for additions and deletions to the weed list as well as classification or designation changes. Any Washington resident can suggest changes. A noxious weed committee is responsible for evaluating proposals. The committee researches and prepares written findings for each proposed addition. Each document detailing the findings includes standard information: plant description, economic importance, geographic distribution, habitat, response to various control methods, and the rationale for its listing. The Noxious Weed committee currently is doing a risk assessment to complement the written findings and better standardize the listing process.

Scotch Broom

PHOTO COURTESY OF THE NOXIOUS WEED CONTROL BOARD

Each year in the fall, the weed listing committee makes its new recommendations to the weed list. The weed board accepts or denies these recommendations following a public hearing. The proposed changes then move through the rule making process (Washington Administrative Code-16-750), resulting in a revised weed list. Once the weed board has adopted the revised weed list, each county board has 90 days (from that date) to adopt a county weed list. In other words, a county noxious weed board uses the revised weed list to develop its county weed list. It is up to landowners to control the listed weeds on their property; the local weed board is responsible for enforcing landowner compliance with the law.

County noxious weed control programs are variable in budget and staffing. Budgets are set by county authority. Unfortunately, that reality also leads to disparity between county program budgets. Many are well funded and have strong enforcement and educational programs. In counties that have fewer financial resources, other programs can take priority over weed control. The result can be a barebones weed control program, one capable of allocating more resources to educate than to enforcing the weed laws.

Coordination Efforts

Washington boasts many examples of successful, collaborative partnerships and projects. That said, opportunities exist for increased cooperation between state agencies, local governments, and stakeholder groups. Interviews, conducted by the council, with county coordinators and agency staff revealed that additional opportunities exist for cooperation in inspecting industrial plants, surveying nurseries, auditing big box stores, and investigating invasive species pathways. The remainder of this section provides a summary of existing coordination efforts across all jurisdictions.

Coordination Success Models

Cooperative Weed Management Areas are inter-agency agreements that cover properties owned or managed by multiple jurisdictions. Parties in an agreement combine resources to tackle a common invasive species, particularly when it crosses political boundaries. These management areas have proven to be effective mechanisms for engaging county, state, and federal agencies, tribes, and other organizations in collaborative efforts.

State noxious weed law (Revised Code of Washington, chapter 17.10) promotes coordination across the state through partnerships that occur between county weed boards, the Washington Noxious Weed Control Board, and the Washington Department of Agriculture. For example, *Spartina* and knotweed control and eradication projects demonstrate how cooperation between state, tribal, local, federal, and private entities has led to significant progress in managing invasive weeds.

Local and State Coordination

Stakeholder groups play an important and successful role in coordinating and prioritizing efforts for many invasive species management programs. The Washington Invasive Species Coalition, the nursery industry, and the Washington Noxious Weed Control Board cooperated to create Garden Wise, a public campaign aimed at promoting non-invasive ornamental alternatives to gardeners.

Invaders at the gate

European green crab or *Carcinus maenas* is a species that originated on the North and Baltic seacoasts. But over several decades, the green crab has invaded many coastal shores including both coasts of North America, South Africa, and Australia. Adult crabs measure about three inches across and have shells ranging from dark green with yellow markings to orange or red. This highly adaptable and resilient crab is able to survive in a wide range of temperatures and salinities. Biologists theorize that one major way the species spreads is as crab larvae that can travel up to five miles a day with the current. Other pathways of introduction include ballast water from incoming ships, bait buckets or boat wells from recreational boaters, and even seaweed packed lobsters. (Live lobsters are shipped to commercial markets in seaweed that may contain green crabs.)

Green crabs were sighted in Willapa Bay and Grays Harbor, Washington as well as the west coast of Vancouver Island in 1998 and 1999. This invasive species competes strongly with Dungeness crab for food and habitat. As small as the green crab is, the species is an efficient forager. It preys on numerous aquatic species, such as clams, oysters, mussels, and small crustaceans. Losses to Washington's crab, clam, and oyster fisheries have the potential to be vast. (The commercial Dungeness crab fishery has an annual average value of almost $20 million, according to data collected between 1990 and 2002. [1]) Since 1991, funding from the governor's office and the state Legislature has supported efforts to control and monitor the green crab. More than 100 monitoring sites and various control methods have kept down green crab populations in Washington. [2]

European green crab

PHOTO COURTESY OF WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

The Department of Fish and Wildlife has set trap lines for the green crabs in the northern most Washington estuaries. The trap lines will serve as an early detection device and enable the agency to respond rapidly to an invasion.

[1 & 2] *Economic and Environmental Costs of Invasive Species in Washington State*, Washington State Department of Agriculture, p. 27.

Garden Wise has proven to be very popular with the nursery industry and the public, with a total of 45,000 brochures distributed.

The Puget Sound Partnership is an important initiative focused on protecting and restoring the Puget Sound ecosystem. The partnership's 2020 Action Agenda is scheduled to be released in December 2008 and will address "marine and estuarine invaders that can upset the marine ecosystem, its biological health, and the region's economy." The partnership has indicated it also is concerned with terrestrial non-native species that can upset the region's ecosystem and can change critical habitat for salmon and other species in our rivers and streams. Coordinating with the partnership to achieve mutual goals and eliminate duplication of effort is a critical component of the council's strategic plan.

Another example of coordination involves public utility districts. For example, staff at the Priest Rapids dam, on the Columbia River are implementing a prevention plan for aquatic invasive species in coordination with the Department of Ecology's freshwater aquatic weed control program and the Department of Fish and Wildlife's aquatic nuisance species program. The prevention plan will focus on education by identifying boat access points and distributing materials during the peak boating season. It also will include plans for implementation, prevention, rapid response, and monitoring.

Within agency programs, coordination also is occurring. Housed within the Department of Fish and Wildlife, staff from the Washington Aquatic Invasive Species Program chair the Ballast Water Work Group and co-chair the Aquatic Nuisance Species Committee. This joint venture allows for inter-agency communication and coordination. Through this collaborative approach, the groups have developed a "Watch List" to help with the prevention and control of aquatic invasive species. The groups also assisted in the development of the Columbia River Basin Interagency Invasive Species Rapid Response Plan for zebra and quagga mussels, and are critical partners with the council.

University and College Coordination

Washington State University, University of Washington, and other state universities and colleges through their academic, research, and extension programs are essential to winning the battle against harmful invasive species. In coordination with the federal government, they operate federally-sponsored programs to provide specialized training, scientific research and on-the-ground assistance and technical expertise. Their work is beneficial to a broad spectrum of environments - agriculture, urban, estuarine and marine.

Tribal Coordination

Tribes have a historical and cultural tie to the land. As sovereign nations, they play an important role in managing invasive species and restoring natural ecosystem processes. Washington tribes contribute to invasive species management by controlling *Spartina*, knotweed, and purple loosestrife, as well as managing many other noxious weeds on their lands. The Jamestown S'klallam Tribe, for example, has used an Environmental Protection Agency grant to remove knotweed and butterfly bush infestations along the lower 8.5 miles of the Dungeness River. The Hoh River, Stillaguamish, and Tulalip Tribes, and others are involved in knotweed control through Coordinated Weed Management Area programs. The Chehalis Confederated Tribes have an active management program for Brazilian elodea and the Yakama Nation is working cooperatively with the Yakima Weed Control Board to eradicate parrotfeather milfoil from ponds associated with the Yakima River.

Coordination occurs between tribes, as well as among such groups as the Columbia River Inter-Tribal Fish Commission and the Northwest Indian Fisheries Commission. Tribal governments independently regulate their members' exercise of treaty rights within their usual and accustomed treaty areas, and co-manage treaties with the state resources in those areas. However, small tribes have few staff and little money to devote to the problem. The federal government has certain tribal trust responsibilities, so agencies such as the Bureau of Indian Affairs, Department of the Interior, and Department of Commerce can help tribes in managing invasive species.

Federal Government Coordination

A full 35 percent of Washington lands are managed by federal entities including the Forest Service, Fish and Wildlife Service, Bureau of Land Management, National Park Service, and the Bureau of Indian Affairs.[31] Coordination among federal agencies is important, and coordination between federal agencies and state and local governments is essential. This is particularly true in areas where state or private landowners share boundaries.

The Aquatic Nuisance Species Task Force coordinates between federal agencies, states, and stakeholders through regional panels and issue specific work groups. It implements the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, including the national ballast water management program. Its mission is to protect limited western aquatic resources by preventing the introduction and spread of exotic nuisance species; coordination of the management and research activities of state, tribal, federal, commercial, environmental, and research entities and other regional panels is the key to protecting western marine and freshwater systems.

[31] *Washington State Major Public Lands Map*, Washington State Department of Natural Resources, 2000.

CASE STUDY IN REGULATORY CONTROL

The Tunicate, *Didemnum sp.* (A colonial sea squirt)

Background. The tunicate, *Didemnum sp.*, is a sponge-like, invertebrate marine organism and prolific spawner. It lives in large, mat-like colonies and can rapidly invade new marine territories. Invasive tunicate colonies – comprising thousands of organisms – affix to underwater rock outcroppings, ship hulls and docks. Once established, invasive tunicates can displace most native organisms by out-competing them for food and space. Presently, seven non-native tunicate species, including *Didemnum sp.*, have been identified and are established in Puget Sound. The Washington Department of Fish and Wildlife (WDFW) has identified three of the species as invasive. The remaining four non-native tunicates represent a lesser threat of becoming invasive.

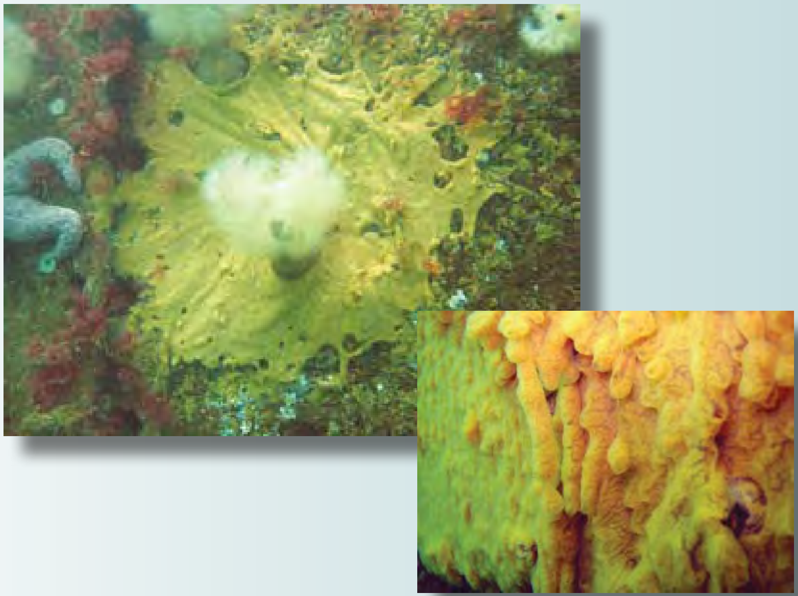
Situation. Currents spread tunicate larvae to different marine locations, including onto established mussel farms. While mussel growers do not contribute to the spread of tunicates through their seeding and planting processes, tunicate larvae can settle onto established mussel farms and proliferate; yet growers can do little to stop infestations.

This example demonstrates where control of an invasive species collides with existing (legal) activities in a manner that may have unintended consequences. WDFW has the authority to use its classification system to list the seven species of nonnative tunicates as "prohibited" and make their possession a crime.

However, for the shellfish industry, the legal issues related to tunicate possession by mussel growers are perplexing. If no adequate methods of tunicate eradication exist and there is no known method for preventing their free-swimming larvae from settling on the mussel farms, what can shellfish growers do to prevent being penalized for simple possession? The law does not allow discretion for situations such as this or for the designation of different classifications by water body. That means once a species is classified as prohibited in one water body, it's prohibited in all state water bodies. Many shellfish growers believe if and when tunicates are designated a prohibited species in Washington, quitting mussel farming will be the only way shellfish growers would be able to avoid possession of invasive tunicates.

Yet, the need to control this invasive species remains. Further, a "prohibited" classification would give WDFW more options to manage tunicates through broader enforcement actions, the designation of water bodies as infested, and rapid response actions.

Conclusion. WDFW has postponed classifying this species as "prohibited" pending further study. The agency is conducting baseline surveys to determine the extent of the current infestation as it carries out management actions to curb the spread of smaller populations. Later this year, the agency plans to review its laws pertaining to aquatic invasive species. In reviewing the laws, WDFW managers will determine how best to address regulatory issues and prepare a comprehensive plan for tunicate management. The agency plans to explore the classification model used by the Washington Noxious Weed Control Board.



The Tunicate, *Didemnum sp.*

PHOTOS COURTESY OF JANNA NICHOLS

Industry Coordination

Because the increased introduction of new invasive species is mainly a human-made problem, a variety of industry sectors play an important role in preventing invasive species from entering Washington's ecosystems. The significance of industry lies in its role as a pathway for invading species to enter the state and to spread to new locations. Invasive species hitch a ride on the hulls of ships coming into Puget Sound and in their ballast water. They may hide in a beautiful ornamental bush purchased for a home garden or the bush itself may be invasive. Fortunately, many industries are working with state and federal agencies and non-governmental organizations to develop regulations, practices, and incentives that reduce their potential to be an invasive species carrier.

Interstate and International Coordination

Because many harmful species hitchhike in packing materials and shipping containers, international coordination is essential. The issue of invasive species is global in nature and efforts to manage our borders likely will depend on more effective global strategies to manage pathways. Eleven major points of entry occur at Canadian border crossings. Also two of the nation's top ten ports of trade – the ports of Seattle and Tacoma – are points of entry for invasive species.

Federal agencies contributing greatly to inspections and risk assessment at border entries include Department of Homeland Security's Customs and Border Protection, Department of Agriculture's Animal Plant and Health Inspection Service, Fish and Wildlife Service, Coast Guard, and Puget Sound/Georgia Basin Taskforce. The U.S. Department of Agriculture works with our trading partners through the international Plant Protection Convention to prevent the introduction of invasive species along with agricultural commodities.

There are many important groups working on regional invasive species goals including the Western Regional Panel on Aquatic Nuisance Species, Pacific Northwest Invasive Plant Council, the Western Weed Coordinating Committee, Pacific Ballast Water Group, Aquatic Nuisance Species Task Force, and the 100th Meridian Initiative Columbia River Basin Team. A cross-section of agency representatives, many of whom are members of the Washington Invasive Species Council, serve on these groups. The council routinely discusses invasive species coordination efforts with the directors of the National Invasive Species Council, Idaho Invasive Species Council, and the Oregon Invasive Species Council.

The Oregon Invasive Species Council is leading a statewide public awareness, prevention and action campaign focused on invasive species, both aquatic and terrestrial. The one-year campaign was launched on Earth Day 2008. The Oregon council has agreed to share with the Washington Invasive Species Council information from a survey that would help establish baseline knowledge as well as interests and behaviors of resource users and stakeholders related to invasive species.

A number of groups coordinate efforts at the national level. For example, the National Plant Board is comprised of the plant pest regulatory agencies of each state and Puerto Rico. Its mission is to foster effective, efficient, and harmonized state programs; to act as an information clearinghouse for pest prevention and regulatory measures; and to encourage coordination and collaboration with federal and international agencies. The Washington Department of Agriculture Pest Program represents Washington on the National Plant Board.

The plant board system is composed of four regional plant boards as well as the National Plant Board. In addition, the directors of the state departments of agriculture also comprise the National Association of State Departments of Agriculture, which is a major vehicle for conveying state concerns about invasive species to federal agencies.

Economic Status and Analysis

In Washington, a picture of the total economic costs and budgets associated with managing invasive species is becoming clearer. By pulling together estimates of funds spent by state agencies and universities to manage invasive species, the council has attempted to quantify the scale of the economic effects of invasive species. Unfortunately, the spending data is incomplete and data collection methods are not consistent, making direct comparisons difficult. As a result, the state lacks a comprehensive perspective on the adequacy of existing agency funding to manage invasive species.

With a few exceptions, individual agencies develop their budgets to manage invasive species in isolation from each other, and miss opportunities to improve efficiency by working together. Part of this isolation results from differing roles – some state agencies serve as a landowner when dealing with invasive species and others regulate or have scientific research or public outreach roles. Varying roles can affect the source and amount of funding they receive and in which ways they administer it. Important research related to invasive species management receives funding through both agency and university budget appropriations, with little or no overall direction. While state spending on invasive species is significant, invading plants and animals continue to spread and new infestations continue to occur. How much spending is needed to fully address the problem is unclear at this point.


Zebra Mussel

CASE STUDY IN PREVENTION

The Zebra Mussel

Background: The zebra mussel, a thumbnail-sized mollusk, is a nuisance aquatic species found widely in the United States. Once introduced into lakes, rivers and saltwaters, it kills off native mollusks and competes with zooplankton for food, in turn, affecting natural food webs. Neither the zebra mussel, nor its close relative the quagga, have been found in Washington waters – yet. The species are widespread in 19 states including the Great Lakes area. Native to the Caspian and Black Seas, zebra mussels came to the U.S. in the mid-1980s through ballast water released from foreign ships. Along with the potential to do serious ecological damage, the mussel species have the ability to clog piping and mechanical systems of industrial plants, utilities, locks and dams. These mussels are hitchhikers, and easily transported on boats, trailers, and other recreational watercraft.

Zebra Mussel

Incident: This incident highlights the regional and international nature of invasive species and Washington's heightened concern for zebra and quagga mussels. On February 4, 2008, the Washington Department of Fish and Wildlife learned of a pleasure boat making its way overland from Lake Mead, Nevada to British Columbia, Canada. An employee with the U.S. Fish and Wildlife Service alerted Washington Fish and Wildlife to the fact that boat contaminated with quagga mussels had left Nevada.

One day earlier, a Canadian resident had flown to Nevada and purchased a boat moored in Lake Mead. The man rented a truck and U-haul to cart his 24-foot watercraft home. He left Lake Mead for British Columbia with a boat and an attached village of mussels in tow. While Nevada state regulations require boats to be decontaminated before leaving a marina, budget constraints and personnel shortages have hindered the enforcement of such laws.

PHOTOS COURTESY OF WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

At 9 p.m. February 3, a California Fish and Game inspector stationed at mandatory checkpoint, stopped the boat owner and his pack of quagga hitchhikers. The boat would have been hosed down here, but problems with the station's decontamination equipment prevented the inspector from cleaning the boat. Instead, the inspector allowed the Canadian resident to continue on his journey after securing his assurances that boat would be professionally decontaminated once he reached his destination. California made contact with the United States Fish and Wildlife Service, and employees there alerted Oregon and Washington.

Early February 4, employees of the Department of Fish and Wildlife learned the boat and its owner were headed north on Interstate-5 to the Washington border. After discussions with counterparts in British Columbia and Oregon, Washington Fish and Wildlife staff stepped into action. The Oregon State Patrol escorted the Canadian resident and boat from Oregon to the Port of Entry weigh station in Ridgefield, Washington.

Conclusion: Washington Fish and Wildlife employees inspected and decontaminated the boat at 4 p.m. February 4. As many as 10,000 juvenile quagga mussels were attached to the boat's trim tabs and lower unit. Most were less than one-eighth of an inch long and appeared alive. Crews hosed down the watercraft with a 140-degree hot water pressure washer and then cleaned with bleach. The owner received a certificate of inspection and decontamination before being allowed to proceed. Fish and Wildlife staff informed their British Columbia counterparts that the decontamination was completed. A British Columbia biologist performed a follow-up inspection at the owner's residence.

The quagga mussel incident demonstrates that an interagency and interstate coordination network is working to prevent the introduction of harmful invasive species. However, communication glitches need to be fixed and non-uniform regulatory and decontamination capacities must be resolved.

Agency and Academia Budgets

To determine how much money Washington state agencies and universities spend on invasive species management, the council drew from two sources. First, the council sent a questionnaire to key organizations and agencies working on invasive species projects. The survey included questions related to current projects conducted in the state, project budgets, and project purpose (See Table A). Second, the council used the State Noxious Weed Funding Report (commissioned by the council) [32] to learn about agencies' noxious weed management activities.

Eight state agencies and two universities provided information, which was used to arrive at the cost figures below. In many cases, the information was complete and in some cases respondents were unable to separate out direct and administrative costs. Nevertheless, the spending figures below offer the best information the council has on the statewide budget for invasive species management. In the future, the council hopes to improve the accuracy of the statewide spending figures by conducting additional surveys with refined definitions and collecting information from federal, tribal, and local governments.

It is important to realize that these are preliminary figures. A future baseline assessment of state spending will provide more thorough figures (See Recommendation No.1).

According to the questionnaire and State Noxious Weed Funding Report, Washington spends an estimated $28.4 million per biennium on invasive species prevention and control measures.

Washington Invasive Species Management, 05-07 Biennium Spending	Total: **$28,443,962**
State Agency Biennial Spending on Invasive Species [33]	**$21,294,455**
Academic Institution Biennial Invasive Species Spending [34]	**$7,149,507**

The council next looked at how the agencies spent their funds.[35] The breakdown of state spending by project purpose is shown in Table A and Figure 1. The data indicate that 47 percent of state spending on invasive species is for containment or control efforts, with much less spent on eradication or prevention.

[32] Washington State Noxious Weed Funding Report, Washington Invasive Species Council, December 2007.

[33] Washington State Department of Natural Resources, Washington Department of Fish and Wildlife, Washington Department of Transportation, Washington State Parks and Recreation Commission, Washington Department of Agriculture, Washington State Noxious Weed Control Board, Puget Sound Action Team, Washington Department of Ecology, Washington State Conservation Commission, Recreation and Conservation Office.

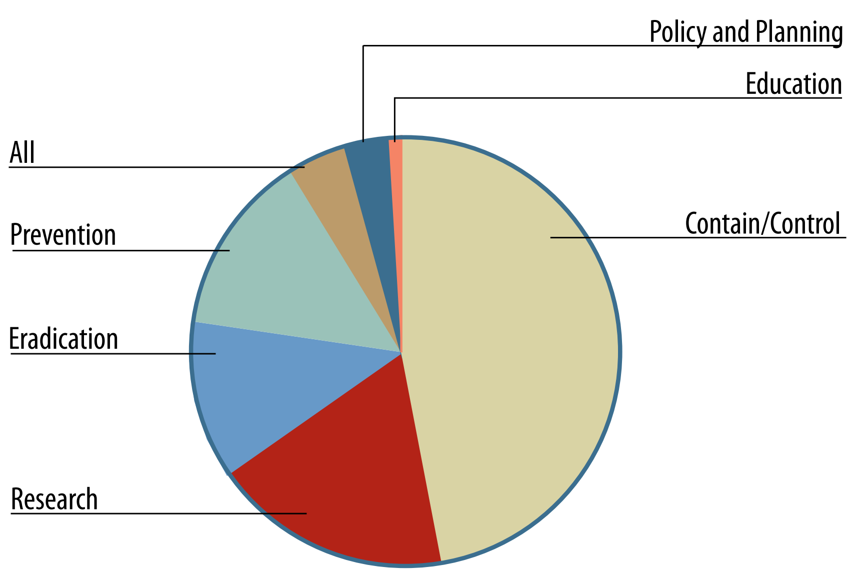
[34] Washington State University and Cooperative Extensions, University of Washington.

[35] Washington Noxious Weed Funding Report, Washington Invasive Species council, December 2007. Washington Invasive Species Council, Questionnaire Results, August, 2007. Using data from these sources, the Council grouped project costs into the seven categories listed in Table A.

Table A

PROJECT PURPOSE	BUDGET (Biennium)	PERCENT OF TOTAL
Contain/Control	$13,456,174	47.31
Research	$5,483,912	19.28
Eradication	$3,685,500	12.96
Prevention	$3,336,500	11.73
All [36]	$1,260,000	4.43
Policy and Planning	$1,060,764	3.73
Education	$161,112	0.57
TOTAL:	$28,443,962	100.00

Figure 1



Note: This is preliminary data

[36] "All" describes entities that associated contain, research, eradication, prevention, policy and planning, and education project purposes with their budget figures and could not be broken into individual categories.

CASE STUDY

AN INVASIVE SPECIES SUCCESS STORY IN EARLY DETECTION AND RAPID RESPONSE

Citrus Long-horned Beetle

Background: *Anoplophora chinensis* or the Citrus long-horned beetle is a serious tree pest native to Korea and China. The beetle, with its shiny, jet-black body and long blue-black antennae, is a lesser known but close relative of the tree-killing Asian long-horned beetle. Since the mid-1990s, Chicago and New York have battled urban infestations of Asian long-horned beetle for years, and spent millions of dollars to destroy infested trees.

Until the summer of 2001, the beetle genus had never been seen on the West Coast. As compared to its cousin, the Citrus long-horned beetle is able to endure a range of climates and produce a greater number of eggs. Females lay 200 eggs, each. Each egg is separately deposited into the bark of a tree. Beetle larvae hatch, tunnel into the heartwood and feed on the tree until they kill it. Both Asian and Citrus long-horned beetles can kill a variety of hardwood trees such as maples, oaks, willows, and poplars.

Incident: In early August 2001, a nursery discovered an unusual beetle in a shipment of bonsai trees imported from Korea. The owner took a captured beetle to the U.S. Department of Agriculture Plant Inspection Station at SeaTac Airport. A federal inspector recognized the beetle as a potential threat and alerted the Washington Department of Agriculture. State biologists, who responded within hours, discovered more beetles and isolated the source of the infestation. However, several beetles escaped into a neighboring greenbelt before all could be contained. A scientific advisory panel determined the Citrus long-horned beetle to be a great, if not greater risk than Asian long-horned beetle. If it became established in Tukwila, the insect could profoundly damage the environment and economy of not only the Pacific Northwest but also the whole of North America.

Citrus Long-horned beetle

PHOTO COURTESY OF ART WAGNER, USDA APHIS PPQ, BUGWOOD.ORG

Because of the beetle's year-long lifecycle, state and federal officials knew they had less than 12 months to plan and carry out an eradication project. It all had to be done before the next generation of beetles emerged and reproduced more widely in the greenbelt and residential area. Eradicating the potential invasive species amounted to cutting down several thousand susceptible trees into which the escaped beetles may have flown and laid eggs. Next, the immediate band of trees surrounding the cut zone received injections of a systemic pesticide to kill any beetles that escaped (however unlikely) during the tree-cutting phase. State agriculture officials also worried about the artificial spread of the beetle in firewood, tree prunings, and other wood debris. Officials placed a quarantine one-half mile outside the beetle introduction site prohibiting Tukwila residents from moving beetle host material (wood, prunings).

The Department of Agriculture launched an education campaign to explain the necessity of the eradication project. Outreach activities included open house meetings, newsletter mailings, and a monthly yard waste disposal day so that residents living in the quarantine area could bring their tree prunings to a chipping site for removal. In addition, residents whose trees had to be cut received financial aid to purchase replacement plants. The U.S. Forest Service funded the restoration of the greenbelt. The funding allowed the Department of Agriculture, in partnership with the State Nursery and Landscape Association, to offer residents coupons to offset their costs and purchase replacement trees and plants. For the next five growing seasons, the Department maintained the firewood quarantine in Tukwila and surveyed the area extensively for any signs of the beetle.

Conclusion: A rapid response to a potential invasive species threat and adequate funding to stem the problem, allowed state and federal agencies to carry out the tree removal and tree injection program in Tukwila. In December 2006, after several years of collecting negative survey data, the Department of Agriculture removed the quarantine on Tukwila and officially declared Citrus long-horned beetle eradicated from Washington. The program's success is attributed to the decisive and immediate action taken. The program went forward because the agencies involved were able to impress upon the public and elected officials the serious nature of the threat and the necessity for action.

Techniques to Manage Invasive Species

Agencies and other groups working on invasive species issues have developed a systematic approach to address the problem. This can be described in a linear fashion. Emergencies and regulatory mandates also impact how invasive species work is performed.

Assessing the Risk

Invasive species are a recognized threat to natural lands and industries. Land managers and others have developed risk analyses to define the threat and manage the risks associated with particular species. A risk analysis is a systematic way of gathering, evaluating, and recording information to prepare for a response to an identified hazard.

A formal risk analysis usually is conducted in response to a specific need, such as a request for an import license for an agricultural commodity. The resulting documentation includes a description of any invasive species that might enter the state with that commodity; detailed information related to the named invasive species and their likelihood of gaining entry; and information as to whether and how the invaders can be kept out, such as by cleaning containers. The risk analysis allows resource agencies to evaluate threats, affords a basis for decision-making, and provides for future adjustment. Risk analyses also can be used to develop lists of invasive or harmful plants, animals, and other organisms that should be prevented from becoming established in Washington.

Quarantines

Once a risk has been described and assessed, managers look for options to respond to that risk. These options usually are defined in regulations, and, in the case of agricultural commodities in international treaties. One such option is a plant quarantine. Under international convention, a plant quarantine is a legal instrument created by a government agency as a means of reducing the risk of pest invasions. It can mandate a range of activities such as direct prohibition of movement of the plant (e.g. homegrown fruit); restrictions on the handling or movement of host or infected materials (e.g. forbidding movement of firewood from the infested area); treatment of a commodity (e.g. subjecting it to heating, fumigation, or soil removal); and inspection to certify the shipment as pest-free. Federal agencies implement international quarantines, which are important to Washington because of the volume of international trade that passes through the state. Plant quarantines also may apply to interstate commerce, in which case federal and state agencies share authority.

Quarantine rules are most effective against known risks, such as the importation of nursery plants, pets, or edible seeds and fruits distributed in the marketplace, and against easily spotted contaminants, the so-called "hitchhiker species." However, quarantines can slow the movement of goods through ports and affect the pace of international trade. A quarantine's effectiveness is limited by the availability of inspection and enforcement resources and diagnostic capabilities.

Most importantly, quarantines are only as effective as the rate of voluntary compliance and the availability of visible enforcement mechanisms.

As no policy or procedure can enjoy a 100 percent success, other methods are needed to address the threat of invasive species.

Early Detection and Rapid Response

Early detection and rapid response clearly is the preferred response model once an invasive species has entered the state, become established, or expanded its range. It is much more effective to remove a small, relatively new population of an invader than it is to wait until the same population is well established and thriving. Early detection requires knowledgeable people actively conducting surveillance to find new species and determine whether or not they likely are to become a threat.

State and federal governments use a response process called Incident Command System [37] to respond rapidly to emergencies. Control plans, such as joint plans to stem zebra or quagga mussels that involve federal and state agencies as well as other nations, also use the incident command process. Once an invasive species has become established, there are multiple management options:

- Eradicate small, newly introduced, or isolated populations of the species.
- Stop its movement or reduce its spread to protect surrounding areas.
- Reduce the population of an established invasive species to minimize harmful effects.
- Implement proper restoration techniques to maintain a sustainable system.
- Take no action, when control options are not feasible.

Eradication

Eradication, or the verified removal of all potentially reproductive units of the invasive species, is the highest level of control. It can be successful only when the species' distribution is known, pathways of introduction are closed, and there is enough information about the species' biology to develop successful eradication methods. Eradication projects often extend over several years with a multi-year follow-up component to verify the outcome. For example, in 1995 the hydrilla eradication program in Pipe and Lucerne Lakes, in King County began. Since 2007 there have been no hydrilla plants in either lake. However, it cannot be called eradicated until no hydrilla sightings have occured over three consecutive years. Follow-up treatment will continue in 2008 and 2009 and surveying will continue until 2012. This is the only infestation of hydrilla in the state. The outlook is promising that the goal of eradication will be met.

[37] The Incident Command System is a management strategy for emergency incidents and rapid response.

Stop the Spread

Containment can be as simple as creating a management buffer around an infestation to stop or slow the spread of the invading species, especially if natural barriers exist. This is the principle behind many quarantines, regulatory barriers to the movement of goods, requirements to sanitize soil-moving machinery, and distribution restrictions on gravel from contaminated sites. Containment strategies require constant monitoring to verify compliance and success.

Reduce the Population

Controlling or reducing invasive species populations, usually to an economic or environmentally significant threshold value, is a strategy often used when eradication is unlikely because the species already is well established, there are no ways to eradicate it, or eradication methods are unacceptable. Long-term monitoring of the species population density is necessary for successful control.

Restoration

The goal behind invasive species control is to recreate a sustainable system once the invasive species has been removed. From the outset, restoration should always be considered a component of eradication or control projects as tenacious, unwanted species tend to flourish on cleared lands. Restoring lands with native plants, whether through natural regeneration or replanting, will help prevent invading plants from re-establishing themselves. Restoration also reduces long-term control costs. Land managers must continue control measures, plant native species, and tend new plantings long enough to give them a competitive advantage.

No Action

No action may be the only choice when the environmental, economic, or social costs of control are simply unacceptable. That may be caused by an invasive species, such as Himalayan blackberry, that has become so ubiquitous that systematic control or even suppression, except on some piecemeal sites, is not feasible. Taking no action may be the only response if we lack an effective tool either to detect an invasive species (insect pest or plant pathogen) at low levels or to control it. The keys to avoiding this unfortunate choice lie in close coordination with the research community; the development of detection and control tools; and a rapid response when highly invasive species are first detected.

Preserving response flexibility, fulfilling minimum procedural requirements, and reacting rapidly to invaders while they remain vulnerable can lead to conflicting goals. To resolve these tensions and pursue an effective eradication campaign, there needs to be a societal consensus, business cooperation, and political will that acknowledges the potential economic and ecological damage likely to result from not responding to threats.

Research, Education, and Outreach

SCIENTIFIC RESEARCH: DATA WILL GUIDE FUTURE SUCCESS

Reliable information provided by scientific research is an essential component of any effective plan to address invasive species. In Washington, scientists at a number of universities, other institutions, and state agencies research aspects of the biology, ecology, control, and management of invasive species. Much of the applied research in Washington focuses on pests that affect the economic value of forestry, agricultural, and horticultural products. Other scientists conduct research related to effective prevention and management models and mapping.

Research challenges are expanding as new invasive species issues come to light, especially in the context of ecological degradation caused by climate change. Among other needs, there is a growing demand for taxonomists to identify new invading species and for trained staff to develop risk assessments to assess which species likely will become invasive. There is a growing demand for research on environmentally safe eradication methods and natural defense mechanisms.

EDUCATION AND OUTREACH EFFORTS

Almost every group engaged in the invasive species arena has an education component in their programs. An estimated 48 government and non-government programs provide information and education related to invasive species in Washington. Secondary schools are becoming leaders in this area. Many classroom curricula encourage students to think about invasive species and the overall well-being of the environment. The following is not a complete list of education efforts, but recognizes some examples of programs at state agencies, non-governmental organizations, and other partners.

- The Washington Department of Ecology has produced many educational materials about freshwater invasive plants and the management of these plants, now available on a comprehensive Web site about aquatic weeds and their management.[38] Ecology staff also identifies freshwater plants for the public and others. They conduct workshops and field tours, present at conferences, and provide technical assistance to lake groups, nursery groups, pesticide applicators, and the public about non-native, freshwater plants.

- To improve public knowledge of aquatic invasive species issues and laws, the Department of Fish and Wildlife created a high-profile, enforcement and emergency response vehicle. The concept is similar to the anti-drug use, D.A.R.E. vehicles used by law enforcement. A full-time officer patrols and makes presentations at sport shows, boat shows, and schools.


PHOTO COURTESY OF ERIC ANDERSON, WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

[38] Washington State Department of Ecology Web site: http://www.ecy.wa.gov/programs/wq/links/plants.html.

- The University of Washington Botanic Gardens conducts a wide variety of education programs, including lectures, courses, demonstrations, and tours.
- Washington State University Cooperative Extension, the Washington Noxious Weed Control Board, county weed boards, and garden clubs offer programs and classes that provide information on invasive species, individual assistance to landowners, programs for schools and service clubs, and information brochures. Members also attend county fairs and other events to get the word out.

Education materials developed by agencies, weed boards, and parks departments target people who engage in outdoor sports, such as hiking and biking, because they are able to get to remote places and can help detect and survey invasive species. These same people also may be responsible for transporting invasive species on their shoes, tires, and gear. For example, it is thought that the New Zealand mud snail is spread on the waders of fly fishers.

VOLUNTEER EFFORTS

Several volunteer monitoring groups, such as those monitoring for green crab and zebra mussel can play an important role in early detection. Other beneficial activities could include public education to demonstrate techniques to prevent invasions.

Many volunteer groups and neighborhood association members remove invasive plants and restore city parks. Volunteers are conducting important invasive species prevention, detection, and control efforts both in the water and on the trail. Groups such as the Backcountry Horsemen of Washington and Pacific Northwest Scuba are active in the community promoting such efforts. There are also many partnerships between city parks, state government, local residents, and non-governmental organizations. The Green Seattle Partnership is an example of public-private coordination. It is a partnership between Seattle and the Cascade Land Conservancy to restore urban forests and city parks.

Non-governmental organizations play an active and important role in engaging residents in restoration and education campaigns. For example, the Mountains to Sound Greenway coordinates volunteers to plant trees and remove invasive weeds from public open spaces. Other organizations conduct programs, such as the Adopt-a-Stream, which educates people about the importance of native plants for stream health. Other examples include the Native Plant Stewardship Program and Wetland Stewards. Many of these programs also focus on training students, teachers, natural resource managers, and the public.

Informed and involved members of the public and stakeholder groups are the 'eyes and ears' of resource management agencies. Outreach and education of those groups will play a crucial role in helping resource managers control the spread of invasive species. Without their help, managers would not recognize many infestations until the species had become well established and the ability to eradicate them diminished.

Sudden Oak Death on tree bark

Phytophthora ramorum causes Sudden Oak Death, a forest disease that has resulted in widespread dieback of several tree species in California and Oregon forests. The first P. ramorum-infested California nursery stock was identified in 2001 (Santa Cruz County). By 2003, the nursery industry was broadly affected by the disease when the pathogen was detected in California, Oregon, Washington, and British Columbia nurseries.

PHOTO COURTESY OF BRUCE MOLTZAN, MISSOURI DEPARTMENT OF CONSERVATION, BUGWOOD.ORG

CASE STUDY IN RESTORATION

Phragmites

Background: *Phragmites australis* is a native grass that grows in wetlands and wet areas. Also known as common reed, the grass is topped with creamy-brown feathery plumes and can grow up to 15 feet tall. It occurs in every continent except Antarctica and may have the widest distribution of any flowering plant. In Washington, the earliest record of *Phragmites* is from Klickitat County in 1882. Studies of peat samples show *Phragmites* has grown in New England tidal wetlands for at least the last 3,000 years; the remains of the grass have been found preserved in the dung of the Shasta ground sloth, dating back 40,000 years.

In the 1990s, some land resource managers proposed listing *Phragmites* as a noxious weed because the species appeared to be aggressively invading wetland areas. At that time, the Washington Noxious Weed Control Board opted against listing *Phragmites* as a noxious weed because it was a native species. The board speculated that *Phragmites'* invasive behavior reflected its ability to take advantage of altered environmental conditions and disturbed landscapes.

Phragmites

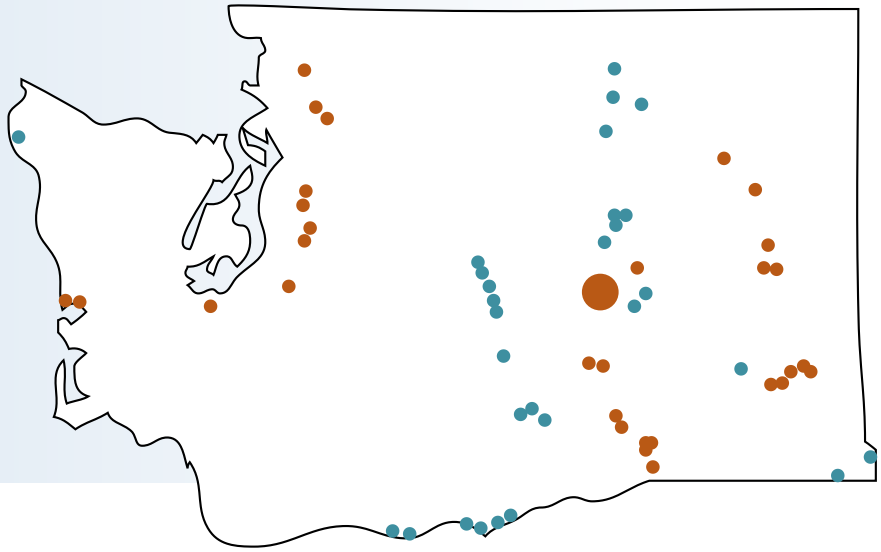
Situation: By 2000, *Phragmites'* rapid colonization of wetland mitigation sites along the Snake River, and the displacement of native wetland vegetation prompted increased concern about this species. On the East Coast, some scientists began to speculate that the aggressive nature of *Phragmites* might be due to an introduction of non-native genotypes. This theory spurred research to determine whether differences in genotypes existed among North American *Phragmites* stands. A Yale University study concluded that aggressive non-native genotypes of *Phragmites* (perhaps introduced in the late 19th century) could overtake and displace native genotypes of *Phragmites* and other native wetland species.

PHOTOS COURTESY OF NOXIOUS WEED CONTROL BOARD

The Yale study and confirmation of the presence of non-native *Phragmites* in Washington – and the fact that invasive species had encroached on wetlands – called for prompt action. In 2003, the Noxious Weed Control Board listed the non-native genotype of *Phragmites* as a noxious weed. At that time, the board listed the non-native genotype of *Phragmites* as a Class C weed because its distribution in the state was unknown.

In 2003, the Washington Department of Agriculture received an Aquatic Weeds Program grant (courtesy of the Washington Department of Ecology) and began surveying *Phragmites* populations to determine the distribution of both native and non-native genotypes of *Phragmites* in the state. Agriculture staff relied on morphologic differences between the genotypes and DNA analysis to confirm Washington populations as native or non-native genotypes (see distribution map below).

Conclusion: Native populations of *Phragmites* on the East Coast have nearly vanished as the result of competition from non-native genotypes and land development. In Washington, as more has become known about the distribution of *Phragmites* genotypes, the Noxious Weed Control Board has taken steps to manage the non-native genotype. The board has done so by upgrading the classification of the non-native genotype of *Phragmites* from a Class C noxious weed (no mandate for control) to a Class B noxious weed (a weed designated for control). In other states the non-native genotype has displaced the native genotype. In Washington, an increased mandate for management of the non-native genotype of *Phragmites* will help protect stands of the native genotype and other native wetland species.



The map shows the known Phragmites distribution in Washington as of December 2004. Blue dots indicate native genotypes and red dots indicate non-native genotypes. The large red dot represents an extensive Phragmites population in the Winchester Wasteway area of Grant County.

Appendix

Washington State and Federal Invasive Species Laws and Regulation

Species	Statute	Agency	Role	Industry Sectors
Animal Kingdom (Diseases Pests)	Animal Quarantine Laws - Animal Damage Control Act, 21, U.S.C. 101 through 135b & 19 U.S.C. 1306	USDA	Regulate, Quarantine	Farming
Aquactic Invasive Species	Clean Water Act	EPA	Permitting, Creates Standards	Commercial Boating, Shipping
Aquactic Invasive Species	Puget Sound Water Quality Protection RCW 90.71	Puget Sound Partnership	Coordination	Multiple
Aquatic Invasive Species	Anadromous Fish Conservation Act, 16 USC 757a-757g; 79 Stat. 1125	USDA, DOI, USFWS	May Conduct Studies and Make Recommendations to EPA About Reducing or Eliminating Substances Detrimental to Fish and Wildlife in Interstate or Navigable Waters or Tributaries	Aquaculture
Aquatic Invasive Species	Aquatic Invasive Species Enforcement Account - Aquatic Invasive Species Enforcement Program for Rereational and Commercial Watercraft, RCW 43.43.400	WSP	Regulate at Port of Entry Weight Stations; Ex Officio Enforcement Of Aquatic Nuisance Species Laws, Educate	Recreational and Commercial Boaters
Aquatic Nuisance Species	Zebra Mussel and European Green Crab Infested Waters, RCW 77.60.120	WDFW	Publish List of Infested Waters, Participate in Regional or National Groups	Aquaculture, Recreational and Commercial Watercraft Shipping, Waterfront Home Owners
Aquatic Animal and Plant Species	Prohibited Aquatic Animal Species - Infested Waters, RCW 77.12.875, WAC 23-212-016	WDFW	Designate Infested Waters, Educate	Recreational Boaters, Waterfront Home Owners, Marinas

See legend on page 69 for complete agency information.

Washington State and Federal Invasive Species Laws and Regulations ***continued***

Species	Statute	Agency	Role	Industry Sectors
Aquatic Animal and Plant Species	Unlawful Avoidance of Aquatic Invasive Species, Invasive Species Check Station, RCW 77.15.293	WDFW	Regulate, Penalty	Recreational and Commercial Boaters
Aquatic Animal or Plant Species	Inspection Authority, RCW 77.15.080(2)	WDFW	Inspection of Transported Watercraft	Recreational and Commercial Boaters
Aquatic Animal Species	Rapid Response Plan, RCW 77.12.878	WDFW	Develop, Implement, Enforce, Rule Making, Signs	Recreational and Commercial Boaters, Marinas, Boat Launches
Aquatic Animal Species, Bullfrogs	Non-Native Aquatic Animal Species Classification, RCW 77.12.020, WAC 220-12-090, WAC 232-12-609	WDFW	Classify as either Prohibited, Regulated or Unregulated Harvest (Bullfrogs)	Multiple
Aquatic Diseases	Aquaculture Disease Control, RCW 77.115	WDFW	Regulate, Inspection	Aquaculture
Aquatic Diseases	Disease Inspection and Control for Aquatic Farmers, RCW 77.115.010, RCW 77.115.020, RCW 77.115.030	WDFW, WSDA	Inspection, Control, Fees, Consultation	Aquaculture
Aquatic Invasive Species	Registration of Aquatic Farmers, RCW 77.15.040	WDFW, DOH	Registration	Aquaculture
Aquatic Invasive Species	Aquatic Invasive Species Prevention Account, RCW 77.12.879	WDFW	Educate, Inspect, Check Stations Research, Monitoring, Prevent, Manage, Develop Early Detection-Rapid Response Plan	Recreational and Commercial Boaters, Marinas, Boat Launches
Aquatic Invasive Species	Aquatic Invasive Species - Inspection, RCW 77.12.882	WDFW	Inspection, Rule Making, Signs	Recreational and Commercial Boaters, Marinas, Boat Launches
Aquatic Noxious Weeds other than purple loosestrife or *Spartina*. Except if not Covered in 77.55.051 (2)	Removal or Control of Aquatic Noxious Weeds, RCW 77.55.081	WDFW	Rule Making for Removal Project Methods, Pamphlet	Restoration Projects

See legend on page 69 for complete agency information.

Washington State and Federal Invasive Species Laws and Regulations *continued*

Species	Statute	Agency	Role	Industry Sectors
Aquatic Plants, Fish, or Wildlife	Unlawful Transport of Fish and Wildlife or Aquatic Plants, RCW 77.15.290, WAC 232-12-016	WDFW	Inspections, Regulate, Enforce Penalty	Multiple
Aquatic Species	Coastal Zone Management Act of 1972	NOAA	Monitoring, Research	Commercial Shipping
Atlantic Salmon	Marine Fin Fish Aquaculture Programs, RCW 77.125	WDFW	Monitor	Net Pens, Aquaculture
Aquatic Invasive Species	Water Pollution Control, RCW 90.48, WAC 173-201A, WAC 173-270	Ecology	Regulate, Control, Prevent	All
Brown Tree Snake and Other Wildlife	Animal Damage Control Act	USDA - APHIS	Research, Control	Multiple
Endangered Species	Endangered Species Act, 16 U.S.C. 1531	DOI, NOAA	Regulate	Multiple
Fish and Wildlife	Forest and Rangeland Renewable Resources Research Act of 1978	USDA	Authorizes Research	Forestry, Agriculture
Forest Insects and Tree Diseases	Forest Insect and Disease Control, RCW 76.06	DNR	Educate, Survey, Regulate	Forestry
Forest Pests and Invasive Species	Multiple-Use Sustained Yield Act of 1960, 16 U.S.C. 528-531	USFS	Regulate	Forestry
Forest Pests, Diseases	Cooperative Forestry Assistance Act, 16 U.S.C. 2104	USDA	Survey, Prevention, Financial Assistance	Forestry
Freshwater Aquatic Weeds and Algae	Freshwater Aquatic Algae Control Account-Freshwater Aquatic Algae Control Program, RCW 43.21A.667	Ecology	Educate, Financial Assistance, Survey	Recreation
Fruit Pests	Inspections and Certifications, RCW 15.17.140	WSDA	Inspection, Certification	Fruit Growers
Fruit Pests	Fruits or Vegetable, RCW 15.17.210	WSDA	Inspection, Regulation	Fruit Growers

See legend on page 69 for complete agency information.

Washington State and Federal Invasive Species Laws and Regulations *continued*

Species	Statute	Agency	Role	Industry Sectors
Invasive Plant and Animal Species	Aquatic Nuisance Species Committee, RCW 77.60.130	WSDA, WDFW, DNR, Ecology, PSAT, DOH, WSP, PSP, NWCB, and WSG Core Members, Tribes, Federal Agencies, Affected Industry Invited	Plan, Coordinate, Report, Recommend Potential Regulations	Aquaculture, Commercial Shipping
Insects, Disease, and Other Damaging Agents	International Forestry Cooperation Act, Section 602b of 16 U.S.C. 4501b	USFS	Provide Assistance, and Deliver Research and Development Products	Multiple
Integrated Pest Management	Integrated Pest Management, RCW 17.15	State Agencies	Management	State Agencies
Invasive Plants	Soil Conservation and Domestic Allotment Act, 16 U.S.C. 590a-590f	USDA, NRCS	Provide Technology, Operates Plant Materials Centers, Technical Assistance, Control, Management, Restoration	Public and Private Landowners
Invasive Plants	Organic Administration Act, 16 U.S.C. 551	USDA	Regulate	Public Landowners
Invasive Plants	Forest Planning Statutes, 16 U.S.C. 1604	USDA	Develop and Maintain Forest Plans	Multiple
Invasive Plants	Public Rangelands Improvement Act of 1978; Federal Land Policy and Management Act of 1976, 43 U.S.C. 1904	USFS	Provides Funding	Public Rangelands
Invasive Species	Washington Invasive Species Council Created, RCW 79A.25.310	Invasive Species Council	Provide Policy Level Direction, Planning, and Coordination	Mutiple
Listed Noxious Weeds	Noxious Weed Control Boards, RCW 17.10, WAC 16-750, 2 WAC 16-75	WSDA, Noxious Weed Control Board, Local Weed Boards	Survey, Educate, Report, Regulate	Agriculture, Forestry, Land Based
Mosquitoes	Mosquito Control Districts, RCW 17.28	Mosquito Control	Taxing and Funding of Eradication	Landowners
Multiple	Food Security Act of 1985, 16 U.S.C. Sections 1240-1240H of 3839aa-3839aa-8	NRCS, EQIP	Technical, Educational, Financial Assistance	Agriculture
Multiple	Federal Agriculture Improvement and Reform Act of 1996,	NRCS, WHIP	Provides Technical, Financial, and Educational Assistance	Landowners

See legend on page 69 for complete agency information.

Washington State and Federal Invasive Species Laws and Regulations *continued*

Species	Statute	Agency	Role	Industry Sectors
Multiple	Fish and Wildlife Coordination Act	NMFS, USFWS	Reviews Development Projects, Issues Grants	Multiple
Multiple	National Environmental Policy Act	All Federal Agencies	Environmental Impact Assessment	Multiple
Multiple	National Forest Management Act of 1976, 16 U.S.C.	USFS	Develop Resource 1600 Management Plans	Forestry
Multiple	Sikes Act, 16 U.S.C. 670o, 74 Stat. 1052	DOI	Requires Planning, Development, Maintenance of Fish and Wildlife Resources on Military Reservations	Military Installations
Non-Indigenous Aquatic Species	Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990, 16 U.S.C. 4701-4751	NOAA - NSGO	Research , Prevention, Control, Management, Restoration	Shipping, Aquaculture
Non-indigenous Marine Species and Organisms, mostly Planktonic	Ballast Water Management, RCW 77.120, WAC 220-77-090, WAC 220-77-095	WDFW	Regulate, Plan, Coordinate Research, Inspect, Monitor, Pilot Program, Rule Making	Shipping
Noxious Weeds	Seeds Screening, RCW 15.49.330, WAC 16-301, WAC 16-302	WSDA	Screening	Agriculture, Horticulture
Noxious, Harmful, Injurious, or Poisonous Plants on Federal Land	Federal Noxious Weed Act, 7 U.S.C. 2814	Federal Land Management Agencies	Requires Cooperative Agreements	Multiple
Oysters - Diseases and Pests	Imported Oyster Seed Permit, RCW 77.60.080	WDFW	Regulate, Permitting	Aquaculture
Oysters - Diseases and Pests	Imported Oyster Seed Inspection, RCW 77.60.090	WDFW	Regulate, Inspection	Aquaculture
Pest - any Invertebrate Animal, Pathogen, Parasitic Plant, or Similar or Allied Organism that can Cause Disease or Damage in any Crops, Trees, Shrubs, Grasses, or Other Plants of Substantial Value	Pest Control Compact, RCW 17.34	Pest Control Insurance Fund	State Funding in an Insurance Pool for Multi- State Pest Impacts	Agriculture

See legend on page 69 for complete agency information.

Washington State and Federal Invasive Species Laws and Regulations ***continued***

Species	Statute	Agency	Role	Industry Sectors
Plant and Bee Pests and Diseases, Insect Pests, Plant Pathogens, and Noxious Weeds	Insect Pests and Plant Diseases, RCW 17.24, WAC 16-470, WAC 16-752-600	WSDA	Survey, Inspect, Regulate	Forest, Agriculture, Horticulture Floriculture, Apiary
Plant Pests	Horticultural Plants, Christmas Trees and Facilities, RCW 15.13	WSDA	Inspection, Licensing, Certification	Horticulture
Plant Pests	Planting Stock, RCW 15.14, WAC 16-322, WAC 16-328	WSDA	Inspect, Regulate	Agriculture, Horticulture
Plants or Plant Products	Plant Protection Act, 7 U.S.C 7701	USDA	Regulate, Quarantine	Nursery
Predatory Animals	Dangerous Wild Animals, RCW 16.30	State Agencies, Local Governments	Regulate, Enforce	Mutiple
Predatory Animals, Rodents, Things, or Pests	Agricultural Pest Districts, RCW 17.12	Pest Districts	Taxing and Funding of Eradication Projects	Agriculture
Prohibited, Regulated, and Unlisted Aquatic Animal Species	Unlawful Use of Prohibited Aquatic Animal Species, RCW 77.15.253, WAC 232-12-016	WDFW	Check Station Inspections, Regulate Transport, Possession or Release, Enforce Penalty	Multiple
Seeds	Federal Seed Act, 7 U.S.C. 1581	USDA	Regulate, Quarantine	Nursery
Shellfish	Restricted Shellfish Areas, RCW 77.60.060	WDFW	Regulate, Permitting	Aquaculture
Spartina and Purple Loosestrife	Control of *Spartina* and Purple Loosestrife, RCW 17.26	WSDA, Ecology, DNR WDFW, and St. Parks	Control, Survey, Eradicate, and Restore on Agency Owned Lands	Shellfish, Recreation
Spartina and Purple Loosestrife	Control of *Spartina* and Purple loosestrife, RCW 77.55.051	WDFW	Control, Survey, Eradicate, and Restore on Agency Owned Lands	Shellfish, Recreation
Weeds	Area of District, RCW 17.04	Weed Boards	Survey, Educate, Regulate, Tax, Fund	Agriculture, Forestry Land-Based
Weeds	Inter-County Weed Districts, RCW 17.06	Weed Districts	Survey, Educate, Regulate, Tax, Fund	Agriculture, Forestry Land-Based
Wild Animal Species, Aquatic and Land Vegetation	Lacey Act, 18 U.S.C. 42	USFWS	Regulate	Trade

Washington State and Federal Invasive Species Laws and Regulations ***continued***

Species	Statute	Agency	Role	Industry Sectors
Zebra Mussel, European Green Crab, and Chinese Mitten Crab	Unlawful Release of Deleterious Exotic Wildlife, RCW 77.15.250	WDFW	Regulate, Enforce	Multiple
Zebra Mussels and European Green Crabs	Imported Oyster Seed – Inspection, RCW 77.60.090	WDFW	Regulate, Inspection	Aquaculture
Zebra Mussels and European Green Crabs	Zebra Mussels and European Green Crabs, RCW 77.60.110, WAC 232-12-01701	WDFW	Educate; Prepare Draft Rules for Legislature, Establish Aquatic Nuisance Species Phone Number Monitoring and Control Programs, Abatement	Recreational and Commercial Watercraft, Shipping, Aquaculture

Legend

APHIS – U.S. Department of Agriculture, Animal and Plant Health Inspection Service
DOD – U.S. Department of Defense
DOH – Washington Department of Health
DOI – U.S. Department of the Interior
DNR – Washington Department of Natural Resources
Ecology – Washington Department of Ecology
EPA- U.S. Environmental Protection Agency
EQIP – U.S. Department of Agriculture, Environmental Quality Incentives Program
USFWS – U.S. Fish and Wildlife Service
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NSGO – National Sea Grant Office
NRCS – U.S. Department of Agriculture, Natural Resources Conservation Service
NWCB – Washington State Noxious Weed Control Board
PSAT – Puget Sound Action Team
PSP – Puget Sound Partnership
RCW – Revised Code of Washington
St. Parks – Washington Parks and Recreation Commission
USDA – U.S. Department of Agriculture
USFS – U.S. Forest Service
WAC – Washington Administrative Code
WDFW – Washington Department of Fish and Wildlife
WHIP – U.S. Department of Agriculture, Wildlife Habitat Incentives Program
WSDA – Washington State Department of Agriculture
WSG – Washington Sea Grant
WSP – Washington State Patrol

WASHINGTON STATE
RECREATION AND CONSERVATION OFFICE
Washington Invasive
Species Council

INVADERS AT THE GATE

WASHINGTON STATE INVASIVE SPECIES COUNCIL 2008 STRATEGIC PLAN

Australian Government
Department of Defence
Defence Science and
Technology Organisation

Performance of the Tin-Free Antifouling Coating International *Ecoloflex* in DSTO/RAN Trials

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DSTO-TR-2203

ABSTRACT

A national and global ban on the application of antifouling paints containing tributyltin (TBT) is being introduced because of the detrimental effects of TBT on non-target marine species. DSTO, supported by the Royal Australian Navy (RAN), undertook a comprehensive program in an attempt to find alternative products that would match or approach the antifouling performance and effective life of TBT-based systems. The evaluation program included static immersion trials, dynamic flow testing, and trials on Navy ship hulls. Within this program, the Akzo Nobel coating *Ecoloflex* demonstrated antifouling efficacy, consistent ablation characteristics, and long term effectiveness on vessels operating in temperate and tropical Australian waters. This was the best performance seen from a copper-based antifouling coating to date and offered the RAN an alternative to TBT-based systems.

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Performance of the Tin-Free Antifouling Coating International *Ecoloflex* in DSTO/RAN Trials

Executive Summary

The antifouling biocide tributyltin (TBT) has provided the most effective means of preventing fouling growth on ship hulls. Self-polishing copolymer (SPC) coatings based on TBT provided the Royal Australian Navy (RAN) with hulls free of fouling for periods up to and exceeding five years without the need for repainting. This performance conferred significant economic and operational savings through increased operational readiness, reduced fuel consumption, extended docking intervals, and reduced docking costs.

However, the impact of TBT on non-target marine species throughout the world has led to widespread regulations and restrictions on the use of antifouling coatings containing TBT. Moves are now underway to implement a global ban on the application of TBT paints. The International Maritime Organisation (IMO), through its Marine Environment Protection Committee (MEPC), developed an instrument to totally ban the application of TBT-containing paints from 1 January 2003. Australian Government policy supported and promoted this IMO action, and further stated that unilateral action would be taken to ban TBT paints from 2006 should there have been a delay in implementation of the IMO instrument.

Available alternatives to TBT paints did not provide the reliable antifouling performance and long term effectiveness afforded by TBT SPC coatings and, when these were used, Navy experienced failures within 18 months under Australian conditions. DSTO, with support from the RAN, undertook a comprehensive program to seek and evaluate products to find the best tin-free alternatives for RAN use. The program utilised DSTO marine immersion facilities in Melbourne and Cairns, a rotor apparatus for simulating ship movement, and patch and hull trials of selected products on Navy vessels. More than 120 products were assessed in this program up to the year 2000.

DSTO/RAN trials on the copper-based antifouling coating *International Ecoloflex*[1], manufactured by *Akzo Nobel Pty Ltd*, demonstrated its efficacy in both panel trials and patch trials on operational vessels. The results for this system were the most promising of any of the candidate products, and indicated it may provide antifouling effectiveness and long term performance comparable with TBT SPC coatings on large vessels. Subject to registration by the National Registration Authority (NRA), the *Ecoloflex* system offered the RAN an effective alternative to TBT systems for surface ships. To fully validate performance, full hull trials of this system were initiated on the ANZAC-Class Frigate *Warramunga* and the Fremantle-Class Patrol Boat *HMAS Geraldton*.

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[1] At the time of this work, *Akzo Nobel Pty Ltd* were affiliated with the *Nippon Paint Co. Ltd*, Japan, who developed and own the name "*Ecoloflex*". The companies have since separated and the equivalent antifouling product marketed by *Akzo Nobel* in Australia is now known as *International Intersmooth 360 SPC.*

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After completing BSc (Hons) and MSc degrees in marine biology at the University of Melbourne in 1977, John Lewis embarked on a career as a scientist in the Defence Science & Technology Organisation, with primary interests in marine biofouling and its prevention, and the effects of RAN activities on the marine environment. John became the head of the Environmental Compliance and Biotechnology Group, within the DSTO Maritime Platforms Division, and led a team investigating new, environmentally acceptable methods of biofouling control, biofouling and marine pest management, environmental compliance of naval vessels, and other aspects of naval operations.

Contents

1. Introduction

Antifouling paints containing tributyltin (TBT) as the primary biocide were proven in the latter decades of the twentieth century to be the most effective means of preventing fouling growth on the underwater hulls of vessels (Lewis, 1998). Self-polishing copolymer (SPC) systems based on TBT provided the Royal Australian Navy (RAN) with fouling-free hulls for periods up to and exceeding five years without the need for recoating. This performance maximised operational readiness, reduced fuel consumption through reduced hull friction, minimised acoustic signatures, extended docking intervals, and reduced docking costs including the need for removal and disposal of spent antifouling coatings.

However, TBT was found to cause malformations in shellfish at ultratrace concentrations and to accumulate in the tissues of marine biota. The use of tin-containing paints is therefore becoming increasingly regulated (Lewis, 2003). Initial controls were directed at prohibiting or limiting their use on recreational craft but moves proceeded toward total national and global bans on the use of paints containing TBT. The International Maritime Organisation, through its Marine Environment Protection Committee (MEPC), developed an instrument to totally ban the application of TBT-containing paints from 1 January 2003 (IMO, 2001). Australian Government policy was to support and promote this IMO action, and further stated that unilateral action would be taken to ban TBT paints from 2006 should there be a delay in implementation of the IMO instrument (Anon., 1998a, 1998b).

The main concern for shipowners and operators about the prospective TBT ban was the lack of alternative products that could be expected to provide reliable antifouling performance and long-term effectiveness comparable to that of TBT SPC coatings. The costs to the operators of even a small amount of fouling growth include increased fuel costs, reduced speed and inability to meet schedules, and more regular dockings and maintenance. Ineffective antifouling coatings also increase the risk of transport of exotic marine pests, of which 80% of those currently known are now considered to have been transported as hull fouling. The RAN directly experienced the shortcomings of the alternatives to TBT paints in the early 1990s when a number of vessels were painted with tin-free antifouling coatings (Lewis, 2002). Severe fouling occurred on these within 18 months of launch.

The primary alternatives to TBT paints are coatings containing copper as the primary biocide (Lewis, 1998). Copper-based paints were first introduced in the mid 19th century but, at the time TBT paints were first introduced in the 1970s, their effective life still rarely exceeded 18-24 months. More recent developments extended their expected life to close to 36 months, but without the reliability provided by TBT coatings. The problems encountered in their performance included:

- the high cuprous oxide loading required to give long life, which often compromised film integrity and led to cracking and other physical failures
- the lack of a suitable paint matrix to generate long-term controlled and consistent polishing and biocide release

- the copper resistance of some major fouling organisms which necessitated inclusion of secondary or booster biocides in the paint formulations to provide broad spectrum performance
- chemical reactions at the paint surface which formed insoluble copper precipitates which blocked further biocide release and led to premature paint failure

In 1989, soon after concerns were first raised about the environmental impact of TBT, DSTO initiated a comprehensive program to seek effective, more environmentally acceptable methods of fouling control for the RAN fleet. Through until 2000 more than 130 systems were included in this program. Initial screening of these materials was undertaken in static immersion and dynamic flow panel trials, which indicates the antifouling efficacy, ablative characteristics and physical resilience of the coating systems. With the cooperation of the Navy, more promising products were then evaluated in patch trials on RAN vessels.

This report presents the results of our studies from 1993 through until 2000 on the *Akzo Nobel* product *International Ecoloflex*[1], which showed promise as one of the first alternatives to the TBT-containing self-polishing antifouling systems to provide similar efficacy, effective longevity and performance.

2. Experimental Trials

2.1 Panel Trials

2.1.1 Raft Trials

Antifouling efficacy of the *Ecoloflex* system was assessed by static immersion using DSTO's two test rafts: at the temperate waters site at Williamstown in northern Port Phillip Bay, Victoria, and at the tropical site in Trinity Inlet, Cairns, Queensland. For each of these sites, coatings were applied to 300 mm x 150 mm mild steel panels. These test panels were then attached to frames and suspended vertically between 0.5 and 1.5 m below the water surface at each site. Two panels were immersed at each site. Panels were inspected regularly for biofouling presence and coating integrity and non-toxic controls routinely immersed to assess the abundance and diversity of fouling settlement. These test procedures accord with *Australian Standard Test Method AS 1580.481.5--1993: Coatings--Durability and Resistance to Fouling--Marine Underwater Paint Systems* (Standards Australia, 1993).

[1] At the time of this work, *Akzo Nobel Pty Ltd* were affiliated with the *Nippon Paint Co. Ltd*, Japan, who developed and own the name "*Ecoloflex*". The companies have since separated and the equivalent antifouling product marketed by *Akzo Nobel* in Australia is now known as *International Intersmooth 360 SPC.*

2.1.2 Rotor Trials

The performance of coatings under dynamic flow conditions was evaluated using the DSTO Rotary Simulator located on Breakwater Pier, Williamstown. This facility consists of a baffled tank in which a drum is rotated with a peripheral speed of 20 knots. Seawater is continually pumped through the tank. The *Ecoloflex* system, along with other experimental systems for evaluation, was applied to the surface of slightly curved, 150 mm x 150 mm mild steel panels and two panels of each system attached to the periphery of the drum. Panels were then inspected at regular intervals for physical integrity, and coating thicknesses measured to enable calculation of ablation, or polishing rates.

2.2 Patch Trials

2.2.1 HMAS Townsville (Trial 1126)

The first of the series of patch trials of tin-free antifouling systems was initiated on the Cairns-based Fremantle-Class Patrol Boat (FCPB) *HMAS Townsville* in March 1993. This trial was initiated following the premature failure of a tin-free system on Cairns-based vessels painted during a period when the ship-repair facilities in Cairns were not registered to apply TBT-containing antifoulings. For example, significant weed and tubeworm fouling were present on the underwater hull of *HMAS Townsville* within 12 months of initial paint application and, by 18 months, fouling growth was adversely affecting ship performance. The patch trial was implemented to enable the performance of tin-free coatings from the major marine coatings manufacturers to be compared under equivalent conditions. *International Ecoloflex* was not available at the time this trial was initiated.

The patch trial on *HMAS Townsville* was terminated at the vessel's subsequent scheduled refit in October 1995.

2.2.2 HMAS Bendigo (Trial 1178b)

As the scheduled refit interval for major RAN surface ships is a minimum of 4 years, a more comprehensive series of patch trials was planned to assess the suitability of available tin-free products over a four year period and on vessels home-ported in different regions of Australia. Three vessels were selected for these trials: the FCPB *HMAS Bendigo* based in Cairns, the destroyer *HMAS Brisbane*, and the FCPB *HMAS Bunbury* based in Western Australia.

Strips of six different antifouling systems were applied to the underwater hull of *HMAS Bendigo* in Cairns in November 1993. 700 mm wide strips were applied to the bow section on both port and starboard sides and extended from 150 mm below the water line to the keel with a gap of 350 mm between strips. The sequence of test coatings varied on the two sides of the hull. Strips were applied on top of the old tin free antifouling after this was high pressure washed at 3000 psi.

Two coatings from *Akzo Nobel* were included in the patch trial: *International Duplex* (*Intersmooth Tin-Free SPC BGA535/537*) and *Ecoloflex* (*SP600*). The marine paint companies *Jotun*, *Hempels*, *Wattyl* and *Resene* also provided materials for this trial.

The trial continued through until April 1998 when *HMAS Bendigo* next docked for refit. Detailed inspections by DSTO staff were undertaken at an emergency docking in February 1995 at the completion of the trial. Underwater inspections and photography of the strips were also undertaken in January 1995 and October 1997. The vessel also underwent an emergency docking in January 1998 but no detailed inspection could be arranged at this time. The entire underwater hull, including the strips, was high pressure washed at this docking.

2.2.3 HMAS Brisbane (Trial 1178a)

The same six paint systems applied to *HMAS Bendigo* were also applied to *HMAS Brisbane* during refit in Sydney in November 1993. Strips of the same width and separation were applied approximately midships on both port and starboard sides from 150 mm below the waterline to 750 mm below the bilge keel. The patches were applied over one coat of *International SPC HISOL BFA 900 Series*.

The trial continued through until March 1999. A detailed inspection was also undertaken during an emergency docking in May 1996.

2.2.4 HMAS Bunbury (Trial 1178c)

Strips were applied to the forward port and starboard hulls of *HMAS Bunbury* in Western Australia in March 1994. The positioning of the strips was the same as on *HMAS Bendigo*.

Unlike the previous two vessels, *HMAS Bunbury* underwent a major docking two years after patch application. At this docking, in February 1996, the test strips were hydroblasted and coatings "refreshed" with additional coat(s) of paint to facilitate the trial running for a further 4 years. Unfortunately, by May 1998, the underwater paint system had suffered premature failure attributed to excessive electrolytic action and full refurbishment of the underwater paint system was necessary. The trial was terminated at this time.

2.2.5 CSL Boronia (Trial 1179)

To assess the performance of tin-free products for harbour and support craft, strips of 5 coatings, including *Ecoloflex*, were applied to the hull of the Crane Stores Lighter *Boronia* in July 1996. *Boronia* is a twin-hulled vessel that operated within Sydney harbour. Strips 700 mm wide were applied to the port underwater hull area from waterline to waterline. This vessel has not been taken out of the water when results for this report were collated in 2000 and no results from this trial are included.

Restructuring of the RAN has led to the ownership and operation of support craft, including this vessel, transferring from the Navy to the privately run company *Defence Maritime Services Pty Ltd*.

2.3 Full Hull Trials

2.3.1 HTS Currawong (Trial T97/012)

The underwater hull of the Sydney tug *Currawong* was fully painted with *International Intersmooth 360 Ecoloflex* in September 1997 to assess the long term performance of this product as an alternative to existing systems on harbour craft. As with *CSL Boronia,* the tug had not been docked prior to the collation of results for this report, so no results are included. As with *CSL Boronia*, this vessel is no longer owned and operated by the RAN.

2.3.2 NUSHIP Warramunga

Tenix Defence Systems undertook a full hull application of *Ecoloflex 360* on the third of the ANZAC frigates under construction for the RAN, *NUSHIP Warramunga*, at their Williamstown facility in July 1999. On 5 May 2000, a small boat was used to examine and photograph the system from alongside. At this time the ship was at the stage of advanced outfit in preparation for sea trials, was still to leave dockside, and had not been drydocked after the hull was painted.

2.3.3 HMAS Geraldton

The first full trial of *Ecoloflex* on an operational naval vessel commenced in January 2000 with a full underwater hull application of *International Intersmooth 360 Ecoloflex* on the FCPB *HMAS Geraldton* in Western Australia. In April 2000 photographs were taken of the visible hull from the wharf alongside.

3. Results and Observations

3.1 Panel Trials

3.1.1 Raft Trials

The first test panels of *International Ecoloflex* were immersed on the Williamstown raft in April 1994. This trial ended prematurely when the raft broke free from its moorings in June 1996. At the inspection prior to this incident, *Ecoloflex* panels were free of macrofouling growth.

Trials recommenced in December 1996 with fresh panels of the *Ecoloflex* system immersed at this time. At the inspection on 3 May 2000, these panels were free of macrofouling growth after 40 months immersion. Figure 1 illustrates the appearance of the panels at the inspection on 23 March 2000. Only slime and mud tubes built by free-living amphipods were present on the *Ecoloflex* panels, whereas the control panels, after less than 2 months, were heavily fouled by tubeworms, macroalgae, barnacles, bryozoans and ascidians. Fouling and physico-chemical data for the raft site over this period are included in the Appendix.

Test panels of *Intersmooth 360 Ecoloflex* and *Intersmooth 460 Ecoloflex* were added to the trial program in October 1998 and were also free of macrofouling on inspection in May 2000.

Ecoloflex panels were immersed on the raft at *HMAS Cairns*, Trinity Inlet, Cairns, in August 1997. When inspected in May 2000, the panels were predominantly covered by a thick slime, unlike the control which was heavily fouled by barnacles and other fouling species (Figure 2). Several barnacles and bryozoan colonies were present on the surface of the *Ecoloflex* panels, but these were loosely adherent and easily dislodged.

3.1.2 Rotor Trials

The first rotor trial which included *Ecoloflex* commenced in March 1994 and continued through until October 1995, the effective rotor exposure time totalling more than 8500 hours. Two panels of each system were included in the trial. Graphs showing the performance in this trial of three *International* systems, a TBT-containing self-polishing copolymer coating (*Intersmooth BFA956/959*), an ablative tin-free coating (*BGA535/536*) and *Ecoloflex* (*XRS071/071*), are illustrated in Figures 3-5. The TBT system is the same system used at that time by the RAN on large surface vessels. The ablative tin-free is the system that gave unacceptable performance when used by the RAN as an alternative to TBT in the early 1990s. The graphs show that, unlike the ablative tin-free product, the *Ecoloflex* ablated consistently through the duration of the trial. Ablation rates for the three systems, calculated by linear regression of the measured data, are summarised in Table 1.

Table 1. Ablation rates of the three International systems in the 1994/1995 rotor trial (XRS 071/072 = Ecoloflex).

Coating System	Ablation Rate (micron/day)	
	Panel 1	Panel 2
BFA 956/959	0.23	0.14
BGA 535/537	-0.02	0.03
XRS 071/072	0.09	0.08

Midway through this trial, in February 1994, one panel of each system was suspended below Breakwater Pier for a period of approximately 6 weeks to test for antifouling efficacy. No macrofouling established on the *Ecoloflex* system during this period. The system also showed no physical defects during the trial.

A second rotor trial which included *Ecoloflex* (*SP600*) panels commenced in October 1996 and continued through until September 1997, a total exposure of 6221 rotor hours. *Intersmooth BFA956/959* was again used as the control. Similar results were obtained as in the earlier trial, with the *Ecoloflex* again showing consistent ablation through the trial period (Figures 6, 7). Ablation rates are presented in Table 2.

Table 2. Ablation rates of TBT SPC (BFA956/959) and Ecoloflex (SP600) in the 1996/1997 rotor trial.

Coating System	Ablation Rate (micron/day)	
	Panel 1	Panel 2
BFA 956/959	0.24	0.41
SP600	0.31	0.29

In this trial, one panel of each pair was also suspended under Breakwater Pier for 10 weeks from September until December 1997. At the end of this period the *Ecoloflex* panel remained completely free of macrofouling, whereas the non-toxic control panel was heavily fouled by a diversity of fouling organisms (Figure 8).

3.2 Patch Trials

3.2.1 HMAS Townsville

Although *Ecoloflex* was not one of the coating systems tested in this trial, the results are of value as a base for assessing antifouling performance on vessels based in Cairns. At the completion of this trial, after 31 months, all five coatings tested had fouled (Figure 9); all were fouled by green macroalgae near the water surface, and all but one were also fouled by macrofouling animals deeper down.

3.2.2 HMAS Bendigo

The first inspection of the test strips after the trial commenced on *HMAS Bendigo* in November 1993 was by divers in January 1995, and this showed the *Ecoloflex* coating to be in pristine condition (Figure 10). The more detailed inspection shortly after this, at the docking in Darwin in February 1995, confirmed the superior performance of the *Ecoloflex* system over the other five systems (Table 3, Figure 11). A second diver inspection in October 1997 found only slime on the *Ecoloflex* surface (Figure 10).

Table 3. Fouling abundance on the port side strips on HMAS Bendigo 15 months after immersion. Values represent percentage surface cover; left of slash = between wind and water line and lower load line, right of slash = below lower load line; + = <5% cover

	System1	Duplex	*Ecoloflex*	System 4	System 5	System 6
Weed	40/-	40/-	10/-	40/-	40/-	75/75
Barnacles	+/-	+/-	-/-	+/-	+/-	5/-
Tubeworm	10/-	10/-	-/-	10/-	+/-	20/5
Bryozoans	5/80	5/-	-/-	+/-	-/-	10/+

Unfortunately the timing and nature of the emergency docking of *HMAS Bendigo* in January 1998 did not allow for a detailed inspection of the test strips. However, a photograph taken shortly after the docking clearly shows continued good performance of the *Ecoloflex* system (Figure 12). At this docking the underwater hull, including the test strips, were high pressure washed. Continued good performance of the *Ecoloflex* was evident at the final inspection in April 1998 (Figure13).

3.2.3 HMAS Bunbury

At the docking of *HMAS Bunbury* for refit in January 1996, the *Ecoloflex* was clearly the best performing coating in terms of both antifouling efficacy and coating integrity (Table 4, Figure 14).

DSTO staff were unable to inspect *HMAS Bunbury* at the docking in Darwin in May 1998, which preceded the premature removal of the test strips. However, the hull surveyors, G.A. Glanville & Co (Naval Architects) Pty Ltd, provided a brief report and photographs of the trial areas. The photographs (Figures 15, 16) show the *Ecoloflex* system to be performing effectively, and the report includes the comment:

> "At the waterline green weed/slime coated all the strips with the exception of the 1st Strip on Stbd and 5th Strip on Port."

These strips were the *Ecoloflex* strips.

Table 4. Ranking of strips on HMAS Bendigo for antifouling performance and coating integrity at the docking in January 1996 (1 = best performance).

	System 1	Duplex	*Ecoloflex*	System 4	System 5	System 6
Antifouling						
- Port	2	6	1	3	5	4
- Stbd	5	6	1	2	4	3
Integrity						
- Port	2	6	1	5	3	4
- Stbd	3	6	1	5	2	4

3.2.4 HMAS Brisbane

When the trial areas on *HMAS Brisbane* were inspected at a docking in May 1996, after 30 months, the *Ecoloflex* system was showing superior performance in both fouling control and coating integrity (Table 5, Figure 17). This effective performance was maintained through to the end of the trial in March 1999, a total period of 64 months (Figure 18).

Table 5. Ranking of strips on HMAS Brisbane for antifouling performance and coating integrity at the docking in May 1996 (1 = best performance).

	System 1	Duplex	*Ecoloflex*	System 4	System 5	System 6
Antifouling						
- Port	6	3	1	3	5	4
- Stbd	6	5	1	4	3	2
Integrity						
- Port	6	2	1	3	4	5
- Stbd	6	3	1	2	4	5

3.3 Full Hull Trials

3.3.1 NUSHIP Warramunga

When inspected from a small boat alongside in May 2000, aided by clear water conditions, *NUSHIP Warramunga* only slime was visible on the submerged surfaces (Figures 19, 20). The integrity of the coating at and above the water line was also sound with no signs of physical degradation.

3.3.2 HMAS Geraldton

Photographs taken of the hull of *HMAS Geraldton* from alongside in April 2000 showed no signs of fouling growth (Figures 21, 22).

4. Discussion

Self-polishing copolymer antifouling paints, based on tributyltin methacrylate as both binder and primary biocide, proved to be superior to other available antifoulings because of their capacity to provide reliable antifouling effectiveness for 5 or more years on large vessels. This performance resulted from their broad-spectrum biocidal efficacy, their consistent polishing rate that generated controlled biocide release, and their physical integrity. Alternative systems could not match this performance because of difficulties in formulating an effective polishing matrix compatible with available tin-free biocides. The best performing alternative systems, containing cuprous oxide as the primary biocide, could provide protection for up to 36 months, although under some conditions failures occurred much earlier.

Panel trials of the *Akzo Nobel* coating *Ecoloflex* demonstrated antifouling efficacy and consistent polishing performance. Under static immersion conditions the coating resisted fouling for more than 3 years, including 3 summer fouling seasons in temperate waters. In tropical waters, panels remained almost macrofouling free after 30 months. Our experience is that Trinity Inlet, Cairns, is the most severe site for testing antifoulings in Australia. The only macrofouling present was easily dislodged and possibly attached to the heavy slime build up from static exposure in these conditions.

In rotor trials, consistent ablation of the coating was observed in two separate trials, and the rate of ablation in the second trial was similar to that observed for the TBT SPC (BFA 956/959) system. This indicated that the formulation could provide long term performance through consistent ablation and therefore controlled biocide release. The basis of this formulation is a copper acrylate polymer that reacts in seawater in a manner analogous to tributyltin methacrylate. However, the copper released from the polymer is insufficient to control fouling in its own right, and cuprous oxide and a booster biocide, zinc pyrithione (ZPT) are also dispersed through the resin. These biocides are released in a controlled manner as the coating ablates.

The results achieved in patch trials verified the performance expected from the panel trials. On the three operational vessels, *HMAS Bendigo*, *HMAS Bunbury*, and *HMAS Brisbane*, the *Ecoloflex* system out-performed the other five test systems and continued to provide effective performance for more than five years. This performance was comparable to that of TBT SPC under the same conditions. The use of three vessels in the patch trial program was planned to enable testing of the coatings in three major operational regions for the RAN: east coast, west coast and north coast. *Ecoloflex* proved to be effective in each of these geographic environments. In addition to the antifouling effectiveness, the coating remained physically sound through all the trials.

The proposed IMO ban on the application of TBT antifouling coatings from 1 January 2003 created an urgent need for shipping to have alternative systems available that have antifouling performance comparable to existing systems. The consequences of not having these systems would be increased operating costs through the increased fuel consumption, speed penalties and docking and repainting costs. The risks of transport of marine pests would also increase. Significant in the dates set by the IMO was their acceptance that effective alternative systems would be available. Initial proposals within IMO to ban TBT were subject to the proviso that the ban would be subject to the availability of effective alternatives. The development of such alternatives in Japan, with *Ecoloflex* a prime example, and evidence of their efficacy were considered sufficient to support a full global ban.

The copper acrylate *Ecoloflex* system met the requirements of efficacy and performance in all trials initiated within the DSTO/RAN evaluation program, confirming the good results reported from overseas. However, full verification that the system is as effective as TBT SPC coatings would only be possible when a large number of vessels, operating under different conditions and in different environments, are fully painted with the system and achieve their intended docking cycles. However, results from this study suggest performance close to that of the TBT-based systems is possible[2].

5. Conclusions

DSTO/RAN trials demonstrated the efficacy of the *Akzo Nobel* copper acrylate system in both panel trials and patch trials on operational vessels. Effective life in excess of five years was achieved. Integral to this performance was the consistent ablation of the coating when exposed to water flow, combined with an effective biocide package.

The proposed global ban on the application of TBT antifouling paints from 1 January 2003 required alternative products offering similar performance to be available. *Ecoloflex* was the first system fully evaluated within the DSTO/RAN antifouling research program to demonstrate such potential.

[2] Subsequent to the trials reported herein, the *International Paints* antifouling formulation *Intersmooth 360 SPC*, equivalent to *Ecoloflex*, was registered by the Australian National Registration Authority (now the Australian Pesticides and Veterinary Medicines Authority) and, from April 2002, the system was phased in across the RAN fleet as a replacement for TBT SPC coatings.

6. References

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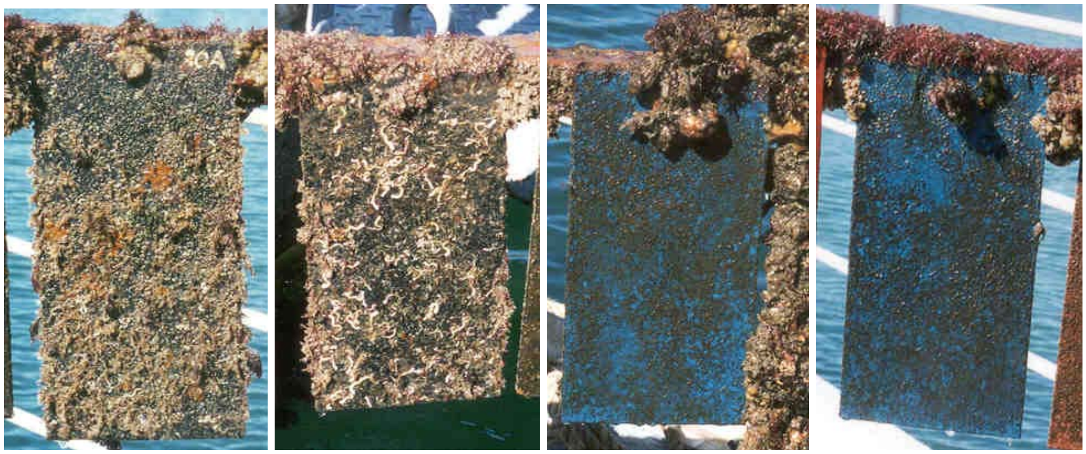

Figure 1: Test panels on Williamstown raft, 23 March 2000: left, control panels after 43 days immersion; right, Ecoloflex panels after 39 months (first immersed 23 Dec 1996)

Figure 2: Test panels on Cairns raft, 12 May 2000: left, control panel after approximately 3 months immersion; right, Ecoloflex panel after 33 months (first immersed 14 August 1997)

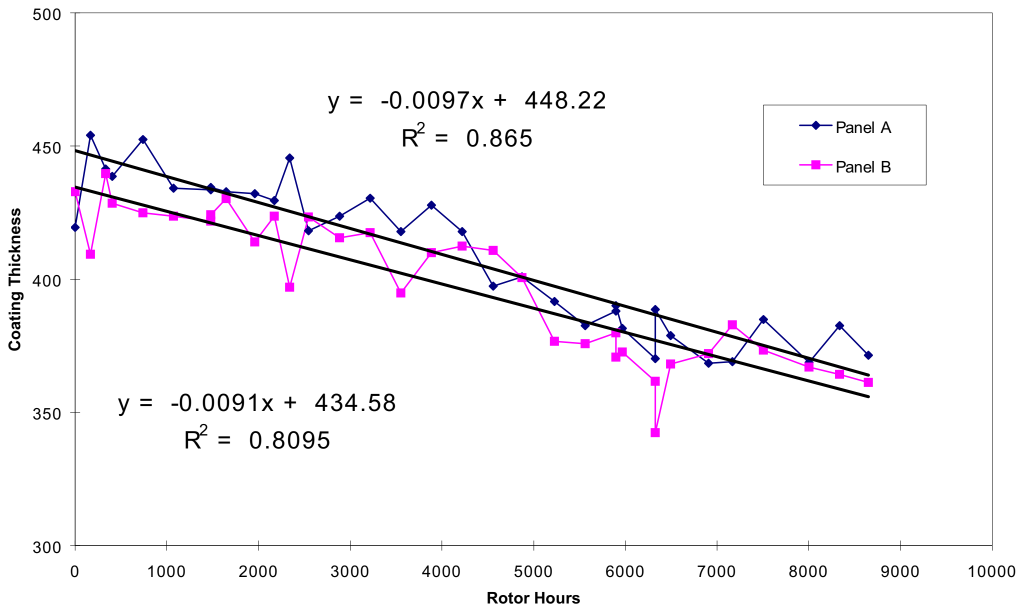

Figure 3: Ablation of the TBT SPC system BFA956/959 in the 1994/1995 rotor trial [In this and subsequent figures, the equations and r values are calculated by linear regression of thickness data for each panel]

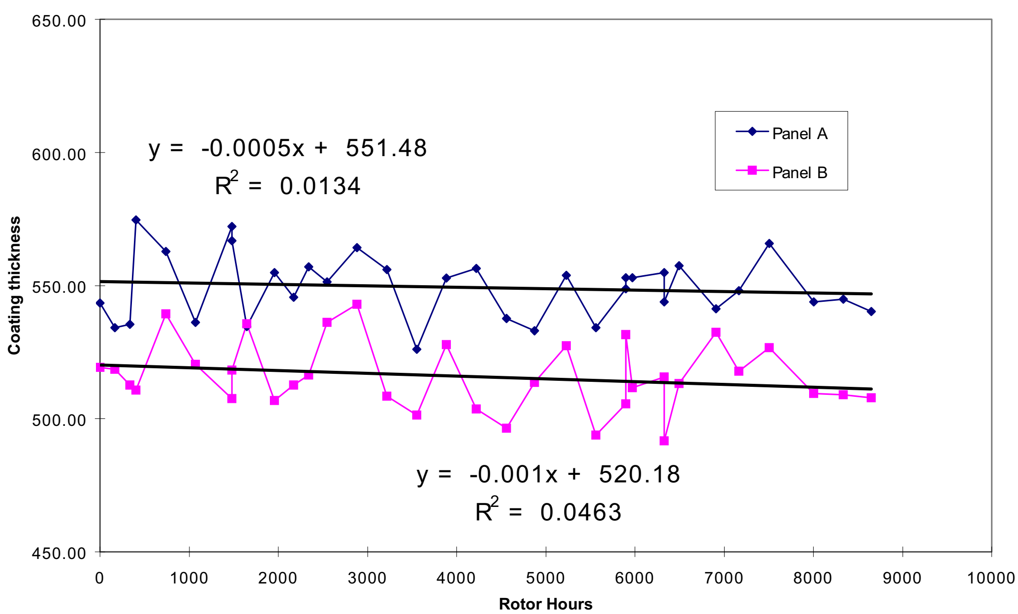

Figure 4: Ablation of the Tin-Free system BGA535/537 in the 1994/1995 rotor trial

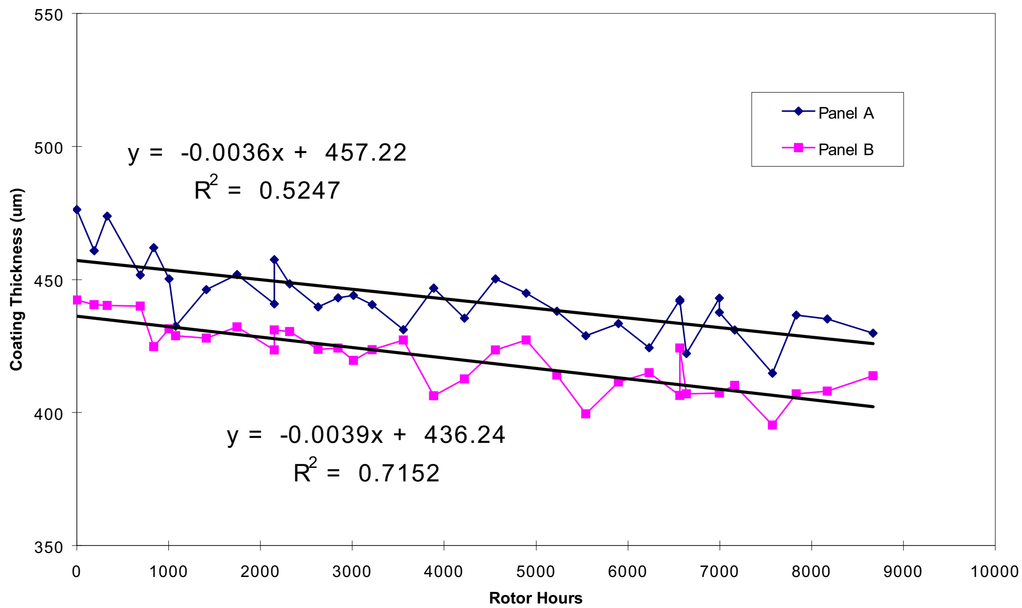

Figure 5: Ablation of the Ecoloflex system XRS 071/072 in the 1994/1995 rotor trial

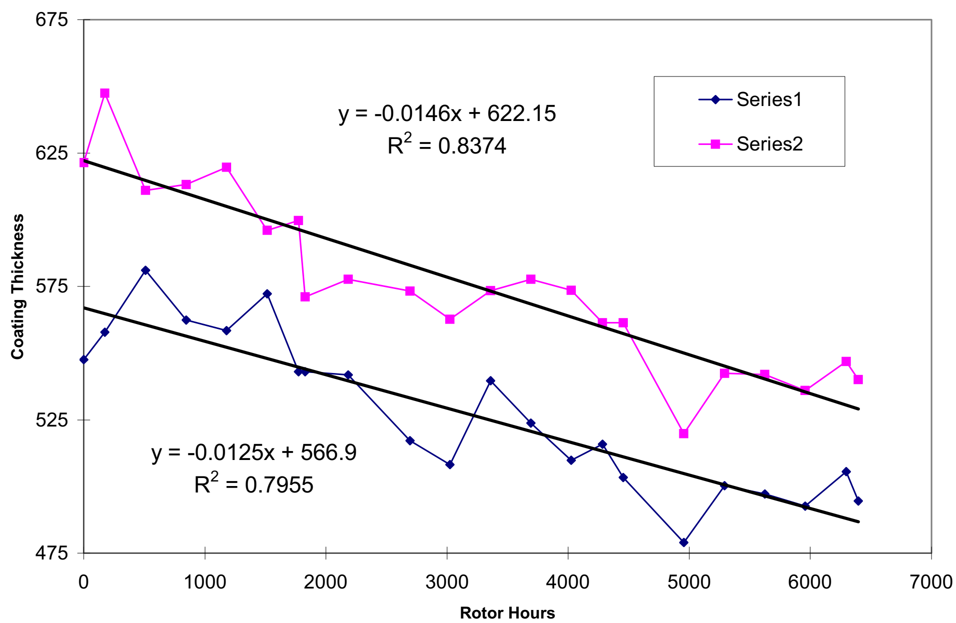

Figure 6: Ablation of the TBT SPC system BFA956/959 in the 1996/1997 rotor trial

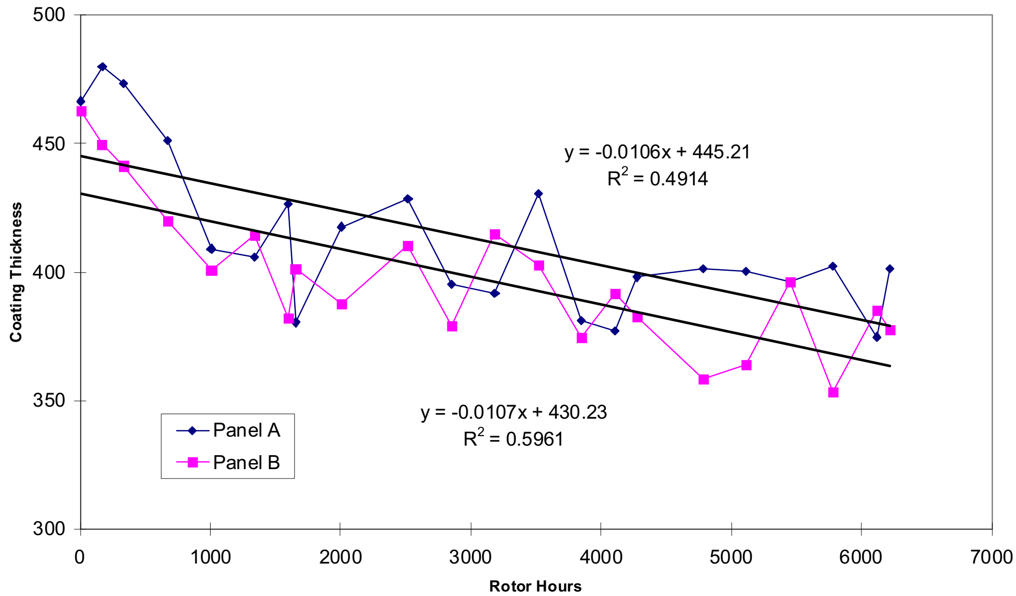

Figure 7: Ablation of the International SP600 (=Ecoloflex) system in the 1996/1997 rotor trial

Figure 8: Ecoloflex panel (right) and non-toxic control (left) after static immersion during 1996/1997 rotor trial

Figure 9: Port side midships test strips on HMAS TOWNSVILLE at completion of trial after 31 months

Figure 10: Underwater photographs of Ecoloflex strip on HMAS BENDIGO in January 1995 (left) and October 1997 (right) showing only slime

Figure 11: Starboard side strips on HMAS BENDIGO, February 1995. Ecoloflex strip is second from right.

Figure 12: Starboard side strips on HMAS BENDIGO, January 1998

Figure 13: Starboard side strips on HMAS BENDIGO, April 1998

Figure 14: Port side strips on HMAS BUNBURY, February 1996. Blue strip is Ecoloflex

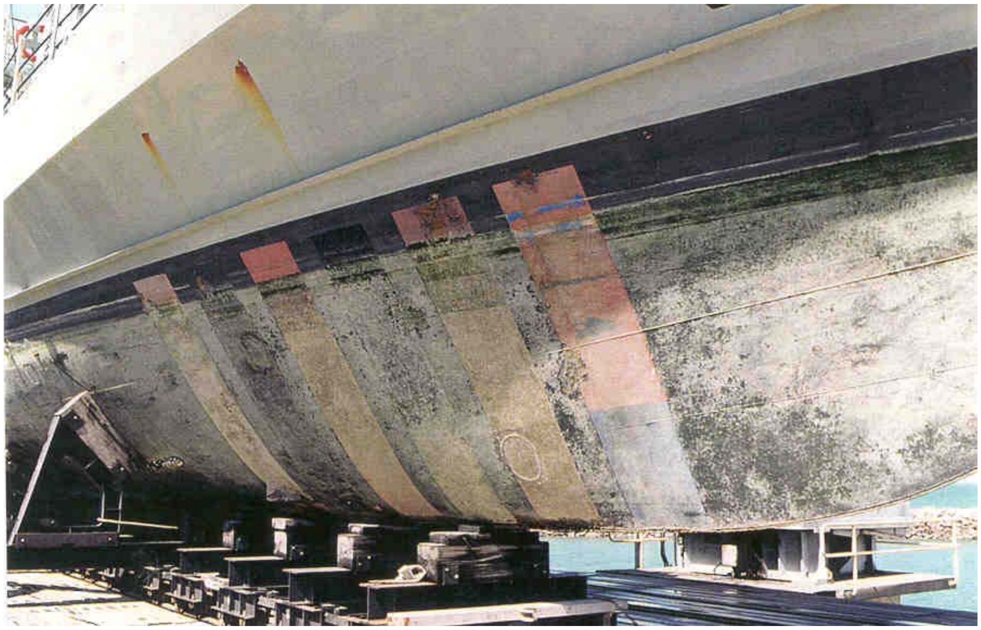

Figure 15: Starboard side strips on HMAS BUNBURY, May 1998. Ecoloflex strip is first from right.

Figure 16: Port side strips on HMAS BUNBURY, May 1998

Figure 17: Port side strips on HMAS BRISBANE, May 1996. Ecoloflex strip is third from right.

Figure 18: Starboard side strips on HMAS BRISBANE, March 1999. Ecoloflex strip is second from right.

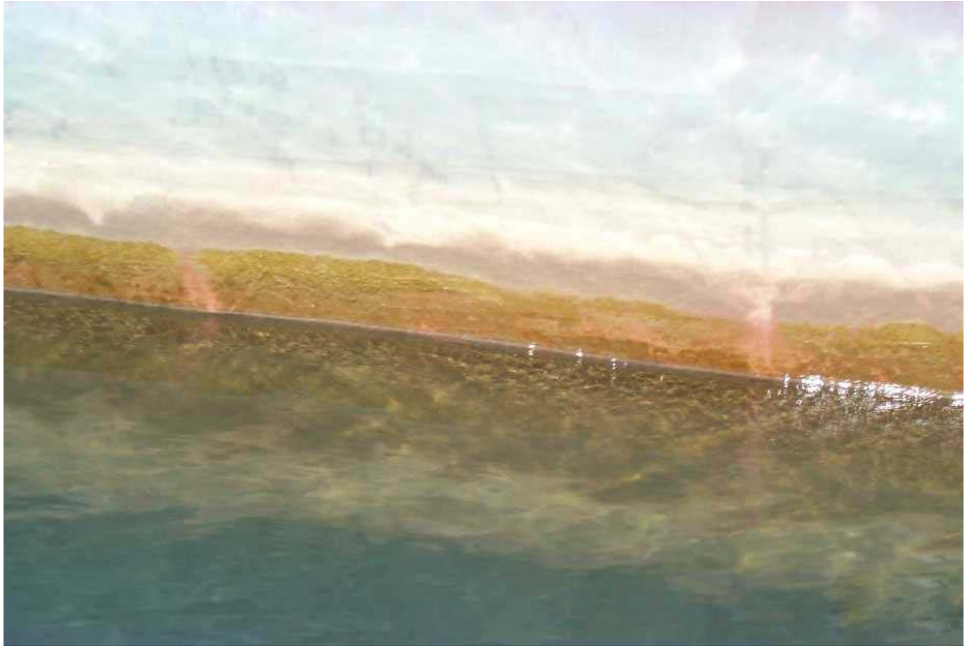

Figure 19: Transom of NUSHIP WARRAMUNGA at Williamstown May 2000

Figure 20: Starboard side of NUSHIP WARRAMUNGA at Williamstown, May 2000

Figure 21: Forward port side of HMAS GERALDTON, Garden Island WA, April 2000

Figure 22: Transom of HMAS GERALDTON, Garden Island WA, April 2000

Appendix A: Williamstown Raft Data

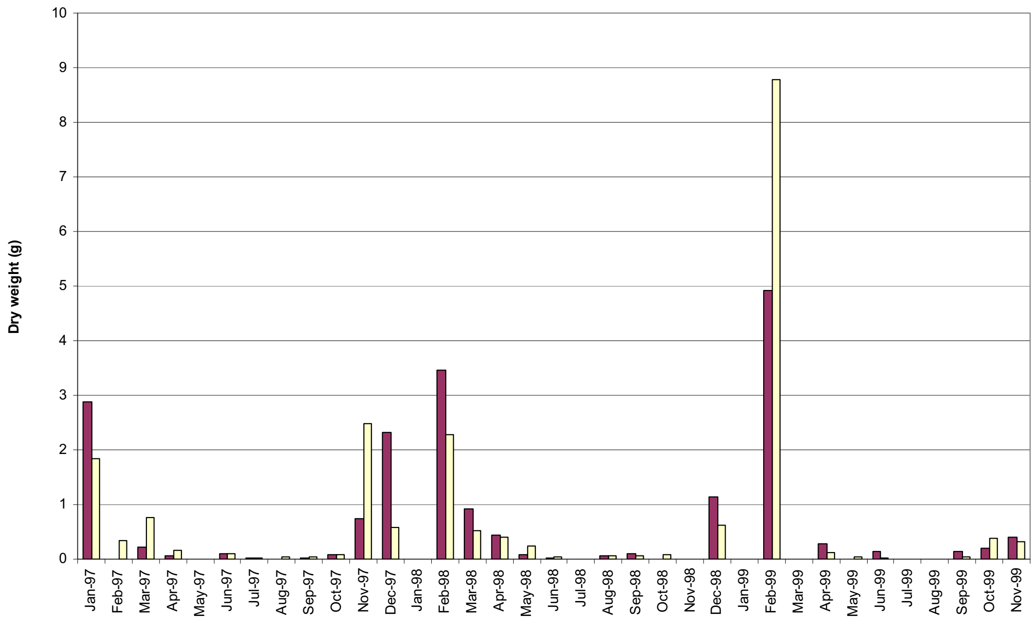

Figure A.1 Seasonal variation in fouling abundance measured as dry weight (g.dm^{-2}) of fouling on monthly control panels (December 1996 – January 2000)

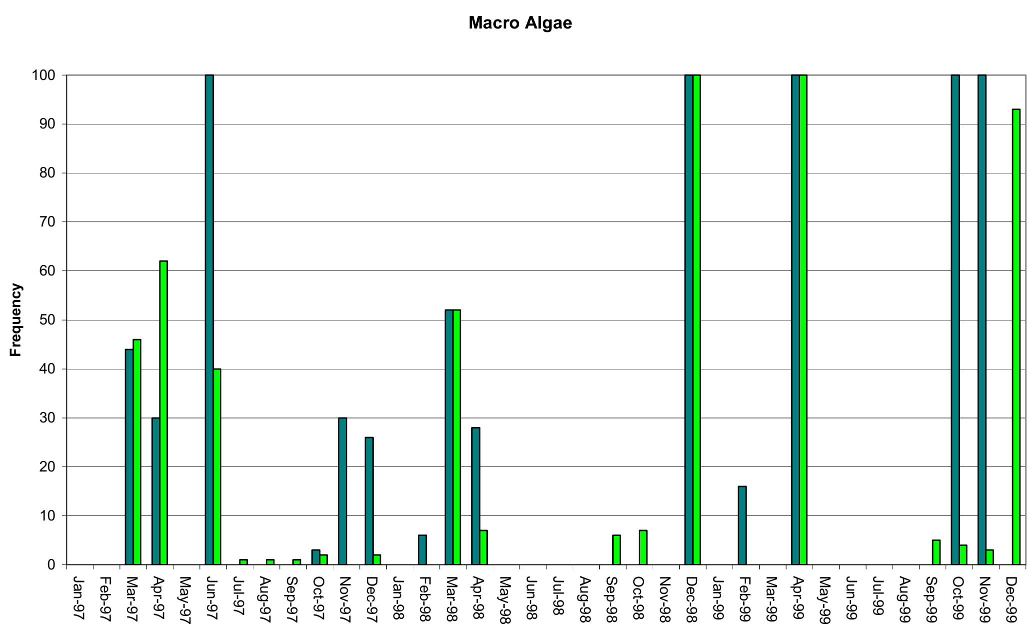

Figure A.2 Seasonal variation in abundance of macroscopic algal fouling on the control panels (December 1996 – January 2000)

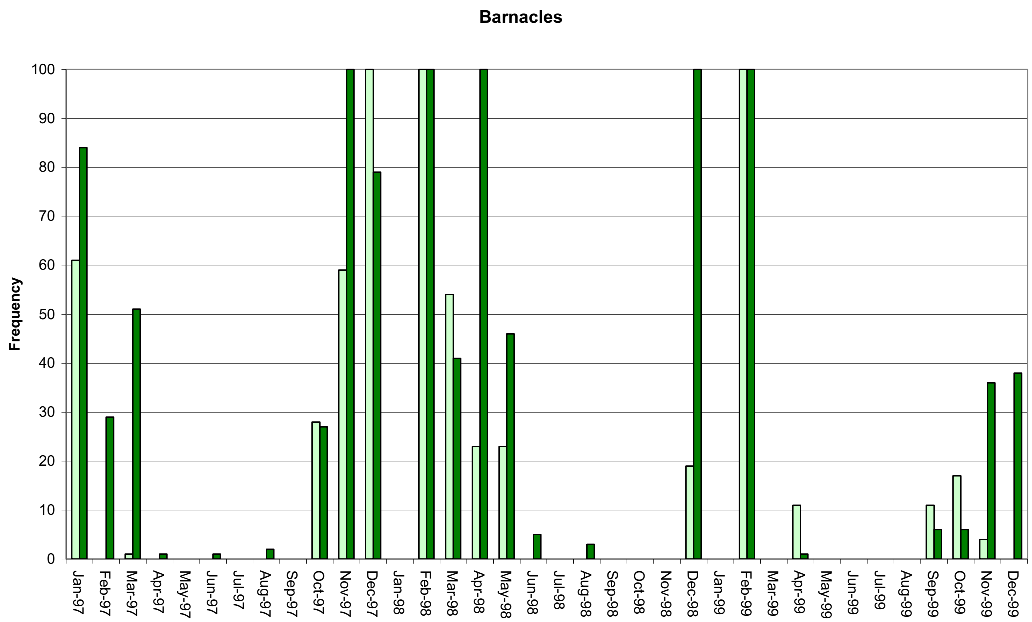

Figure A.3 Seasonal variation in abundance of barnacles on the control panels (December 1996 – January 2000)

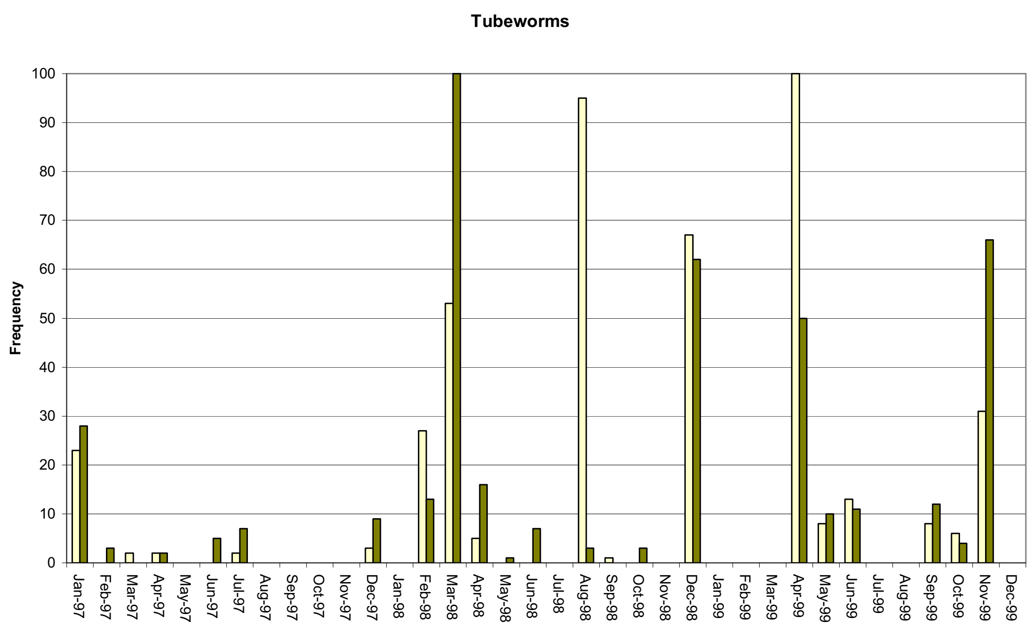

Figure A.4 Seasonal variation in abundance of tubeworms on the control panels (December 1996 – January 2000)

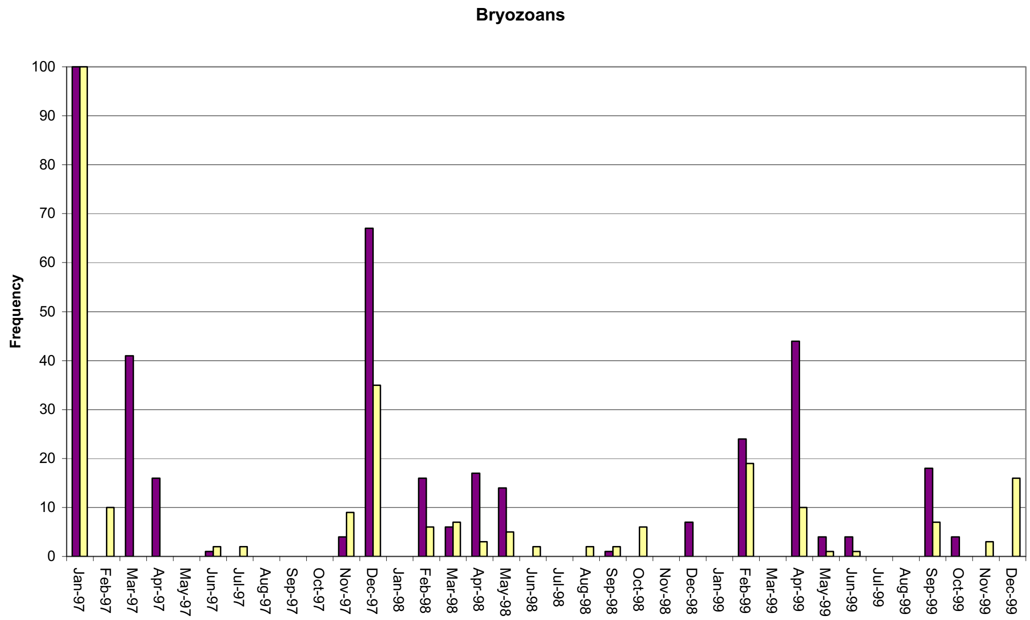

Figure A.5 Seasonal variation in abundance of bryozoans on the control panels (December 1996 – January 2000)

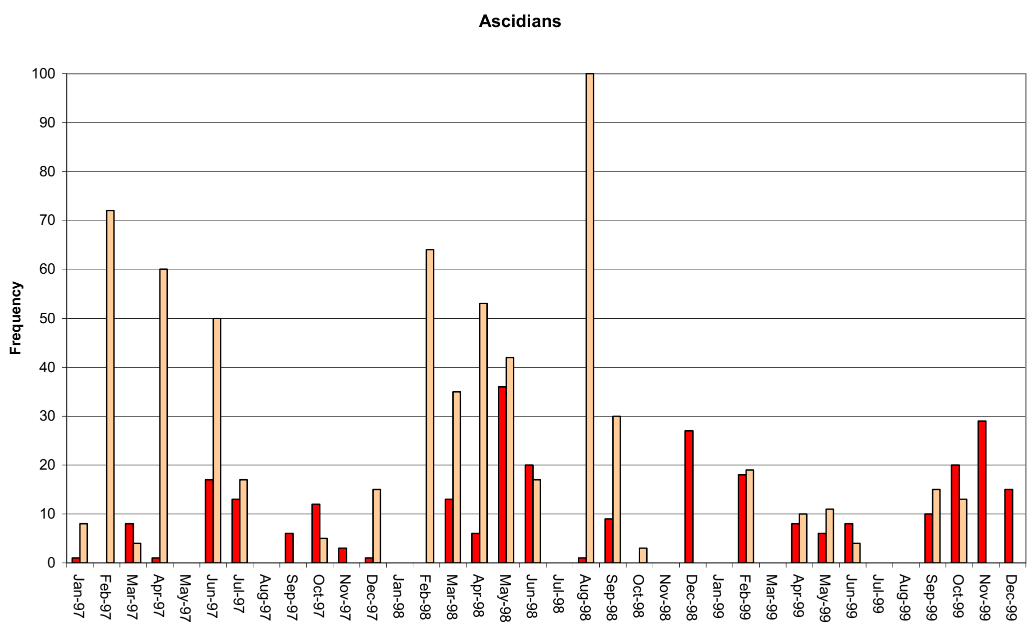

Figure A.6 Seasonal variation in abundance of ascidians on the control panels (December 1996 – January 2000)

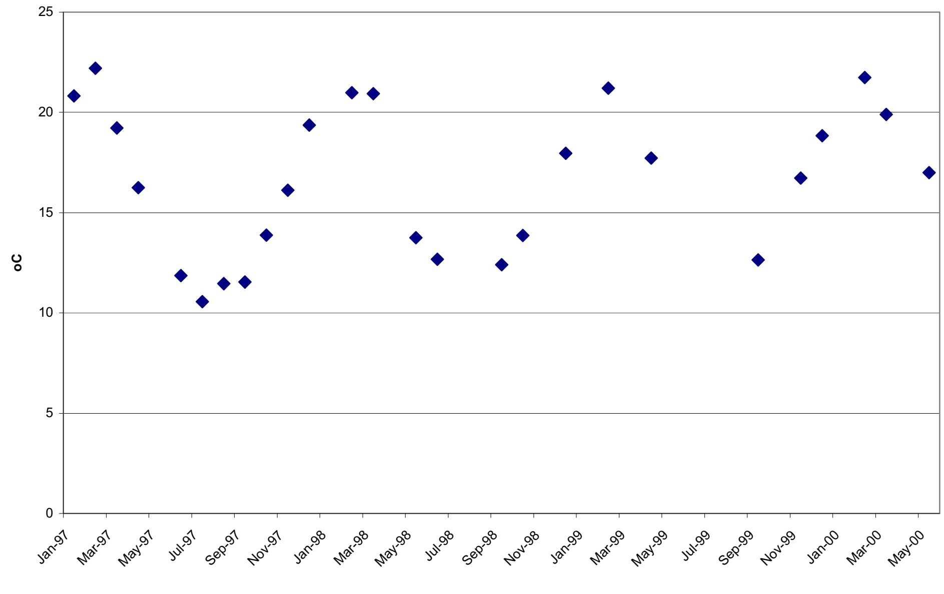

Figure A.7 Seasonal variation in water temperature measured 1 m below the water surface at the raft site (January 1997 – May 2000)

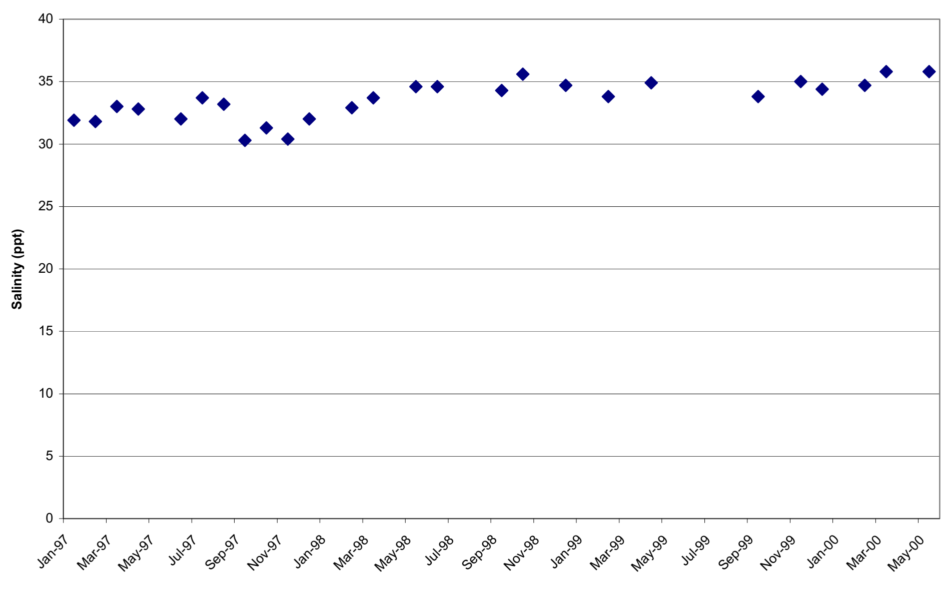

Figure A.8 Variation in salinity (ppt) as measured 1 m below the water surface at the raft site (December 1996 – January 2000)

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antifouling paint, protective coatings, biofouling, paints

19. ABSTRACT
A national and global ban on the application of antifouling paints containing tributyltin (TBT) is being introduced because of the detrimental effects of TBT on non-target marine species. DSTO, supported by the Royal Australian Navy (RAN), undertook a comprehensive program in an attempt to find alternative products that would match or approach the antifouling performance and effective life of TBT-based systems. The evaluation program included static immersion trials, dynamic flow testing, and trials on Navy ship hulls. Within this program, the Akzo Nobel coating *Ecoloflex* demonstrated antifouling efficacy, consistent ablation characteristics, and long term effectiveness on vessels operating in temperate and tropical Australian waters. This was the best performance seen from a copper-based antifouling coating to date and offered the RAN an alternative to TBT-based systems.

An Australian Government Initiative

THE NATIONAL SYSTEM FOR THE PREVENTION AND MANAGEMENT OF MARINE PEST INCURSIONS

National Biofouling Management Guidance for **Non-trading Vessels**

This collaborative effort is supported by the Australian Government, state and Northern Territory governments, marine industries, researchers and conservation groups.

Important

This guidance document is part of a series setting out a **consensus view of** effective **biofouling** management practices.

The guidance documents are made available on the understanding that the **Commonwealth** of Australia is not thereby engaged in rendering professional advice.

The Commonwealth does not warrant the accuracy, currency or completeness of the Guidance documents, or their relevance for any particular purpose. In particular it should be noted that legislation, regulations and bye-laws may vary between different jurisdictions and ports in Australia. Consequently the guidance documents do not purport to state what is necessary or sufficient to comply with laws applying in any place.

Before relying on the guidance documents in any important matter, users should obtain appropriate professional advice to evaluate their **accuracy**, currency, completeness and relevance for their purposes.

April 2009

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Northern Pacific seastar image courtesy of John Lewis ES Link Services Pty Ltd

Cover images: **Customs patrol boat, and fisheries patrol vessels** - Australian Customs Service
Luxury yacht - Superyachts, NSW Maritime
Tug boats - Woodside Energy Ltd
Dredge - Andy May, Van Oord Australia Pty Ltd

Design: www.symagy.com 5710

National Biofouling Management Guidance for **Non-trading Vessels**

Contents

1. Introduction

1.1 Overview

Under the *National System for the Prevention and Management of Marine Pest Incursions* (the National System) voluntary biofouling management guidance documents have been developed for a range of sectors operating within Australian waters.

Along with most shipping and boating sectors in Australia, non-trading vessels have been recognised as presenting a risk of marine pest translocation and introduction via biofouling. The voluntary biofouling management guidance for non-trading vessels has been developed to assist industry manage this risk.

Far left, northern Pacific seastar in large numbers on tidal flat

Image: Fisheries Research and Development Corporation

Left, Chinese mitten crab in heavy concentrations on the foreshore

Image: Dr. Stephan Gollasch of GoConsult

Below, Asian green mussel present on a heavily biofouled keel

Image: NT Government

Guidance documents under the National System such as the *National biofouling management guidance for the petroleum production and exploration industry* and similar documents titled the National biofouling management guidelines have been developed for a range of sectors including commercial vessels, recreational vessels, and commercial fishing vessels.

Marine species and pests can be translocated to and around Australia via biofouling on vessel hulls and in damp or fluid-filled spaces (niche areas) such as anchor lockers, bilges, sea chests or internal seawater systems. Marine pests are species with invasive traits that can cause significant adverse impacts to marine industries, the environment, human health and/or amenity if introduced, established or translocated within Australia, as well as generating substantial costs for eradication attempts or ongoing management.

For more information on marine pests please refer to **www.marinepests.gov.au**.

Applying the recommendations within this document and implementing effective biofouling controls can also assist vessel operators to minimise:

- hull and propeller inefficiency, resulting in a decrease in fuel consumption and increase in range and speed
- corrosion of pipework, valves and other internal seawater system components
- blocked or impeded flow into and within internal seawater distribution systems, resulting in increased efficiency of cooling, air conditioning and fire fighting systems
- increased maintenance efforts and repair costs associated with clearing biofouling from blocked systems.

Further information on marine pest threats to Australia can be found at Appendix A.

1.2 Purpose and scope

These recommendations provide practical management options for operators of non-trading vessels for the management of biofouling hazards associated with vessels and equipment. These recommendations only cover biofouling. Details of other marine pest management measures for marine pest risks such as ballast water can be found at **www.marinepests.gov.au**.

This guidance document will be periodically reviewed to ensure that the content remains current and practical to industry and end users.

Non-trading vessels encompassed by these recommendations are listed in the categories below:

General	**Government owned, contracted or chartered**	**Transport service vessels (note—some of these vessels may at times be owned, contracted or chartered by governments)**
• barges • cable ships • dredges • heavy lift vessels • lighters (including oil recovery vessels) • research vessels • tall ships • trailered vessels • super yachts	• customs launches • defence vessels • harbour and inshore patrol vessels, including - fisheries vessels - marine administration vessels - marine safety vessels - national/marine parks vessels - water police vessels - coastal patrol vessels	• charter boats • pilot boats • ferries • tugs and line handling boats • water taxis

Non-trading vessels not encompassed by these recommendations include:

- Cruise vessels

Although cruise vessels are considered to be non-trading vessels, their size, operational activity and maintenance regimes are similar to that of commercial vessels and therefore are referred to the *National biofouling management guidelines for commercial vessels*.

- Offshore support vessels & pipelay vessels

These vessels are classed as non-trading vessels but are variable in their operational activities and spend much of their time working for the petroleum production and exploration industry, thus these vessels are referred to *National biofouling management guidance for the petroleum productions and exploration industry.*

1.3 Delineation of responsibility

It is recommended that when applying these recommendations, any Australian Government, state, Northern Territory or local regulations be considered. For more information please refer to **www.marinepests.gov.au**.

2. Biofouling risk management

2.1 The biofouling pathway

For a vessel or equipment to cause a biofouling marine pest incursion, three key steps need to occur:

1. colonisation and establishment of the marine pest on a vector (vessel, equipment or structure) in a donor region (e.g. a home port, harbour or coastal project site where a marine pest is established)
2. survival of the settled marine pests on the vector during the voyage from the donor to the recipient region
3. colonisation (for example, by reproduction or dislodgement) of the recipient region by the marine pest, followed by successful establishment of a viable new local population.

At each step there are factors that affect the total number of individual organisms and species that successfully survive to the next stage of the biofouling pathway.

These three steps provide the foundation for understanding, managing and assessing whether a particular vessel and equipment will have a low or high risk of causing a marine pest incursion.

Live mussels found on the keel of a vessel (left) shows that Asian green mussel can survive sea journeys and potentially establish in new areas as they have on this submerged power station infrastructure.

Images: NT Government (left), Chris Gazinski, courtesy Mote Marine Laboratory (below).

2.2 The benefits of managing biofouling risks

Ensuring that appropriate biofouling risk reduction measures are implemented is advantageous for the non-trading vessel sector for reasons including:

- avoiding inadvertent marine pest incursions (not inspecting potentially high risk vessels until after their arrival at a location clearly poses much greater incursion risks than if the vessel's biofouling has previously been managed)
- avoiding the costs and delays of having to manage emergency vessel slipping and cleaning if a marine pest is discovered on the vessel after its initial mobilisation
- reducing the risk that the non-trading vessel sector may be implicated in the translocation or introduction of a marine pest.

Regular vessel maintenance is the best defence against invasive marine species.

Image: John Polglaze, URS Australia

2.3 Assessing the biofouling risk

The following factors need to be considered when assessing the risk of a vessel or equipment assisting in the translocation of a marine pest and to reduce the likelihood of an incursion:

- surface cleaning—removal of biofouling in a licensed vessel maintenance facility (such as a drydock) prior to departure from locations with a known or potential marine pest
- cleaning of internal seawater systems—treatment of internal seawater systems to prevent or remove biofouling (such as fitting a cathodic anode system to prevent biofouling)
- presence/absence of an effective antifouling coating—any wetted surface that is not protected by an antifouling coating will accumulate greater levels of biofouling than a coated surface
- status of the antifouling coating—its age, type, suitability to vessel, surface type and type of operations as well as its history of use in relation to the manufacturer's recommendations
- stationary or low-speed[1] working periods—the longer a wetted surface remains stationary or moving at low-speed in port or coastal waters, the more likely it is to accumulate biofouling (particularly if the antifouling coating is not designed for low-speed and/or low-activity operations, as many coatings rely on minimum vessel speeds to activate biocide layers or to wash off any biofouling)
- number and size of niche areas associated with vessel types—sheltered and/or areas without antifouling coating provide a location where many marine species (including mobile species such as fish, crustaceans, seastars and marine snails) are protected from strong water flow, avoiding dislodgement and allow settlement and growth
- voyage transit speed—marine pests are generally more capable of surviving slower voyages (such as towing) because they are not subjected to strong water flows compared to faster speeds[2] typical for non-trading work vessels and many trading vessels

Primary biofouling establishing in areas where the antifouling coating has been damaged.

- voyage route and duration—survivorship of marine pests is greater on slow east-west voyages (which remain within a similar latitude band) than on north-south (trans-equatorial) routes where temperature changes are greater. The shorter the transit across oceans, the more chance that the marine species will survive temperature change and/or limited food sources available in oceanic waters. Since almost all marine pests are coastal and harbour species, vessels operating in offshore deepwater environments are less likely to accumulate or translocate marine pests, compared to vessels or equipment that operate in ports and shallow coastal waters
- method of transit—survival of marine pests on vessel hulls and towed equipment is much higher than on hulls and surfaces, which are transferred as deck cargo on conventional or special heavy lift vessels. Most marine species, cannot tolerate prolonged exposure to air therefore, removal from the water (i.e., desiccation) can be an effective control option for marine pests. The effectiveness of desiccation as a control method also depends on the species and life history stage concerned and the relative humidity of the drying environment. As a general guide complete removal (i.e. no contact with water) and exposure to direct sunlight, warm temperatures and low humidity will kill most marine species within seven days. However, any compromise on these conditions such as exposure to seaspray can enable some species to survive up to eight weeks

Niche areas such as sea chests provide sheltered environments for marine pests.

Image: Forgacs Engineering Pty Ltd

1 Low-speed refers to vessels that generally operate at <5 knots.
2 Faster speeds refer to vessels that generally operate at >15 knots.

- environmental compatibility between departure and arrival regions—the risk of a successful marine pest establishment can be assessed based on the similarity of the departure and arrival regions with respect to:
    - water temperature range
    - salinity range
    - water depth range
    - habitat range (i.e. substrate types).

The assessment of biofouling risk should be guided by reference to any Australian Government, state, Northern Territory or local regulations.

2.4 Mitigating the biofouling risk

A risk assessment should be undertaken to examine factors influencing the translocation risk posed by particular vessels. As the risks vary from vessel to vessel the assessment should be undertaken in an objective, transparent, consistent and readily reportable way. The following flow chart shows the basic components of a risk assessment process for assessing and managing vessels and equipment intended to be moved to or within Australian waters.

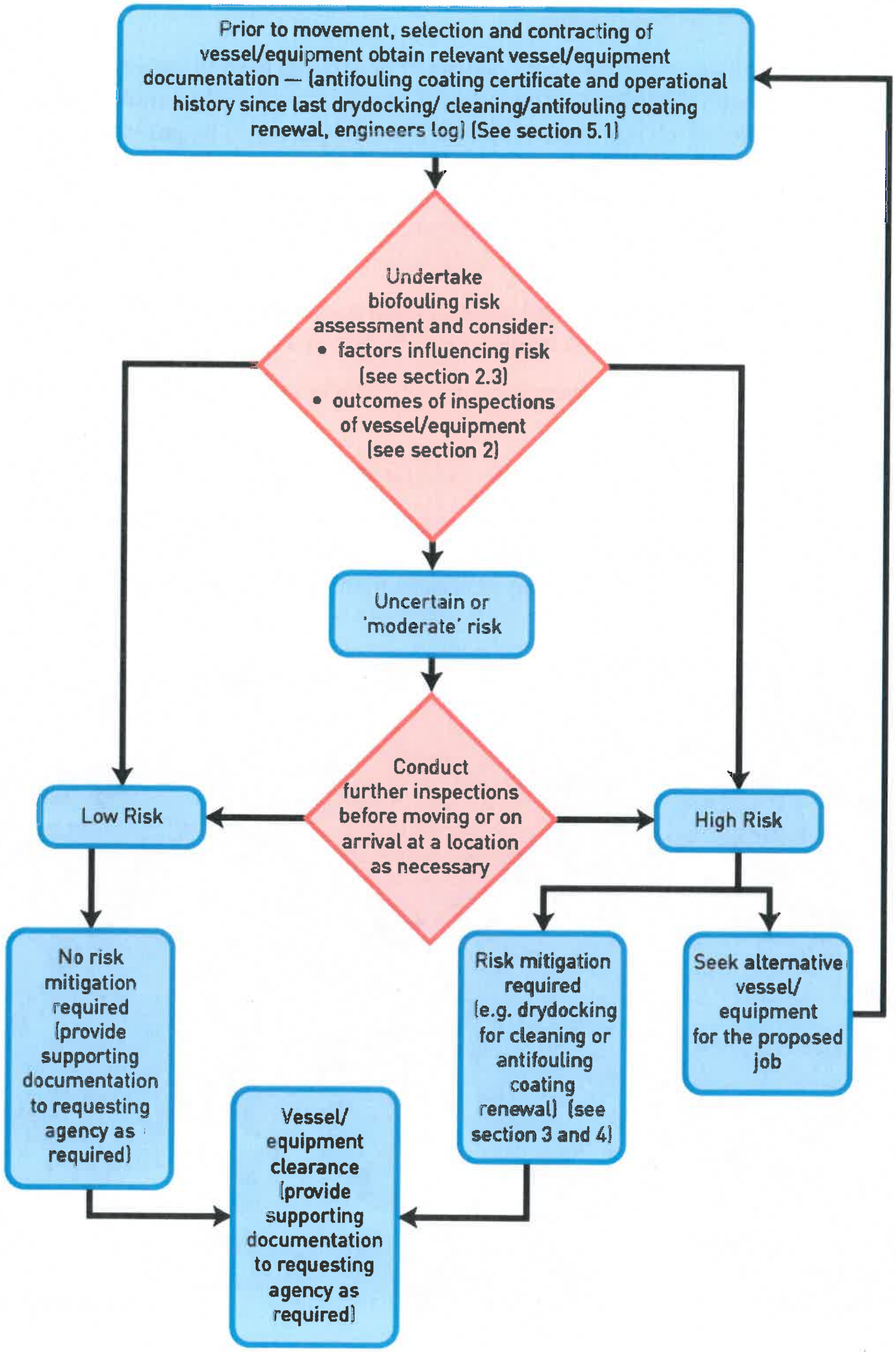
If vessels or equipment are found to have heavy biofouling or to pose a high risk of accumulating heavy biofouling, it is advised that biofouling mitigation treatments such as drydocking, cleaning and antifouling renewal be considered. Sections 3 and 4 of these recommendations provide information about managing the biofouling risk for specific vessel types, as well as related maintenance and repair information.

It is important to maintain clear and detailed records of all biofouling mitigation, maintenance and repair activities carried out on a vessel. Please see section 5 of these recommendations for more detailed information on record keeping.

Hull cleaning and renewing antifouling reduces biofouling and the risk of spreading marine pests.

Image: Mermaid Marine Australia Ltd

Generic approach to a biofouling risk assessment



3. Management of vessels

3.1 Introduction

All vessels have some degree of biofouling, even those which may have been recently cleaned or had a new application of an antifouling coating. Research has shown that the biofouling process begins within the first few hours of a vessel's immersion in water. Generally, the longer a vessel has been in water, the greater the size and complexity of its biofouling community. The type, amount and location of biofouling is influenced by a number of factors, such as:

- vessel design and construction, particularly the number and design of niche areas subject to biofouling including hull fittings
- the number, size and configuration of sea chests and other niche areas
- the layout, extent and configuration of internal seawater systems
- construction materials (e.g. cupro-nickel pipes are less prone to biofouling than steel) any marine growth prevention systems (MGPS) (e.g. copper dosing or chlorination systems) which may be installed

Biofouling below the waterline is not always evident when the vessel is in the water.

Image: NT Government

- any active marine growth control procedures (e.g. regular propeller cleaning) which may be employed
- typical operating profile, including factors such as operating speeds including periods spent operating at low speeds, ratio of time underway compared with time alongside, moored or at anchor, and where the vessel is stored when not in use
- places visited, the duration of stay and the time of year of stay, particularly extended stays in ports or anchorages with similar conditions to other ports within Australia and/or where known or suspected marine pests may be present
- inspection and maintenance procedures
- maintenance history, including type, age and condition of any antifouling coating including factors such as nature of coating/s, suitability of coating to the vessel operating profile, age, quality of application and maintenance including slipping and hull cleaning practices.

The biofouling which may be found on and in a vessel reflects the vessel's design, construction, maintenance and operations. Each of these aspects introduces particular biofouling vulnerabilities but also offers opportunities to limit the extent and development of biofouling, with commensurate reduction in biosecurity risks.

Suggested measures to minimise biofouling risks during each phase of a vessel's life are presented in the following sections.

3.2 Biofouling reduction and management measures

3.2.1 Design and construction

Any structural modifications to the hull or hull appendages should satisfy all relevant engineering standards and class requirements and be subject to approval, if appropriate, by regulatory authorities.

Hull voids and openings and other external niches

It is advisable that as far as practicable small niches and sheltered inaccessible areas be excluded from vessels in the design stage. Where the exclusion of niches is not practicable, these can be designed so that they may be easily accessed for effective inspection, cleaning and application of antifouling coatings.

Other means of reducing external biofouling include:

- rounding/bevelling protrusions on intake/outlet ports and similar areas to promote more effective application of an antifouling coating
- designing the corners of hull openings to be rounded to promote more effective application of an antifouling coating
- grouting/caulking gaps in and behind sacrificial anodes and impressed current cathodic protection (ICCP) strips, when fitted.

Sea chests

It is advisable that sea chests:

- be of simplified design, eliminating or minimising internal niche spaces and facilitating ease of access for in-water and drydock inspection, maintenance and painting (i.e. ideally sea chest interiors should feature smooth plates and wherever possible minimise internal structural members such as frames and stiffeners)
- have intake apertures/pipes flush with the sea chest interior surfaces
- use rounded—as opposed to square—bars on intake grills
- be easily accessible to divers for inspection and cleaning (e.g. have hinged grates, which can be open and shut by divers)
- fitted with a MGPS or other method for eliminating biofouling
- be 100 per cent free draining when the vessel is in a maintenance facility
- be able to be blanked-off for in-water treatment of biofouling
- be minimised in number and size.

Internal seawater systems

When designing internal seawater systems, consideration can be given to:

- using cupro-nickel pipes
- installing an effective MGPS, ensuring that the point of injection of MGPS dosing is located in the sea chests or as close as practicable to inlets
- minimising bends, kinks and flanges
- promoting ease of disassembly for inspection and cleaning
- inclusion of filters and strainers and inspection ports.

3.2.2 Operations

Selection of antifouling coating/s

It is essential that vessel operators obtain technical advice from the antifouling coating manufacturer or the supplier as different antifouling coatings are designed for different vessel operating profiles (including operating speeds, activity, maintenance and docking cycles). This will ensure the most appropriate antifouling coating is selected and applied according to the coating specification prepared for each application, with particular attention to surface preparation, coating thickness and the number of required coats.

Other factors that should be considered when selecting an antifouling coating to reduce the risk of marine pests include:

- tailored, differential application of antifouling coatings to match required performance and longevity with expected wear and water flow rates in specific high wear or low flow areas, such as the bow area, rudder, or sea chest interiors
- application of an antifouling coating on the (accessible) inner portions of the throats of intake/outlet ports
- application of an antifouling coating on areas not normally treated, such as main (and thruster/auxiliary) propeller/s and log probes
- application of cavitation resistant antifouling coatings, edge retentive and high performance anticorrosive coatings on surfaces and edges prone to coating damage.

Match antifouling coatings to the vessel's operating profile.

Preparation for movement to or between operating areas

The highest risk of a marine pest translocation will occur when a vessel moves between two broadly similar marine biogeographic regions, either from overseas to Australia or within Australia.

This risk increases if certain predisposing factors occur, such as when the vessel:

- is heavily biofouled
- has been inactive or operated at low speeds for an extended period before the move between regions
- has a worn, ineffective or aged antifouling coating

Image: John Lewis
ES Link Services Pty Ltd

- has areas where no antifouling coating is applied
- has operated in a port or area where a known or potential marine pest is known to occur.

To manage these risks, vessel operators should evaluate biofouling-related biosecurity risks before movement between locations.

Available risk reduction measures include:

- slipping or drydocking the vessel where practical or undertaking an inspection and thorough clean to remove biofouling, and repairing or replacing/renewing the antifouling coating
- conducting an in-water inspection by divers, and potentially undertaking an in-water clean if appropriate (please refer to specific information in section 3.2.3 of these recommendations in relation to the regulations surrounding in-water cleaning practices in Australia)
- inspecting internal seawater systems, cleaning strainer boxes, and dosing or flushing these systems (Noting that the use of chemicals in the aquatic environment is governed by the Australian Pesticides and Veterinary Medicines Authority. Please refer to www.apvma.gov.au for chemical handling and use information)
- inspecting and cleaning above water equipment and areas which may accumulate mud, sediments and/or marine pests, including dredge fittings, anchor cables and lockers, buoys, floats and booms and similar equipment
- providing prior advice to the relevant regulatory authorities of any concern regarding biofouling, and management actions undertaken or intended to be implemented.

Extended periods spent alongside, at anchor or operating at low speeds

During periods of low-speed/low-activity operations or inactivity, considerable biofouling can accumulate on underwater hull surfaces and niche areas. This is particularly the case in areas where an antifouling coating may be worn, damaged, depleted or not applied, or the antifouling coating applied is not designed for low activity or low-speed operations. The application of an antifouling coating optimised for use on low-speed vessels is critical for those vessels that typically operate at low speeds.

Vessels operating at low-speed/ low-activity accumulate significant biofouling.

Image: Andy May, Van Oord Australia Pty Ltd

If a vessel has been inactive or has operated intermittently or continually at low speeds it may accumulate substantial biofouling in as little as a month, especially in circumstances where the vessel has not operated in accordance with antifouling coating manufacturer's recommendations. If heavy biofouling is detected on a vessel, biofouling risk reduction measures need to be implemented before such a vessel moves to another location away from the port or anchorage where it has been stationary or operated at low speeds. These risk mitigation measures may incorporate a vessel inspection and appropriate cleaning before the vessel is moved from the location where it has been stationary.

Prior to undertaking in-water cleaning in Australia, approval from the relevant state and Northern Territory authorities must be granted and conditions may be imposed in line with the Australian and New Zealand Environment and Conservation Council (ANZECC) Code of Practice for Antifouling and In-Water Hull Cleaning and Maintenance[3] (please see section 3.2.3 of these recommendations for more information on in-water cleaning).

3 ANZECC Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance (1997) available at: **www.environment.gov.au/coasts/pollution/antifouling/code/index.html**

Anchors and cables, berthing lines, booms and other floating equipment

Steps should be taken to ensure items periodically immersed in water, such as anchors and cables, ropes, fenders and small boats (tenders) are clean of biofouling such as entangled seaweed, mud and other sediments after recovery and before stowage. For example, a high pressure washdown (using a firehose if cable washdown spray is not fitted) should be used to clean anchors and cables of mud and sediment at the time of anchor retrieval.

Anchor wells and chain lockers should also be checked periodically and kept clear of biofouling, mud and sediments.

Anchor wells are an effective niche area for mud, sediments and biofouling to accumulate.

Image: Aquenal Pty Ltd

3.2.3 Maintenance and repair

Slipping and drydocking

Regular slipping or drydocking of vessels should be undertaken to repair or renew the antifouling coating. This maintenance should be undertaken within the life projected for the antifouling coating by the antifouling manufacturer or supplier and a full antifouling coating reinstated on all painted underwater surfaces, including areas of damage and degradation, to provide effective antifouling protection through to the next scheduled drydocking. Records of all maintenance and repair work completed on the vessel should be documented and receipts retained as verification of biofouling management activities.

When applying an antifouling coating to a vessel, it is essential that vessel operators obtain technical advice from the antifouling coating manufacturer or supplier to ensure the most appropriate coating is selected and that it is applied according to the specification prepared for each application, with particular attention to surface preparation, coating thickness and the number of required coats.

Slipping or drydocking of vessels is also the most effective means for inspection, detection and removal of biofouling from the hull and niche areas.

Thorough preparation of surfaces before applying antifouling paints improves paint effectiveness.

Image: John Lewis
ES Link Services Pty Ltd

Along with the physical removal of biofouling, extended slipping or drydocking also results in death of biofouling by desiccation (air exposure). However, some marine pests can survive or release reproductive propagules even after long periods of air exposure, particularly if attached in sheltered, damp niches out of direct sunlight. As a general guide, complete removal (i.e. no contact with water) and exposure to direct sunlight, warm temperatures and low humidity will kill most marine organisms within seven days. However, any compromise on these conditions can enable some organisms to survive up to eight weeks.

Most vessels are hydro- or grit-blasted as a standard practice whenever drydocked and this will remove most external biofouling. It is essential that cleaning efforts during drydock or slipping specifically target niche areas. Means to improve the effectiveness of biofouling removal of niche areas include:

- cleaning any gaps between a fitting and the hull, such as may occur behind sacrificial anodes and stabilisers
- extending all retractable equipment, such as thrusters and dredge ladders, to permit access for cleaning of these fittings and any associated housings or voids
- opening up and cleaning sea chests, and physically removing any attached and detached biofouling debris, which may accumulate in them
- cleaning internal niches around shafts and propellers and nozzles, such as stern tubes, shaft couplings, ropeguards and bearings and rudder hinges
- cleaning other voids and niches, particularly apertures and orifices such as small bore intakes and outlets.

In-water inspection

In-water inspection is a useful means to inspect the condition of antifouling coatings and biofouling status of a vessel without the scheduling logistics and expense associated with slipping or drydocking. Dive and remotely operated vehicle (ROV) surveys are used for this purpose although they do have limitations regarding visibility and available dive time compared with the area to be inspected as well as difficulties with effectively accessing many biofouling prone voids and niches.

Niche areas on a non-trading vessel where biofouling can accumulate.

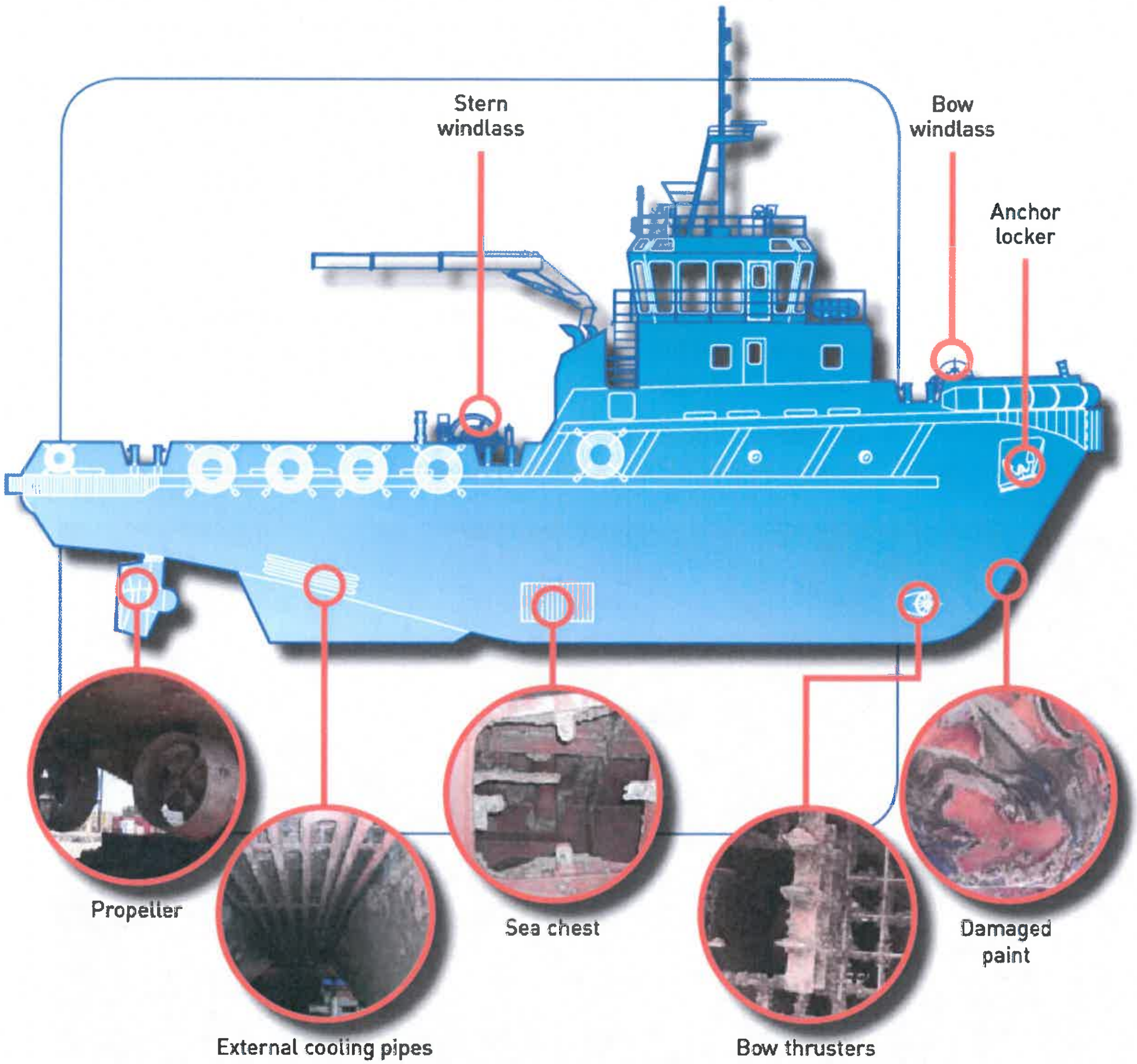


Illustration adapted from a diagram provided by Mermaid Marine Australia Ltd.

Images: John Polglaze, URS Australia (sea chest)
John Polglaze, URS Australia courtesy of Helix ESG (bow thruster)
Wallace McFarlane, QLD DPI (external cooling pipes)

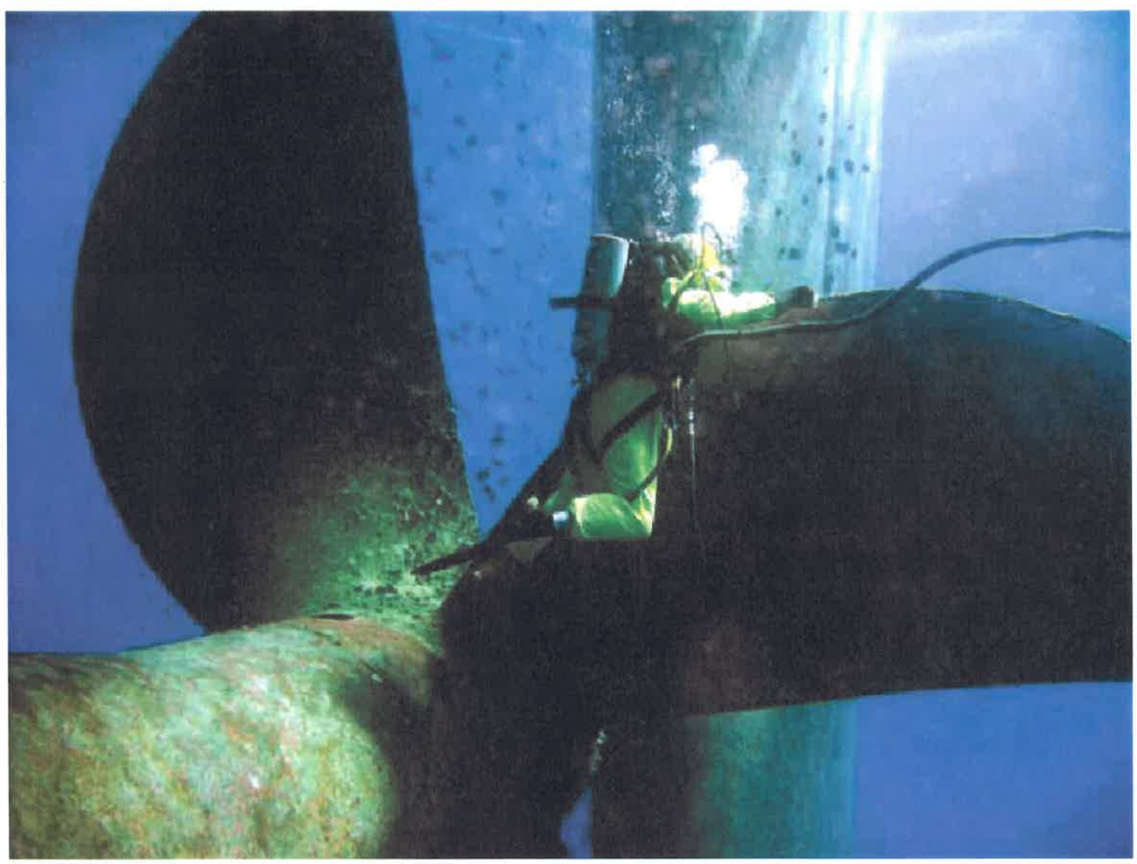
To be a useful tool in assessing the biosecurity risk posed by the biofouling present on a vessel, in-water dive inspections should only be undertaken by suitably qualified and experienced divers familiar with biofouling and marine pests. Where they exist, some port state requirements for biofouling management have recommended or accredited biofouling inspection divers to conduct these inspections.

It is recommended that when planning to conduct an in-water inspection, a formal procedure should be arranged to ensure that all accessible risk prone niches are examined. A formal procedure should involve:

- an inspection report sheet and photographic equipment
- an in-water procedure which encompasses known or likely biofouling risk areas and fittings, and is supervised or conducted by a suitably qualified and experienced person
- an appraisal of any internal seawater system/s and niches (strainer boxes, anchor cable locker, bilge spaces)

Ensure that divers undertaking in-water inspections and/or biofouling removal are suitably qualified and experienced.

Image: Neptune Marine Services Ltd



- a precautionary approach with respect to the amount and type of biofouling that may be present in inaccessible niches, such as sea chests and thruster tunnels, where grilles often prevent ROV or diver access

- where suspicious or suspected marine pests are detected, specimens should be collected and passed to the responsible regulatory authority for further examination. However, wherever possible consult with the regulatory authority surrounding their recommended collection and preservation methods. As a general guide collected specimens should be preserved in a sealed container in a solution of 70 per cent ethanol/30 per cent fresh water or otherwise sealed and labelled in a plastic bag and stored in a freezer until they taken for identification. It is important to ensure that there is only one specimen per container/bag. If arriving internationally all specimens must meet the Australian Quarantine and Inspection Service (AQIS) import conditions which can be found at **www.aqis.gov.au**.

In-water inspections should be undertaken periodically as a general means of routine surveillance, augmented by specific occasions as necessary to address any particular situations of elevated risk. Specific occasions when an in-water inspection may be warranted (as an alternative to slipping or drydocking), include:

- at the conclusion of an extended period of inactivity[4] or low-speed[5] operations when planning to move a vessel from an overseas location to Australia

- when planning to move a vessel from one region in Australia to another

- after a known or suspected marine pest is discovered on a vessel or within the vessel's niche areas such as the internal seawater systems, or a secondary translocation has occurred in proximity to a detection of a species of concern.

If considered necessary in-water inspections may be required by relevant regulatory authorities including the Australian Government and states and Northern Territory.

4 Extended periods refers to the order of months (as a minimum)
5 Low-speed refer to vessels that generally operate at ←5 knots

In-water cleaning of hulls and propellers

The removal of biofouling from vessel hulls and propellers is known to significantly improve a vessel's efficiency through the water and reduce the risk of translocating marine pests. However, scrubbing biofouled antifouling coatings not only prematurely depletes the antifouling coating and leads to rapid re-fouling but generates biofouling debris in the water column creating a pulse of biocide that can harm the local environment. To address this issue, many state and territory governments abide by Australian and New Zealand Environment and Conservation Council (ANZECC) Code of Practice for Antifouling and In-Water Hull Cleaning and Maintenance 1997 (under review) (the ANZECC Code). The ANZECC Code for in-water cleaning applies to in-water cleaning in Australian waters and stipulates:

1) no part of a vessel's hull treated with antifouling coating is to be cleaned in Australian waters without the written permission of the Harbour Master, local government or state environmental protection agency (administering authority)

2) in-water hull cleaning is prohibited, except under extra ordinary circumstances and permission will not normally be granted

3) the cleaning of sea chests, and other niche areas may be permitted provided that any debris removed (including encrustation, barnacles, weeds) is not allowed to pass into the water column or fall to the sea bed and subject to any other conditions attached to the permit. An application seeking permission to carry out this work must be lodged with the administering authority at least five working days prior to the anticipated start date. Such application will detail how encrustations, barnacles and other debris will be contained and or collected for disposal as well as the method of disposal

4) the polishing of ship's propellers may be permitted subject to any conditions attached to the permit. An application seeking permission to carry out 'propeller polishing' must be lodged with the administering authority at least five working days prior to commencement of the work.

Should a permit be granted, it is recommended that divers use the opportunity to inspect all niche areas for biofouling.

Areas that should be specifically inspected by divers include:

- rudder stock and hinge
- stabiliser fin apertures
- rope guards and propeller shafts
- cathodic protection anodes
- sea chests and bow thrusters
- overboard discharge outlets and sea inlets
- areas of antifouling coating damage or grounding.

Inspection and maintenance of internal seawater systems

Regular inspection of internal seawater systems can identify biofouling accumulations. Treatment of internal seawater systems offers a means of removing biofouling, leading to improved system performance while simultaneously reducing marine pest risks. Flushing and/or dosing can be undertaken as either a periodic treatment or in response to a specific biofouling problem.

There are two separate chemical processes used to maintain seawater systems, chemical cleaning and chemical dosing. Chemical cleaning is the addition of an acid to dissolve or digest any established biofouling from the internal seawater system pipework. Chemical dosing is used as either a routine addition of chemical to the seawater system to keep pipework free of biofouling or a shock dose to eradicate established biofouling. Chemical dosing is a viable option when more rigorous treatment may be necessary.

The selection and application of chemical cleaning agents requires consideration of a number of factors including pipework configurations, components (including valves, joints and seals), materials (e.g. rubber, plastics, polycarbonates, polyvinyl chloride, alloys and solders) and their compatibility with the intended agent and method of application. While this approach may be costly and time consuming to implement, if this option is used to treat internal seawater systems, disposing of all chemicals and materials must be done so using approved disposal locations and facilities.

Regular inspections of internal seawater systems will help identify areas where biofouling is building up and allow timely treatment.

Images: URS Australia

Freshwater flushing can kill marine species if the infected pipework can be isolated for several days, however the resulting calcareous and organic debris may need chemical removal or high pressure flushing to avoid clogging. Chemical treatment to kill marine species can similarly leave the system fouled by shells and other chemical and biological residue.

The choice of treatment agent—and its correct usage and disposal—warrants appropriate consultation to avoid compromising pipework integrity, vessel safety and environmental protection. Research to identify effective and safe treatment methods for killing marine pests remains part of the development program for the National System. Further advice should be sought from competent authorities and product agents.

3.2.4 Decommissioning and disposal

Decommissioned vessels or those slated for sale are often stationary for extended periods in ports and anchorages before final disposal. During this period of inactivity considerable biofouling can accumulate on underwater hull surfaces and fittings. This is particularly the case when an antifouling coating is worn, damaged or depleted or not designed for static performance, and in areas where the antifouling coating is not applied such as niche areas. Vessels are often decommissioned at the end of a docking cycle, when the antifouling coating is at the end of its anticipated life.

Decommissioned vessels would typically shutdown their internal seawater systems effectively starving and/or asphyxiating any marine pests within those systems. If internal seawater systems are to remain in use, then the ongoing operation of an MGPS or other dosing routines should be used to control biofouling.

A range of options exist to limit biofouling risks while a vessel is being prepared for decommissioning and disposal. These include:

- operation of an MGPS or other dosing routines, for any internal seawater systems, which remain in operation during the period of vessel inactivity
- blanking off sea chests (if not required for water uptake) external to the grates
- blanking off any other intakes and voids, such as bow thruster tunnels and rudder support strop holes will reduce niche areas available to harbour marine pests.

Assess the biofouling risk before relocating a decommissioned vessel.

Image: Wallace McFarlane QLD DPI

Before a vessel which has been inactive is moved to another location away from the port or anchorage, an assessment of the hull and niche areas should be conducted and significant biofouling removed in accordance with any relevant in-water cleaning guidelines and regulations (please see section 3.2.3 of these recommendations for further details on in-water cleaning). This will ensure that any biofouling that is obtained throughout the period of inactivity is from the location where the vessel was inactive and will not be conveyed to another location within Australia, reducing the chances of translocating a marine pest. If the vessel is re-entering service, a drydocking may be necessary to restore an effective antifouling coating on the hull and to ensure niches are free of biofouling.

4. Specific vessel classes

The following section outlines issues and measures for operators to address differences in the design and operational characteristics of specific vessel classes which can facilitate biofouling. The vessel specific information contained in this section should be considered in conjunction with the general guidance presented in sections 2 and 3 of these recommendations.

Operators of vessel types not represented in this section should take guidance from the information presented in line with the most similar vessel type/s, taking account of comparable design and operating characteristics.

Any in-water hull cleaning should abide by the ANZECC Code (see section 3.2.3 of these recommendations for specific details) and in accordance with the antifouling coating manufacturer's recommendations.

Furthermore, the removal, collection and disposal of biofouling and antifouling coatings in vessel maintenance facilities should abide by the ANZECC Code and occur at a licensed facility that has adequate waste management facilities to capture and dispose of collected matter.

4.1 Barges

Barges can be susceptible to biofouling and assist in the translocation of marine pests due to:

- periods spent stationary or operating and being towed at low-speed in ports and coastal areas
- for towed barges, biofouling has little impact on their efficiency through the water, hence less incentive to adopt high performance antifouling coatings
- damage to antifouling coatings from work activities, and regular groundings (e.g. as is the case for landing barges)
- mud, sediments and biofouling entangled in anchors and other related equipment
- transfers between coastal areas and islands, accentuating marine pest translocation risks.

These risks can be minimised by:

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle, including regular inspection, scheduled drydockings and cleaning and maintenance as necessary
- ensuring that anchors and cables are cleaned after use, and checked clear of mud, sediments, biofouling or entangled biofouling (such as seaweed) before stowage
- physically removing any obvious biofouling from berthing lines (by hand and/or high pressure washdown), then leaving lines to thoroughly dry before stowage
- if the chosen antifouling coating is in line with the operating profile of the vessel regular maintenance regimes should be followed although due to the vessel's operating profile, regular inspections of the niches areas may be necessary to ensure that they are free of biofouling
- using an effective MGPS or other inspection and treatment routines, for any internal seawater systems.

Image: URS Australia

Operators of landing barges that regularly ground should be aware of the need for regular hull inspection and maintenance to prevent biofouling accumulation on damaged coating areas. It is also recommended that the antifouling coating be repaired as necessary to maintain its effectiveness and longevity.

Operators of barges servicing island communities and remote coastal areas and between Australian ports or moving internationally need to be aware of the risks of translocating marine pests. They should ensure that the hull remains as free of biofouling as practicable and that berthing lines, anchors, cables and other immersible gear are checked regularly and kept free of entangled biofouling, mud and sediments.

4.2 Lighters

Lighters can be susceptible to biofouling and assist in the translocation of marine pests because they can spend long periods stationary or operating at low-speed in ports and coastal areas.

These risks can be minimised by:

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle, including regular inspection, scheduled drydockings and cleaning and maintenance as necessary
- physically removing any obvious biofouling from the berthing lines (by hand and/or high pressure washdown), then leaving lines to thoroughly dry before stowage
- undertaking a biofouling inspection, and if necessary, appropriate hull maintenance before relocation of a lighter from one port or coastal area to another.

4.3 Heavy lift vessels

Management of biofouling risks for these vessels is addressed in sections 2 and 3 of these recommendations.

Heavy lift vessels may pose some risk according to the deck cargo they are carrying, such as small vessels, items of marine infrastructure or mobile drilling rigs which may be heavily biofouled. All cargo should be thoroughly inspected and cleaned of marine pests in the location where the cargo is loaded before transport.

Image: Ashley Coutts, Cawthron Institute

Residual biofouling on heavy lift vessel cargo items may die due to desiccation during the period of transit, but this cannot be relied upon as some organisms can survive or release reproductive propagules after long periods of air exposure, particularly if in sheltered, damp niches out of direct sunlight or exposed to seaspray (please see section 2.3 and 3.2.2 for further details).

4.4 Dredges

Dredges can be susceptible to biofouling and assist in the translocation of marine pests due to:

- long periods spent operating at low-speed in ports and coastal areas
- long periods spent stationary in ports and anchorages between jobs
- damage to antifouling coatings in some locations as a result of work activities
- surfaces, components and fittings not treated with antifouling coatings due to operating and material requirements
- entrainment and capture of mud, sediments and biofouling in dredge equipment and ancillary fittings
- transfers from one coastal area to another, facilitating marine pest translocation risks.

Image: URS Australia

These risks can be minimised by:

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle, including regular inspection, scheduled drydockings, and cleaning and maintenance as necessary
- ensuring that anchors and cables are cleaned after use and checked clear of mud, sediments, biofouling or entangled biofouling (such as seaweed) before stowage
- ensuring that cable lockers are checked and if necessary cleaned clear of mud, sediments, and entangled biofouling before transit of the dredge to another area
- undertaking biofouling inspections when deemed appropriate and in line with the maintenance schedule of the vessel. The inspection should include the underwater hull area, and if necessary, thorough cleaning or flushing of suction and discharge pipes and hoses, hoppers, hopper doors and hinges, cutters, dredge ladders, trailing arms, buckets, pontoons and similar. This needs to occur particularly after a period of a month or more of inactivity or extended low-speed operation and before transit to another area. Where practicable, this equipment should also be rinsed or flushed with fresh water
- using an effective MGPS or other inspection and treatment routines for internal seawater systems
- cleaning of internal seawater system strainers and emptying of decantation tank/s (if fitted) at the completion of a dredging operation and before transit to another area.

National guidelines for assessing dumping activities including dredging permit applications can be found at **www.environment.gov.au/coasts/pollution/dumping/guidelines/**.

4.5 Cable ships

Cable ships can be susceptible to biofouling and assist in the translocation of marine pests due to:

- extended periods spent moored or berthed in ports and anchorages between jobs
- surfaces, components and fittings not being treated with antifouling coatings due to operating and material requirements
- entrainment of mud and sediments in immersible working gear and recovered cables.

These risks can be minimised by:

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle including regular inspection, scheduled drydockings, cleaning and maintenance as necessary
- ensuring immersible and floating equipment (e.g. pontoons, mooring system components) is inspected and cleaned after use and checked clear of mud, sediments, biofouling or entangled biofouling (such as seaweed) before stowage
- ensuring that all mud, sediments and biofouling is, as far as practicable, cleared from cable or pipe recovered from the seabed. Any accumulation of this material on the deck or working areas of the vessel should be discarded in the source location, or contained on board for disposal ashore in appropriate waste disposal facilities
- undertaking a biofouling inspection and if necessary appropriate hull maintenance before relocation of a dredge from one coastal area or port to another. Particular attention should be given to areas and components where antifouling coatings are absent or damaged
- using an effective MGPS or other inspection and treatment routines, for internal seawater systems.

4.6 Customs vessels

Customs vessels and their tenders can be susceptible to biofouling and assist in the translocation of marine pests due to:

- variable speed and activity in operation
- operations in varying coastal areas and remote islands
- operations in marine protected areas not normally visited by vessels, increasing the risk of translocating a marine pest to this area
- work in close proximity to vessels which represent elevated biofouling risks, with the risk for transfer of marine pests from one of these vessels to a Customs vessel or its tender.

Image: Australian Customs Service

These risks can be minimised by:

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle, including regular inspection, scheduled drydockings, and cleaning and maintenance as necessary
- undertaking regular biofouling inspection of the underwater hull area, and a clean if deemed necessary
- ensuring that anchors and cables are cleaned after use and checked clear of mud, sediments, biofouling or entangled biofouling (such as seaweed) before stowage
- ensuring that cable lockers are periodically cleaned and checked clear of mud, sediments and entangled biofouling
- using an effective MGPS or other inspection and treatment routines, for internal seawater systems
- avoiding direct contact between a Customs vessel and illegal vessels of the type regularly intercepted during Customs patrols
- periodically inspecting the underwater surfaces and immersible gear (e.g. anchor and cable) of embarked tender/s to ensure these are clear of mud, sediments biofouling and entangled biofouling.

4.7 Defence vessels

Defence vessels include a broad spectrum of vessel classes, some of which are similar in design and operation to other non-trading vessel categories such as Customs vessels, harbour craft, barges and research vessels. Defence vessels can be susceptible to biofouling and assist in the translocation of marine pests due to:

- variable speed and activity in operation
- extended periods of inactivity in port between operations and exercises, and during alongside maintenance procedures.

Australian Defence vessels are required to manage biofouling in accordance with the Defence Instruction on Policy for the Management of Ballast Water and Ship Biofouling.

Image: John Lewis ES Link Services Pty Ltd

Vessels under contract or charter to Australian Defence should seek guidance from the Australian Defence Instruction on Policy for the Management of Ballast Water and Ship Biofouling as well as relevant information presented in sections 2, 3 and 4 of these recommendations.

4.8 Harbour and coastal patrol vessels

This category includes a variety of limited range marine and harbour administration and patrol vessels such as those used by or for water police, fisheries, marine administration, marine safety (including search and rescue), national/marine parks and other coastal patrol vessels.

Operators are advised to maintain regular inspection and cleaning schedules to prevent biofouling and minimise the translocation of marine pests as a result of vessel movements.

Operators of trailered vessels should refer to section 4.17 of these recommendations.

4.9 Research vessels

Research vessels and deployment of associated immersed and subsea equipment may assist in the translocation of marine pests.

These risks can be minimised by:

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle including regular inspection, scheduled drydockings, cleaning and maintenance as necessary
- ensuring that immersed and subsea equipment (e.g. nets, bottom grabs and other sampling gear) is inspected and cleaned after use and checked to be clear of mud, sediments, biofouling or entangled biofouling (such as seaweed) and dried before stowage
- ensuring that all mud, sediments and biofouling is, as far as practicable, cleared from equipment recovered from the water column or seabed. Any accumulation of this material on the deck or working areas of the vessel should be discarded in the source location or contained on board for disposal ashore at a licensed facility that has adequate waste management facilities to capture and dispose of collected matter.

Management of biofouling risks for these vessels is further addressed in sections 2 and 3 of these recommendations.

Image: CSIRO Marine & Atmospheric Research

4.10 Ferries

Ferries that move between separate coastal regions or mainland and offshore islands (Kangaroo Island, Rottnest Island and islands in the Great Barrier Reef region) pose a risk of assisting in the translocation of marine pests. As these vessels may be operating in pristine or sensitive marine environments, vessel operators need to be aware of the need to effectively reduce biofouling risks to protect the value of these locations on which their business may be based.

These risks can be minimised by:

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle, including regular inspection, scheduled drydockings, cleaning and maintenance as necessary
- ensuring that anchors and cables are cleaned after use, are clear of mud, sediments, biofouling or entangled biofouling (such as seaweed) before stowage
- ensuring that cable lockers are periodically inspected and cleaned of mud, sediments and biofouling
- use of an effective MGPS or other inspection and treatment routines for internal seawater systems.

Ferries that move within a particular port or estuarine area pose a reduced risk for translocating marine pests, particularly when they operate in a single location.

4.11 Charter boats

Charter boats can be susceptible to biofouling and assisting marine pest translocation. This is due to extended periods spent moored or berthed in ports and anchorages between jobs or in periods of low commercial demand. Similar to ferries, charter boats tend to operate in pristine or sensitive marine environments often undertaking numerous day trips from ports to nearby areas. These are regular, typically high speed movements, of generally well maintained vessels, however vessels may operate from inshore/ports or source waters with a history of marine pests/detections. Vessel operators need to be aware of the need to effectively reduce biofouling risks in order to protect the value of the locations on which their services depend. These risks can be minimised by:

Image: Kyle Marks

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle including regular inspection, scheduled drydockings and cleaning and maintenance as necessary
- slipping and cleaning vessels prior to commencement of the charter season including inspection and cleaning of internal seawater systems.

Charter vessels which visit isolated regions such as the Kimberley coast and outer areas of the Great Barrier Reef, need to be particularly vigilant to avoid the translocation of marine pests via biofouling into protected areas.

Operators of trailered vessels should refer to section 4.17 of these recommendations.

4.12 Water taxis

No specific measures are recommended for water taxis.
Applicable general guidance is provided in sections 2 and 3 of these recommendations.

4.13 Pilot boats

No specific measures are recommended for pilot boats.
Applicable general guidance is provided in sections 2 and 3 of these recommendations.

4.14 Tugs and line handling boats

Harbour tugs and line handling boats can be susceptible to biofouling and assist in the translocation of marine pests due to:

- long periods spent operating at low-speed in ports and coastal areas
- long periods spent stationary in ports and anchorages
- damage to antifouling coatings as a result of work activities
- tug movement between ports or different coastal regions
- contact with berthing lines and cables from ships visiting that port from a different port.

These risks can be minimised by:

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle including regular inspection, scheduled drydockings, cleaning and maintenance as necessary
- ensuring that warps and lines are free of any biofouling or entangled biofouling by physical removal by hand or high-pressure hosing and allowed to thoroughly dry before being stowed or re-used in a new location
- visually inspecting lines received from visiting vessels to check that there is no obvious biofouling either attached or entangled.

Image: Svitzer Australasia

4.15 Super yachts

Super yachts can be susceptible to biofouling and assist in the translocation of marine pests due to:

- variable speed and voyage activity
- extended periods of inactivity in ports between voyages.

These risks can be minimised by:

Image: Superyachts - NSW Maritime

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle, including regular inspection, scheduled drydockings, and cleaning and maintenance as necessary
- ensuring that anchors and mooring lines are cleaned after use, and checked clear of mud, sediments, biofouling or entangled biofouling (such as seaweed) before stowage
- ensuring that cable lockers are periodically inspected and cleaned of mud, sediments, and entangled biofouling
- using an effective MGPS or other inspection and treatment routines for internal seawater systems

Treatments listed above can apply equally to vessels associated onboard super yachts that are periodically deployed, such as tenders and jet skis.

Additional general guidance is provided in Sections 2 and 3 of these recommendations.

4.16 Tall ships

Tall ships (often with wooden hulls and sometimes known as slow moving wooden vessels) e.g. sail training vessels and vessel replicas, can be susceptible to biofouling and assist in the translocation of marine pests due to:

- low-speed and variable voyage activity
- extended periods of inactivity in ports between voyages
- wooden hulls vulnerable to infestation by marine wood boring organisms.

These risks can be minimised by:


Image: Kyle Marks

- selecting, applying and maintaining an effective antifouling coating appropriate to the vessel's operating profile and docking cycle, including regular inspection, scheduled drydockings and cleaning and maintenance as necessary
- ensuring that anchors and cables are inspected after use and cleaned of mud, sediments, biofouling or entangled biofouling (such as seaweed) before stowage
- ensuring that cable lockers are periodically inspected and cleaned of mud, sediments, and entangled biofouling
- undertaking a biofouling inspection and, if necessary, appropriate hull maintenance before embarking on voyages.

4.17 Trailered vessels

Apart from the normal risks posed by any vessel within the non-trading vessel sector, trailered vessels have the potential to translocate marine pests from one area to another via both the vessel and/or its trailer.

These risks can be minimised by:

- regularly inspecting and removing entangled or attached biofouling (including slime) from the external surfaces of the boat
- regularly inspecting and removing entangled biofouling, mud and sediment from the trailer
- thoroughly draining, cleaning and rinsing with freshwater the boat motors, hull fixtures (e.g. cable locker, bait locker) and interior
- rinsing the vessel with freshwater (internal and external) and trailers before moving from one location to another.

5. Recording and reporting

5.1 Record keeping

It is recommended that vessel operators maintain a biofouling record book for each vessel. The book should record details of all inspections and biofouling management measures undertaken on that vessel.

A biofouling record book will assist in the assessment of the potential biofouling risk of a vessel and catalogue supporting documentation providing verifiable evidence that a vessel is unlikely to present an unacceptable biofouling risk. It is advised that copies/originals of all receipts and documentation are kept for verification of biofouling management conducted.

Information which should be recorded in a biofouling record book includes:

- details of the antifouling coating used, and where and when applied[6]
- dates and location of slippings/drydockings, including the date the vessel was re-floated, and any measures taken to remove biofouling or to renew or repair the antifouling coating
- the date and location of in-water inspections, the results of those inspections and any corrective action taken to deal with observed biofouling
- details of fitted MGPS systems, their operation and maintenance and the dates and details of inspection and maintenance of internal seawater systems, the results of those inspections and any corrective action taken to deal with observed biofouling and any reported blockages, reduced seawater pressures, elevated cooling temperatures that may imply biofouling build-up, as documented in the engineer's log

An example of a biofouling record book and information to be recorded is included at Appendix B to these recommendations. This format is an example only. Vessel operators should check with jurisdictions about the preferred type and format of information required.

6 Vessels greater than 400 gt and capable of international voyages should be in possession of an International Antifouling System Certificate (IAFSC), as required by the International Convention o the Control on Harmful Antifouling Systems on Ships (AFS) 2001. This certificate should be carried on board the vessel and available for documentation requested by regulatory authorities. Vessels less than 400 gt should seek to be issued with a statement of conformance against the requirements of AFS 2001 that is then carried on board the vessel.

5.2 Reporting

Vessel operators should notify the relevant regulatory agencies on arrival within a state or territory, particularly if they find or suspect a marine pest is present on the vessel, to enable formal identification and initiation of appropriate management action. Signs of a suspected marine pest could include unusually heavy biofouling, dominance of the biofouling by one species or a 'new' species not seen before in the region.

Where suspicious or suspected marine pests are detected, specimens should be collected and passed to the responsible regulatory authority for further examination. However, wherever possible consult with the regulatory authority about their recommended collection and preservation methods. As a general guide collected specimens should be preserved in a sealed container in a solution of 70 per cent ethanol/30 per cent fresh water or otherwise sealed and labelled in a plastic bag and stored in a freezer until they taken for identification. It is important to ensure that there is only one specimen per container/bag. If arriving internationally all specimens must meet the AQIS import conditions which can be found at **www.daff.gov.au/aqis**.

6. Glossary

Antifouling coating (AFC)	any paint or other coating specifically designed to prevent or deter the attachment and growth of biofouling organisms on a surface. Includes biocidal coatings and fouling-release coatings
Fouling release coatings	non-biocidal coatings with surface properties that minimise the strength of adhesion of biofouling organisms resulting in detachment by vessel movement
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZECC Code	Australian and New Zealand Environment and Conservation Council, Code of Practice for Antifouling and In-Water Hull Cleaning and Maintenance 1997 (under review)
AQIS	Australian Quarantine and Inspection Service
Bilge/spaces	the lowest and typically damp internal spaces of a hull where water can accumulate
Biocide	a chemical substance that is poisonous to living organisms
Biofouling	marine organisms attached to any part of a vessel hull (including the hulls, rudders, propellers and other hull appendages) or internal seawater systems (including sea chests and pipe work), or any equipment or equipment spaces attached to or onboard the vessel (including mooring devices, anchor wells, cable lockers, cargo spaces, bilges etc)
Biofouling organism	any species that attaches to natural or artificial substrates such as piers, navigation buoys, pilings or hulls or other organisms; including both attached organisms, and mobile organisms living on or between the attached biofouling.
Biota	all biological organisms, including micro-organisms, plants and animals
Chemical dosing	the slow and continuous injection of chemicals (can be used to eradicate a pest)
DAFF	the Australian Government Department of Agriculture, Fisheries and Forestry
Drydocking support strips (DDSS)	the areas of the hull that are covered by supporting blocks when a vessel is drydocked, hence fresh antifouling cannot be reapplied to these areas

Entrainment	the capture of an organism within a flow or vector such as ballast water
Exotic marine species	any non-native species that may or may not be present in Australia's marine environment
Hull	the wetted surfaces of a vessel including its propulsion and steering gear, internal cooling circuits, sea strainers, bow thrusters, transducers, log probes, anchors, anchor chains, anchor lockers and bilge spaces
ICCP	impressed current cathodic protection
Introduce/ Introduction	deliberate or unintentional human-assisted movement of a species to any location not part of its natural (native) range
Invasive	ability of an introduced species to spread across natural or semi-natural habitats by its own means and form dominant populations
Marine pest	any exotic marine species that poses a threat to Australia's marine environment or industry, if introduced, established or translocated
MGPS	marine growth prevention system
National System	National System for the Prevention and Management of Marine Pest Incursions.
Niche	protected or refuge areas on a vessel that facilitate the settlement and survival of biofouling organisms
Pathway	route taken by vector/s from point A to point B
Route	a geographic track or corridor taken or formed by a vector
ROV	remotely operated vehicle
Sea chest	a recess built into a vessel's hull, covered by a coarse grill that contains one or more seawater intakes for engine cooling, ballast uptake, fire fighting and other onboard functions
Translocation	only refers to the accidental or intentional transportation of an organism from one location to another, and does not refer to a successful introduction or incursion
Vector	the physical means, agent or mechanism which facilitates the translocation of organisms from one place to another
Vessel	any ship, barge, mobile drilling unit, work boat, craft, launch, submersible etc

Appendix A – Marine pest threats to Australia

Introduced marine pest threats

Biofouling is the growth of marine organisms on underwater surfaces. It is particularly common on and in vessels and other floating or immersed man-made objects. Biofouling can occur on vessel hulls and underwater fittings such as rudders and propellers, and in voids such as sea chests. It also occurs in the pipework of internal seawater systems, such as engine cooling circuits and other systems that draw seawater.

Along with other marine pest transport vectors such as ballast water, biofouling is a biosecurity concern because a vessel or other object carrying biofouling may transport a potential marine pest into Australian waters or between different regions within Australia.

Biofouling communities not only contain the more common types of marine species such as barnacles, tubeworms, bryozoans, mussels and algae but can also contain mobile species such as crabs, sea stars, small fish and associated parasites and diseases, including known invaders. Biofouling is also an important secondary vector for the regional spread of harmful species where an initial incursion may have been associated with another vector, such as ballast water or aquaculture. For example, the spread of the golden mussel *Limnoperna fortunei* in Brazil, which is believed to be primarily due to biofouling, is estimated at approximately 240 km per year up-river since its first invasion in 1991 (probably in ballast water).

Not all exotic marine species associated with biofouling represent a biosecurity threat. The Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE)[7] has undertaken an extensive literature review to establish a trigger or target list of exotic marine species considered to pose a high risk of a significant impact if introduced to Australian waters. Criteria have been established to judge these impacts. To meet the criteria, the species must have:

- demonstrated invasive history
- a high likelihood of having major impacts in Australia based on the available data and characteristics of Australian environments and marine communities

- demonstrated impacts in native or invaded ranges on:
  - economy
  - environment
  - human health and/or
  - amenity
- one or more relevant translocation vectors.

Harmful marine species translocated by biofouling may not only have serious impacts on the environment, society and industries but also ongoing costs associated with their management or eradication attempts. Some high impact marine species known to have been translocated by biofouling include: Asian green mussel (*Perna viridis*) in the Caribbean; clubbed tunicate (*Styela clava*) and sea vase (*Ciona intestinalis*) in Canada; an introduced alga (*Hypnea musciformis*) in Hawaii; and the black-striped mussel (*Mytilopsis sallei*) in Darwin Harbour, Australia where eradication cost in excess of $2 million.

Biofouling has been estimated to be responsible for:

- 74 per cent of non-indigenous marine invertebrates transported to the Hawaiian Islands (Eldredge and Carlton, 2002)
- 42 per cent of marine species unintentionally introduced into Japan (Otani, 2006)
- 69 per cent of adventive marine species arrivals in New Zealand, with a further 21 per cent possibly as biofouling or in ballast water (Cranfield et al., 1998)
- 78 per cent of introduced marine species in Port Phillip Bay, Australia (Hewitt et al., 2004)
- more than half of the ship-mediated species introductions into the North Sea (Gollasch, 2002)
- 70 per cent of the species that have invaded coastal North America via ships have either been moved by biofouling alone, or could have been moved by biofouling and ballast water (Fofonoff et al., 2003)
- more than 70 per cent of introduced algal species around the world are believed to have been introduced via vessel biofouling, while only 15 per cent were likely via ballast water (Hewitt et al. 2007)

7 CCIMPE is a consultative committee composed of State, Territory and Commonwealth representatives and provides advice in marine pest emergency situations.

- the introduction of marine species to Australia, New Zealand and the North Sea between 1995 – 2002 alone, 77, 50 and 40 per cent of species respectively were introduced via vessel biofouling (Hewitt et al. in press).

Once a marine pest becomes established in Australia the possibility and/or success of eradication is usually low. Preventing the translocation and entry of a marine pest in the first instance is the most effective and cost-efficient means of protection and is the primary objective of the recommendations.

Marine pests which have already become established in Australian waters, eradication is generally impossible and management is aimed at containment of the pest to the location/s where it has become established. Vessel biofouling controls are a major means of limiting the risk of translocation of marine pests to new areas.

Further information

Further information on biofouling management and biosecurity controls is available from the Australian Government or state and territory authorities. Please refer to **www.marinepests.gov.au** for contact details.

Appendix B – Biofouling record book

Example only

Please note: This is an example of the information that may be included in a biofouling record book. Vessel operators should check with jurisdictions about the preferred type and format of information required.

Time since last maintenance event (example slipping/drydocking)

Name of vessel

Vessel type

Average cruising speed

Call sign

IMO no. (if applicable)

Vessel dimensions:

- length overall
- width (beam)
- draft (max and min)

Type of last full coating of antifouling applied to the vessel, date of application, facility where applied and type of any underlying antifouling coatings

Internal seawater systems in the vessel, including location of strainers, and any associated marine growth prevention systems (MGPS) and/or cleaning or dosing procedures.

Diagram of vessel indicating underwater hull form (such as below) which may include recognised biofouling niches:

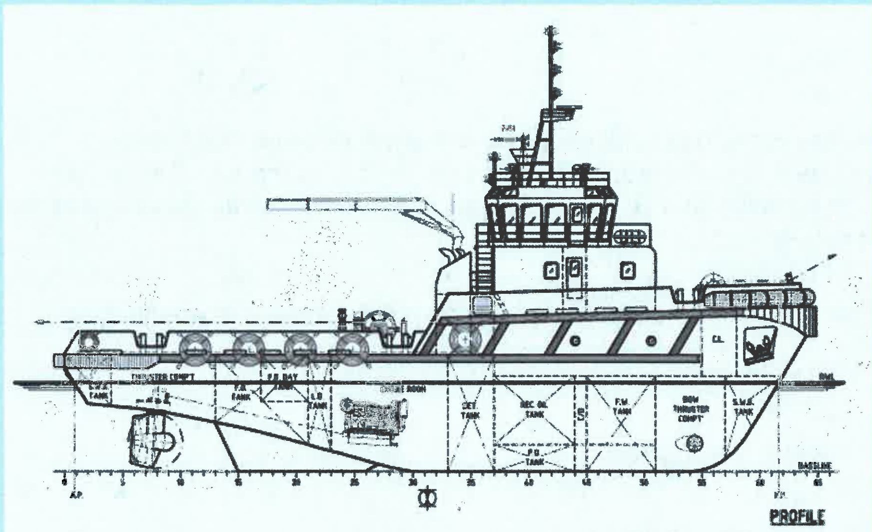


Diagram: Mermaid Marine Australia Ltd.

Entries in the biofouling record book

Entries in the Biofouling Record Book should include:

1. vessel maintenance:
   a. date and location that the vessel was removed from the water
   b. date that vessel was re-floated
   c. any hull cleaning that was performed, including areas cleaned and method used for cleaning
   d. any antifouling coating, including patch repairs, that was applied while drydocked, detailing type of antifouling coating and areas applied, and surface preparation work undertaken (e.g. complete removal of underlying antifouling coating or application of new antifouling coatings or seal coat over the top of existing antifouling coating)
   e. details of the antifouling coating specifications applied to each area such as type (e.g. self-polishing co-polymer), manufacturer, expected effective life, operating conditions required for coating to be effective (including any operational constraints e.g. not effective for long periods of lay-up), cleaning requirements and any other specifications relevant to coating performance
   f. name and signature of the person in charge of the activity.

2. When the underwater hull area, fittings, niches and voids have been inspected by divers:
   a. date and location of dive survey and reason for survey
   b. area or side of the vessel surveyed
   c. general observations with regard to biofouling (i.e. extent of biofouling and predominant biofouling types [e.g. mussels, barnacles, tubeworms, algae and slime])
   d. whether any suspected marine pest/s were found, and action taken
   e. name and signature of the person in charge of the activity.

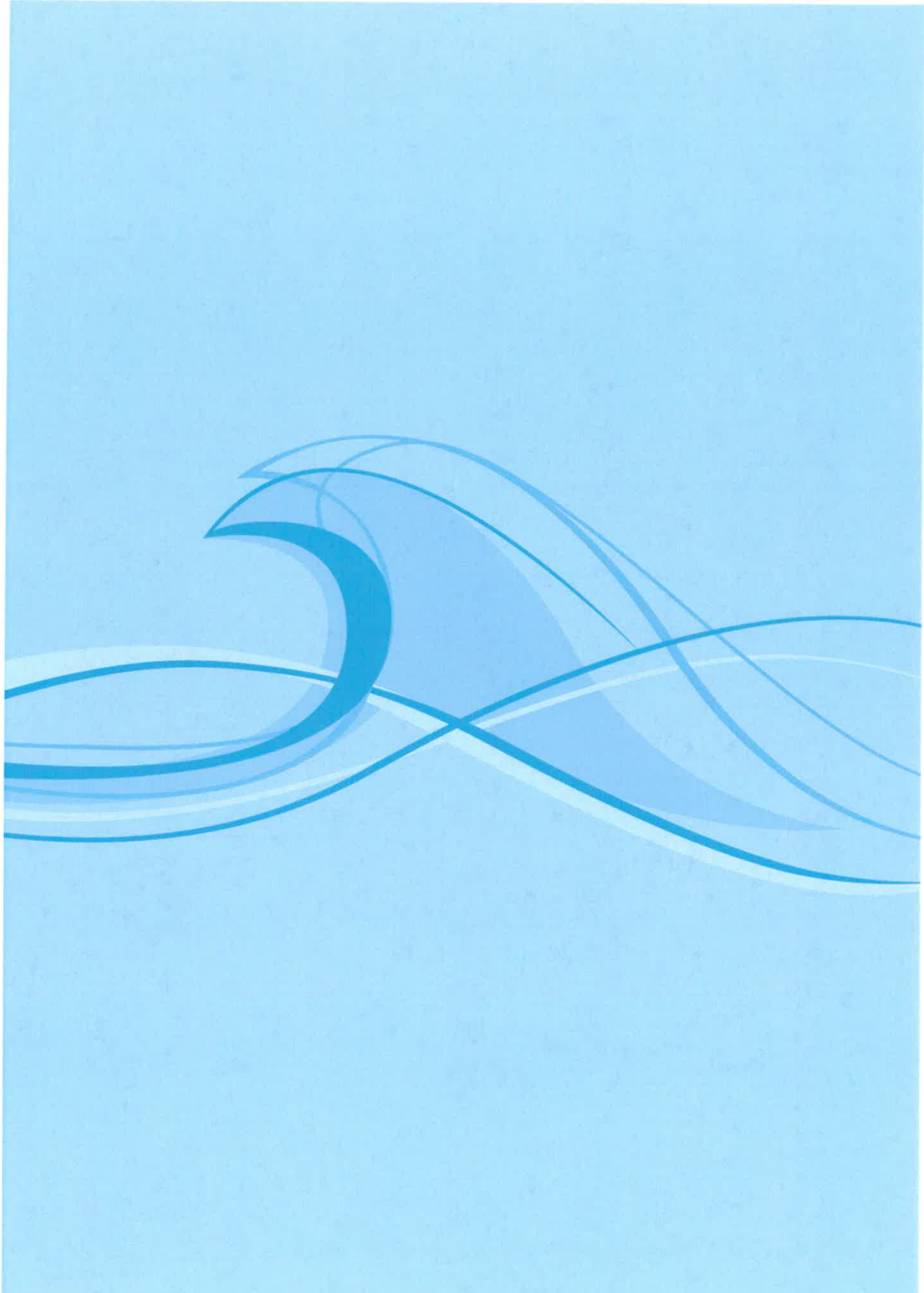
3. When the underwater hull area, fittings, niches and voids have been cleaned by divers:
   a. date and location of vessel when cleaning occurred
   b. hull areas, fittings, niches and voids cleaned and method used
   c general observations with regard to biofouling (i.e. extent of biofouling and predominant biofouling types [e.g. mussels, barnacles, tubeworms, algae and slime])
   d. whether any suspected marine pests were found, and action taken
   e. name and signature of the person in charge of the activity.

4. When the internal seawater systems have been inspected and cleaned or treated:
   a. date and location of vessel when inspection and/or cleaning occurred
   b. general observations with regard to biofouling of internal system (i.e. extent of biofouling and predominant biofouling types [e.g. mussels, barnacles, tubeworms, algae and slime])
   c. any cleaning or treatment undertaken and procedures and materials used
   d. whether any suspected marine pests were found, and action taken
   e. name and signature of the person in charge of the activity.

5. Periods of time when the vessel was laid up for an extended period of time:
    a. date and location where vessel was laid up
    b. maintenance action taken prior to and following period laid up
    c. precautions taken to prevent biofouling accumulation (e.g. sea chests blanked off).

6. For vessels arriving internationally: details of inspection or review of vessel biofouling quarantine risk (where applicable):
    a. date and location of vessel when quarantine review occurred
    b. regulatory authority (AQIS) conducting the inspection/review and details of procedures followed or protocol adhered to and inspector/s involved
    c. result of quarantine inspection/review
    d. name and signature of the person in charge of the activity for the vessel.

7. Any additional observations and general remarks.



PLoS one

The Effects of Copper Pollution on Fouling Assemblage Diversity: A Tropical-Temperate Comparison

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Abstract

Background: The invasion of habitats by non-indigenous species (NIS) occurs at a global scale and can generate significant ecological, evolutionary, economic and social consequences. Estuarine and coastal ecosystems are particularly vulnerable to pollution from numerous sources due to years of human-induced degradation and shipping. Pollution is considered as a class of disturbance with anthropogenic roots and recent studies have concluded that high frequencies of disturbance may facilitate invasions by increasing the availability of resources.

Methodology/Principal Findings: To examine the effects of heavy metal pollution as disturbance in shaping patterns of exotic versus native diversity in marine fouling communities we exposed fouling communities to different concentrations of copper in one temperate (Virginia) and one tropical (Panama) region. Diversity was categorized as total, native and non-indigenous and we also incorporated taxonomic and functional richness. Our findings indicate that total fouling diversity decreased with increasing copper pollution, whether taxonomic or functional diversity is considered. Both native and non-indigenous richness decreased with increasing copper concentrations at the tropical site whereas at the temperate site, non-indigenous richness was too low to detect any effect.

Conclusions/Significance: Non-indigenous richness decreased with increasing metal concentrations, contradicting previous investigations that evaluate the influence of heavy metal pollution on diversity and invasibility of fouling assemblages. These results provide first insights on how the invasive species pool in a certain region may play a key role in the disturbance vs. non-indigenous diversity relationship.

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Introduction

A key question that has long puzzled ecologists is to understand which factors make ecosystems vulnerable to biological invasions [1,2,3]. Disturbance has been identified as a key factor in promoting invasions. Studies focused on the distribution of exotics in different systems have concluded that high frequencies of disturbance may facilitate invasions by increasing the availability of resources (e.g. space, light) and reducing competition with native species [4,5,6].

Estuaries and bays are an appropriate system to test the influence of disturbance on invasions, as these habitats are frequently exposed to an abundant supply of invasive larvae as a result of ballast water release, as well as to elevated regimes of anthropogenic disturbance. This makes fouling assemblages colonizing hard substrates in these environments extremely vulnerable to invasion [7,8]. In this context, metal pollution is a typical pollutant within harbors and marinas, appearing in the form of antifouling paints, industrial waste and other sources [5,9]. The most modern marine antifouling paints contain a copper based biocidal pigment and are applied to ship hulls and to several fixed structures (e.g. pilings, pontoons, buoys) to stop the growth of fouling organisms [10].

However and despite the efficiency of these copper-based coatings, fouling still occurs due to deteriorating paint, presence of biofilms, method of application, and increasing copper tolerances [11]. As a common pollutant in the marine environment, copper has been recognized as one of the three most toxic heavy metals to marine invertebrates, affecting their reproduction, growth, and abundance [9]. In addition, pollution can be considered a category of disturbance (anthropogenic) to an ecosystem and may affect community structure [12,13]. Besides promoting invasion success by creating new habitats, introducing propagules and decreasing numbers of native species, these anthropogenic disturbances also deteriorate the capacity of the natives to resist new invaders [14].

Ballast tanks and ship hulls have been identified as major vectors for the transport and dispersal of nonindigenous species (NIS) [3,15,16] and research has shown that certain populations of NIS appear to have a superior tolerance to heavy metal pollution when compared to related native species [7,17,18,19]. In a manipulative experiment aiming to test the effects of heavy metal pollution on the diversity and invasibility of marine hard-substrate communities in Australia, Piola and Johnston [5] found that increasing exposure to copper decreased native species diversity with no significant change in NIS. Copper exposure also increased the dominance (measured as percent cover in settling plates) of exotics [5]. Employing a different methodology in San Francisco Bay with fouling assemblages, Crooks et al. [20] recently showed a similar outcome: average native diversity was significantly sensitive to copper pollution while exotic richness was not. Both studies seem to confirm that anthropogenic shifts of abiotic determinants may facilitate the success and process of biological invasions and therefore, different repercussions at the level of pollution impacts and NIS management are expected [5,20].

The probability of establishment of a non-native population and its expansion in a certain area/realm depends in part on the supply of potential invaders [3,21]. In the marine realm, this so called 'propagule pressure' may change with the frequency of ship arrival [22]. Together with biotic and abiotic factors, this variation in propagule supply contributes to exotic diversity. However, exotic diversity should not be considered as a measure of invasibility by itself [2]. To account for the variation of propagule pressure in patterns of invasions, novel methods in propagule supply manipulation came to surface in recent years [22]. For example in a study developed in Australia, Clark and Johnston [23], successfully manipulated larvae of the invasive bryozoan *Bugula neritina* by injecting spawned larvae into containers with developing fouling communities. They explored the relationship between metal pollution and propagule supply and concluded that propagule pressure and disturbance interacted to affect fouling recruitment [23]. Another approach to account for propagule pressure is to experimentally manipulate environmental conditions (e.g. disturbance) using natural colonization [24]. Piola and Johnston [18] employed this method in marine fouling assemblages and concluded that the number of NIS increased with the exposure to metal pollution.

Most invasions in the marine system are described from temperate latitudes [25] but its probable causes remain relatively unexplored. However, several factors have been linked to such fact: (i) NIS follow the '*latitudinal gradient of species richness*', which states that the tropics hold more species than do higher latitudes; (ii) more research attention or density of marine stations in temperate regions [3,25]. In this context, there is no reason to presuppose that tropical marine communities are either more or less sensitive to copper and other heavy metal toxicants than temperate or boreal species. However, for individual species, at least in temperate environments, increased temperature often, but not uniformly, leads to increased toxicity. This may be as much a reflection of the increased metabolism of the organism and the speed with which it takes up the element, and more rapid damage than an intrinsic change to the means or mechanisms of toxicity. Alternatively, some species show a midrange optimum temperature at which toxicity is a minimum suggesting that these organisms are less affected by the toxin under otherwise less stressful conditions (see e.g., [26,27]).

In addition, the importance of function has been recognized for the relationship between diversity and ecosystem functioning and sustainability [28,29]. Functional differentiation based on relevant criteria better describes the ecological dissimilarity between species. As a result, the inclusion of this metric (whose parameters are detailed below) in biodiversity studies was proposed in recent studies (e.g., [30,31,32,33,34,35]).

The present study examines the effects of metal pollution in exotic and native diversity in marine fouling communities. We conducted a field experiment in one temperate (Virginia) and one tropical (Panama) region, where species identity, functional identity and specific abundances (percent cover) were assessed. We hypothesize that (a) total diversity (taxonomic and functional) is sensitive to copper pollution (disturbance); (b) non-indigenous diversity (taxonomic and functional) is more tolerant to copper pollution than native diversity; (c) this scenario may differ across (tropic and temperate) regions.

Materials and Methods

Study sites and experimental design

The experiment lasted 9 weeks (September to December 2009) and was conducted, simultaneously, in two different biogeographic regions: Virginia's Eastern Shore Region (VA; 37°36′N, 75°41′W) and the Caribbean side of the Panama Canal, Panama (PA; 9°22′N, 79°57′W). At each region, we deployed 24 fibreglass plates (14×14×0.3 cm G-10 Epoxy glass). Plates were mounted on bricks using cable ties and suspended vertically on individual racks underneath docks at approximately 0.5 m depth.

To test the effects of metal pollution on sessile invertebrate assemblages, we exposed these communities to different concentrations of copper. We applied different loads of the antifouling (AF) paint Interlux® Ultra-Kote (76% Copper oxide) on the margins of a 100 cm^2 colonization area in order to create a disturbance gradient: 96 cm^2 of the non-toxic primer Primocon® (no disturbance or D0); 28 cm^2 of AF paint and 68 cm^2 of primer (disturbance 1 or D1); 56 cm^2 of AF paint and 40 cm^2 of primer (disturbance 2 or D2); and 96 cm^2 of AF paint (disturbance 3 or D3) (Fig. 1A). In all treatments, 4 layers (each layer individually 75 microns thickness) of paint were applied.

We used a randomized block design to test for spatial heterogeneity with three blocks of 4 disturbance treatments. Each disturbance treatment was randomly replicated twice in each block resulting in 24 replicates per region (4 treatments×2 replicates×3 blocks = 24 plates) (Fig. 1B). Minimum distance between plates was 0.5 meters and minimum distance between blocks was 15 meters.

Sampling and Functional Richness

After 9 weeks of colonization, all plates were retrieved from the field and photographed. For each plate we determined species richness, total cover and bare space by recording the number of species identified from the photographs using image analysis software CPCe [36]. Each image was sub-divided into a 3×3 grid of 9 cells, with 11 random points per cell resulting in 99 points analyzed per picture. This stratified random sampling method ensured that points were sampled in each region of the image [36]. In addition, each plate was carefully examined using a dissecting microscope to better measure total species pool. Sessile macroinvertebrates were identified to the lowest possible taxonomic group and assigned to four categories: native, NIS and cryptogenic (unspecified origin) based on existing literature reports, or to unresolved (based on an inability to identify to species level).

Functional groups (FG) encompass all species of a community which share a certain number of traits linked to ecological functions [37] and are typically defined according to the way in which they use and compete for any kind of resources (e.g. light, space) [30]. In this study, functional groups were determined according to five dimensions: body size, growth form, trophic type, modularity and motility (see Table 1 in [38,39]). For each species, the functional group was defined as the set of ecological qualities realized at the adult stage. Here, we employed the following traits: body size (small, medium, large, very large), growth form (encrusting, massive, bushy, filamentous), trophic type (autotroph, suspension feeder, deposit feeder), modularity (solitary, colonial)

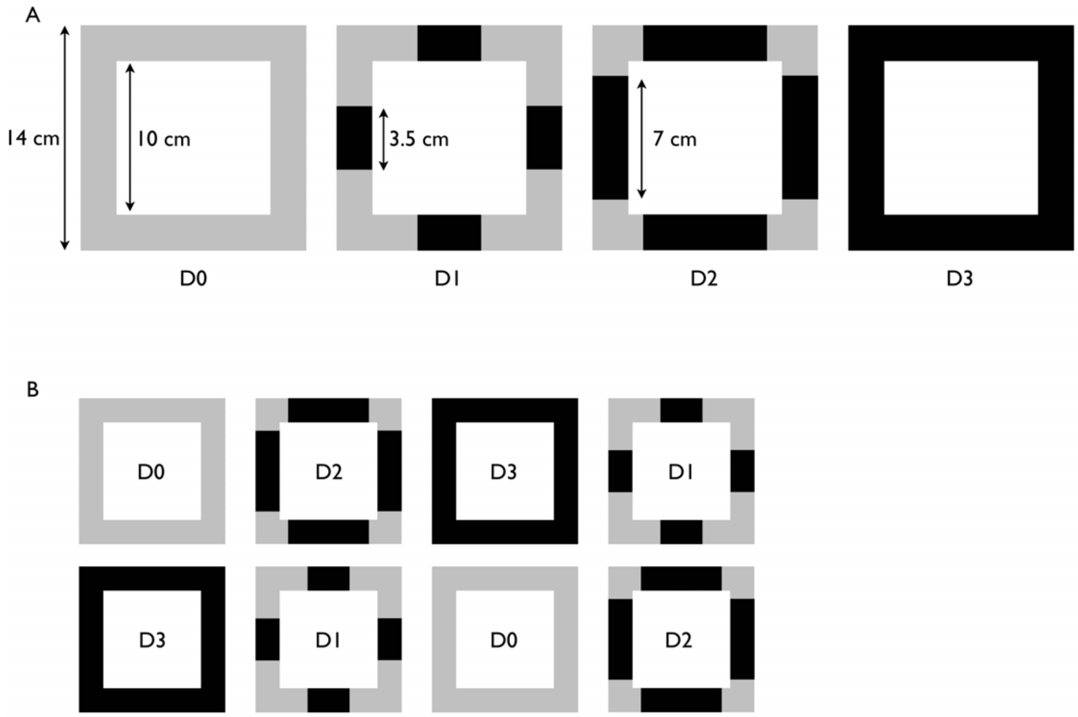

Figure 1. Diagram illustrating the experimental design employed. (A) We applied 4 different loads of a copper based antifouling paint: no disturbance (D0), 28 cm^2 of AF paint (D1), 56 cm^2 of AF paint (D2) and 96 cm^2 of AF paint (D3). (B) Representation of one block with 2 replicates per treatment.
doi:10.1371/journal.pone.0018026.g001

and motility (attached), which could theoretically produce $4\times4\times3\times2\times1 = 96$ functional groups.

Copper content analysis

Water samples were taken twice after 3 and 6 weeks in Virginia to test Cu leaching from the AF paint. Eight plates from one block (2 replicates per disturbance treatment) were placed individually in buckets with 2L of seawater for a 2 h period. Each bucket was aerated to provide O_2 and to ensure water mixing. A volume of 50 ml of seawater per treatment (n = 2) was then filtered to a polypropylene sample tubes using a syringe and disposable syringe filters (Whatman* GD/X 25 mm). To prevent contamination nitrile gloves were used during this procedure. Water samples were kept refrigerated, brought to the laboratory as soon as possible, and acidified to 0.5% V/V with ultrapure HNO_3. Cu content was determined within 3 months after sampling. Water samples were extracted with APDC-NaDDDC/chloroform and diluted into 6% ultrapure HNO_3 to remove the seawater matrix and concentrate the samples following the methods of Riedel et al. [40]. The samples were analyzed for Cu by inductively coupled plasma-mass spectrometry (ICP-MS) using a Perkin-Elmer Elan II. These eight plates were brought back to the field within 3 hours of each sampling event but were not considered for the community structure analysis.

To test whether the biota present in the colonization area of each treatment was accumulating copper we analyzed the tissue of the most common organism across all treatments in Virginia (the barnacle *Amphibalanus improvisus*). At the end of the experiment four individuals of *Amphibalanus improvisus* per treatment were sampled whenever possible from the central area of the plate. Samples of dry tissue were digested with ultrapure HNO_3, HCl and $HClO_4$ in open Teflon® vials, and diluted with 0.5% ultrapure HNO_3 for Cu analysis by ICP-MS, following the methods of Riedel and Valette-Silver [41].

Statistical analysis

A one-way ANOVA was performed to test Cu leaching from the AF paint after 3 and 6 weeks. A one-way ANOVA was also used to test the copper accumulation from the barnacle *Amphibalanus improvisus* across disturbance. In case of a significant effect, the Tukey's HSD *post hoc* analysis identified which paint dosages differed in their efficiency in leaching and causing accumulating of copper in organisms on the panels.

Hypotheses about the effects of disturbance, block and their interaction in species and functional richness of fouling assemblages were tested with two separate two-factorial ANOVA for each region. Blocks were treated as a random factor (3 levels) and disturbance as a fixed factor (4 levels). Diversity measures (dependent variables) included total richness (taxonomic and functional), native richness (taxonomic and functional), invasive richness (taxonomic and functional), and cryptogenic richness. Homogeneity of variances was tested with the Cochran's test and dependent variables were Log_{10} transformed if needed. Tukey's HSD *post hoc* analysis was used to examine significant effects of disturbance in diversity.

For multivariate analysis, taxonomic and functional richness at both regions were contrasted across disturbance treatments and blocks using a two-factor permutational multivariate ANOVA (PERMANOVA) where disturbance was operated as a fixed factor and block as random factor. We used the SIMPER routine to measure the contribution of each taxon to average dissimilarities between controls and the highest disturbed treatment. The more significant taxa causing these dissimilarities were identified [42]. SIMPER and PERMANOVA analysis were performed with PRIMER 6 [43] and its PERMANOVA+add-on [44].

Table 1. List of macroinvertebrates and their respective functional groups (see [38] for details) set by phylum found across the four disturbance treatments (D0–D3) in Panama (Pa) and Virginia (Vi) after 9 weeks of colonization.

Taxon	Functional group	Site	Disturbance levels D0	D1	D2	D3	Status	Source
Porifera								
Chelonaplysilla erecta	LESS	Pa	●	○	○	○	C	[57]
Halichondria bowerbanki	XMSS	Vi	●●	●●	●●	○	C	[58]
Halichondria melanadocia	XMSS	Pa	●●	●	○	●●	N	[59]
Haliclona tubifera	XMSS	Pa	●●	●●	●●	●●	N	[59]
Leucandra sp.	LMSS	Pa	●	○	○	○	Unresolved	[59]
Lissodendoryx spinulosa	LMSS	Pa	○	●	○	○	N	
Mycale arndti	LESS	Pa	●	○	○	●	N	[59]
Mycale microsigmatosa	LESS	Pa	●●	●	●●	●	N	[59,60]
Sycon sp.	LMSS	Pa	●	○	○	●	Unresolved	
Tedania ignis	XESS	Pa	●	●	●	●	N	[60]
Cnidaria								
Edwardsia elegans	LMSS	Vi	●	○	○	○	N	[61]
Bougainvillia sp.	LFSC	Pa	●●	●●	●●	●●	C	
Cladonema radiatum	LFSC	Pa	●	○	○	○	C	[59]
Clytia sp.	LFSC	Pa	●	●	●	●	Unresolved	
Corydendrium parasiticum	LBSC	Pa	●	○	○	○	C	[60]
Eudendrium album	LBSC	Vi	●	○	○	○	C	[62]
Obelia bidentata	MBSC	Vi	○	○	○	●●	C	[62]
Obelia bidentata	MBSC	Pa	●	○	●	○	C	[60]
Tubularia larynx	LFSC	Vi	●●	●●	●●	●●	C	[62]
Unknown Anemone	LMSS	Vi	●	○	○	○	Unresolved	
Unknown Anemone	LMSS	Pa	○	●	○	○	Unresolved	
Bryozoa								
Bugula neritina	LBSC	Vi	●●●	●●	●●●	●●	NIS	[63]
Bugula neritina	LBSC	Pa	●	●●	●	●	C	[64]
Bugula stolonifera	LBSC	Vi	●●	●●	●●	○	N	[65]
Aetea ligulata	LBSC	Pa	○	○	●	●	C	[66]
Anguinella palmata	LBSC	Vi	●●	●	●	●	C	[67]
Bowerbankia sp.	LBSC	Pa	●	○	○	○	Unresolved	
Electra bengalensis	LESC	Pa	●●	●●	●	○	NIS	[68]
Savignyella lafontii	LBSC	Pa	●●	●	●	●	C	[60]
Schizoporella pungens	XESC	Pa	●	●	○	○	N	[60]
Scrupocellaria carmabi	LBSC	Pa	●	○	●	●	N	[66]
Schizoporella sp.	XESC	Vi	●	○	○	○	Unresolved	
Unidentified Bryozoan		Pa	●	○	○	○	Unresolved	
Watersipora subtorquata	XMSC	Pa	○	○	○	●	C	[64]
Chordata								
Ascidia sp.	LMSS	Pa	○	○	○	●	Unresolved	
Diplosoma listerianum	XESC	Pa	○	●●	●●	●	C	[69]
Ecteinascidia turbinata	LMSC	Vi	○	●	○	○	NIS	[70]
Herdmania pallida	LMSS	Pa	●	○	○	○	C	[71]
Molgula manhattensis	LMSS	Vi	●	●●	●●	●●	N	[72]
Perophora viridis		Pa	●	○	○	○	N	[72]
Phallusia nigra	LMSS	Pa	○	●	○	○	NIS	[69]
Styela canopus	LMSS	Pa	●●	●	●	●	NIS	[69]
Symplegma brakenhielmi	XESC	Pa	●●●	●●●	●●●	●	C	[73]

Table 1. Cont.

Taxon	Functional group	Site	Disturbance levels D0	D1	D2	D3	Status	Source
Crustacea								
Amphibalanus improvisus	MMSS	Vi	●●●	●●●	●●●	●●●	N	[74]
Amphibalanus improvisus	MMSS	Pa	●●	●●	●●	●●	N	[74]
Corophium sp.	MMSS	Vi	●●	●●	●●	●●	Unresolved	
Polychaea								
Polydora cornuta	LFSS	Vi	○	○	●	●	N	[75]
Branchiomma bairdi	LMSS	Pa	●●	●●	●●	●●	N	[76]
Hydroides elegans	LMSS	Pa	●●	●●	●●	●●	NIS	[77]
Pileolaria militaris	MMSS	Pa	●●	●●	●●	●●	C	[78]
Pomatoceros minutus	MMSS	Pa	●●	●	●	●	C	[79]
Salmacina tribranchiata	XMSC	Pa	●●	●●	●●	●●	N	[79]
Spirorbis sp.	MMSS	Vi	●	○	○	○	Unresolved	
Spirorbis tuberculatus	MMSS	Pa	●●	●●	●●	●●	NIS	[80]
Mollusca								
Anomia peruviana	LMSS	Pa	●●	●●	●●	●●	NIS	Canning-Clode, unpublished
Ostreidae	LMSS	Pa	●	●	●	●	Unresolved	

Appearance of organisms is shown by ○, not present; ●, ≤1% mean cover; ●●, <10% mean cover; ●●●, >10% mean cover; Taxa were also classified as native (N), non-indigenous (NIS) and cryptogenic (C) based on literature, or to unresolved (based on an inability to identify to species level).
doi:10.1371/journal.pone.0018026.t001

Results

After 9 weeks of colonization, in Virginia we found 16 macroinvertebrates and 9 FG and Panama's plates were colonized by 40 species and 12 FG (Table 1). In Virginia, 5 species were identified as native (31%), 2 as NIS (13%) and 6 as cryptogenic (38%). Plates from Panama included 12 natives (30%), 14 cryptogenic (35%) and 6 NIS, (15%). Barnacles and hydroids were more abundant in Virginia whereas numbers of sponges and tunicates were higher in Panama. In addition, barnacles appear to be more tolerant to copper pollution as their average abundance does not change with increasing disturbance (Table 1).

The applied disturbance treatments were effective as shown in Figures 2, S1 and S2. Figures S1 and S2 show examples of individual fouling communities across disturbance treatments in both study sites. After 3 and 6 weeks in Virginia, average

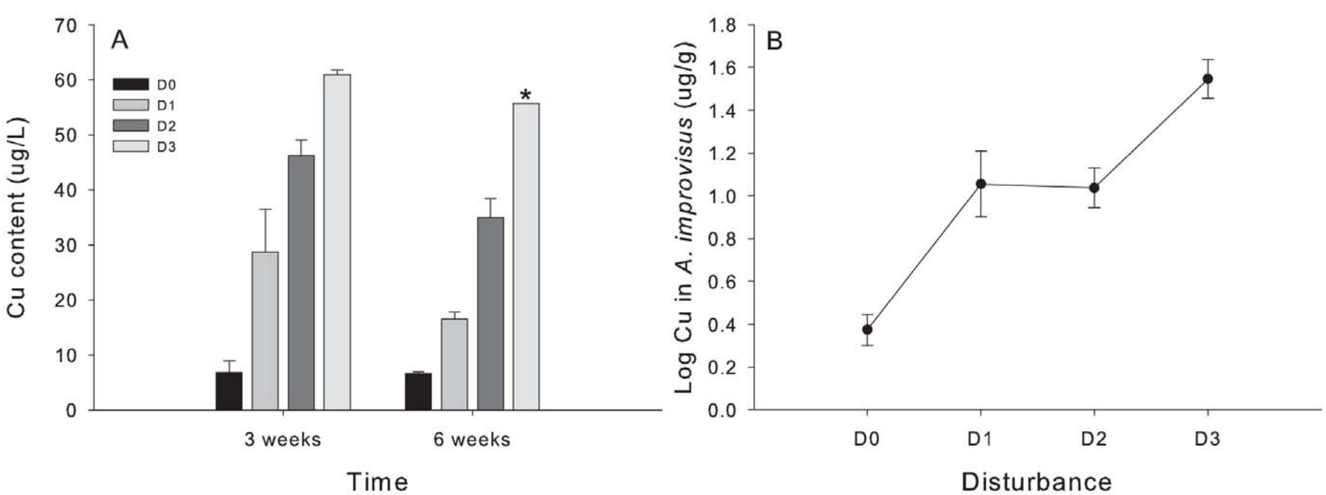

Figure 2. Test for treatment's efficiency. (A) Copper content from water samples after a 2 hr exposure to disturbance panels taken after 3 and 6 weeks in Virginia from independent buckets containing individual disturbance treatments (n = 2); (B) Quantity of copper measured after 9 weeks from the tissue of *Amphibalanus improvisus*, the most common organism across all disturbance treatments in Virginia (n = 4). Means and standard deviations are indicated. Disturbance treatments abbreviations are as in Figure 1. * There is no standard deviation at D3 after 6 weeks as there was only one replicate.
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concentration of copper significantly increased with the different dosages of AF paint (ANOVA - 3 weeks: $F = 59.59$, $P < 0.01$; 6 weeks: $F = 94.36$, $P < 0.01$). D3 was not included in the 6 weeks model due to the loss of replicates. *Post hoc* analysis revealed that copper dosages were all significantly different from each other (Fig. 2A; Tukey's HSD$<$0.05). Although mean copper concentration from the different treatment seems to decrease in time, no significant differences were found. In addition, at the end of the experiment, the accumulation of copper in *Amphibalanus improvisus* significantly increased with disturbance (ANOVA: $F = 20.48$, $P < 0.01$). With the exception of D1 and D2, *post hoc* analysis determined that copper concentration in barnacles were significantly different across disturbance treatments (Fig. 2B; Tukey's HSD$<$0.05).

The two-factorial ANOVA performed for each region did not detect any block effect, which indicates that the experimental units were heterogeneously distributed (Table 2). In general, diversity was sensitive to increasing copper exposure in Panama while in Virginia only native functional richness was affected by copper disturbance (Fig. 3; Table 2). In Panama, total number of species and FG significantly decreased with disturbance where *post hoc* testing identified (Tukey's HSD$<$0.05) differences between the controls and the disturbance treatments (Fig. 3A–B). No differences among the disturbed plates were detected. Similarly, Panama's native diversity (taxonomic and functional) was affected by disturbance (Fig. 3C–D; Table 2). More species and FG were observed in the untreated plates (Tukey's HSD$<$0.05). In Virginia, *post hoc* analysis identified significant differences in native functional diversity between D0 and D3 and between D1 and D3 (Fig. 3D). No significant relationship between non-indigenous diversity and disturbance was observed in Virginia likely because the invasive signal was too low (Fig. 3E–F). In contrast, Non-indigenous species in Panama were sensitive to disturbance with significantly more NIS in the controls and D1 than in D3 (Fig. 3E; Table 2).

No significant relationship between disturbance and total diversity was observed in Virginia (although there is a marginal

Table 2. Results from the 2-factorial ANOVA on different diversity measures for Virginia and Panama.

		Virginia				Panama			
Diversity measure	**Source of variation**	**df**	**MS**	**F**	**P - value**	**df**	**MS**	**F**	**P - value**
Total species richness	D	3	3.23	5.74	0.092	**3**	**47.15**	**9.15**	**0.011**
	B	1	0.06	0.11	0.761	2	3.88	0.75	0.511
	D*B	3	0.56	0.29	0.831	6	5.15	1.16	0.390
	Error	8	1.94			12	4.46		
Total functional richness*	D	3	0.23	3.67	0.157	**3**	**0.02**	**5.56**	**0.036**
	B	1	0.56	9.00	0.058	2	0.00	0.06	0.946
	D*B	3	0.06	0.09	0.963	6	0.00	1.66	0.215
	Error	8	0.69			12	0.00		
Native taxonomic richness*	D	3	2.75	6.60	0.078	**3**	**0.08**	**10.20**	**0.009**
	B	1	2.25	5.40	0.103	2	0.01	1.35	0.329
	D*B	3	0.42	0.56	0.659	6	0.01	0.54	0.766
	Error	8	0.75			12	0.01		
Native functional richness	D	**3**	**2.42**	**14.50**	**0.027**	**3**	**7.15**	**7.25**	**0.020**
	B	1	1.00	6.00	0.092	2	0.54	0.55	0.604
	D*B	3	0.17	0.44	0.728	6	0.99	1.03	0.453
	Error	8	0.38			12	0.96		
Invasive taxonomic richness	D	3	-	-	-	**3**	**2.49**	**7.78**	**0.017**
	B	1	-	-	-	2	0.04	0.13	0.880
	D*B	3	-	-	-	6	0.32	0.70	0.657
	Error	8	-			12	0.46		
Invasive functional richness	D	3	-	-	-	3	0.15	1.00	0.455
	B	1	-	-	-	2	0.04	0.27	0.770
	D*B	3	-	-	-	6	0.15	0.73	0.633
	Error	8	-			12	0.21		
Cryptogenic richness	D	3	4.06	4.53	0.123	3	5.50	2.40	0.166
	B	1	0.06	0.07	0.809	2	0.79	0.35	0.721
	D*B	3	0.90	0.75	0.550	6	2.29	1.53	0.250
	Error	8	1.19			12	1.50		

*Data was $\log_{10}$ transformed for total functional richness and native taxonomic richness in PA. Analysis was not performed for non-indigenous richness in Virginia due to a weak signal (only two species: *Bugula neritina* present in all disturbance treatments and *Ecteinascidia turbinata* in only one treatment). Significant results ($P < 0.05$) highlighted in bold ($n = 4$ in Virginia; $n = 6$ in Panama). Disturbance = D and Block = B represent the source of variation.
doi:10.1371/journal.pone.0018026.t002

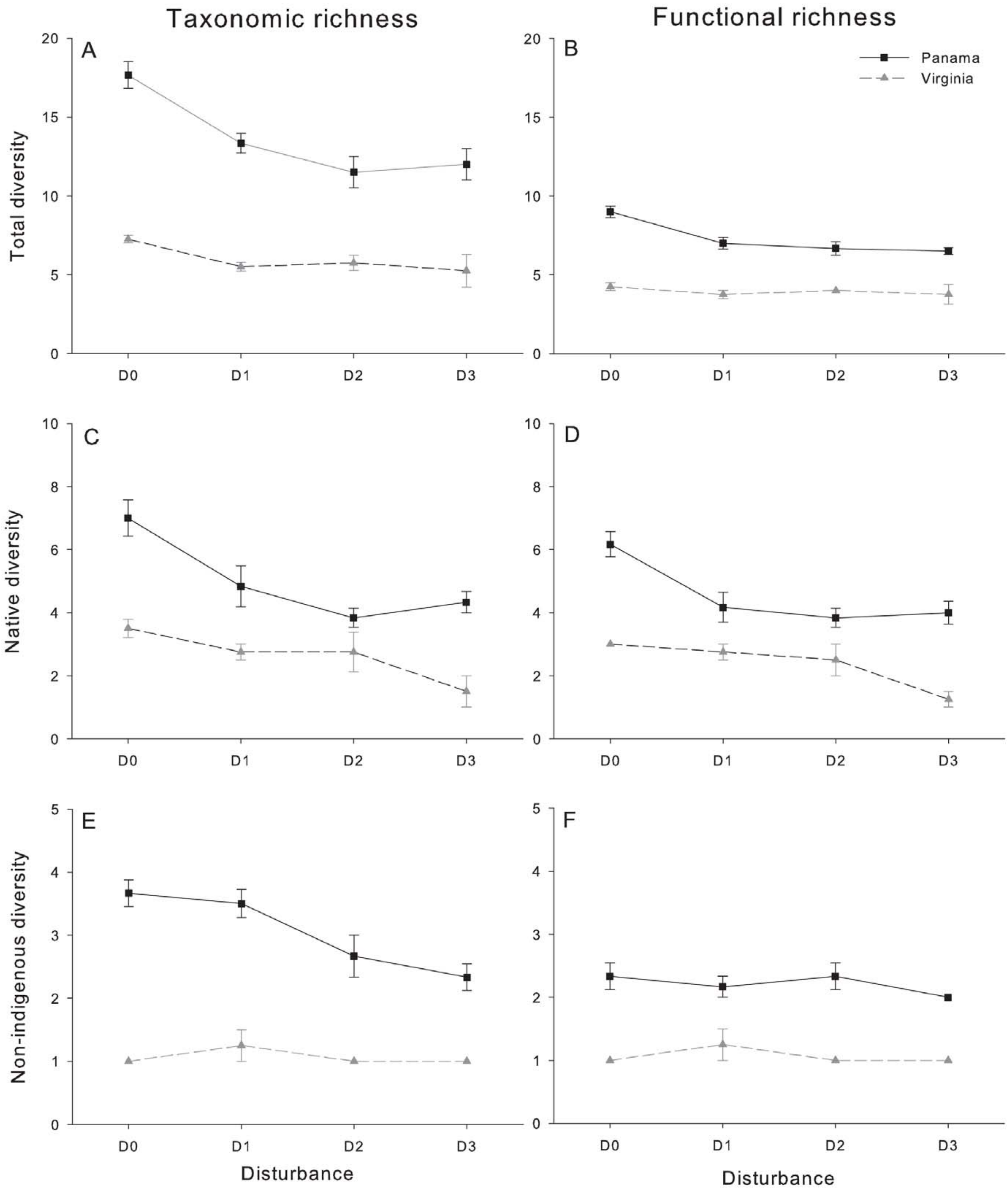

Figure 3. Relationship between disturbance and different measures of diversity in Virginia and Panama. Diversity measures are: total taxonomic richness (A); total functional richness (B); native taxonomic richness (C); native functional richness (D); non-indigenous taxonomic richness (E); and non-indigenous functional richness (F). Means and standard errors are indicated (n = 4 in Virginia; n = 6 in Panama). Disturbance treatments abbreviations are as in Figure 1.

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Table 3. Effects of disturbance (independent variable) on diversity (dependent variable) of fouling communities.

Diversity measure	Virginia		Panama	
	R^2	*P*-value	R^2	*P*-value
Total species richness	0.25	0.051	**0.46**	**0.000**
Total functional richness*	0.05	0.430	**0.43**	**0.001**
Native taxonomic richness*	**0.40**	**0.008**	**0.33**	**0.003**
Native functional richness	**0.51**	**0.001**	**0.35**	**0.002**
Invasive taxonomic richness	0.01	0.670	**0.47**	**0.000**
Invasive functional richness	0.01	0.670	0.05	0.281
Cryptogenic richness	**0.32**	**0.022**	0.15	0.061

Results of the linear regression analysis are shown for Virginia and Panama. *Data was $\log_{10}$ transformed for total functional richness and native taxonomic richness in PA. Significant results ($P<0.05$) highlighted in bold (n = 4 in Virginia; n = 6 in Panama).
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significance for total species richness – Table 3). In addition, native diversity (in terms of both taxonomic and functional) and cryptogenic species are negatively affected by disturbance in Virginia. In Panama, metal pollution significantly reduces total and native diversity. Furthermore, numbers of NIS also significantly decreased with enhancing copper pollution in Panama (Table 3). The available space on the settling plates was also affected by disturbance in Panama as average open space increased with disturbance (D0: 26.6%±16.2; D1: 35.5%±11.9; D2: 61.3%±19.3; D3: 55.6%±22.9). In Virginia, open space was constant across disturbance treatments (average open space between 60 and 45%).

We performed separate multivariate analysis on the effects of disturbance on community composition at each region and found that significant differences at both regions were observed between disturbance treatments (Table 4). In addition, PERMANOVA detected a block effect in community composition in Virginia, which probably reflects a lower replication at this region. According to SIMPER routines, three species and three FG were essential in differentiating control from D3 assemblages in Virginia. Average abundance of the barnacle *Amphibalanus improvisus* increased with disturbance while a higher abundance of the exotic *Bugula neritina* was found in the controls (Table 5). Accordingly, the exotic *Anomia peruviana* also had a 9% negative contribution to dissimilarities between treatments in Panama, while the abundances of two native species increased with disturbance.

Discussion

In this study, we examined the effects of copper pollution (disturbance) on diversity of fouling assemblages in a temperate and a tropical region using an expanded approach: diversity was categorized as total, native and non-indigenous and we also incorporated taxonomic and functional richness. Moreover, to the best of our knowledge, this is the first study to directly compare the response of tropical and temperate fouling assemblages to copper exposure. Our findings indicate that total fouling diversity is sensitive to metal pollution, whether taxonomic or functional diversity is considered. Thus, the shape of the relationship between disturbance and total diversity is more pronounced in the tropics. Similarly, disturbance also played a key role in decreasing native diversity and non-indigenous species richness in Panama. In fact, tropical assemblages appear to be more sensitive to copper exposure relative to temperate assemblages probably because increased temperature often leads to increased toxicity (see eg., [26,27]).

One factor that has frequently been suggested to control biodiversity in different systems is disturbance [45,46]. However, a universal definition of disturbance is debatable, as its classification ranges from abiotic to biotic or natural to anthropogenic [47,48]. Disturbance has been often defined as the loss of biomass [49] which can facilitate the establishment of new individuals by altering the resource opportunities available to the species in a system [50,51]. Disturbance has also been defined as an 'ecological disruption that leads to some type of open opportunity or vacant area in a community [13]. We believe we have created a disturbance regime by applying different loads of an antifouling (AF) paint composed of a heavy metal toxicant (Cu) in the margins of settling plates. Thus, with samples taken from water as well as from the most abundant organism across all treatments, we demonstrated that the applied disturbance treatments were effective. We showed for two periods in time (3 and 6 weeks) a clear increasing pattern between the concentration of copper taken

Table 4. Summary of the two-factor PERMANOVA of the multivariate data.

Site	Source of	Taxonomic richness				Functional richness			
	variation	df	MS	Pseudo-*F*	*P*-value	df	MS	Pseudo-*F*	*P*-value
Virginia	B	**1**	**2431.10**	**3.05**	**0.030**	**1**	**2495.60**	**4.11**	**0.025**
	D	3	1741.10	2.54	0.150	**3**	**1572.50**	**4.87**	**0.049**
	BxD	3	685.64	0.86	0.601	3	322.74	0.53	0.824
	Residual	8	795.98			8	607.24		
	Total	15				15			
Panama	B	2	2225.80	1.22	0.2869	2	1234.10	0.94	0.510
	D	**3**	**3572.00**	**2.35**	**0.0185**	**3**	**2872.00**	**2.24**	**0.042**
	BxD	6	1521.40	0.83	0.7576	6	1282.30	0.97	0.514
	Residual	12	1822.20			12	1317.90		
	Total	23				23			

Significant results ($P<0.05$) highlighted in bold (n = 4 in Virginia; n = 6 in Panama). Disturbance = D and Block = B represent the source of variation.
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Table 5. Results from the SIMPER routine performed with multivariate data from both Panama and Virginia to identify which species or FG contributed more (≥10%) to observed changes in community composition between untreated controls (D0) and highest disturbance (D3).

	Taxonomic diversity			Functional diversity	
Site	**Source**	**Status**	**Contribution (%)**	**Source**	**Contribution (%)**
Virginia					
	Amphibalanus improvisus	N	39(+)	MMSS	44(+)
	Bugula neritina	NIS	25(−)	LBSC	32(−)
	Tubularia larynx	C	12(+)	LFSC	12(+)
Panama					
	Symplegma brakenhielmi	C	25(−)	XESC	34(−)
	Salmacina tribranchiata	N	10(+)	LMSS	15(−)
	Haliclona tubifera	N	10(+)	XMSS	14(−)
	Anomia peruviana	NIS	10(−)	XMSC	12(+)

Taxa classified as native (N), non-indigenous (NIS) and cryptogenic (C) based on literature. Contribution (%) and direction of change (+ positive; - negative) are indicated (n = 4 in Virginia; n = 6 in Panama).
doi:10.1371/journal.pone.0018026.t005

from water samples and the different dosages of AF paint. This indicates that the pollutant (Cu) was leached from the AF paint in different concentrations creating a clear disturbance gradient. Additionally, we also demonstrate that the barnacle *Amphibalanus improvisus* has accumulated copper with increasing disturbance implying that the biota colonizing the area delimited by the AF paint in the different treated plates has accumulated distinctive copper concentrations.

It is widely considered that disturbance can have variable effects on diversity causing a variety of shapes between the two factors [47,48,52]. One conceptual formulation of the effects of disturbance on diversity is the intermediate disturbance hypothesis (IDH, [45]) that predicts a unimodal relationship with maximum diversity at 'intermediate' levels of disturbance. The foundation behind this concept is that high frequencies of disturbance and longer-lived species cannot persist in the same system; at low disturbance strong competitors force pioneer species to extinction; at intermediate rates of disturbance, diversity is maximized due to the coexistence of competitors and colonizers [45]. However, a recent meta-analytical comparison examining 94 studies on the diversity–disturbance relationship in different systems has shown that the unimodal pattern was only observed in 18% of the studies [52]. In their review, Hughes *et al.* [52] found that disturbance most commonly decreases diversity. Although our experiment was too short for an adequate test of the IDH, we also found that disturbance significantly decreased total species richness in both sites (it is marginally significant in Virginia probably due to lower replication – see table 3) and total functional richness in Panama.

In the present study, we have demonstrated that numbers of native species (and FG) are strongly reduced with augmenting the concentration of copper. This seems to be in consensus with recent investigations that used copper as a disturbance in fouling assemblages [5,20]. Piola and Johnston [5] performed a manipulative experiment in Australia to evaluate the influence of heavy metal pollution on diversity and invasibility of marine hard-bottom assemblages. In order to create an increasing pollution regime, they also used coatings of a copper-based antifouling agent. Their findings indicate that by increasing pollution exposure, native species diversity was severely reduced [5]. More recently, Crooks *et al.* [20] conducted an experiment in San Francisco Bay to investigate the role of abiotic factors in affecting the invasibility of a community. In their study, PVC plates were periodically removed from the field and placed into buckets with different copper concentrations for a 72 h period before being returned to the Bay. Although a different experimental design was employed, Crooks *et al.* [20] concluded that average native species richness was significantly reduced by copper exposure, as the present study.

In this study, the average number of NIS in Panama significantly decreases with augmenting copper concentration, which partially contrasts the findings of the two previously mentioned studies [5,20]. Piola and Johnston have not found a significant change in non-indigenous richness with increasing copper exposure but concluded that the spatial dominance of NIS (measured as percentage cover) increased with metal pollution in all their study sites [5]. Similarly, Crooks *et al.* 's study concluded that their exotic species pool was not sensitive to copper exposure [20]. The absence of any significant pattern for NIS in Virginia is probably due to a weaker invasive signal (only 2 NIS were found) when compared to Panama. Native diversity at both sites displayed similar patterns with disturbance (linear negative relationship) as they show similar native signals (33% for Panama and 31% for Virginia). However, our observation that non-indigenous richness was higher in the tropics seems to be consistent with recent reviews that regard NIS to follow the latitudinal gradient of species richness, with diversity decreasing towards the poles [3,25]. Higher numbers of NIS in Panama were expected, as our study site was located in the eastern mouth of the Panama Canal, considered a key vector in promoting biological invasions [53].

In addition, this observed invasion pattern across latitude has also been linked to other factors such as historical baseline information, propagule supply, resistance to invasion and disturbance [25]. Furthermore, recent studies showed that species rich or poor communities located in tropical waters are more susceptible to invasions [54,55]. However, although we found more NIS in the tropics, it should be noted at this point that this study did not cover intermediate regions between Panama and Virginia. Having more study sites across latitude would be beneficial to support the idea that NIS are following the latitudinal gradient of species richness. Moreover, there was a large percentage of species in both systems that could not be resolved as 'native' or 'NIS' (these were categorized as cryptogenic or unresolved). However, because total diversity (where all cryptogenic species were included) decreased with copper exposure in both regions, we believe that this lack of resolution would likely not impact conclusions concerning the role of disturbance to native or NIS diversity.

We conclude that diversity is sensitive to copper pollution in fouling assemblages, whether taxonomic or functional richness is considered. Native diversity was severely reduced by disturbance in both sites, and more importantly, non-indigenous richness decreased with increasing metal concentrations, contradicting previous investigations. This pattern only occurred in the tropics most likely due to the different proportions of NIS per site (more NIS in the tropics). This study also corroborates that pollution is a category of disturbance (anthropogenic) as we show it affects total diversity and availability of resources (open space). Finally, this investigation represents the first study exploring the effects of metal pollution on diversity that incorporates functional diversity in addition to species richness as a dimension of biodiversity. Functional diversity was consistently less sensitive to copper pollution than species richness possibly because toxicant sensitivities are considered to be highly species specific and substitution within functional groups may obscure structural impacts on communities. This corroborates recent studies that confirmed species richness as the most sensitive indicator of pollution effects on biodiversity [56].

Supporting Information

Figure S1 Individual replicates from fouling communities in Virginia across disturbance treatments. Panel A – D0; panel B – D1; panel C – D2 and panel D – D3. See Methods for details.
(TIF)

Figure S2 Individual replicates from fouling communities in Panama across disturbance treatments. Panel A – D0; panel B – D1; panel C – D2 and panel D – D3. See Methods for details.
(TIF)

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Author Contributions

Conceived and designed the experiments: JCC MT GMR. Performed the experiments: JCC. Analyzed the data: JCC. Contributed reagents/materials/analysis tools: JCC PF GFR MT GMR. Wrote the manuscript: JCC PF GFR MT GMR.

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Delayed effects of larval exposure to Cu in the bryozoan *Watersipora subtorquata*

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ABSTRACT: Larval experience affects early post-metamorphic performance of a range of marine invertebrates, and even brief events during the larval stage can be important. One of the important larval stresses for organisms living in urban coastal environments is exposure to toxicants. Larvae may pass through patches of toxicants in their dispersal stage with the potential to affect their post-metamorphic performance. However, most studies on embryonic or larval tolerance to pollutants end at, or before, metamorphosis, have little follow-up and almost all are done under laboratory conditions. In this study, we tested whether short-term larval exposure to copper has short- and long-term carry-over effects in the encrusting bryozoan *Watersipora subtorquata* by following settlement and metamorphosis in the laboratory, then transplanting colonies into the field, in 2 seasons and at 2 sites in SE Australia. Cu at 100 µg l^{-1} accelerated larval attachment in winter and summer, but inhibited metamorphosis. When transplanted to the field, juveniles survived and grew well, and effects on survival and growth did not appear until several weeks or months after settlement. Larval exposure to Cu reduced survival of colonies to about 2/3 that of control colonies in summer and at 1 site, reduced survival to about 20% that of controls in winter. The fall in survivorship occurred abruptly after 3 to 5 wk in summer and 14 wk in winter. The surviving colonies grew more slowly than the controls. In general, there was little temporal variation in Cu effects, but there was spatial variation in effects on survival and growth of colonies within and between sites.

KEY WORDS: Cu · Carry-over effects · Attachment · Metamorphosis · Post-metamorphic survival · Post-metamorphic growth · Spatial variations · Temporal variations · Bryozoan

INTRODUCTION

Larval and post-metamorphic processes have, in the past, largely been treated as independent events. Only recently have biologists found evidence of the impact of larval experience on post-metamorphic performance of marine invertebrates (reviewed in Pechenik et al. 1998), and even short-term larval experiences can carry over to future life history stages of development. Most studies to date are on impacts of larval starvation or delaying metamorphosis with the effects usually appearing in the days following metamorphosis.

One important larval stress for organisms living in urban coastal environment is exposure to toxicants. During their dispersal stage, larvae may pass through patches of toxicants, such as areas of industrial discharge or stormwater runoff, and near surfaces of ships coated by antifouling paint. Embryos or larvae are generally more sensitive to pollutants than are juveniles or adults (Connor 1972, Calabrese et al. 1973, Moore & Dwyer 1974); hence, early larval experience of environmental contaminants may affect post-metamorphic performance. Pechenik et al. (1998) predicted that exposing larvae to sublethal pollutant stress would cause similar impacts to those of starvation on juvenile survival, growth rates,

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competitive ability, time to reach reproductive maturity or fecundity. However, so far, laboratory studies on embryonic or larval tolerance to pollutants end at, or before, metamorphosis, have little follow-up and most are done under laboratory conditions. Even when carry-over effects of prolonged swimming or larval nutrition have been examined, they have generally not extended very far beyond the completion of metamorphosis, leaving open the possibility that some effects may only become apparent after a considerable time.

In a previous study, we found there were impacts of brief larval exposure to Cu on performance of the arborescent bryozoan *Bugula neritina* (T. Y.-T. Ng & M. J. Keough unpubl. data). Larval photopositive behaviour was affected and the metamorphosis was delayed or inhibited. Post-metamorphic survival and growth of the colonies were reduced, although the actual combination of effects varied between different sites. Here, we extend this approach to another bryozoan and test whether brief larval stresses have effects on attachment and metamorphosis of larvae as well as on juvenile and adult colonies. To understand the consistency of any effects, we transplanted colonies to 2 field sites in SE Australia during the summer field season and repeated the experiment at 1 site in winter.

Watersipora subtorquata is an encrusting bryozoan that is widely distributed in protected temperate and subtropical waters. Some older laboratory data exist on its sensitivity to metals. Wisely & Blick (1967) compared the toxicity of Cu on larvae of several fouling species, including bryozoans, molluscs, polychaetes and crustaceans. *Watersipora* was the most sensitive species and the LC_{50} of Cu (citrate form) over a 2 h exposure was about 600 µg l^{-1}. *Watersipora* larvae swam less freely and sank after experiencing a high Cu dose (Wisely 1962a). Although the larval survival and behaviour were sensitive to Cu, attachment was more resistant (Wisely 1958). Juveniles of *Watersipora* could grow over Cu-based antifouling paints of moderate toxicity or be found in Cu-polluted water in marinas (Weiss & Ketchum 1945, Weiss 1947, Wisely 1958, Turner et al. 1997). The fate of colonies after larval experience of Cu is unclear because previous studies were of short durations.

Specific questions asked in this study are: (1) does a short-term larval exposure of *Watersipora subtorquata* to Cu affect the larval attachment and metamorphosis? or (2) the post-metamorphic survival and growth of field-transplanted colonies? and (3) do these effects vary with seasons or sites? We answered these questions by both laboratory and field investigations. In the laboratory, we looked at the effects on larval attachment and metamorphosis in summer and winter. Then we transplanted the settled juveniles to 2 field sites to measure their subsequent survival and growth.

MATERIALS AND METHODS

Sample collection. Mature colonies of *Watersipora subtorquata* for the winter experiment were collected at Breakwater Pier, Williamstown, in Port Philip Bay, SE Australia, by snorkelling. For the summer experiment, we used those left-over colonies of the control after the winter experiment had been finished. Some other reproductive colonies were recruited from the plates hung from the pier before the start of summer at St Kilda Pier, St Kilda, in Port Philip Bay. Colonies were transported back to the laboratory and put in a recirculating seawater system. They were kept in darkness overnight and induced to spawn under bright light the next day (Wisely 1958).

Cu exposure. Analytical grade $CuCl_2 \cdot 2H_2O$ was the reference toxicant used to provide Cu^{2+}, which is the most toxic form of Cu (Andrew et al. 1977). Marine Biological Laboratory artificial seawater (Cavanaugh 1956) was used as the dilution medium instead of natural seawater in order to minimise any variation in effects arising from complexation of Cu with organic components from natural seawater. Complexation can reduce the amount of Cu^{2+} in solution. A pilot study showed that larvae behaved and settled normally in the artificial seawater.

In all experiments, the exposure period was set to 6 h, to represent a brief but substantial part of the larval period of *Watersipora* spp. (e.g. *Watersipora cucullata*: Wisely 1958). Artificial seawater was used as the control and the Cu treatment was at a concentration of 100 µg l^{-1}. This concentration was selected because it is well below the LC_{50} for the bryozoan larvae (M. J. Keough unpubl. data) and therefore sublethal, but high enough to provide some stress. All the apparatus for toxicity tests was soaked in 5% nitric acid overnight and rinsed with distilled water before use (Greensberg et al. 1994).

Attachment and metamorphosis. Winter and summer laboratory experiments were conducted in May 1999 at room temperature (ca. 15°C) and November 1999 (ca. 22°C), respectively.

Bottoms of plastic Petri dishes (90 mm in diameter) were roughened by sand paper to maximise attachment. We put 15 larvae into each Petri dish containing control or Cu solution with 10 replicates for each treatment. All samples were kept in darkness. Numbers of larvae swimming and attached were observed at 3, 6, 24 and 48 h in the winter experiment. Since a saturation of most responses was found after 24 h in the winter experiment, the summer observation times were 3, 6, 9 and 24 h. After 6 h, the control or Cu solution was replaced with natural seawater. As *Watersipora subtorquata* larvae undergo metamorphosis, their orifices begin to appear and initial stages of calcification are indicated by the development of ridges. We began recording the development of a clear orifice and ridge after 24 h, at daily intervals until 144 h.

Field study. The winter field study was conducted between late May and early October 1999 (18 wk) with average seawater temperature around 11°C in Melbourne. The summer study was conducted between late December 1999 and late March 2000 (12 wk) with average seawater temperature around 20°C.

Field sites: In winter, as a limited number of larvae could be obtained, the field experiment was conducted at St Kilda pier only. In summer, experiments were conducted at 2 sites, St Kilda Pier and Breakwater Pier. Both sites are located in Port Philip Bay, a large (2000 km^2) embayment in Victoria, in SE Australia. Breakwater Pier is situated 7 km southwest of Melbourne. The pier extends 300 m from the shore and includes a rocky breakwater on the northern side. St Kilda Pier is situated about 4.5 km away from the Breakwater Pier and also includes a rocky breakwater. The sessile assemblages of bryozoans, ascidians, sponges, hydroids and polychaetes have been described elsewhere (Russ 1977, Klemke 1993, Todd & Keough 1994, 1998, Keough & Raimondi 1995). The background dissolved Cu concentrations in both sites are less than 3 $\mu g\ l^{-1}$ (Fabris et al. 1999, Webb & Keough 2002).

Survival and growth: After the attachment and metamorphosis experiment, settled juveniles were transplanted to the field to measure their post-metamorphic performance. Juveniles on the edge of Petri dishes or that did not develop orifices were scraped away. The size of ancestrulae was measured from the anterior (tip of orifice) to the posterior end before transplanting. Positions of juveniles were marked on the Petri dishes before transplanting, so that any newly recruited colonies could be identified and removed at each field visit. Dishes with the juveniles were bolted on the underside of PVC backing panels (80 × 35 × 1 cm) to minimise light and sedimentation. There were 10 replicate dishes for each treatment with about 8 settled juveniles each. Petri dishes from the control and Cu treatments were bolted alternately on the backing panels in order to ensure that any micro-environmental variation could not bias the outcome of the experiment. There were 3 backing panels that were hung horizontally and separately, 2 m apart and 1.5 m below the low water mark.

Backing plates were removed from the water and placed into a holding tank at weekly intervals. Survival of colonies was recorded, and pale colonies with empty zooids were defined as dead. New recruits or colonies that overlapped the neighbouring colonies were scraped off *in situ* in order to prevent cessation of growth at the contact edge of overlapping colonies (Gappa 1989, Barnes & Rothery 1996). Colonies were also photographed with a 1 cm grid-marked perspex plate placed underneath the dish. Since *Watersipora subtorquata* colonies are generally circular in shape and only produce buds at the outer edge, diameter of the colony was used as a measurement of their area or size (Bak et al. 1981, Bathgate 1994). Size of colonies was measured from the projected slide images on a white paper, with the scale taken from a perspex plate. Three diameters were measured from different edges of colonies (Bak et al. 1981) when colonies were growing irregularly, and the geometric mean of these diameters was used as the size of each colony. The winter and summer experiments ended at Weeks 18 and 11, respectively.

Statistical analyses. We tested for the normality and homogeneity of our data by looking at boxplots of the data before analysis. We did not apply the arcsine transformations to our data analyses. Most of our percentage data in the samples fell into 2 types—all intermediates (~50 to 70%) or all extremes (~0 or ~100%). The intermediate data were generally normally distributed, so they did not need transformations. For the data at extreme range, an arcsine transformation did not improve the normality.

Repeated measures analysis of variance was used to test for variation in Cu effects over time, with Cu treatment as the between-subjects effect and time as the repeated effect. *T*-tests were used to identify times affected by Cu when there was a significant Time × Cu effect. For the field experiments, we analysed the variation in Cu effects arising from different backing panels by doing a 3-factor (Cu and panels as the between subjects factors) repeated measures analysis of variance. When we found significant interactions between Cu and panels, we analysed the effects of Cu on each panel separately. When there was no Cu × Panel effect, we omitted the panel factor and re-ran the model.

RESULTS

Attachment and metamorphosis

In winter, fewer larvae swam in the Cu treatment over time (Table 1), with an obvious effect at 24 h (t = test: $p < 0.001$; Fig. 1a). In summer, the effect of Cu was consistent, appearing after 3 h, with only about $^1/_2$ of the larvae swimming in the Cu treatment (Fig. 1b). Attachment of larvae during the first 9 h was higher in summer than winter (Fig. 1c,d). In winter, Cu accelerated the attachment of larvae (Table 1), with the greatest effect at 24 h (t-test: $p = 0.008$; Fig. 1c). In summer, Cu had similar effects (Table 1, Fig. 1d), but large effects were apparent by 3 h.

Table 1. *Watersipora subtorquata*. Repeated measures analyses results for experiments on larval exposure to Cu. p-values in bold indicate significant differences at $\alpha = 0.050$. p = 0.000 denotes value <0.0005

Experiment	Cu			Time × Cu (× Panel)		
	df	p	MS_{error}	df	p	MS_{error}
Winter laboratory study						
Free-swimming	1	**0.010**	532.574	3	**0.000**	104.802
Attachment	1	0.088	801.800	3	**0.000**	124.315
Ridge development	1	**0.022**	1053.896	3	0.361	254.367
Orifice development	1	0.982	1473.949	2	0.085	475.732
Summer laboratory study						
Free-swimming	1	**0.001**	739.550	3	0.071	156.414
Attachment	1	**0.026**	928.717	3	**0.024**	142.983
Ridge development	1	**0.017**	178.666	4	**0.000**	32.267
Orifice development	1	**0.012**	236.344	4	0.165	113.391
Winter field study						
Survival	1	**0.041**	2622.010	18	**0.000**	224.703
Size	1	0.049	38.913	18	**0.003**	4.467
Summer field study						
Survival – St Kilda						
Pooled panels	1	0.092	4060.645	12	**0.007**	201.008
Panel 1	1	0.577	5685.121	12	0.999	337.042
Panel 2	1	**0.033**	2044.613	12	**0.000**	85.761
Panel 3	1	0.229	3639.973	12	**0.034**	112.204
Survival – Williamstown	1	0.384	1234.378	9	**0.002**	60.817
Size – St Kilda						
Pooled panels	1	0.075	173.092	12	**0.005**	14.352
Panel 1	1	**0.043**	232.457	12	**0.000**	16.609
Panel 2	1	0.377	146.897	12	**0.009**	13.934
Panel 3	1	0.778	273.521	12	0.963	21.069
Size – Williamstown	1	0.333	59.750	9	0.070	7.858

All attached larvae developed ridges faster in summer than winter (Fig. 1e,f). In winter, Cu inhibited ridge development consistently (Table 1). In summer, Cu also inhibited the ridge development (Table 1), but the effect was apparent only at 48 h (*t*-test: $p < 0.001$; Fig. 1f) with similar rates as the control after that. Development of the orifice in summer was generally faster than in winter (Fig. 1g,h). In winter, Cu did not affect the orifice development but it had consistent effects in summer (Table 1).

Field study

In winter, the effect of Cu was consistent across panels (repeated measures analyses of survival, p = 0.958; size, p = 0.932), so panels were omitted from the statistical model. Survival of colonies in the field remained very high, and only after a long period (11 wk) did it start to drop in both treatments (Fig. 2a). Survival of colonies was lower in the Cu treatment (Table 1) and the effect appeared after Week 14 (*t*-tests: $p < 0.050$ at Week 14; $p < 0.010$ between Weeks 15 and 18). In summer, a strong interaction was found between panel and treatment at St Kilda (Table 1), so colonies on each panel were analysed separately. No effect of Cu was detected on Panel 1 (Table 1, Fig. 3a) while there were significant effects on Panels 2 and 3 (Table 1, Fig. 3b,c). The effects appeared about 5 wk after transplant. At Williamstown, no significant variation caused by panels was found, and Cu reduced the survival of colonies after Week 3 (Table 1, Fig. 2c).

In winter, growth was only analysed up to Week 12 because there were insufficient colonies in the Cu and control treatment in the later weeks. After transplant, starting from Week 3 (*t*-tests: $p < 0.050$), colonies in the Cu treatment grew more slowly and were smaller than colonies in the control (Table 1, Fig. 4a). In summer, at St Kilda, different panels had different effects of Cu over time (Table 1). Both Panels 1 and 2 had larger colonies in the Cu treatment (Fig. 5a,b), while Panel 3 had no significant difference in the size of colonies in both treatments (Fig. 5c). At Williamstown, no strong interaction between panels and effects of Cu was found. Colonies in the Cu treatment were similar in size to the colonies in the control (Table 1, Fig. 4c).

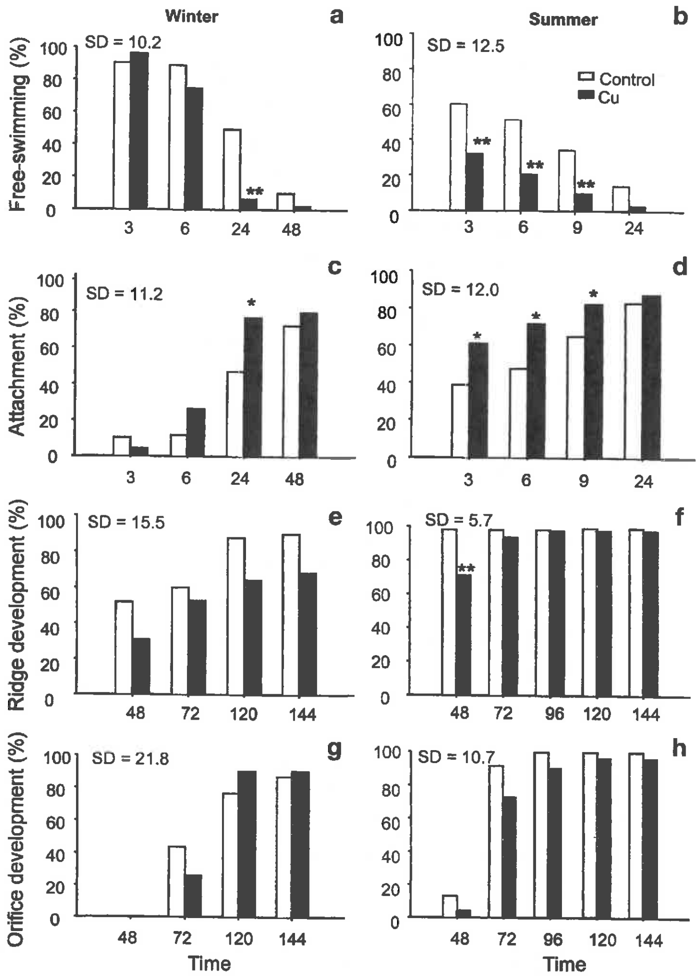

Fig. 1. *Watersipora subtorquata*. Effects of Cu on attachment and metamorphosis in winter and summer. (a) Free-swimming (%), winter; (b) free-swimming (%), summer; (c) attachment (%), winter; (d) attachment (%), summer; (e) ridge development (%), winter; (f) ridge development (%), summer; (g) orifice development (%), winter; (h) orifice development (%), summer. Each bar represents the mean value and SD is the square-root of MS_{error} of the Larvae × Time effects, which are used to assess the differences between treatments through time. *$p < 0.05$, **$p < 0.01$, $n = 10$

DISCUSSION

Cu accelerated the attachment and inhibited the metamorphosis of *Watersipora subtorquata* larvae in summer and winter. These effects were also observed in past studies with a higher Cu dose and longer exposure on bryozoans (Miller 1946, Wisely 1958, 1962a,b). Our earlier study (unpubl.) showed that exposure to Cu (100 µg l^{-1}) for 6 h did not affect the attachment of the arborescent bryozoan *Bugula neritina*, but it deterred the development of lophophores. This study showed that Cu affected both the attachment and metamorphosis of *W. subtorquata*. The reason for this difference between species is unclear, although one potential cause, a difference in length of the larval stage, appears unlikely. In Port Phillip Bay, *W. subtorquata* larvae have a swimming period that is 8 to 20 h longer than that of *B. neritina*. However, extending the swimming period in *B. neritina* did not alter the effects of Cu (T. Y.-T. Ng & M. J. Keough unpubl. data).

There was variation in the effects of Cu on attachment and metamorphosis between seasons. Cu inhibited the development more in summer than winter, as it deterred both ridge and orifice development in summer but only ridge development in winter. In winter, Cu effects developed through time, while they were apparent almost immediately in summer. This pattern may be explained by the different larval activities in

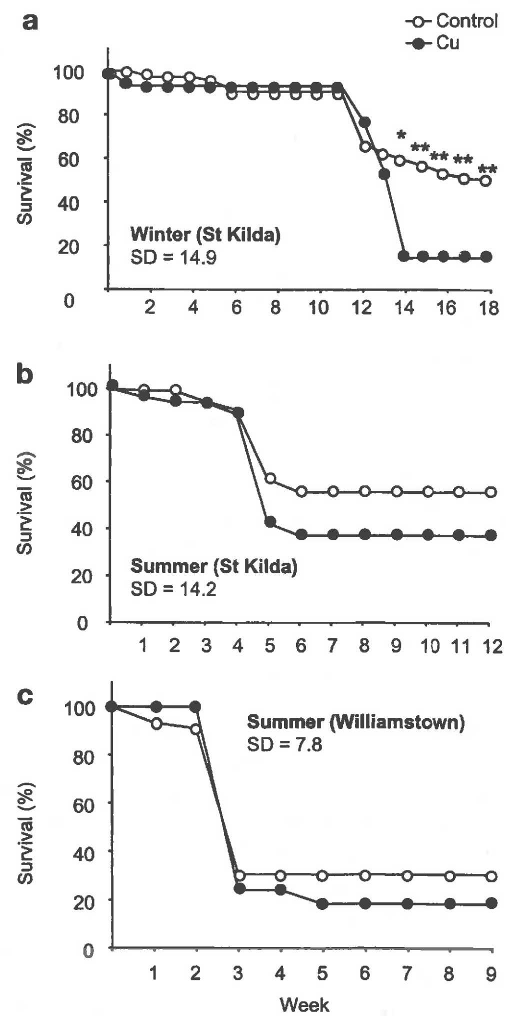

Fig. 2. *Watersipora subtorquata*. Effects of Cu on survival of field-transplanted colonies in winter and summer. (a) Winter, St Kilda, n = 9; (b) summer, St Kilda, n = 10; (c) summer, Williamstown, n = 6. The data are mean values and SD is the pooled SD (see Fig. 1). SD for St Kilda was calculated from repeated measures analyses (Cu × Panel). *$p < 0.05$, **$p < 0.01$

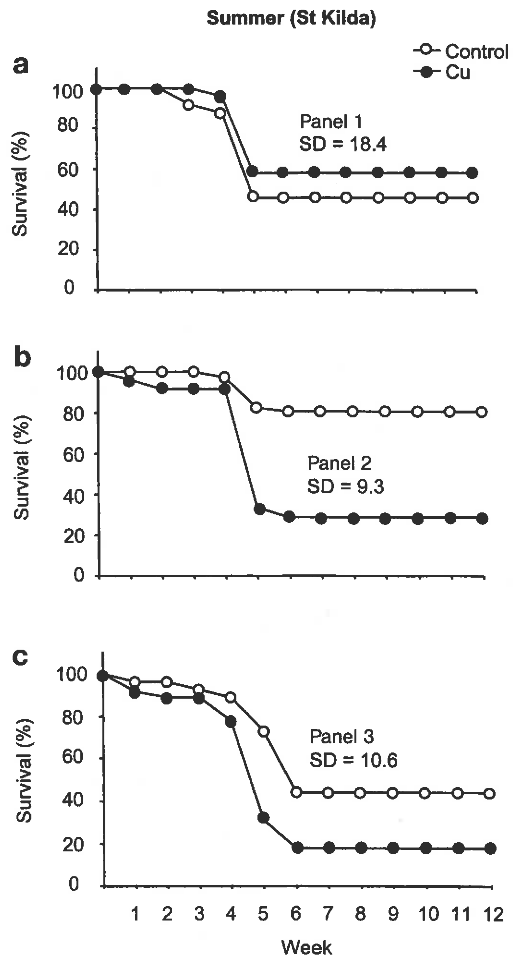

Fig. 3. *Watersipora subtorquata*. Effects of Cu on survival of field-transplanted colonies on different panels in summer at St Kilda. (a) Panel 1, n = 4; (b) Panel 2, n = 3; (c) Panel 3, n = 3. The data are mean values and SD is the pooled SD (see Fig. 1)

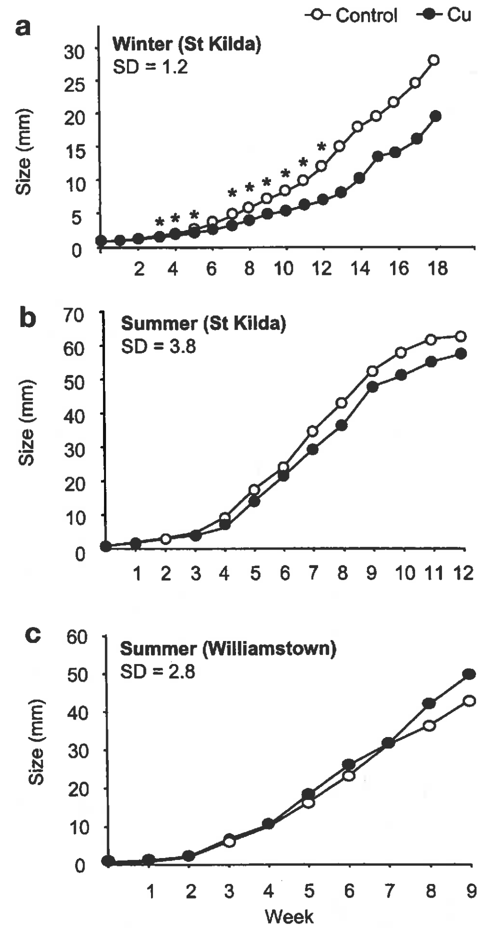

Fig. 4. *Watersipora subtorquata*. Effects of Cu on size of field-transplanted colonies in winter and summer. (a) Winter, St Kilda, n = 9; (b) summer, St Kilda, n = 10; (c) summer, Williamstown, n = 6. The data are mean values and SD is the pooled SD (see Fig. 1). SD for St Kilda was calculated from repeated measures analyses (Cu × Panel). *$p < 0.05$

different seasons. In summer, the temperature is higher and the metabolic activity of larvae is higher and hence, larvae started attachment or metamorphosis earlier than in winter, resulting in an early effect of Cu; an effect that persisted.

Although *Watersipora* larvae attached faster in a Cu-polluted environment, their metamorphosis was slower or incomplete. This delay could provide a time lag of 12 to 24 h in the commencement of feeding and result in a higher risk of predation or slower rate of colony development.

There are few studies following the fate of a colony after the larvae pass through the toxicant pulse. Here, we provide the first evidence of carry-over effects of a toxicant on the post-metamorphic performance of *Watersipora subtorquata*. A larval exposure to 6 h Cu had carry-over effects on survival and growth of *Watersipora* colonies, with the effects not appearing until weeks (summer) or months (winter) after exposure. This is far later than has been reported for other carry-over effects.

Watersipora colonies survived well for at least 5 wk after transplant in both seasons, contrasting to the survival drop at the beginning in *Bugula neritina* (Keough 1986, 1989, Keough & Chernoff 1987, T. Y.-T. Ng & M. J. Keough unpubl. data) and juveniles of most other marine invertebrates (Gosselin & Qian 1997, Hunt & Scheibling 1997). However, a dramatic drop in survival of *Watersipora* colonies occurred in the later period and far fewer colonies survived in the Cu treatment. The size of colonies was about 10 to 15 mm in diameter, corresponding to approximately 100 zooids, when the survival dropped significantly in both treatments. The colonies had undergone several cycles of budding at that time and it is unlikely that the larva could accumulate enough Cu in 6 h to affect all zooids.

Therefore, it is possible that the delayed effect on survival was caused by the damage to some biochemical pathways in the larvae after the exposure, which was passed on during budding. There is also a lot of evidence showing that stress experienced at larval stage impairs the performance of later stages of a range of marine invertebrates (Highsmith & Emlet 1986, Pechenik & Eyster 1989, Woollacott et al. 1989, Orellana & Cancino 1991, Pechenik & Cerulli 1991, Miller 1993, Pechenik et al. 1993, 1996a,b, Hoare et al. 1995, Qian & Pechenik 1998, Gebauer et al. 1999, Maldonado & Young 1999). Pechenik et al. (1998) explained these effects by suggesting that the magnitude and timing of gene transcription for future development of marine invertebrates may be interrupted in their early stage. Here, the effects of Cu on survival appeared 2 mo earlier in summer than in winter. This faster occurrence of Cu effects in summer was also found in the laboratory study of attachment and metamorphosis.

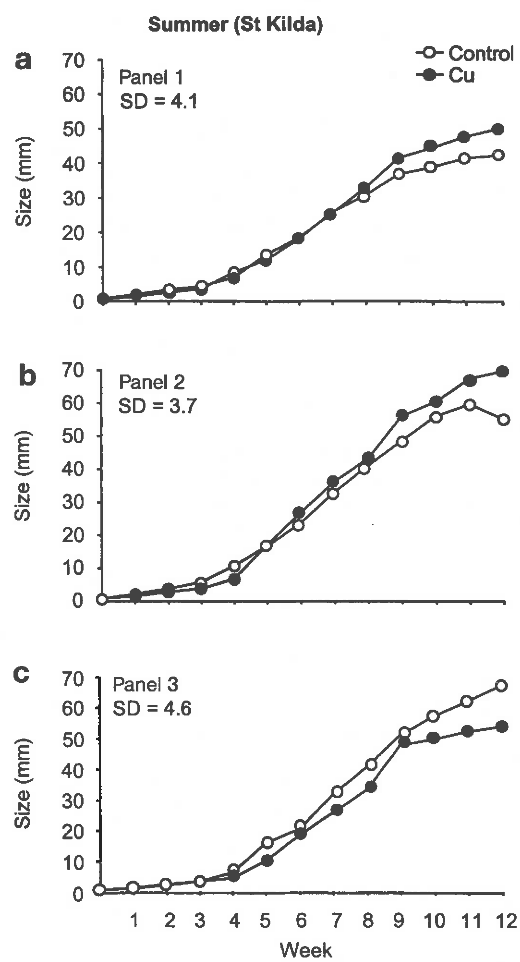

Fig. 5. *Watersipora subtorquata*. Effects of Cu on size of field-transplanted colonies on different panels in summer at St Kilda. (a) Panel 1, n = 4; (b) Panel 2, n = 3; (c) Panel 3, n = 3. The data are mean values and SD is the pooled SD (see Fig. 1)

The carry-over effect on colony growth happened as soon as the colony started to grow rapidly. Cu reduced the growth of colonies in both seasons, but more dramatically in winter and only on 2 of 3 panels at 1 site in summer. Hoare et al. (1995) suggested that the exposure to Cu could alter the larval physiology, reducing the lipid reserve that is essential for larval metamorphosis and growth. While reduced lipid reserves might account for smaller ancestrulae, it is surprising that such effects persist through several cycles of budding, when budding is fuelled by feeding of many zooids. However, larvae of the ascidian *Diplosoma listerianum* with energy reserves presumably depleted by prolonged swimming, produced zooids with smaller feeding structures (Marshall et al. 2003). Colonies continued to produce such zooids for several weeks after metamorphosis.

When the survival and growth profiles of colonies were compared, we found that the survival of colonies in both treatments decreased in temporal coincidence with the increase of growth rates in both seasons. In addition, in summer, embryogenesis might also have started when the survival of the colonies decreased, as the reproductive zooids were first observed 2 wk later. Therefore, it is possible that the mortality rate rose with a shift in colony activity. In bryozoans, successive zooids are linked by a strand of nutritive and nervous tissues known as the funiculus, through which translocation of metabolites is believed to occur (Bobin 1977, Lutaud 1977, Best & Thorpe 1985). One study of fragmentation suggested that resources may not be distributed evenly for growth to every live zooid in the *Watersipora subtorquata* colonies, and that there is more growth in the younger zooids than the older zooids (Hart 2001). The responsibility for growth is mainly with the few zooids behind the growing edge and that resources in zooids further back may contribute more to reproduction (Hart 2001). In addition, the translocation of resources for growth has been demonstrated from the central to peripheral zooids in the bryozoan *Membranipora membranacea* (Best & Thorpe 1985). Therefore, a faster growth or embryogenesis of *Watersipora* may reflect a change in resource allocation in the colonies and increased demands of fast growth or embryogenesis may affect any colonies in poorer condition.

In the field, the effects of Cu on survival of *Watersipora subtorquata* did not appear for weeks or months; however, in contrast, the effects on *Bugula neritina* colonies occurred shortly after colonies were transplanted (T. Y.-T. Ng & M. J. Keough unpubl. data). The differences between species may relate to the difference in growth profiles—*B. neritina* grew faster at the beginning, then slowed down, while *W. subtorquata* grew slowly just after metamorphosis, accelerating later.

Effects of Cu on survival and size of colonies also varied between sites or among panels in summer. The small-scale variation among panels was small at Williamstown but large at St Kilda. At St Kilda, the variation among panels in colony growth was more than in survival. The distribution of field experimental panels may explain the small-scale variation of Cu effects. Panels 2 and 3 were hung 1 m apart along the pier pilings, and Panel 1 was hung from another pier piling, which was 5 m away. There may have been more microhabitat differences between Panel 1 and the other panels, which caused the spatial difference in response by colonies on different panels. In fact, small- and large-scale variation of the performance of the arborescent bryozoan *Bugula neritina* has already been reported in our earlier study (unpubl.) as well as others (Keough 1986, 1989, Keough & Chernoff 1987). Environmental variables, e.g. salinity, temperature, water flow, sedimentation and food, can affect the growth or zooid morphology of bryozoan colonies (Hughes & Hughes 1986, Hughes 1992, Okamura 1992, Keough & Black 1996, O'Dea & Okamura 1999). St Kilda Pier has more food, a higher water flow and more sedimentation than Breakwater Pier (T. Y.-T. Ng unpubl. data). These variations may have caused the differences in the response of bryozoan colonies between sites.

To summarise, this study demonstrates that *Watersipora subtorquata* larvae exposed to Cu for 6 h attached faster in winter and summer, but metamorphosis was either delayed or totally inhibited. Well-developed colonies in the Cu treatment started to die and grow more slowly later in the field. There was generally no temporal difference in response to Cu except that the time of occurrence of effects was earlier in summer than winter. However, in summer, effects were very dependent on different spatial scales, within and between sites.

The results for *Watersipora subtorquata* and *Bugula neritina* have several important implications. In a practical sense, they reinforce other calls for caution in use and interpretation of laboratory toxicity studies. Larvae that were exposed to toxicants for a short period, much less than the conventional 48 and 96 h, survived and settled, but they subsequently grew slowly or died sooner. This delayed mortality of apparently healthy individuals must be incorporated into any interpretation of laboratory studies. A more positive result from this work is that the technique used here, of laboratory exposure, followed by transplantation to the field, is a useful tool for investigating subtle effects of toxicants on individual performance. Individual performance can be measured in a more natural and ecologically relevant way. Finally, this unexpected and fascinating result for survival of *W. subtorquata* shows that larval stresses can have prolonged or delayed carry-over effects. This result extends the links between larval experience and adult performance factors further into organisms' life cycles. Identifying the underlying mechanism will be a challenge.

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