IMPROVING WATER QUALITY AT ENCLOSED BEACHES

A Report on the Enclosed Beach Symposium and Workshop (Clean Beaches Initiative)

John Largier
Bodega Marine Laboratory
University of California Davis
jlargier@ucdavis.edu

and

Mitzy Taggart
Heal the Bay
mtaggart@healthebay.org

Prepared for
State of California
State Water Resources Control Board
Clean Beaches Initiative

Final Report, June 2006

EXECUTIVE SUMMARY
IMPROVING WATER QUALITY AT ENCLOSED BEACHES

Enclosed beaches are popular throughout California. The term "enclosed beach" is used to describe beaches that are located within sheltered bays, harbors or estuaries. Also known as 'sheltered' beaches, 'bay' beaches or 'pocket' beaches, enclosed beaches are characterized by low wave energy, often resulting in warm, calm waters. Enclosed beaches are popular family destinations, rich with amenities including playgrounds, picnic areas, and educational and boating facilities. An estimated 24 million people visit enclosed beaches in California annually. In addition to direct human benefit, the sheltered waters off these beaches also provide key habitat (e.g., eelgrass beds) for a rich diversity of animals and plants, including acting as important nursery areas for young fish.

Exceedance of state standards for fecal indicator bacteria is most common at enclosed beaches. Between 1999 and 2004, standards were exceeded 15% of the time at enclosed beach sites during the AB-411 monitoring period of May through October. This is 5 times more often than at open coastal beaches and 2.5 times more often than at beaches receiving urban runoff flow. Wet weather statistics are worse, with exceedances occurring 51% of the time at enclosed beaches, compared to 29% at stormdrain-impacted beaches and 22% at open-coastal beaches.

The State Water Resources Control Board (State Water Board) Clean Beaches Initiative program (CBI) was initiated in 2001 with the goal of improving beach water quality and increasing visitor days by providing funding for water quality improvement projects. To date, over $78 million has been allocated to polluted beaches throughout California. However, little CBI funding ($11.2 million) has been used directly for source abatement and FIB reduction projects at enclosed beaches, even though these beaches are some of the most polluted beaches in the state. This is primarily because of the complex nature of the water quality problem at enclosed beaches.

In recognition of the unique characteristics and persistent nature of the water quality problems at enclosed beaches, the State Water Board initiated an enclosed beach summit to encourage more water quality improvement projects at enclosed beaches. Specific objectives of the "Enclosed Beach Symposium and Workshop" were:

- To encourage new CBI proposals with a high likelihood of success
- To identify solutions to beach pollution
- To identify impediments to development and implementation of solutions
- To identify future actions necessary to remove these impediments
- To facilitate information-sharing

The specific character of enclosed beaches raises a number of challenges and points to limitations in underlying knowledge that act as significant impediments in developing and implementing solutions. These uncertainties include (i) the role of sand and sediment, (ii) water circulation in very-nearshore waters, (iii) analytical methods, (iv) source tracking, (v) health risks, and (vi) health standards as applied to enclosed beaches.

Working groups identified actions that can abate contaminant sources, modify sediments, enhance circulation, or focus on policy changes. Details of proposed actions were developed for three case studies: Kiddie Beach, Cabrillo Beach and Campbell Cove.

Working groups also identified numerous impediments to successful action, including the above-listed uncertainties. These impediments include conflicting priorities (competing beneficial uses, involvement of multiple agencies, community opposition) and administrative limitations associated with the CBI process, including (i) restrictive funding requirements, (ii) 20-year operation and maintenance requirement, (iii) monitoring requirement, (iv) project timelines, and (v) insufficient communication between the applicants, the State Water Board and the Clean Beach Task Force.

The symposium and workshop resulted in the following recommendations:

- Remove CBI impediments in guidelines for Proposition 50 funding (as allowable by legislative requirements). Give specific attention to timelines, studies and pilot projects, and adaptive approaches.
- Improve communication between project proponents, the State Water Board and the Clean Beach Task Force.
- Encourage applications from priority beaches through working with the Regional Water Quality Control Boards.
- Remove impediments through studies in critical areas of uncertainty, specifically on rapid indicators, sediment and wrack influences, epidemiology, enhanced circulation, and source identification.

TABLE OF CONTENTS

EXECUTIVE SUMMARY..2

1. INTRODUCTION...5
2. THE PROBLEM: FECAL BACTERIA AT ENCLOSED BEACHES...................9
3. RESPONSES TO THE PROBLEM 14
4. IMPEDIMENTS TO ACTION...17
5. RECOMMENDATIONS 21

APPENDIX A: Recent State Policy Developments Related to Fecal Contamination of Beaches……..……………………………………23
APPENDIX B: Symposium and Workshop Agenda..26
APPENDIX C: Summaries of Presentations on General Themes 29
APPENDIX D: Summaries of Presentations on Specific Beaches 44
APPENDIX E: Beach Case Studies 72
APPENDIX F: Speaker Biographies...79

1. INTRODUCTION

Enclosed beaches are an important natural and economic resource for California. These beaches are located within sheltered bays, harbors or estuaries (Figure 1) and characterized by low wave energy and warm waters – they are also known as pocket beaches, bay beaches or sheltered beaches. Enclosed beaches are popular family destinations, rich with amenities including playgrounds, picnic areas, and educational and boating facilities. More than 24 million people visit California's enclosed beaches annually (Table 1), enjoying these specially calm and warm waters. These sheltered waters also provide key habitat for a rich diversity of animals and plants and act as important nursery areas for young fish.

BEACH	VISITORS	AWARDED	SPENT TO-DATE	COMPLETE
Campbell Cove	75,000	$500,000	$262,230	Yes
Mother's Beach	200,000	$2,000,000	$9,467	No
Cabrillo Beach	611,681	$1,250,000	$1,250,000	Yes
Avalon Beach	1,000,000	$500,000	$550,00	Yes
Kiddie Beach	n/a	$1,500,000	$360,210	Yes
Baby's Beach	1,000,000	$750,000	$880,000	Yes
Mission Bay	12,000,000	$3,000,000	$1,402,580	No
Newport Bay	8,900,000	$500,000	$298,679	No
Colorado Lagoon	n/a	$1,250,000	$148,924	Yes
TOTAL	**23,786,681**	**$11,250,000**	**$4,801,880**	

TABLE 1. *Estimated annual visitor numbers and funds made available for enclosed beaches through the Clean Beaches Initiative (CBI). A further $6,994,868 of Proposition 40 funding for enclosed beaches is pending final approval.*

Water quality at beaches in California are routinely tested and compared with the State's recreational water quality health standards. These standards, and the associated monitoring and public notification requirements, were established by Assembly Bill 411 in 1999 (see Appendix A). AB 411 set health standards for fecal indicator bacteria (FIB) based on the results of epidemiological studies that identified quantitative associations between negative health outcomes and swimming in waters contaminated with FIB. The requirements of AB 411 have been applied to most recreational beaches in California and they are the primary driver behind state and local government beach water quality actions.

Exceedance of health standards occurs more frequently at enclosed beaches than at other beaches in California. Mostly located within 11 sheltered bays, 117 enclosed beach monitoring sites are routinely sampled by local agencies for FIB (see http://healthebay.org/). Between 1999 and 2004, health standards were exceeded 15% of the time in the AB-411 monitoring period of April through

October (Figure 2). This is five times more often than at open coastal beaches and even 2½ times more often than at beaches receiving urban runoff flow – the original target of the AB411 legislative action. During wet weather, water quality at enclosed beaches is worse, with exceedances occurring 51% of the time, notably more often than the 29% and 22% at stormdrain-impacted and open-coast beaches, respectively. During the 2004-2005 wet-weather season, all of the enclosed beaches received an "F" on Heal the Bay's annual Beach Report Card, compared with 4 out of 5 stormdrain-impacted beaches and 4 out of 7 open-coast beaches (http://healthebay.org/).

FIGURE 1. *Popular Mothers Beach in Marina del Rey.*

The public health impact of poor water quality at enclosed beaches is of particular concern because enclosed beaches are popular with young children. Epidemiological studies observe that health effects in children are higher than in adults swimming in waters with elevated FIB densities, possibly due to increased ingestion of water and sand.

The State Water Resources Control Board (State Water Board) Clean Beaches Initiative (CBI) program started in 2001 with the goal of improving beach water quality and increasing visitor days (i.e., decrease days that beaches are posted due to exceedances) by providing grant funding to local beach management. Many Californian beaches have received funding through this State Water Board program with a total of $78.3 million from Propositions 13 and 40 (Appendix A). As of August 2005, $11.2 million of the CBI funds have been directed at enclosed beaches, mostly used to conduct Phase I investigations, which include source identification, circulation, and feasibility studies. A further $23 million from Proposition 50 will be available through the Clean Beaches Initiative in 2006. To date, very little CBI funding has been used directly for source abatement and FIB reduction projects at enclosed beaches, primarily because of the complex nature of the water quality problem at enclosed beaches, and in some cases, because local beach agencies have not applied for, or failed to use, CBI funding.

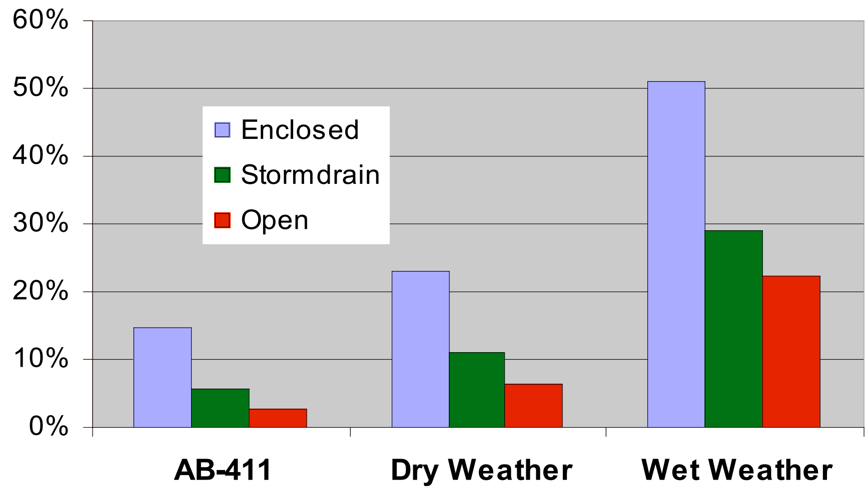

FIGURE 2. *Exceedance days 1999-2004*

Recognizing the unique characteristics and persistent nature of the water quality problems at enclosed beaches, the State Water Board initiated an enclosed beach summit, in which beach managers, clean water advocates, consultants, and academics could jointly tackle this problem. A symposium was planned and linked with a workshop, allowing for an overview of the problem and hands-on discussion of real-world beach problems (Appendix B). The summit was held in August 2005 at the Ocean Institute, Dana Point.

<u>The symposium and workshop</u>

The goal of the "Enclosed Beach Symposium and Workshop" was to improve water quality at popular enclosed beaches in California. Specific objectives were:

- To encourage new CBI proposals for enclosed beaches with a high likelihood of success;
- To identify solutions to beach pollution at enclosed beaches;
- To identify impediments to development and implementation of these solutions;
- To identify future actions necessary to remove these impediments;
- To facilitate information-sharing.

The first-day symposium was attended by over 80 people and included most of the key people currently working on enclosed beach water quality in the state. The morning session was comprised of presentations on general themes, providing the latest scientific understanding of several key issues including bay and beach circulation, engineered solutions, the role of sediments, source abatement methods, and epidemiology (Appendix C). The afternoon session was comprised of presentations on specific beaches, providing the latest results from studies and actions at nine of California's enclosed beaches (Appendix D). Together these presentations and a guided field trip to nearby Baby Beach (Figure 3) formed a basis of understanding of the enclosed beach pollution problem and provided a collation of lessons learned and ideas on potential solutions.

The second-day workshop was intended as a forum to brainstorm solutions to the enclosed beach problem and to identify ways that CBI funding could be used to measurably improve recreational water quality at enclosed beaches (Appendix E). Attendance was limited to 38 experts and local beach managers – an invited group of scientists, engineers, beach managers, and State Water Board personnel selected because of their experience and knowledge. The group included experts in civil engineering, hydrology, microbiology, public health, and oceanography. The workshop consisted of breakout groups and plenary discussion on solutions to the problem and impediments to achieving those solutions through the CBI.

This report is comprised of a section that describes the problem and the environment (section 2), followed by sections that outline possible solutions (section 3), impediments to solutions being implemented (section 4), and recommendations for action (section 5). A summary of the workshop case studies is appended as Appendix E.

FIGURE 3. *Popular Baby Beach in Dana Point Harbor.*

2. THE PROBLEM: FECAL BACTERIA AT ENCLOSED BEACHES

Fecal indicator bacteria (FIB) are commonly used as an indicator of health risk associated with water contact activities at beaches in California, the USA and worldwide. The association of high levels of FIB (coliform and/or enterrococcus) with swimming-related health impact stems from several epidemiological studies conducted around the world (Pruss 1998, *Int. J. Epidemiology 27*). The results of these studies form the basis for FIB health standards for recreational waters. The levels of FIB in waters off enclosed beaches are frequently in excess of these standards.

FIGURE 4. *Mission Bay, in which several popular enclosed beaches are located. Note the surrounding urbanization and development along the shores of the bay.*

Enclosed or sheltered beaches are found in bays, harbors, marinas, and estuaries. They are sheltered from high-energy waves, providing calm, warm and safe waters for swimming and wading. In addition to beaches in harbors like Ventura Harbor, Mission Bay and Los Angeles Harbor, low-energy beaches are also located in natural bays such as off Avalon, Capitola and Santa Barbara. These enclosed beaches share several common characteristics, each of which may be a relevant factor in the observed FIB levels:

- Characterized by small waves and thus limited mechanical energy to turn over large volumes of sand.
- Characterized by limited exchange with ocean, resulting in poor flushing, low dilution, and long residence.
- Located in bays with shallow, warm and turbid waters and significant water-sediment interaction.
- Characterized by organic-rich sediments and suspended sediment that may provide FIB habitat.
- Located in bays that receive significant creek and stormdrain inflow.
- Characterized by many amenities and urban infrastructure close to the water.

- Subject to multiple uses – beach users, boaters, residents, birds, fish, etc.
- Located in bays that provide rich habitat for many birds and some mammals.

This unique set of characteristics affects FIB sources, retention of pollution near the beach, and the types of abatement measures that could be effective. For example, because of poor water circulation, even small FIB sources may result in significant water quality impacts. Further, bacteria contamination of sand and sediment may be more important at enclosed beaches than at open coastal beaches, where sand and sediment are reworked more frequently. Additionally, many of the amenities that make enclosed beaches popular destinations are also potential sources of FIB including boats and restroom sewer lines. Likewise, the high number of birds found at many enclosed beaches may be a significant source.

Poor water circulation may be a significant factor in the water quality problem at many enclosed beaches. The degree of retention of waters at a specific beach is a combination of bay-scale, beach-scale and site-scale circulation. Bay-scale circulation will determine how rapidly the bay as a whole exchanges waters with the open waters of the coastal ocean. Most of the bays in which these enclosed beaches are found have bay-scale residence times of days to weeks (e.g., Mission Bay, Figure 4). Beach-scale circulation depends on the proximity of the beach to faster currents, with more rapid flushing occurring at beaches near the bay mouth and in major channels. Many enclosed beaches are located in the calmest and warmest back-bay waters to avoid conflict with boat traffic and they are exposed to very weak tidal currents (e.g., Mothers Beach, Marina del Rey, Figure 1). Site-scale circulation is a function of local morphology and small-scale patterns at the site. A number of monitoring sites are located in coves sheltered from even weak tidal currents or in broad shallow regions where the boundary layer friction reduces flow speeds and mixing (e.g., Campbell Cove, Figure 5).

Increasing water circulation at enclosed beaches may improve water quality, but there may be several other potential impacts due to increased circulation that must be considered. While weak circulation and long residence may not be the cause of high FIB levels, it is a confounding factor and enhancing circulation may serve to flush high levels from the bay and the vicinity of the beach. However, flushing of ankle-depth waters at beach sites may not result from projects designed to enhance circulation in the channels of the bay proper. Proposed engineering solutions have typically focused on low-energy devices that serve to organize circulation rather than increase flow velocities, thus having negligible effect on sediment resuspension. However, the increased flushing acts also on biogenic material, larvae and spores, potentially affecting other water properties (e.g., nutrient levels), ecosystem productivity and the sustainability of marine populations. Further, while increased circulation and mixing will dilute high FIB densities, it could also spread low-density pollution to other areas, which may serve to spread the health risk over a greater area (depending on dose-response relationships for specific pathogens).

FIGURE 5. *Campbell Cove at the mouth of Bodega Harbor.*

Survival and re-growth of FIB may play a significant role in poor water quality at enclosed beaches. While weak circulation may allow persistence of high FIB levels, persistence in the absence of continued inputs may also indicate survival and/or re-growth of fecal bacteria populations in enclosed waters. Many recent studies have found a relationship between coliform levels in water and in the underlying sands, with levels in the sediment often exceeding that in the water. Elevated levels of FIB have been observed near the sediment surface, in submerged sands, in sands covered by wrack (algal mats at tideline), and even in foreshore and backshore sands or irrigated parklands adjacent to the water. This suggests a complex interaction between bacterial populations in the water and in sediment, and raises the prospect of amplification – that a small FIB inoculation may grow, leading to significant FIB levels at some later time. Additionally, the survival and re-growth of diverse microbes may differ markedly.

Thus, at enclosed beaches it is possible that microbial survival and growth rate could significantly affect densities in the water column and sediment. Differences in survival could also affect the quantitative relationship between fecal bacteria levels and health risks. It is possible that the impact of microbial ecology on the relationship between FIB densities and health risk may be more pronounced at enclosed beaches than at open-coast beaches where transport and mixing is likely the dominant factor influencing the distribution of most microbial populations in the water and sediment.

In addition to complexities of circulation, sediment-water exchange, and microbial ecology, there are many possible sources of FIB input to enclosed bays. The tendency for natural drainages to enter the ocean through sheltered waters is aggravated by the urbanization of areas surrounding enclosed bays. Further, runoff in highly impervious urban areas can be year-round, in contrast to dry summer watercourses under natural conditions. Additional FIB sources may be associated with development of marinas and bayside lands and with the large numbers of birds that use the habitat available in enclosed bays (Figure 6).

FIGURE 6. *Cormorants on a floating structure in Mission Bay.*

Another area of uncertainty is the relationship between FIB and health risk at enclosed beaches, specifically in cases where the FIB source is possibly not human. A recent epidemiology study in Mission Bay found small increases in diarrhea and skin rash in swimmers compared with non-swimmers after extensive source abatement efforts were implemented throughout the bay. However, the study did not find a statistically significant relationship between increased health risks and increasing FIB densities – suggesting that FIB densities were not helpful indicators of the health impacts. These results stand in contrast to prior epidemiological studies where an association between increased FIB densities and increased health impacts were observed – these prior studies being conducted in open coastal waters and in the presence of a known source of human sewage or urban runoff.

In summary, high levels of FIB at enclosed beaches may be due to greater inputs, greater survival, weak transport and mixing, and/or accumulation in the sediment. Indeed, there are many uncertainties associated with characterizing and abating FIB levels and health risk at enclosed beaches. These are summarized in Table 2 and further addressed in the next section on responses to the problem.

TABLE 2: Uncertainties in FIB Pollution Mitigation at Enclosed Beaches

Role of Sand and Sediment

- How long do FIB and pathogenic microbes survive in sheltered warm bays?
- Is significant re-growth occurring?
- Does FIB in sand significantly contribute to FIB densities in ankle-deep waters?

Water Circulation

- To what extent does enhanced water circulation lead to improved water quality in shallow nearshore waters (ankle- to waist-deep)?
- What is the optimal method for improving circulation in ankle- to waist-deep waters?

Analytical Methods

- How significantly do long lag-times between sample collection and analytical results hamper source characterization and tracking?
- What portions of the FIB populations are measured with current analytical methods?
- What are the false positive/false negative rates associated with current FIB analytical methods?
- How quantifiable are the current pathogen analytical methods?

Source Tracking

- How reliable and quantifiable are the current source-tracking techniques such as ribo-typing?

Health Risks

- What is the human health risk of exposure to non-human FIB?
- Can policy guidance be developed for relative health risks due to animal waste vs. human waste exposure?

Health Standards

- Are the current health standards appropriate for enclosed beaches with non-point source pollution?

3. RESPONSES TO THE PROBLEM

Symposium presentations and workshop discussions identified a variety of possible responses to the problem of FIB health standard exceedances at enclosed beaches. These responses fell into four primary categories: (1) Abate contaminant sources, (2) Sediment modification, (3) Circulation enhancement, and (4) No action. While some of these responses have already been implemented at enclosed beaches, efficacy is varied and in some cases unknown. Other responses are suggestions for possible future action. In spite of the common characteristics of enclosed beaches, it is clear that each beach needs to be recognized as a special case and that the efficacy of responses will vary from beach to beach. Further, in many cases, multiple responses will be necessary to reduce FIB levels and preclude exceedances.

<u>Abate contaminant sources</u>

The first response to elevated bacteria levels at enclosed beaches is to remove all sources of human sewage, since reduction of health risks associated with pathogens is the primary goal. A thorough sanitary survey that comprehensively examines sanitary sewer lines, including sources such as restroom lines and boater pump-out facilities, should be conducted. Illicit discharges from boats, homeless populations and nearby septic tanks should be evaluated and abatement actions taken. Urban runoff and stormwater inputs should be evaluated and redirected from the beach whenever possible. After human sewage sources, bird and animal sources should be reduced to lower the risk of cross-species pathogenic health impacts. Workshop attendees noted that these source abatement steps would likely reduce human health risks, but may not completely abate high FIB levels. In particular, eliminating or reducing wildlife, bird and aquatic populations may not be feasible nor desirable, specifically where natural populations are an important component of the bay ecosystem (e.g., Campbell Cove).

<u>Sediment Modification</u>

Beach sand and sediment may host significant populations of indicator bacteria and thus may act as a reservoir and proximal source for overlying waters. The removal of surface sands from the beach or under shallow waters may mitigate this phenomenon. But, long-term efficacy of this approach is unclear without source abatement as bacteria can be quickly re-introduced to the new, clean sand. For example, at beaches on Lake Michigan, indicator bacteria rapidly colonized the new surface sediments following sand modifications. Sediment type may also be modified, replacing fine sands typically found on enclosed beaches with coarser sands. Similarly, increased current and wave action can help turn over surface sediments and prevent bacteria populations developing, but this may result in significant changes to the habitat and natural marine populations.

Circulation Enhancement

Enclosed beaches are usually characterized by weak circulation and the slow flushing of waters off the beach, specifically of ankle-deep nearshore waters. Increasing circulation in these shallow nearshore waters would more rapidly mix and dilute indicator bacteria, resulting in lower FIB densities at the beach. There are a number of devices available for increasing circulation, as well as options to increase circulation through modifying channels and increasing tidal or wind-driven flows.

Circulation Devices
Several mechanical flow enhancement devices were discussed at the workshop: *Oloid, Solar Bee, Tornado Aerator, Instreem Unit*, and a submerged infusion pump (banana blade pump). The *Oloid* gently agitates, circulates and aerates the water through rotating a specially shaped blade with a movement likened to that of a fish tail. This is a low-power and quiet option, but (as with most options) involves a visible surface unit. *Oloid* units have been tested in deployments at Baby Beach (Dana Point) and in Newport Bay. The *Solar Bee* draws up to 10,000 gpm from below the machine and spreads it horizontally over a large surface area. This is specifically useful in areas where vertical mixing and surface renewal are needed. The *Solar Bee* is solar powered, but has battery storage for low light days. The *Tornado Aerator* produces a jet flow into the water. The *InStreem* unit pulls water from the surface as well as the water column and spins it through large rotating plastic disks at 200 gallons per second. *InStreem* units have been tested in Newport Bay. While most of these mechanical devices are very effective at moving water, they all require ongoing operation and maintenance. Further, they have a visual impact that may be opposed by local residents or other stakeholders. A monitoring program is required to determine whether the increased water movement from a circulation device is effective in flushing the nearshore beach waters and in lowering FIB levels – this can be achieved through a combination of dye studies and FIB monitoring.

Reconfiguration of Beach or Harbor
The conversion of natural bays and estuaries to harbors and marinas involves construction of channels. Initial design of these harbors and marinas typically did not take into account flushing rates and residence times. Modification of existing channel configurations may be an effective way to allow tidal or wind-driven flows to flush nearshore waters more effectively. These projects may be expensive and their efficacy difficult to predict. The most probable responses would involve small modifications, such as the modification of a sheet-pile groin and building of a rubble-mound groin considered in the Hobie and Kiddie Beach Circulation Improvement Study.

<u>"No Action" alternative</u>

Responses other than source abatement involve modification of the environment, either through changes to sediments or the movement of water. These changes may have undesirable impacts on other beneficial uses. At the heart of this potential conflict between diverse beneficial uses is the realization that "bacteria friendly" environments are specific low-energy habitats in bays and estuaries that include eelgrass beds and that are favored by birds, young fish and other organisms. In spite of persistent elevated levels of FIB, the "no action" option should be considered when significant negative impacts may occur, but only after comprehensive sanitary work has been completed, all human sources removed, and any other abatement action taken that does not result in negative impact on other uses. Epidemiological studies may be needed to support a "no action" alternative. The comprehensive sanitary survey, source abatement and epidemiology completed for Mission Bay is an example. Studies at Campbell Cove to-date suggest that high FIB levels may be "natural" and "no action" may be the only alternative that does not result in significant impact on other highly valued beneficial uses. This may also be true for some non-enclosed beaches. In many cases the "no action" alternative may require policy action, such as revisions to local and state regulations (e.g., revisions to the Basin Plan).

FIGURE 7. *Campbell Cove.*

4. IMPEDIMENTS TO ACTION

The workshop participants identified impediments that slow or prohibit actions identified as responses to water quality problems at enclosed beaches. Special attention was given to those impediments that could be removed – thus allowing more effective responses to the ongoing pollution at enclosed beaches. Impediments are clustered into two groups: general impediments, and those associated with the CBI process.

General Impediments

Competing Beneficial Uses
A solution to the recreational water quality problems at an enclosed beach may have significant adverse affects on other beneficial uses such as ecological habitat and recreational boating. Effort and resources may need to be directed at development of strategic abatement plans that consider broad stakeholder input and competing beneficial uses.

Sample Analysis Lag-time
The time required to analysis samples for FIB (24 hrs or longer) greatly impedes source-tracking and source characterization studies. Further, this lag increases the uncertainty associated with public health protection monitoring.

Source Identification
There are significant questions about the validity/reliability of analyses that seek to identify the ultimate source or origin of the fecal bacteria, specifically whether they originate from humans. Studies that identify specific species and strains of bacteria may be valuable, particularly as our understanding of indicator bacteria ecology improves.

Health Risk
The association between indicator bacteria levels and health risk should be further assessed. The dual objectives of meeting health standards and reducing health risk may confound abatement efforts and may even be in conflict in some cases. More comprehensive epidemiology data collected at enclosed beaches are needed to further refine the use of FIB (or other indicators) as a measure of health risk at enclosed beaches.

Re-growth and Amplification
Beach managers need more specific understanding of the role of sediment and beach wrack in harboring FIB densities, including the potential for re-growth or amplification of bacteria populations.

Multiple Agency Involvement
Significant projects at enclosed beaches require approval and cooperation from multiple agencies, which can lengthen the project timeline.

Community Opposition
Local residents and other stakeholders may oppose structural and visible solutions, as with the opposition to the *Instreem* units in Newport Bay.

<u>Impediments associated with the CBI process.</u>

Restrictive Funding Requirements
Studies, operational solutions, packages of actions, and adaptive approaches are not easily funded. The lack of support for studies forces a focus on implementing a solution even if the cause of the pollution is not understood well enough to develop and design a successful solution. Likewise, funding of pilot projects is difficult. Managers are reluctant to engage in projects requiring long-term O&M without reduced uncertainty on the success of a project. The emphasis on funding capital projects ('bricks and mortar') excludes operational solutions that may be more effective and more affordable. Further, there is a perception that the CBI is biased towards a project comprised of a single solution, rather than a package of actions that collectively reduce pollution. The CBI funding process is not amenable to an adaptive or iterative approach – a fully developed solution must be proposed to receive funding. Once begun, it is difficult and time consuming to modify the scope of a project when new data and information become available, even though development and implementation of new and innovative solutions would stem from adaptive approaches.

The 20-year Requirement
The requirement to sustain water quality benefits for 20 years imposes a significant and often unacceptable operation and maintenance commitment from local beach managers.

Monitoring Requirement
The bond legislation requires monitoring to ascertain project effectiveness, but to-date acceptable protocols for monitoring during construction and after project implementation have been unclear and inconsistent.

Project Timelines
The CBI funding timeline is too short for many projects, once all phases are included (e.g., permitting, construction, evaluation). Specifically, this short timeline excludes beach and/or harbor reconfiguration projects, given the time required for design, environmental review, permitting, and stakeholder involvement. In the case of seasonal exceedances, each phase of the project (assessment, implementation, evaluation) can take a year. The CBI timeline is 5 years (three years to encumber and an additional two years to spend funds).

Limited Communication between Clean Beach Task Force (CBTF), State Water Board and other Beach Experts and Managers

Project proponents are unclear about how and when they can communicate with the CBTF about their project proposals, and how to receive feedback on improving a proposal. Further, feedback from the CBTF is slow because the group only meets quarterly. Once funding has been received, communication with the CBTF is limited and there are few opportunities or mechanisms for beach managers and experts to share information, aside from this symposium and workshop.

<u>Conditions imposed by funding sources</u>

Many of the impediments associated with the CBI stem from the conditions associated with the propositions that make funding available. The specific conditions associated with each proposition are summarized in Table 3. Future CBI funding will be from a combination of Propositions 40 and 50.

TABLE 3. *Requirements of the Propositions that Provide Funds to the CBI.*

<table>
<tr><th>Funding Source</th><th>Eligibility</th></tr>
<tr><td>Proposition 13</td><td>Municipalities, local public agencies, educational institutions, nonprofit organizations, Indian tribes, and state agencies</td></tr>
<tr><td colspan="2">Projects shall:
1. Demonstrate the capability of contributing to sustained, long-term water quality or environmental restoration or protection benefits for a period of 20 years
2. Address the causes of degradation, rather than the symptoms
3. Be consistent with water quality and resource protection plans prepared implemented, or adopted by the State Water Resources Control Board (State Water Board), the applicable Regional Water Quality Control Board, and the California Coastal Commission (CCC);
4. Be consistent with recovery plans for coho salmon, steelhead trout, or other threatened or endangered aquatic species;
Applicants shall:
1. Inform the State Water Board of any necessary public agency approvals, entitlements, and permits that may be necessary to implement the Project; and applicants shall certify to the State Water Board that such approvals, entitlements and permits have been granted.
Recipients shall:
1. Provide a matching contribution consistent with §79148.8(f) of the Act for the portion of the Project consisting of capital costs for construction;
2. Be required to submit to the State Water Board a monitoring and reporting plan; and
3. Submit a report to the State Water Board that summarizes the completed activities and indicates whether the purpose of the Project has been met.
The State Water Board shall:
1. Review project proposals in consultation with the State Coastal Conservancy and the Beach Water Quality Task Force (BWQTF) to determine if they are consistent with the requirements of the Act and make recommendations for funding; and
2. Provide the opportunity for public review and comment</td></tr>
<tr><th>Funding Source</th><th>Eligibility</th></tr>
<tr><td>Proposition 40</td><td>Project must protect or restore water quality at a beach named on the Competitive Project List to receive funds during Phase 1, and on the Competitive Location List (CLL) to receive funds during Phase II</td></tr>
<tr><td colspan="2"><u>Projects shall:</u>
1. Be consistent with California's nonpoint source control program;
2. Demonstrate the capability of contributing to sustained, long-term water quality or environmental restoration or protection benefits for a period of 20 years;</td></tr>
</table>

3. Address the causes of degradation, rather than the symptoms;
4. Be consistent with water quality and resource protection plans prepared implemented, or adopted by the State Water Board, the applicable Regional Water Quality Control Board (RWQCB), and the State Coastal Conservancy; and
5. Be consistent with recovery plans for coho salmon, steelhead trout, or other threatened or endangered aquatic species.

Applicants shall:

1. Inform the State Water Board of any necessary public agency approvals, entitlements, and permits that may be necessary to implement the Project, and applicants shall certify to the State Water Board at the appropriate time that such approvals, entitlements, and permits have been granted.

Recipients shall:

1. Be required to submit to the State Water Board a monitoring and reporting plan;
2. Submit a report to the State Water Board that summarizes the completed activities and indicates whether the purpose of the Project has been met; and
3. Use grant funds only for the costs of construction or acquisition of capital assets as specified in Section 16727 of the Government Code.

The State Water Board **shall:**

1. Rreview project proposals in consultation with the State Coastal Conservancy and the Clean Beaches Task Force (CBTF) to determine if they are consistent with the requirements of the Act, and make recommendations for grant funding;
2. The State Water Board must provide opportunity for public review and comment in awarding the funds;

Funding Source	Eligibility
Proposition 50	Municipalities, local public agencies, educational institutions, nonprofit organizations, Indian tribes, and state agencies

The State Water Board will be drafting guidelines for Prop 50 funds ($23M) in summer 2006 and soliciting proposals in fall/winter 2006. Funds must be encumbered by June 2008 and spent by June 2010

5. RECOMMENDATIONS

1. Remove CBI impediments in guidelines for Proposition 50 funding (as allowable by legislative requirements).

- Timeline. Extend allowable project implementation timelines. Insufficient time for project implementation is one of the most significant impediments identified. Clearly, it is critical that allowable project timeframes are longer than the time required for permitting, design, construction and assessment.
- Studies & Pilot Projects. Earmark a limited amount of funds for feasibility studies and pilot projects that are part of a phased approach to a solution. Feasibility studies and pilot projects are especially critical for enclosed beaches because these beaches have not responded to more traditional mitigation measures.
- Adaptive Approach. Allow for some adaptive or iterative management of projects. Since enclosed beaches require innovative approaches, which carry inherent uncertainty, project teams require the ability to adapt project designs as new data and information become available. The funding process must be flexible enough for changes in project design and schedule to accommodate adaptive management. The use of “agreements” by the State Water Board, instead of “contracts”, would provide more flexibility.

2. Improve communication between project proponents, the State Water Board and the CBTF.

The problem of limited communication between project proponents, the CBTF and the State Water Board was one of the most frequently identified impediments. Good communication is critical because solving water quality problems at most enclosed beaches will require local managing agencies to implement innovative and largely untested methods in the face of much scientific and site-specific uncertainty. To accomplish this, local agencies would greatly benefit from on-going support and guidance from the CBTF and the State Water Board throughout all phases of project implementation. Currently, the CBTF, comprised of the state’s leading experts in beach water quality, represents a valuable and under-utilized resource. Recommended actions for better communication include:

- Create mechanism for pre-proposal discussions and review by the CBTF, including presentation of ideas at CBTF meetings.
- Provide opportunities for project managers to communicate with CBTF during project implementation, including communications between quarterly meetings and the possibility of local CBTF working groups.
- Explore possibility of providing a fee to allow selected CBTF members (or other experts), to play an active liaison and advisory role on specific projects, as needed.

- o Develop and discuss CBTF-approved monitoring protocols.
- o Create an email list-serve for use by the State Water Board and the CBTF to send out communication on important CBI information and deadlines to the beach water quality community.
- o Routinely update the CBI web page.
- o Investigate potential for a State Water Board sponsored beach pollution mitigation symposium every second year.

3. Encourage applications from priority beaches.

Proposals have not been received from all of the most polluted beaches. Reasons for the lack of application may be related to project costs not covered by CBI (such as monitoring and long-term operation and management), unrealistic timelines, or uncertainty as to what projects will be effective. It is recommended that discussion between beach managers, State Water Board, CBTF and Regional Water Quality Control Boards is increased with the aim of identifying a set of possible actions that could make use of available CBI funding. In some limited cases, these discussions may include the no-action alternative and possible amendments to the Basin Plan if (i) significant sanitary survey work has been completed, (ii) all human sources abated, (iii) other FIB sources reduced, and (iv) further FIB source abatement would result in significant undesirable impacts on other beneficial uses.

4. Remove impediments through study in critical areas of uncertainty.

- o Rapid indicators. Develop rapid indicators of fecal bacteria concentration and/or pathogens that can be used in sanitary surveys.
- o Sediment and wrack. Evaluate the role of sediment and wrack in accounting for high FIB densities in shallow nearshore waters off enclosed beaches. Specifically look at increased survival, re-growth and/or amplification of bacterial populations in submerged and beach sediments and the importance of grain size and organic content. Also, examine the effectiveness and negative impacts of remediation measures.
- o Epidemiology. Conduct epidemiological studies to further assess the association of health risk with elevated FIB levels at enclosed beaches.
- o Enhanced circulation. Explore methods of enhancing the circulation of water in ankle- to waist-deep water and the effect of this on reducing FIB levels. Include studies of the effectiveness of reconfiguring beaches to enhance circulation. Collaborations with ecologists are encouraged to allow assessment of any deleterious effects on habitat.
- o Source identification. Develop standardized and well-accepted methods for identifying source (human, bird, dog, etc.) and develop state-endorsed sanitary survey protocols. This effort would include updating, enhancing, and promoting the use of the protocols developed by the State as required by AB 538 (State Water Board 2001).

APPENDIX A

Recent State Policy Developments Related to Fecal Contamination of Beaches

APPENDIX A. RECENT STATE POLICY DEVELOPMENTS RELATED TO FECAL CONTAMINATION OF BEACHES

The California State Legislature passed Assembly Bill 411, AB 411 (Chapter 765, Statutes of 1997), in 1997 as a means to improve public health notification in areas where nearshore ocean waters may be contaminated with high levels of fecal indicator bacteria (coliform and enterrococcus). AB 411 set statewide bacteriological health standards for marine recreational waters within California. AB 411 also mandated that the waters off beaches with storm drains that discharge during dry weather and visited by more than 50,000 people per year be monitored at least weekly from April 1 through October 31 by the local health officer or environmental health agency, and mandated public notification of exceedances of the bacteriological standards at these beaches. Beginning in 1999, Department of Health Services (DHS) regulations implementing AB 411 required that local officials must post warning signs on beaches that exceed standards set for total coliform, fecal coliform and enterrococcus. In addition, any beach suspected of being contaminated with sewage must be immediately closed until bacterial monitoring indicates the waters are safe for human contact.

In 1999 the Governor signed AB 538 (Chapter 488, Statutes of 1999) that required the State Water Board in conjunction with the State Department of Health Services and a panel of experts to develop source investigation protocols for use in investigations of storm drains that produce exceedances of the state bacteriological health standards. The State Water Board reported to the Legislature by March 2001 on the protocols developed. The legislation stopped short of requiring the protocols be used for sanitary surveys and the protocols were never widely used. Additionally, the requirement to conduct sanitary surveys at beaches that exceed the health standards during three weeks of a four-week period (or 75% of the time if monitored more frequently than weekly) has not been enforced.

In response to the poor water quality highlighted by the dramatic number of postings and closures revealed by AB411-mandated water sampling at California's beaches, the State of California established the Clean Beaches Initiative (CBI) Grant Program as part of the Budget Act of 2001 (Budget). The Budget appropriated $32,298,000 from Proposition 13, (the *Costa-Machado Water Act of 2000).* In addition on September 20, 2002, the Governor signed AB 2534 (Chapter 727, Statutes of 2002) appropriating an additional $46 million from Proposition 40 (the *California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002)* to the CBI Grant Program. A further $23 million has been made available to the CBI from the *Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002* (Proposition 50).

The major goal of the CBI Grant Program is to reduce health risks by improving water quality at California's beaches through providing project grant funding to local agencies. In general, CBI grant funds are being used to 1) implement urban runoff pollution reduction and prevention programs, 2) improve, upgrade, or convert existing sewer collection or septic systems to reduce or eliminate sewage spills, and 3) implement management practices to eliminate upstream sources of bacterial contamination for the restoration and protection of coastal water quality.

Assembly Bill 2534 required the State Water Board to appoint an outside task force to review and recommend projects to the State Water Board for funding from Proposition 40. The Clean Beaches Task Force (CBTF) members are experts in the field of beach water quality, and were selected from university researchers, local agencies, scientific organizations, and representatives from non-profit organizations throughout coastal California. Recognizing the complexities involved in reducing fecal bacterial contamination in enclosed bays, the CBTF has placed special emphasis on trying to find workable solutions, such as convening this symposium and workshop.

APPENDIX B

Symposium and Workshop Agenda

DAY ONE – 17 August 2005 – SYMPOSIUM

REGISTRATION

INTRODUCTION & WELCOME
- John Norton, State Water Board
- Supervisor Thomas W. Wilson, 5th District, County of Orange

MORNING SESSION
Enclosed Beaches: Issues and Solutions
- Enclosed Beaches: Problem Characterization and Policy Overview
  Mitzy Taggart, D. Env., Heal the Bay
- Circulation at Enclosed Beaches
  John Largier, Ph.D., University of Davis
- Engineering Solutions
  Ying Poon, P.E., D.Sc., Everest International Consultants, Inc.
- Sand as a Source
  Richard Whitman, Ph.D., Lake Michigan Ecological Research Station, USGS
- Source Abatement
  Lisa Kay, Weston Solutions, Inc.
- Epidemiology
  Steve Weisberg, Ph.D., Southern California Coastal Water Research Project

LUNCH

AFTERNOON SESSION
California Enclosed Beach Case Studies: Problem Characterization and Solution Analyses
- Marina (Mother's) Beach
  Laurie Ames & Richard Mast, DMJM Harris
- Kiddies Beach
  David Cannon, Everest International Consulting
- Cabrillo Beach
  John Foxworthy, Port of Los Angeles
- Campbell Cove
  Jeff Lewin, Sonoma County, Department of Health Services
  Linda Rasmussen, Ph.D., University of California San Diego
- Babies Beach
  Vincent Gin, County of Orange, RDMD

BREAK & GUIDED WALK OF BABIES BEACH

- Colorado Lagoon
  Kim Garvey, Moffat and Nichol

- Mission Bay
  Ruth Kolb, City of San Diego
  John Largier, Ph.D., University of California Davis
- Newport Bay
  Bob Stein, City of Newport
- Avalon Beach
  Stanley Grant, Ph.D., University of California Irvine

DAY TWO – 18 August 2005 - WORKSHOP

BREAKOUT GROUPS
Introduction and Instructions
Steve Weisberg, Ph.D., SCCWRP

BREAKOUT SESSION I
Three Case Studies - Engineering and Management Solutions BREAK

BREAKOUT SESSION II Impediments to Solution Implementation and Recommendations to the State Water Board

LUNCH

PLENARY SESSION
As a group, we will discuss, debate, and integrate findings and recommendations of the workshop for the three case study beaches and for enclosed beaches in general. These findings and recommendations will provide the basis of a comprehensive symposium and workshop report.

APPENDIX C

Summaries of Presentations on General Themes

Synthesis Presentation
Subject: Policy and Overview

California's Enclosed Beaches

Mitzy Taggart, D. Env.
Heal the Bay

Some of California's most polluted beaches are enclosed beaches located in sheltered bays, harbors and marinas; yet an estimated 24 million people visit them annually to recreate in their warm, calm waters. Enclosed beaches are popular family destinations, rich with amenities including playgrounds, picnic areas, and educational and boating facilities. They also house important biological resources – their calm waters provide important nursery and eel grass habitat. Protection of public health at these beaches is of particular concern because children are the primary user group. Several epidemiological studies have observed a higher incidence of health effects in children compared to adults swimming in waters with elevated fecal bacteria densities.

More exceedances of the recreational water quality health standards occur at enclosed beaches than other marine beaches in California. Approximately 117 enclosed beach monitoring sites are routinely sampled by local agencies for traditional fecal indicator bacteria (FIB). Between 1999 and 2004, health standard exceedances were observed 15% of the time throughout the AB-411 monitoring period, 2.5 times more often than at stormdrain beaches, and 5 times more often than at open coastal beaches. Water quality at enclosed beaches during wet weather is very poor. Wet weather exceedances occurred 51% of the time at enclosed beaches, compared to 29% and 22% of the time at stormdrain-impacted beaches and open coastal beaches, respectively. During the 2004-2005 season, 100% of the enclosed beaches received F's on Heal the Bay's annual Beach Report Card, compared to 82% of the stormdrain-impacted beaches and 57% of the open coastal beaches.

Enclosed beaches have a unique set of characteristics that affect source characterization and abatement measures. These characteristics include reduced water circulation, low sand transport rates, and abundant amenities located near the water. Water quality impacts from small FIB sources may be significant because of poor water circulation. Sand and sediment contamination may be significant because sand transport and renewal is low. Many of the amenities that make enclosed beaches popular destinations are potential sources of FIB including boats and restroom sewer lines. Impacts from a single pollution event such as a rainstorm may last much longer because of reduced water circulation. Mitigation measures that successfully reduce FIB densities at other types of marine beaches may be inadequate at enclosed beaches because source characterization at enclosed beaches is unique.

Many enclosed beaches have received funding to improve water quality through the State Water Resources Control Board (State Water Board) Clean Beach Imitative program. A total of $76 million have been made available to cleanup the most polluted beaches in California. $8.9 million of these funds have been encumbered to enclosed beaches. Almost $17 million is currently available for projects, and it is anticipated that an additional $23 million will be available through the CBI in 2006. Much of the CBI funding granted to enclosed beaches has been used to conduct Phase I investigations which include source identification, circulation, and solution feasibility studies.

The goal of the Enclosed Beach Symposium and Workshop is to develop solutions that will achieve bathing water quality standards at enclosed beaches and protect human health. Specific objectives include:

- Facilitate information-sharing among enclosed beach managers
- Identify solutions to enclosed beach pollution
- Identify impediments to development and implementation of solutions
- Identify future actions necessary to remove these impediments
- Encourage new CBI proposals with a high likelihood of success

We hope to use this symposium and workshop to build upon the CBI Phase I projects already completed and develop future projects that will solve the water quality problem at enclosed beaches. Developing practical solutions to water quality problems at enclosed beaches is confounded by the ubiquitous nature of FIB indicators; the high variability of FIB densities and the beach nearshore environment; and limitations in our current understanding of key issues including the ecology of FIB and near-shore circulation. However, near-term, practical solutions may exist, starting with systematic source identification and abatement steps to remove human sources, followed by measures such as engineered circulation solutions and effective sand management strategies. We hope this symposium and workshop will spur new CBI grant proposals for enclosed beaches that can be funded by CBI and successfully implemented to achieve water quality standards at California’s most polluted beaches.

Synthesis Presentation
Subject: Circulation

Circulation at Enclosed Beach

John Largier
Bodega Marine Lab (UC Davis)

Characterizing Enclosed Beaches.

Enclosed beaches appear to be more susceptible to fecal contamination (as seen in FIB monitoring data). This is true for both wet and dry seasons.

Enclosed beaches are defined by shelter from offshore energy – i.e., shelter from waves and currents. This leads one to identify a variety of specific attributes:

- Longer residence time (T_{res}) due to weaker currents and slower flushing.
    - If T_{res} is longer than T_{bact} (survival time of specific bacteria), then residence time is not an issue – bacteria die off quicker than they are mixed away.
    - If T_{res} is shorter than T_{bact}, then longer residence times yield higher bacterial levels.

  Suggestions that FIB may survive for long times in enclosed waters.

- Spatially confined "zone of impact". In the presence of weaker currents, contaminants will be dispersed slower and high levels are only expected in nearby vicinity of source.

- Waters are often warm, dark and with high levels of suspended organic material – possibly allowing longer term survival of bacteria (increased T_{bact}).

- Low energy waters are typically characterized by thick, organic sediments – providing a habitat in which bacteria may survive.

- With weaker flow in the main channel, waters along the shoreline (the boundary) may stall and exhibit near-zero motion over a tidal cycle or even longer, resulting in an inability to remove contaminants.

- Estuarine habitat. The combination of water properties, morphology, sediment type, and associated flora define a specific habitat that attracts specific birds and mammals. Some of these biota can be significant sources of FIB.

Caution: removing weak circulation also means loss of associated habitats.

Enclosed beaches are typically found within a harbor or estuary – i.e., close to an inflow location (e.g., a creek) and/or dense urban development.

- High loading of contaminants.

<u>Circulation along Enclosed Beaches.</u>

Circulation along enclosed beaches depends on the entrance channel configuration and the circulation of the bay/lagoon as a whole. It also depends on where the site is located and the potential for small-scale shoreline effects.

- Studies of bay-scale circulation – time to flush out bay with ocean waters. “Tidal diffusion”.

- Studies of site location – proximity of beach to active channel flow; is site at channel end or channel side? Is it better to invoke a 1- or 0-dimension model?

- Studies of boundary layer effects – size and location of boundary layers (where flow separates from edge or bottom) and presence of “sticky water”.

Synthesis Presentation
Subject: Engineered Solutions

Improving Water Quality at Enclosed Beaches by Enhancing Water Circulation

Ying Poon, P.E., D.Sc.
Everest International Consultants, Inc.

Some of the most popular beaches in Southern California are located within harbors and bays. The calm waters make these beaches ideal for recreational activities. However, many of these enclosed beaches suffer problems of poor water circulation due to minimal tidal exchange. This lack of water circulation may contribute to poor water quality (i.e. high bacteria levels) at some of these beaches. The studies presented here are based on the experience of the author over the past few years working on projects to improve water quality by enhancing water circulation at the following locations:

- Hobie Beach and Kiddie Beach – City of Oxnard, Ventura County
- Newport Dunes Lagoon and Newport Island Channels - City of Newport Beach, Orange County
- Baby Beach - City of Dana Point, Orange County

Through these projects, different methods to enhance water circulations were evaluated. In addition, site-specific approaches and tools were developed for evaluating the potential water quality improvement associated with improving water circulation. Although each enclosed beach has its unique characteristics that need to be studied individually, there are some commonalities among enclosed beaches such that a general approach can be developed to address water circulation issues. Examples will be drawn from these three prior projects to illustrate how to conduct a water circulation improvement project, as well as on how to evaluate whether a project will be successful in improving water quality.

Circulation improvements can be achieved by either modifying existing structures that inhibit circulation or using a mechanical device to move water. For majority of enclosed beaches the latter option is a more feasible choice. There are many mechanical devices on the market that have been used for improving water circulation and/or increasing aeration. Some of these mechanical flow enhancement devices that have been considered for the above project locations include: InStreem, Oloid, Tornado, and water jets (pumping). The advantages and disadvantages of these devices, as well as the factors that need to be considered in choosing a device for a particular site will be discussed.

To have a better understanding on how some of these devices may work in the enclosed beach environment, testing of the InStreem and Oloid have been conducted at Newport Bay. Through these test programs, not only were the performance of these devices evaluated, but ways to improve the performance of the devices were also found. In addition, these test programs enabled the public to observe and provide comments on the operation of these devices.

To link circulation enhancement with water quality improvement, hydrodynamic and water quality models are valuable planning tools for implementing a circulation enhancement project. These computer models can be used in the following aspects:

Understanding Existing Hydrodynamic Conditions – each site has its unique hydrodynamic conditions. Numerical model can be used to evaluate exiting tidal flow conditions for a project site, so that the circulation enhancement devices can be positioned in a way to enhance rather than work against the existing tidal current.

Alternative Development – based on the understanding of hydrodynamic conditions for the project location, different potential circulation enhancement alternatives can be efficiently developed with the help of hydrodynamic modeling.

Alternative Evaluation – water quality modeling can be used to evaluate potential water quality improvements for different alternatives by comparing existing and with project conditions. However, to effectively use the numerical model, the objective of the project has to be clearly defined. This can be achieved by having a clear understanding of the water quality issue of the project location through analyses of historical water quality data. For example, an objective for a circulation enhancement program can be defined as an alternative that can reduce bacteria levels at the project site by a factor of five if historical data show that statistically bacteria level at the site exceeds water quality standard by a factor of five. Once a water quality improvement objective is defined, a water quality model can be used to evaluate whether the selected alternative can achieve the defined objective.

In summary, the implementation of a program to improve water quality at enclosed beaches through circulation enhancements needs to consider the following:

- Understand of the site conditions
- Understand the characteristics, limitations, and performance of the selected circulation enhancement device for the site
- Define water quality improvement objectives
- Develop and evaluate different alternatives for achieving the objective
- Implement a monitoring program to evaluate the performance of the selected alternative

Synthesis Presentation
Subject: Sand

Shorelines as Sinks and Sources of Indicator Bacteria

Richard Whitman
USGS

Research into sources and movement of *E. coli* has been frustrated by oversimplified paradigms and inability to account for contributing causes of contamination. Our research on Lake Michigan and a coastal stream shows how intrinsic *E. coli* in soils/sediments influences water quality and consequently compromises its use as an indicator species.

Historically, swimming advisories due to excessive concentrations of fecal indicator bacteria (*E. coli*, enterococci) are common along marine and freshwater coastlines. Although human and animal wastes are generally considered major contributors of fecal indicator bacteria, over the years it has been realized that there are other external sources (e.g., soil and sediments, water, plants), perhaps unrelated to human or animal contamination, that can significantly impact water quality. The main objective of this paper is to provide a summary of our research on ambient *E. coli* occurrences (and to a lesser extent, enterococci) in beach sand and soil under temperate conditions, and to demonstrate how these intrinsic sources affect background levels of indicator bacteria and impact apparent water quality, especially in temperate environments.

To our knowledge the first author and associates conducted the earliest work on the occurrence of *E. coli* in pore water at a freshwater beach. Other early work in marine water had been done, including studies by Ginsberg et al. of *E. coli* occurrence in shallow surface sands of a Mediterranean beach and by Oshiro and Fujioka on *E. coli* occurrence in marine surface sands of Hawaii. In the early 1990s, studies on beach pore water of southern Lake Michigan revealed that *E. coli* counts in foreshore sand were 5 to 10-fold higher than in adjacent lake water. *E. coli* counts were highest in the foreshore sand, followed by submerged sand and then beach water; counts were low in the swash zone. The horizontal distribution of *E. coli* in surface sand within the first 5 m landward of the lake was roughly even, but vertically counts decreased rapidly starting at about 30 cm below the water table; no *E. coli* was detected in groundwater. Further studies showed that *E. coli* concentrations in pore waters were generally lower in northern Lake Michigan (Sleeping Bear Dunes National Lakeshore) and at beaches of Grand Traverse Bay. A few samples taken from South Twin Island, Apostle Islands National Lakeshore within Lake Superior, had <10 *E. coli*/ml of pore water, but no *E. coli* was found in adjacent lake water.

These findings prompted new questions, particularly regarding the relationship between surface water and the watershed, and the ubiquity and persistence of indicator bacteria in these habitats. The goals of the studies summarized in this paper were to learn about the non-enteric ecology of indicator bacteria (*E. coli*, enterococci), to investigate their usefulness as indicators of water quality, and to develop a balanced perception of the public health and regulatory implications of using these indicators.

Many studies have shown that *E. coli* and enterococci can routinely be recovered from beach sand (10, 14, 16, 19, 22), although the mechanism of their occurrence is not well-understood. There are two possible hypotheses for this phenomenon – (1) direct fecal contamination or concentration by sand, and (2) long-term persistence and perhaps growth (of indicator bacteria) under permissible conditions. In an intensive study at a freshwater beach in Chicago (23), we found that *E. coli* can persist in foreshore sand for extended periods, and it (sand) was a major source for elevated *E. coli* levels in the nearby swimming water. The major findings of this study were (1) *E. coli* in sand and water were significantly correlated, with concentrations in foreshore sand highest followed by submerged sand and water of increasing depth, (2) shoreline birds (gulls) contributed to the *E. coli* in the sand, (3) *E. coli* readily re-occurred in newly placed sand within two weeks, indicating it has the potential to establish in beach sand as a part of the other indigenous microorganisms, and (4) temporal-spatial distribution, DNA-fingerprinting, and in vitro and in situ growth observations showed that *E. coli* may be sustained in temperate beach sand during summer months without external inputs.

Direct fecal contamination of the foreshore sand was further investigated, and a few potential sources were identified. A major discovery was made when it was found that *Cladophora* spp. that had accumulated along the beach shore had *E. coli* and enterococci counts often in excess of 10^4/g. Since massive growths of *Cladophora* (in nearshore waters) and accumulation along shorelines is a common sight at numerous beaches of Lake Michigan from Wisconsin through northern Michigan, *Cladophora* can be a significant source of indicator bacteria and potentially bacterial pathogens to foreshore sand and also nearby swimming water (5, 13). Another direct source of contamination in the Chicago beach study was the population of gulls on the beach. In DNA analysis, *E. coli* and enterococci were analyzed from bird feces and foreshore sand, and the two sources matched in several instances, indicating that gulls were contributing to the fecal indicator bacteria populations in the sand (6).

Studies on indicator bacterial occurrence in beach sand have generally focused on areas adjacent to the shoreline (1, 10, 22, 23). One potential drawback of this approach is determining whether sand-borne indicator bacteria are actually indigenous to the system, or represent transient, residual populations from external sources, such as runoff, aquatic birds, or lake water. Generally, backshore beach areas are relatively less subject to such influences. In a recent study (24), we analyzed the seasonal occurrence and recovery of *E. coli* and enterococci in subsurface backshore beach sand at the groundwater table. We found that there was no significant difference in *E. coli* counts in sand samples taken at 5 m intervals from 0-40 m inland, suggesting that (*E. coli*) distribution in surface beach sand was widespread. Further, for over a year, both *E. coli* and enterococci were consistently recovered in deep, backshore beach sand near the groundwater table, which is less likely to be the result of contamination from birds or runoff. Based on these observations we conclude that backshore sand at the water table may act as a reservoir for indicator bacteria and potentially for human pathogens.

There has been cumulative evidence that indicator bacteria occur naturally in upstream soils and sediments, leading to confusion about contamination sources and unnecessary closures of impacted recreational beaches. We conducted a series of studies in a coastal stream to examine *E. coli* dynamics in creek water, sediments, and nearby forest soils. There is no discernable evidence of human (sewage) contamination in the stream, but non-point sources (e.g., wild animals) have been suggested as the primary reason for elevated levels of *E. coli*. We found significant correlations between *E. coli* numbers in stream water and submerged sediment, submerged sediment and margin sediment, and margin sediment and sediments 1 m from shore. Mean *E. coli* was highest in stream sediments followed by, in order of magnitude, margin sediments, spring sediments, stream water, and isolated pools. In the nearby forest soils, *E. coli* counts were low, but high outliers were very common; there was a significant correlation between sediment moisture and *E. coli* counts. Our study indicated that extensive ditching of the wetlands, consequent manipulation of stream order within the watershed, erosion of riparian sediment, and loss of wetlands were primary reasons for elevated *E. coli* levels in the creek.

Several researchers have proposed that soil-borne indicator bacteria be considered as part of the natural biota because of their widespread occurrence in tropical soils. More recently we obtained preliminary evidence that *E. coli* can similarly persist in temperate forest soils (3), but its distribution and relative abundance in these habitats is not fully explored yet. We conducted a series of experiments to understand further the ubiquity and growth potential of *E. coli* in temperate forest soils. We observed that *E. coli* has the ability to colonize and persist in organically rich sandy forest soils (of northwest Indiana) for two years or more; it may even grow in the soil under certain conditions. The findings of our research provide comprehensive evidence that lake sediments, foreshore sand, backshore sand, creek water and sediments, and forest soils in temperate locations may (1) play a major role in bacterial water quality, (2) be important non-point sources of indicator bacteria to water rather than a net sink, (3) be environmentally, and perhaps hygienically, problematic, and (4) be capable of supporting autochthonous indicator bacteria for sustained periods, perhaps independent of known sources (sewage, animal waste). Persistence and potential growth of indicator bacteria in sediments and soils could have a serious impact on recreational water quality issues.

Synthesis Presentation
Subject: Source Abatement

Systematic Approach to Source Identification and Abatement

Lisa Marie Kay
Weston Solutions, Inc

Determining sources of bacteria within a watershed is often difficult due to the complex nature of point and non-point sources (e.g., urban runoff, storm water flows, birds or other wildlife, human sewage, etc.), environmental interactions, the partitioning of bacteria within various environmental compartments (particularly sediment), the re-growth of bacteria, and the transport of bacteria to surface waters via groundwater flow. These variables are further complicated by the effects of environmental parameters such as water temperature and day length, which results in diurnal and seasonal patterns in bacterial contamination. Enclosed bays are unique and often complex systems with numerous potential sources of bacterial contamination.

The systematic approach to source identification and abatement focuses on achieving quick successes wherever possible by identifying contributions to bacterial water quality impairment and implementing actions to reduce or eliminate sources. The intent of this systematic approach is not necessarily to implement a single solution to solve the water quality problem, but rather to take incremental steps toward water quality improvements. During both the Mission Bay Source Identification Study – Phase I and the San Diego River/Dog Beach Water Quality Improvement Study a systematic approach was employed to:

Step 1- Identify potential pollutant sources
Step 2 – Conduct investigations (visual observations, sampling/analyses, assessment)
Step 3 – Where potential sources are identified and verified through investigation, develop and implement solution/action.
Step 4 – Sample to determine success of solution
Step 5 – Repeat steps as necessary

This is the approach planned for Marina del Rey and in a portion of the Los Angeles Harbor Main Ship Channel.

Developing the appropriate steps for finding and abating sources requires flexibility to adapt the investigation depending upon findings. First, a thorough list of potential sources is created following a site reconnaissance or review of aerial photos and maps. At Mission Bay the potential sources from field reconnaissance were initially identified as shown in Table 1 below.

After potential sources are identified, observations are made and sampling is conducted to determine if these identified sources are high in indicator bacteria. During observations all potential sources of bacteria are visually investigated, documented and samples are collected from potential sources. The investigation of potential sources may require a combination of visual observations and special study. The following are examples of investigative techniques:

Table 1. Potential Sources of Bacterial Contamination (Selected Sites Only)

Site #	Site Name	Illicit Boat Discharge	Restroom Infrastructure	Birds and Other Wildlife	Irrigation Runoff	Storm Drains	Restroom Washdown	Homeless Activities	Dog Waste	RV Pump Outs	Creek inputs	Groundwater	Other
1	Bonita Cove	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y
6	Campland	N	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y

Illicit boat discharge - Sampling could be conducted at various times around docked boat areas. Alternatively, dye tablets could be required for all boats entering an enclosed bay area.
Restroom infrastructure - Closed circuit television techniques could be employed to look for cracks or breaks in lateral sewer lines.
Birds and other wildlife – Observations include bird counts, beach face bird droppings, and samples of receiving waters would be taken. Correlation of bird counts/migratory patterns to receiving water bacteria counts would be investigated.

Where high bacterial counts are found, potential solutions or actions are developed and implemented. Follow-up sampling to determine the effectiveness of these actions is conducted both from the sources and in receiving waters. This process is repeated as necessary and investigations are adapted to address each potential source.

For example, a large duck population was being fed by visitors near the beach area at Campland in Mission Bay. Large amounts of duck fecal material were deposited on the beach face and entered the receiving waters on rising tides. As a course of action, weekly beach grooming to pick up duck feces was implemented. Beach

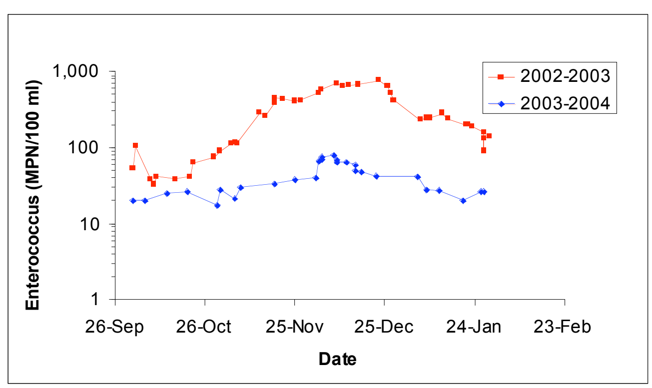

Figure 1. Bacterial Densities At Campland

water quality sampling demonstrated a measurable improvement after implementing beach grooming in 2003 (Figure 1).

At another beach area adjacent to a resort hotel, samples of flowing water from discharge pipes near receiving waters were found to have high bacteria counts. Upon further investigation it was determined the pipes drained a resort koi pond. The connection was rerouted, eliminating flow and discharge of bacterial contaminated water to the bay.

Synthesis Presentation
Subject: Epidemiology

Recreational Water Contact and Illness in Mission Bay, California

Steve Weisberg, Ph.D.
Southern California Coastal Water Resources Project

Fecal indicator bacteria are routinely monitored at marine recreational bathing beaches to assess the public health risk of contracting swimming-related illness. There have been numerous epidemiology studies that demonstrated the relationship of indicator bacteria to health risk, but they have been mostly conducted on beaches impacted by point sources with known human fecal contributions. Few studies have examined this relationship at beaches where non-point sources are the dominant fecal input source.

Here, we present an epidemiology study conducted in Mission Bay, California, where nearly 20% of the historic routine bacterial samples failed water quality standards but the dominant fecal source appears to be non-human. The study focused on three primary questions: (1) Did water contact increase the risk of illness during the two weeks following exposure to water? (2) Among those individuals with water contact, were there associations between illness and measured levels of traditional indicators of water quality? and (3) Among those individuals with water contact, were there associations between illness and measured levels of non-traditional indicators of water quality?

The project was designed as a cohort study. Nearly 8,800 participants were recruited from the six most popular swimming beaches in Mission Bay on weekends and holidays during the summer of 2003. Each participant provided their current state of health and degree of water exposure on their day at the beach. On the same day, water quality was monitored for traditional fecal indicator bacteria (enterococcus, fecal coliforms, total coliforms). A subset of samples was also measured for non-traditional indicators, including new methods for measuring traditional indicators (chromogenic substrate or quantitative polymerase chain reaction [QPCR]), new bacterial indicators (*Bacteroides*), and viruses (somatic and male-specific phage, adenovirus, Norwalk-like virus).

Ten to 14 days later, the participants were contacted by phone and interviewed about symptoms of illness that occurred since their visit to the beach. They were queried about multiple types of illness: gastrointestinal illnesses (diarrhea, nausea, stomach pain, cramps, vomiting, highly credible gastrointestinal illness 1 or 2 [HCGI-1 or HCGI-2]); respiratory illnesses (cough, cough with phlegm, nasal congestion or runny nose, sore throat, significant respiratory illness); dermatologic outcomes (skin rash, infected cuts or scrapes); and non-specific symptoms (fever, chills, eye irritation, earache, ear discharge, eye irritation or redness). Multivariate analysis was conducted to assess relationships between health outcomes and degree of water contact or levels of water quality indicators. These analyses were adjusted for confounding covariates such as age, gender, and ethnicity.

Of the measured health outcomes, only skin rash and diarrhea were consistently significantly elevated in swimmers compared to non-swimmers. For diarrhea, this risk was strongest among children 5 to 12 years old. The risk of illness was uncorrelated with levels of traditional water quality indicators. Of particular note, the state water quality thresholds were not predictive of swimming-related illnesses. Similarly, no correlation was found between increased risk of illness and increased levels of most non-traditional water quality indicators. A significant association was observed between the levels of male-specific coliphage and HCGI-1, HCGI-2, nausea, cough, and fever, but we interpret these associations cautiously because so few participants were exposed to the water at times when male-specific coliphage was detected.

While we found that traditional fecal indicators were ineffective predictors of health effects, it is difficult to extrapolate this finding beyond Mission Bay. Mission Bay is unusual in that it has been subjected to thorough cleanup activities that source tracking studies confirm leave human fecal sources as only a minor contributor. Moreover, Mission Bay has an unusually long hydraulic residence time compared to other coastal systems, which affects the age and viability of waterborne fecal material. This study, though, does suggest the need for further evaluation of traditional indicators in circumstances where non-point sources are the dominant fecal contributors.

APPENDIX D

Summaries of Presentations on Specific Beaches

Kiddie Beach and Hobie Beach Circulation Improvement Study

David Cannon
Everest International Consultants, Inc.

In response to Assembly Bill 411 (AB 411), the Ventura County Environmental Health Department (EHD) designed a year-round monitoring program for the beaches along the Ventura County coastline in the fall of 1998. As part of this coastal monitoring program, the EHD developed a monitoring and reporting program for Kiddie Beach and Hobie Beach, which are both located within Channel Islands Harbor (Harbor). The monitoring program involves the sampling, testing, and reporting of indicator bacteria levels at three locations within Kiddie Beach, one location within Hobie Beach, and one location off the southern entrance channel jetty near Kiddie Beach. Since monitoring began in the fall of 1998, Kiddie Beach and Hobie Beach have been posted frequently for exceedances of the indicator bacteria AB 411 criteria. The exceedances of the indicator bacteria AB 411 criteria occur primarily in the shallow water areas of the two beaches.

Kiddie Beach is approximately 450 feet in length and Hobie Beach is approximately 430 feet in length. Kiddie Beach is fairly uniform in width along the length of the beach varying in width from 115 feet to 130 feet at mean lower low water (MLLW) with an average beach width of about 120 feet at MLLW. Hobie Beach is highly variable in width along the length of the beach varying in width from 75 feet to 250 feet with an average beach width of about 150 feet at MLLW. While Kiddie Beach is comprised of a sandy area along the entire length of the beach, the eastern portion of Hobie Beach contains almost no sand being composed almost entirely of a rock revetment backing Victoria Avenue. At mean higher high water (MHHW), Hobie Beach is almost completely inundated with no visible beach area while Kiddie Beach decreases to an average beach width of approximately 70 feet. There are two storm drains in the vicinity of the two beaches. The eastern storm drain flows during the summer when there is enough water but it is not known whether or not the western drain flows during the summer.

Between June 2000 and May 2001, Larry Walker Associates (LWA) conducted a study for the Ventura County Harbor Department (VCHD) to identify the sources of indicator bacteria responsible for exceedances of the AB 411 criteria. The results of the LWA study indicated that several low grade "diffuse" sources are responsible for the indicator bacteria exceedances. The study suggested that a lack of circulation in the vicinity of the two beaches creates an environment capable of supporting high levels of bacteria. LWA recommended implementation of a wide range of best management practices to address the multiple sources of bacterial contamination, including diversion of dry weather storm flows, improved trash control, feral cat management, and bird deterrents. LWA also recommended conducting a study to identify methods that might improve harbor circulation in the vicinity of the two beaches.

Ventura County has implemented most of the recommendations in the LWA study, including diversion of dry weather storm flows from the drain adjacent to Kiddie Beach, improved trash control, feral cat management, and installation of bird deterrents. Unfortunately, although implementation of these measures did appear to provide short-term improvements in water quality it does not appear to have substantially improved the long-term water quality conditions at Kiddie Beach and Hobie Beach as exceedances of the AB 411 criteria still continue along the two beaches. In September 2001, the VCHD issued a Request for Qualifications from consulting firms to conduct the circulation improvement study (Study) recommended in the LWA study. Everest International Consultants, Inc. (Everest) was selected to conduct the Study in November 2001 and the firm was given the notice to proceed with the Study in August 2002. The purpose of the Study was to develop alternatives to improve water circulation in the nearshore vicinity of the two beaches and evaluate the feasibility of implementing the alternatives from an engineering, environmental, and economic standpoint. The study purpose, objectives, and methods are summarized in this presentation as well as the major results and conclusions of the Study.

The results of the circulation analyses under existing conditions indicated that Kiddie Beach and Hobie Beach are areas of relatively poor circulation compared to the harbor entrance channel. The relatively shallow water within the two beaches causes an increase in friction to flow that slows water movement. This reduction in water velocity decreases the degree of circulation within Kiddie Beach and Hobie Beach. In addition, the two beaches are characterized by circulation eddies. Of the two beaches, Hobie Beach has the poorer circulation with lower velocities and more pronounced circulation eddies than Kiddie Beach. Tidal currents dominate harbor circulation and contaminant dispersal resulting in the movement of contaminants in and out of the harbor. The movement of the water tends to disperse contaminants originating from the two beaches relatively quickly via mixing of the water in the beach area with water in the entrance channel and inner harbor areas.

It was not possible to predict actual reductions in AB 411 exceedances associated with improvements in circulation because there were no data (e.g., DNA) on bacteria loading (e.g., spatial and temporal distribution of bacteria sources and magnitudes) in the Harbor area. This led to the development of a scientifically-based method to assess the performance of each alternative at improving circulation that was based on numerical modeling of the simulated dispersal of an artificial contaminant that served as an indicator of flushing. Although the method did not allow predictions of actual bacteria concentrations, it did provide a methodology sufficient to facilitate comparison of one alternative to another as well as comparison of the alternatives to a baseline condition.

The assessment of existing conditions and corresponding identification of opportunities and constraints led to the development of three alternatives to improve circulation in the vicinity of Kiddie Beach and Hobie Beach (Alternatives 1, 2, and 3). Alternative 1 would involve modification of the existing sheetpile groin through removal of various seaward portions of the sheetpile groin. Alternative 2 would involve removal of the existing sheetpile groin and subsequent replacement with a rubblemound groin structure. Alternative 3 would involve the deployment and operation of mechanical circulation enhancement devices within Kiddie Beach and Hobie Beach. The three alternatives were analyzed to estimate the circulation improvement effectiveness. The results indicated that progressive removal of larger portions of the sheetpile groin under Alternative 1 would produce progressive decreases in contaminant concentration. The results indicated that Alternative 2 would be the least effective at reducing contaminant concentrations. The results indicated that Alternative 3 would be the most effective at reducing contaminant concentrations and it was the only alternative that met the circulation improvement objective developed for the Study. If the County decides to implement a circulation improvement alternative then it was recommended that the County pursue the most flexible alternative in terms of deployment and removal, which would be the use of mechanical circulation enhancement devices (Alternative 3). The analysis showed that this alternative would be the most effective at improving circulation and it can be stopped quickly at any time if problems are encountered during operation.

Campbell Cove Fecal Bacteria & Harbor Circulation Study

Jeff Lewin
County of Sonoma Department of Health Services
&
Linda Rasmussen
Scripps Institution of Oceanography

Bodega Bay is located in the southwesterly portion of Sonoma County. Much of the year Bodega Harbor has little or no freshwater flows with 90% of the seasonal rainfall occurring between October and April. Bodega Harbor is one of the three most active fishing ports in Northern California. Harbor seals and sea lions are resident in rookeries on Seal Rock, approximately 1/3 mile from the Bodega Harbor jetty mouth.

Campbell Cove State Beach is a 0.2 mile-long beach area within the Sonoma Coast State Beach that is a popular for families, school field trips, divers because of being protected from the rough northern surf and water temperatures often 10° warmer than the open coastline water temperatures. There are about 75,000 visitors annually at the beach.

Bodega Bay was made popular in 1963 with the filming of “The Birds” by Alfred Hitchcock. In the 1950’s, PG&E planned to construct what was to be the nations first nuclear power plant named Atomic Park. Construction included a 90-foot by 120-foot deep hole that was constantly being replenished by fresh water, that is known as the “Hole-in-the-Head.” The plant was never completed as it was dangerously close to the San Andreas fault. The “Hole-in-the-Head” is now a deep circular lagoon that creates a small continuous fresh water flow onto Campbell Cove State Beach.

Problem Definition

Pursuant to AB 411, Sonoma County Department of Health Services began sampling seven beaches in August 1999 on a weekly basis from April 1 through October 31. Monitoring data at Campbell Cove showed regular seasonal fluctuations with significant coliform and enterococcus concentrations occurring August through November. Department staff conducted sanitary surveys and ocean water sampling at different locations in the harbor, around the marinas, and the Bodega Bay Public Utilities District sewer treatment plant, however no sources for the fecal bacteria was determined.

Department staff worked with three cooperating agencies in the preparation of a Clean Beaches Initiative grant (CBI) for a tidal circulation, fecal bacteria source identification and source abatement project. These agencies were: Bodega Marine Laboratory/Scripps Institution of Oceanography; North Coast Regional Water Quality Control Board; and the State of California Department of Parks and Recreation. The County of Sonoma contracted with Dr. Mansour Samadpour with the Institute for Environmental Health to conduct ribotyping of ocean water and sediment samples to determine the source of the fecal contamination. Department staff collected animal fecal droppings from numerous birds and mammals that were submitted to Dr. Samadpour to add to his E. coli library.

A. Circulation Study

To help determine possible sources of Campbell Cove contamination, Scripps Institution of Oceanography (UC San Diego) , in collaboration with Bodega Marine Laboratory (UC Davis), conducted a study of the harbor circulation during the spring and fall of 2003. The primary objectives of the study were to

1) measure current speed and direction in the harbor and adjacent bay over different tidal phases, using current profilers and drifters;
2) introduce inert dye tracers into the harbor and bay as proxies for contaminated waters and measure movement and dispersion by aerial photography and image processing ;
3) conduct surveys of temperature, salinity and density in the harbor and adjacent bay water to determine the effects of stratification which often occurs in tidal estuaries.

These features were observed during the Spring and Fall surveys which could influence contaminant transport and retention in the harbor and cove:

Current data from acoustic doppler current profiling units (ADCP's) in both the front and rear of the harbor show velocities that are constant throughout the water column, enabling a large amount of exchange between the bay outside and harbor water. The flow velocities are about two times greater near Campbell Cove than at the rear of the harbor, providing even more volume exchange in that area.

Temperature surveys of the harbor by CTD casts during different tidal phases showed a large intrusion of cold bay water during flood tides that affected water properties all the way to the rear of the harbor. Likewise, during ebb tides, surface-warmed rear harbor water was able to flow out to the mouth of the channel within one ebb tide. This suggests that there is a very large degree of flushing of the harbor by bay water during each tidal cycle.

Tidal flushing is particularly important in the vicinity of Campbell Cove where consistent, vertically uniform tidal flows have the effect of near total replacement of water in that basin with each tidal cycle.

Drifters released in the harbor corroborated the CTD and ADCP data, and showed currents transporting surface water in the channel the entire length of the harbor within one tidal cycle. Drifters released more than a couple hundred meters outside the harbor were not entrained into the flood tide current entering the harbor.

Dye release experiments also showed that advective transport within the harbor is quite rapid, particularly within the main channel. Water in the rear marinas and over the tidal flats did not have such high velocity, but drainage did occur over the tidal flats, primarily into the main channel, and dispersion was still significant enough to dilute dye patches to non-visible levels over a tidal cycle. No dye tracers were ever detected more than a single tidal period from their release time (i.e., dilution of at least 10:1 was achieved). Some retention of dye was observed near the edges of the Gaffney Point tidal flats and along the eelgrass boundaries of Campbell Cove, but these were also diluted to non-visible levels within one tidal cycle.

The circulation study suggests the following probabilities for transport of bacteria from potential source regions to Campbell Cove:

Back Harbor (Spud Point Marina, Porto Bodega, etc.)
Results from dye releases, drifters, ADCP current measurements, and CTD surveys all indicate that there is not rapid advection out of the marina and that the connection between the marinas and the main channel is weak. Waters that did enter the main channel from this area during our experiments had undergone significant dilution. Once in the main channel, these waters are flushed rapidly through the harbor with each tidal cycle. It is therefore unlikely that the back harbor area is a source of high concentrations at Campbell Cove, without simultaneous contamination at other locations.

Bodega Bay (outside mouth of harbor, including Bodega Rock, Doran Beach)
Drifter experiments indicated that the withdrawal zone for bay water entering the harbor during flood tide is small and localized, extending not more than a few hundred meters offshore from the harbor mouth. It is unlikely that contamination from sources beyond this zone (i.e., seals at Bodega Rock, boats in the bay) would have an impact on Campbell Cove, particularly with the more energetic mixing and dilution that occurs in the bay as opposed to the harbor.

However, nearshore waters may be entrained from distances greater than a few hundred meters as they are moved past the harbor mouth by ambient circulation. For example, under westward flows past the mouth (e.g., fall study), pollutants introduced along Doran Beach may move alongshore and then into the mouth. Likewise, under eastward flow (e.g., spring study), pollutants introduced along Bodega Head may be entrained by tidal flows into the mouth.

Gaffney Point Tidal Flats
Dye releases over the tidal flats during ebb tide showed transport mainly in the direction of the central channel. However, some dye along the southwestern side of the flats did move shoreward and toward Campbell Cove en route to the main channel. If water draining from the flats became entrained in the boundary layer in the nearshore zone, it could persist longer than we observed. This could occur if a source was nearer to the shore than the dye releases, or if there was a long-lived or continuous source (such as bird populations) that introduced contaminants into the flats over many tidal cycles.

Campbell Cove
Campbell Cove itself could be a source for contaminants found there. As with the tidal flats, dye released near shore had a tendency to hug the shoreline, dispersing alongshore but not offshore. Also, dye released in the center of the cove at flood tide dispersed more or less radially, and some became entrapped in the eelgrass nearshore while the main patch advected up the channel. If there was a contaminant source at or near the shoreline it is possible that contaminants could persist in the boundary layer for longer than one tidal cycle. One scenario in which this could occur is if there were a persistent source along the shoreline that introduced contaminants steadily (such as frequent bird populations, as observed near the freshwater drainage from the "hole in the head"); then, the slow flushing of these ankle-deep waters would allow them to persist or accumulate over time.

B. Fecal Bacteria Study

A sample of the "Hole-in-the-Head" fresh water flow onto Campbell Cove beach was collected and submitted for fecal bacteria indicator organisms and for general mineral analysis and nutrient concentrations. Results indicated the freshwater was not a source of either. Department staff collected sediment samples at the other six AB 411 beaches for background purposes and all six beaches were essentially clean of fecal bacteria. A dye study of the vault privy ruled it out as a source of fecal contamination.

On October 2, 7, 9, 14 and 16, 2003, Department staff collected ocean and sediment samples at six locations in the harbor and bay: Campbell Cove sediment; Campbell Cove ocean water knee deep; Gaffney Point knee deep; Westside Park channel; Campbell Cove channel; and Seal Rock. Samples were analyzed for fecal bacteria indicator organisms and for membrane filtration with three dilutions to isolate E. coli colonies for submittal for ribotyping.

The results were dramatic for fecal contamination in the sediment samples at Campbell Cove beach. Knee-deep ocean water samples at Campbell Cove were excessive at times, whereas the other four sampling locations were fairly clear of fecal contamination. Staff conducted follow-up sediment sampling at Campbell Cove at the center of the creek flowing into the ocean, and at 10 yards and at 20 yards on either side of the creek. Results indicated all sediment samples were significantly contaminated.

Response

The E. coli ribotyping results pointed to the source of fecal contamination as avian (sea gulls) and marine mammals (harbor seals and sea lions). Looking towards source abatement options, Department staff and the cooperating agencies applied for a CBI Phase 2 grant for a project to determine the relative risk to human health from avian and marine mammal sources and the degree to which the "Hole-in-the-Head" freshwater flow is an attractant for birds and seals/sea lions. Unfortunately, the CBI grant was targeted for capital projects for source abatement and the proposal was not accepted.

Department staff contacted the State Department of Health Services and received a letter that stated, "From the health exposure standpoint, it does not matter what species defecated, i.e., sea gull, sea lion or harbor seal, if fecal coliform or *Escherichia coli* is present, the health risk exists. Following the "Precautionary Principle," Department staff had permanent signs posted at appropriate locations at the beach advising the public that sand/sediment is subject to periodic bacterial contamination due to birds and marine mammals and digging or disturbing sand/sediment may pose health risks.

Future plans may be to obtain grant funds to: monitor phytoplankton concentrations that may contribute to nutrient load for bacteria growth; conduct a site assessment for culvert diversion of the "Hole-in-the-Head" flow to discourage sea gulls from being attracted to the beach; and determine the cause of marine mammal fecal bacteria source through tidal circulation studies because seals and sea lions are rarely spotted on the beach and drifters released more than a couple hundred yards outside the harbor were not entrained into the flood tide current entering the harbor.

Conclusions

- Circulation studies showed the most likely source areas for contamination of the Cove were Campbell Cove itself, or the nearby tidal flats, both of which have large shorebird populations.
- Both circulation and bacterial data point to avian bacteria as a major source; bacterial ribotyping also indicated the presence of marine mammal bacteria.
- Avian and marine mammals fecal contamination sources should be considered in development and implementation of appropriate controls for protecting public health ("Precautionary Principle").
- Need cost-effective, certified test methods for identifying fecal bacteria contamination as either animal or human source.
- Voice our support for research for identifying pathogenicity of animal fecal contamination for setting water quality standards.

Other Participants: Dr. Steven Morgan, Dr. John Largier (formerly SIO) and Dr. Amber Mace, UC Davis; Melissa Carter, SIO; Dr. Linden Clarke, Oregon State University (formerly SIO); Marty Isom, Sonoma County Health Dept.; Peter Otis and Robert Klamt, North Coast Regional Water Quality Control Board.

Case Study
Mission Bay

Mission Bay Water Quality Management Plan Summary

Ruth Kolb
City of San Diego

Introduction

Mission Bay is considered to be one of San Diego's most beautiful recreational areas and a unique aquatic facility. In addition, Mission Bay serves as the outlet for approximately 80 square miles of urbanized tributary area. The aesthetic quality and recreational benefits of Mission Bay have been diminishing in recent years due to the recurrent posting of "Contaminated Water" signs. Mission Bay was listed in 1998 as an impaired water body under Section 303(d) of the Clean Water Act for high bacteria counts.

Description and of Projects

At this time, there are seven projects that comprised the Mission Bay Water Quality Management Plan that had clear project objectives and discrete usable work products. While each of the projects individually provide important information for understanding and controlling bacterial pollution in Mission Bay, the full potential of the Mission Bay Water Quality Management Plan resided in the interdependence of the projects. Provided below is a brief description of projects that comprised the Mission Bay Water Quality Management Plan.

A. Mission Bay Contaminant Dispersion Model (Completed)

The Contaminant Dispersion Model determined how contaminants moved within the eastern portion of Mission Bay and provided information that assisted in the development of an improved procedure for posting and closing shoreline areas when they are impacted with bacterial contamination. The Contaminant Dispersion Model assisted in determining the source(s) of bacterial contamination in waters adjacent to impacted beaches along the eastern shoreline of Mission Bay. In addition, this study provided better information for managing health risks to recreational users of Mission Bay and increased the credibility of both warnings and statements concerning beach water quality.

B. Mission Bay Human Pathogenic Viruses and Epidemiology Study (Completed)

The Mission Bay Human Pathogenic Viruses and Epidemiology Study was designed to determine if there are health risks associated with water contact recreation in Mission Bay. This study examined five to six beach areas that are adjacent to bacterial contaminated water. Water samples were analyzed using advanced virology techniques to determine if human pathogenic viruses are present at these beach sites. Molecular biology techniques were used to qualitatively determine if sources of bacterial pollution are from human or non-human sources. This part of the study was coordinated with a collaborative epidemiology study to determine the human risk factor associated with swimming in Mission Bay. An attempt was made to look at risk factors associated with both human and non-human bacterial contamination.

C. Mission Bay Bacteria Source Identification Study (Completed)

The Mission Bay Bacteria Source Identification Study was designed to identify and abate bacteria sources by focusing on previously identified problem areas. This project achieved this goal by sequencing the study of potential sources from most important and readily remedied (e.g. human sewage) to least (e.g. birds). A total of 12 locations were selected in Mission Bay for investigation. The Bay was divided into four quadrants for investigation activities: Northeast, Northwest, Southeast, and Southwest Mission Bay. The project goal was to significantly reduce beach postings and closures in Mission Bay. Using advanced microbiological tracking methods found that birds were the single largest source of bacteria to Mission Bay.

D. Mission Bay Water Quality Survey (Completed)

The Mission Bay Water Quality Survey provided for bacterial monitoring at five shoreline stations in Mission Bay and at nineteen stations in the bay tributaries of Rose and Tecolote Creeks. The purpose of this monitoring was to determine whether there are areas in the watersheds to Mission Bay that consistently show high levels of bacterial contamination. This was the only study that provided watershed water quality monitoring. The Mission Bay monitoring points were set up with assistance from the Regional Water Quality Control Board to aid in the development of the Total Maximum Daily Loads.

E. Rose and Tecolote Creeks Water Quality Improvement Project (In Progress)

The Rose and Tecolote Creeks Water Quality Improvement Project examined water quality data from small sub-watersheds throughout the main watersheds of Rose and Tecolote Creeks to determine appropriate best management practices (BMPs) to reduce the main pollutants of concern. As funding is available, structural BMPs will be designed and constructed in the selected sites within Rose and Tecolote Creeks watersheds. Post-construction water quality monitoring will be conducted to determine BMP effectiveness and the ability of the BMPs to restore water quality in the selected areas. A GIS-based Watershed Information Management System database will be designed and used throughout the project.

F. Tecolote Creek Treatment Wetland (Pending Additional Funding)

The Tecolote Creek Treatment Wetland project designed a salt marsh at the mouth of Tecolote Creek. The intent of the treatment wetland design is to assist with the removal of pollutants of concern that flow into Mission Bay from Tecolote Creek. As funding is available, the treatment wetland will be constructed and will be associated with interpretive features to heighten the awareness of the importance of watershed management in maintaining water quality within Mission Bay.

G. Mission Bay Water and Sediment Testing Project (Completed)
The Mission Bay Water and Sediment Testing Project was the first phase of a comprehensive study to evaluate sediment quality, benthic and pelagic communities in the waters adjacent to the mouths of Rose, Cudahy and Tecolote Creeks. This study developed baseline data for the selected areas in Mission Bay and began the process of analyzing the relationship between monitoring data for Mission Bay and environmental factors. The Mission Bay Water and Sediment Testing Project utilized citizen monitoring as a means to educate students and the general public about the environmental and human health impacts of urban runoff.

Case Study
Cabrillo Beach

Inner Cabrillo Beach Water Quality Improvement Project

John Foxworthy
Port of Los Angeles, Engineering Division
&
Patrick Kinney
Kinnetic Laboratories, Inc.

BACKGROUND

Inner Cabrillo Beach is located inside the breakwater of the Port of Los Angeles, along the San Pedro shore in the western Harbor. Inner Cabrillo Beach has served the urban areas of City of San Pedro and of greater Los Angeles since the early 1900's and is the home of the Cabrillo Aquarium and the recently restored Cabrillo Bath House. This beach is thus of immense value as a marine science teaching resource with thousands of school children participating in classes at the aquarium and in field activities on
Inner Cabrillo Beach. Inner Cabrillo Beach is also a very important and historical urban beach and is especially valuable as a scarce resource accessible to the Los Angeles area as one of the few urban beaches that is protected from open ocean waves. Because of the importance of this sheltered beach for the large Los Angeles urban population, this beach has a high priority for clean up even though it is a difficult problem caused by multiple factors. Complicating factors also exist with potentially conflicting natural resources such as heavy bird use and extensive eelgrass habitats existing immediately offshore the beach.

THE BEACH ENVIRONMENT

Sources of Bacterial Contamination

This present study was partly funded by the State of California Clean Beaches Initiative along with the Port of Los Angeles, with cooperation by the U.S. Army Corps of Engineers Engineering Research and Development Center. The Port of Los Angeles' emphasis for this project is an iterative approach to scientifically identify sources of contamination, design corrective measures, implement these measures as appropriate, and monitor beach performance results until satisfactory results were achieved. The following results were obtained:

- The offshore Outer Harbor waters are clean, except during storm events, and return to good water quality in a few days following a storm as demonstrated by bacterial measurements. Offshore time series monitoring results indicate that Outer Harbor water presently meet new TMDL requirements. Thus sources local to the beach account for frequent violations.

- Onshore source studies associated with the beach facility infrastructure found leaking sanitary sewers and a non-functional storm water drain that discharged both over and under the sand in the southern end of the beach. An old abandoned sanitary sewer outfall was also found to be intact from the bluff to the beach with indications of upland source influences beach violations.
- Heavy bird use occurs at Inner Cabrillo Beach, with up to 600 birds (gulls, skimmers) using the beach during dawn to dusk, with no use at night. Longer term statistics of beach performance 50 months before and 50 months after installation of a bird exclusion structure show improvement, for example 58% of enterococcus samples were violations before installation as compared to 34% after installation. Genetic ribotyping of nearshore waters indicated over 50-60% of *E. coli* contamination to be from avian host sources.

The bacteria found at the beach face have been tested for host sources: 50-60% Gull and other birds, 12% human/sewage, 7% cats, 3% dog, 10% Rodent/other mammals, and 10% other sources.

Circulation Characteristics

Field current meter and dye studies carried out in the western Outer Harbor as well as
the inshore area of Inner Cabrillo Beach show slow tidal currents and low circulation
offshore Inner Cabrillo beach. Three dimensional hydrodynamic models were used calibrated with this field data. With wind, a two-layer flow dominates the circulation, moving surface water offshore and bringing bottom water to shore during the predominate southwest wind conditions. Dye studies at the beach under early morning calm conditions demonstrate low mixing. Model results indicated high residence times at the beach face, especially for the bottom water (approximately 8-10 hours) that is brought to the beach and upwelled. Preliminary model runs of an infusion pump placed offshore indicate that a pump capacity of 10,000 to 30,000 gpm would be necessary to influence the nearshore circulation at Inner Cabrillo Beach. These results have been supplemented by a field pump infusion study at 20,000 gpm. These model and field test results will be used to examine designs for an infusion pump correction alternative.

Sediment Characteristics

Eelgrass beds with fine particulate sediments and detrital materials exist just offshore Inner Cabrillo Beach at les than -1 foot MLLW. Dry weather violations are associated with high tide-range conditions (violations with significant tidal range and occurring on a rising tide, after a low tide). Organic rich particulate material eroded by the small surge at low tide are brought from the nearby eelgrass beds to the beach face by the undercurrent during these conditions and have been implicated with beach violations. Bacterial contamination has been found to be frequently associated with the presence of particulate materials.

Elevated levels of bacteria are found in upland soils, surficial sediments in nearshore eelgrass beds, decaying organic material and most importantly in association with the very fine particulates that get suspended in the swash zone. Bacterial measurements that contain two phases (particulates and water) demonstrate a high degree of variability due to bacteria associated with the particulates, with enterococcus exceedances most often implicated.

Beach sands extracted with sterilized sea water have generally shown relatively low bacteria concentrations in the extracts except immediately after a rain event and for a few days where storm water has run across the beach. These beach sands are fine sands with clay and poor permeability.

RESPONSES

Responses Considered and/or Implemented

The Port of Los Angeles has replaced the leaking sanitary sewers above the beach. Replacement of the defective storm water outfall located at the southern end of the beach has also been carried out, including dry weather diversion to the sanitary system and a first flush diversion of storm water to the launch ramp area. The City of Los Angeles has also repaired a leaking water main that may have contributed to the transport of contamination through the old sewer outfall and the outfall will be sealed with concrete. Earlier, the bird exclusion structure was constructed.

Other responses being considered include the following:

- Repair/extension of the bird exclusion structure.
- Reconfigure beach by removal of fine sand/clay beach sands and replacement with coarse sand.
- Raise the elevation to +8 feet MLLW to prevent frequent beach flooding depositing particulates and debris.
- Investigate removal of eelgrass from the immediate swim area and mitigate elsewhere.
- Design and implement infusion pump installation.
- Remove storm drain overflow from Inner Cabrillo Beach.

Preliminary Implementation Results

Installation of the bird exclusion structure and Implementation of drainage and water line replacements have not sufficiently reduced the level of violations at Inner Cabrillo Beach. Violations, especially due to enterococcus, continue at the beach associated with certain high tide-range conditions during dry periods and during wet weather events.

CONCLUSIONS

Bacterial contamination at Inner Cabrillo Beach has been found to originate from a variety of sources and to be facilitated by a number of conditions and mechanisms at the beach, including low circulation at the beach face and a

source of organic rich particulates. Design and implementation of the above identified corrective actions
will continue together with monitoring of results in order to achieve compliance with water quality standards at Inner Cabrillo Beach.

Case Study
Baby Beach

Dana Point Harbor, Baby Beach
Pilot Circulation Project Using Oloid Devices

Vincent Gin
County of Orange, RMDM

The Beach

Baby Beach is a small artificial beach located in the inner most back corner of Dana Point Harbor, California (Orange County). The beach is owned and operated by the County of Orange and is about 700 feet wide and nestled below the bluffs of Dana Point. Constructed in 1969 by the US Army Corp of Engineer, Dana Point Harbor is protected from the Pacific Ocean by two breakwaters and divided into two marinas, East Basin and West Basin.

Baby Beach is surrounded by residential and commercial properties on the cliffs above, the County's Youth & Group public facility to the east and the Ocean Institute to the west. The areas immediately adjacent to the beach are parking lots and a grass picnic park. Visitors consist of beach goers, picnic groups, kayakers, day camp youths from the Ocean Institute, sailing students from the Youth & Group Facility, and dog walkers.

The Problem

Since 1999, when Assembly Bill 411 (AB411) established three indicator bacteria (fecal coliform, total coliform and enterococcus) and numeric targets for beach water quality, Baby Beach has been frequently posted for exceeding those standards.

The History

The frequent postings at Baby Beach led the County of Orange to initiate a number of formal and informal investigations. Several sources for the bacteria were suspected and eventually marginalized: leaking sewer lines; old septic tanks; and boaters. The suspicions eventually focused on mammalian and avian sources and storm drains conveying bacteria and nutrients that feed bacteria. In addition to bacteria sources, the geometry of the harbor, the cliffs behind the harbor and the location of Baby Beach within the harbor were suspected of exacerbating the bacteria issue by limiting harbor water circulation and allowing the onshore winds to pin the surface water against the beach. Interestingly, the west breakwater is semi-porous and shoaling at the lee side of the break water as well as sand migration at Baby Beach would indicate some degree of harbor water circulation.

Informal investigations included several approaches. Biodegradable drogues (grape fruit) were deployed for visual indication of harbor water circulation patterns. Groundwater wells were installed and the water tested to eliminate septic tanks as a bacteria source. Geographic and temporal variance in the bacteria levels were investigated around Baby Beach. California Proposition 13 and 40, Clean Beaches Initiative grant funds were used to commission a historical bacteria monitoring data study, harbor water circulation study, avian study, and a bacteriological study.

Pinpointing the major source(s) of bacteria and developing capital projects or best management practices has been difficult because indicator bacteria originate from multiple sources such as humans, birds, animals, foods, soil and plants. Microbial source tracking (MST) techniques designed by researchers to distinguish the origin of indicator bacteria are still under development. There is still no single MST method that is accurate and reliable enough for routine use. Thus, in a recent study conducted at Baby Beach, traditional bacteriological methods were utilized to prioritize potential sources of all three indicator bacteria. The quantity of bacteria was determined from possible sources such as storm drain water, sediments, bird stools, groundwater seepage and in beach water during high beach usage events such as swimming and boating. Historical monitoring data indicate that the majority of postings have been due to single sample exceedances of enterococci. Thus, these organisms were further identified to species level by Orange County Public Health Laboratory. Several general conclusions were reached: the 24-inch storm drain at the west side end of Baby Beach and the fine grained sediment at the outlet of the storm drain contained high levels of indicator bacteria, indicative of retention and possible regrowth of bacteria in this environment. At Baby Beach, the predominant enterococci species found both in sediment and water included *Enterococcus faecalis*, *E. faecium*, *E. hirae*, *E. casseliflavus* and *E. mundtii*. The distribution (proportion) of species present in intertidal sediment was comparable to those found in the beach water. Also, there was no significant difference between the species distribution in beach water samples passing and failing bacterial standards. These findings, together with the high densities found in sediments and storm drain water, suggest that there may be constant loading of a stable enterococcal population to beach water from intertidal sediments and/or other continual sources such as urban runoff. Thus, it is possible that increased levels of enterococci in beach water may occur as a result of environmental factors other than recent fecal contamination events. The circulation study indicated that onshore winds tend to pin the surface level water against Baby Beach (where the AB411 samples are taken). Limited circulation and thus inadequate flushing of bacteria may also contribute to the persistence of indicator bacteria at Baby Beach.

Since the completion of the Prop 13 and 40 studies, urban runoff (low flow) in the 24-inch west storm drain has been diverted to sewer, vessel pump out has been upgraded and bird deterrent netting under a nearby pier is currently being replaced.

The Pilot

While much of the previous investigation was focused on indicator bacteria sources, the pilot circulation project focused on the enhancing the natural circulation of the harbor waters. Previous circulation studies indicated that the rest of the harbor waters circulates well and that Baby Beach in the back corner suffers from limited circulation, especially with onshore winds. Certainly, engineered solutions exist for moving massive quantities of water, but visual impacts, power requirements, and especially noise impacts are of special importance in a quiet and small beach. In addition, too much and/or too powerful artificial circulation might erode the beach. Baby Beach required small and quiet circulation devices that could move the surface waters and also effect ankle deep waters near the shore.

To evaluate a promising new water circulation device called Oloid, the County of Orange, the City of Dana Point and West Technology, Inc. partnered to initiate a three-month pilot project in early 2005. With the County acting as the project manager and lead funding agency, the City providing partial funding, and West Technology providing Oloids and supporting services at no cost, six oloids were installed in the near shore area of Baby Beach. Dr. Ying Poon of Everest International Consultants was retained to provide engineering and scientific services. The pilot project is currently underway and in the monitoring phase.

Oloids are small geometrically shaped paddles that are purported to move water efficiently with very little power consumption. Supported by pontoons and submerged two feet below the water surface, each Oloid is powered by a ½ horsepower electrical motor. Because the device is supported by pontoons, the submerged depth of the Oloid below the water surface remains constant, regardless of the tides, and the water flow is primarily near the surface where it is most needed. The units generate little noise during operation, owing to low electrical power requirement.

To evaluate the Oloids, a monitoring plan was developed based on the existing AB411 monitoring program. The County's AB411 program consists of six sample locations around Baby Beach: one at the nearby pier, four along the beach, and one at the adjacent Youth & Group dock. The six points are sampled once per week for the AB411 program. The pilot project increased sampling frequency to twice per day, five days per week for eight weeks during the pilot. Monitoring was dividing into 2-week blocks during which the Oloids were turned on and off. The objective of the monitoring was to evaluate the relative influence of the Oloids on bacteria levels at the beach (and the pier and dock). Due the limited nature of the pilot project, insufficient controls and the lack of numerical modeling of the harbor waters, the ultimate effect on beach postings was beyond the scope of the project.

In addition, a two-day dye tracer evaluation is scheduled for September 2005. Rhodamine WT will be introduced at the Baby Beach and water samples will be taken on several transects and the concentration of dye measured with a fluorometer. The dye tracer measurements will be conducted twice, one day with the Oloids on and one day with the Oloids off. The objective of the dye tracer measurement is to quantify the relative dispersion rate of the Rhodamine WT dye (acting as a bacteria substitute).

The Next Step

While the results of the pilot project are not yet available, the County of Orange has submitted a State of California, Proposition 40, Phase II grant application for the permanent installation of artificial circulation devices at Baby Beach. Included in the grant application is numerical modeling of the harbor waters to design and engineer the specific location, angle and other parameters for permanent installation of circulation devices. The numerical model will also serve to reinforce the results of the pilot project. It is the County's hope and expectation that the Oloid devices will be a powerful tool in addressing bacteria levels at enclosed beaches and that the State will provide grant funding for implementation.

References

State of the Beach Report, Baby Beach Region, Dana Point Harbor, California
Science Application International Corporation, Environmental Sciences Division, Prepared for the County of Orange, June 2003

http://www.ocwatershed.com/watersheds/sanjuan_baby_beach.asp
Circulation Study Report, Baby Beach Region, Dana Point Harbor, California
Science Application International Corporation, Environmental Sciences Division, Prepared for the County of Orange, March 2003

http://www.ocwatershed.com/watersheds/sanjuan_baby_beach.asp
Baby Beach Bacteriological Special Studies Report, Dana Point Harbor, California
Science Application International Corporation, Environmental Sciences Division, Prepared for the County of Orange, June 2003
http://www.ocwatershed.com/watersheds/sanjuan_baby_beach.asp

Data Mining Task for State of the Beach Report: Evaluation of Bacteriological Data & Associated Parameters for Baby Beach, Dana Point Harbor, California
Science Application International Corporation, Environmental Sciences Division, Prepared for the County of Orange, January 2003
http://www.ocwatershed.com/watersheds/sanjuan_baby_beach.asp

Baby Beach Avian Use: Results of a Focused Bird Survey
Allen, Shannon M., Scheidt, Vincent N., January 2005
Prepared for the County of Orange of Orange

Case Study
Colorado Lagoon

Colorado Lagoon Restoration Feasibility

Kim Garvey
Moffat Nichol

Background

The Colorado Lagoon is a small tidal lagoon in the middle of a suburban neighborhood in Long Beach, California. It serves three main functions: hosting sensitive habitat, providing public recreation (including swimming), and retaining and conveying storm water. The site is degraded in many respects due to being overburdened by these competing uses.

A restoration feasibility study was completed in February 2005. The goal of the study was to evaluate alternatives to maintain and improve all three functions. Several surveys were performed to determine the lagoon's existing conditions for water and sediment quality, tidal hydraulics, and biological habitat. These surveys, as well as feedback from several public and technical advisory committee meetings, were used to develop a set of alternatives that can be implemented individually or in total.

The City of Long Beach conducts bacteria sampling of the lagoon on a weekly basis. Bacteria sampling from December 2000 to August 2004 showed several AB411 exceedances mostly for total coliform and E.coli (fecal coliform) / total coliform ratios, and to a lesser extent for enterococcus and E.coli, during both wet and dry seasons. Potential sources of pollutants include urban/commercial runoff from eleven storm drains which discharge into the lagoon, local golf course runoff, and direct input to the lagoon from humans who use the lagoon for swimming and picnicking, pet waste, and a diverse bird population, including ducks. The water quality is further compromised by limited circulation. The lagoon is connected to Alamitos Bay and the Pacific Ocean through a 900-foot long tidal culvert to/from an adjacent waterbody, the Marine Stadium. Visual inspection of the culvert revealed a significant amount of marine growth accumulated on the inside walls and sediment along the bottom of the culvert. Sediment in the western arm of the lagoon is listed on the California State 303(d) impaired water body list for metals and pesticides.

The Beach Environment

The lagoon's water covers approximately 10 acres and is Y-shaped. The culvert is located at the base of the Y and the designated swimming area is along one of the arms of the Y. The deepest water is approximately 15 feet deep, NGVD29. Tidal gauges were installed in the Colorado Lagoon and Marine Stadium to study the difference between the two water bodies. The lagoon's low tides are cut off by approximately 2 feet as compared to the ocean tide and Marine Stadium and the tidal range is 4.5 feet. The tidal residence times are at least one to two weeks longer than for the Marine Stadium.

Additional water quality and sediment sampling was conducted during the feasibility study, including sampling of the discharge from the storm drains and sampling of various areas of the lagoon over different times of the day. As expected, the storm drain discharges were an order of magnitude higher than the receiving waters and early morning sampling concentrations were an order of magnitude higher than at noon-time. Sediment sampling was generally consistent with the State 303(d) listings. Lead levels in the sediment exceeded the Title 22 hazard level.

Responses

Alternatives were developed to address all three restoration objectives and were categorized as either relating to remediation or restoration. A consensus was formed that water and sediment quality remediation must occur first in order for habitat restoration to be fully successful. Remediation alternatives include: cleaning the tidal culvert and/or building an open channel between the lagoon and the adjoining Marine Stadium in order to improve circulation, installing storm drain diversions and treatment systems, dredging the lagoon to remove contaminated sediments, and construction of bio-swales to treat dry weather runoff into the lagoon. Restoration alternatives include: recontouring the lagoon's slopes to increase mudflat intertidal habitat area, removing non-native vegetation and planting native vegetation, and installing recreational elements such as interpretative kiosks and a perimeter trail.

Conclusion

The feasibility study has been completed and the City is currently pursuing implementation funding. Lessons learned include the value of field surveys and historical data and the importance of developing affordable solutions.

Case Study
Marina (Mother's) Beach

Marina Beach, Marina Del Rey
Water Quality Improvement Project

Joe Chesler, Lauri Ames
County of Los Angeles, Department of Beaches and Harbors
&
Pat Kinney, Ph.D.
Kinnetic Laboratories, Inc.
&
Richard Mast
DMJM+Harris

BACKGROUND

Marina Beach is a protected, man-made sand beach in the upper part of the Marina del Rey small boat harbor located in Los Angeles County along the shores of Santa Monica Bay. Daily monitoring of Marina Beach for bacterial indictor organisms carried out by the City of Los Angeles Bureau of Sanitation shows that Marina Beach has frequent exceedances of State of California water quality objectives (REC-1) for body contact beneficial uses. These exceedances occur frequently in the winter rain season, but also occur at low frequency during dry weather conditions. Marina del Rey has been the subject of a Total Maximum Daily Load (TMDL) determination and actions by the Los Angeles Regional Water Quality Control Board. The number of allowable days of bacterial exceedances at Marina Beach has been specified by the TMDL.

THE BEACH ENVIRONMENT

Sources of Bacterial Contamination

The source study was funded by the State of California Clean Beaches Initiative and a final report is available (Kinnetic Laboratories, Inc. 2004. Phase I Final Report, Marina Beach Water Quality Improvement Project, Bacterial Source Studies and Recommendations). Recommended corrective action projects for Marina Beach are now underway by the County of Los Angeles along with TMDL required monitoring within the Marina. Additional studies have been started recently to develop similar recommendations for the upper basins. The following results of were obtained by the source study:

- The pattern of water quality exceedances at Marina Beach shows generally low exceedances during dry weather conditions, particularly in the summer months.
- The waters of the Marina del Rey harbor are clean (REC-1 Standards) except during storm events and return to good water quality in a few days following a storm as demonstrated by bacterial measurements (top and

bottom) on transects throughout the Marina. These results are consistent with the monthly monitoring data. Thus sources local to the beach account for frequent violations.

- The major sources of bacterial violations at Marina Beach are local storm water drains that sheet flow directly across the sand at the beach during storm events. In addition, storm drains from the adjoining peninsulas empty into Basin D adding bacterial contamination to the waters of the local Basin and adjacent to the beach.
- Local sanitary sewers were inspected and found to be in communication with salt water, with salinities running up to 20 ppt in the sanitary sewers at high tide. Flow generally enters on the outside of the lining previously installed inside the present sewer lines and then flows into the unlined manholes. However the low elevations of the sewer inverts relative to MLLW along with the low permeable mud substrate of Marina del Rey apparently prevent significant leakage of sanitary sewage out to the waters of Basin D. This is evidenced by the fact that only a few bacterial violations occur at Marina Beach during the summer dry weather.
- Bird use at Marina Beach is almost exclusively seagulls. Use is low to moderate with numbers typically in the 10-30 range. Picnic areas at Marina Beach are in covered though open buildings above the beach and trash cans are covered on the beach. Thus there is not a lot of food to attract birds. A bird exclusion structure has also been in place on the beach for years and covers the whole beach. Repairs are needed to the lines and poles are missing at the children's swim area where the birds congregate.

<u>Circulation Characteristics</u>

Dye studies and hydrodynamic modeling studies were carried out for Marina del Rey and for Basin D where Marina Beach is located (Resource Management Associates RMA-2, 10, & 11). The purpose was to determine the transport of bacterial contamination to the beach from sources outside Basin D during both dry weather and wet weather conditions and to examine infusion pump performance. Conclusions from these studies are as follows:

- Transport of bacterial contamination from Basin E above to the Marina Beach face does not appear to be important during non-storm conditions.
- Contamination from Ballona Creek outside the Marina does not appear to be a factor.
- Transport of small sewage discharges from boats in the marina can be a transitory factor under certain tide and wind conditions but only from sources near the upper end of Basin D.
- An infusion pump of 30,000 gpm could reduce contamination from a continuous source at the beach by about 50%, or remove a transient source in about 12 hours from the immediate area of the beach.
- Storm event simulations showed that bacteria contamination penetrated Basin D from elsewhere in the Marina during storm events facilitated by stratified freshwater flow near the surface. Nevertheless, significant

reductions in bacteria in waters of basin D near Marina Beach were predicted by model results if local storm water discharges were diverted from Basin D.

Sediment Characteristics

Marina Beach is a low wave energy beach in the upper end of Marina del Rey Harbor. The beach slope is very shallow, and the lower tidal sections have an obvious content of estuarine mud mixed with the sand (though the lower intertidal is still firm to walk on). The low intertidal substrate is consolidated with algae growing on it. The beach was constructed as part of the marina. Several feet of sand have been placed onto an estuarine mud substrate, so the entire beach is not made of porous sand but is a layered structure of dry or wet sand, with dry clay/mud immediately underneath, then underlain by wet clay/mud of the original marshland. Water seeping from the surface sand layer on the beach in dry weather conditions was found to be seawater with low bacterial levels; water seeping from the beach during or after a storm was found to be fresh/brackish with high levels of bacteria. These levels dropped after a period of several days with no rain. Interstitial water was found to contain elevated levels of enterococcus in some areas of the upper beach, but porosity of the estuarine mud layer seemed to prevent transport to the beach face. Extractions of beach sand with sterilized seawater resulted in low numbers of indicator bacteria except after a rain when these measurement resulted in high levels of indicator bacteria as a result of storm water flowing over and through the upper sand layer on the beach.

RESPONSES

Recommended Responses

The study results showed that local sources of contamination are important at Marina Beach and should be mitigated. Alternatives were evaluated and the parts recommended for implementation are the following:

- Divert local storm water drainage from Marina Beach and Upper Basin D areas to discharge to Basin C or to the main Channel of Marina del Rey.
- Install local water infusion pump(s) to experimentally explore the effect of increased local circulation, mixing, and dilution at the Marina Beach face to address low numbers of dry weather exceedances.
- Line/repair local sanitary sewers and install floor drains in bathrooms connecting to the sanitary sewer.
- Incorporate guidelines in Marina Operations Practices to control local Basin D sources, including repair of bird exclusion structure, implementation of a boat discharge and wash down program, and implement experimental sand management practices at the beach.

Diversion of local storm water and the experimental water infusion pump project are being implemented with the assistance of State Grant funds. Sanitary sewer repairs are planned and a study of Marina Operation Practices has been completed.

Case Study
Newport Beach

Circulation Improvement Program

Bob Stein
City of Newport Beach

Newport Bay and Harbor has been transformed over the past century by significant dredging, bulkhead construction and fill activities. One of the unintended consequences is that some portions of Newport Bay are in large measure hydraulically isolated from the tidal flows which in turn reduces flow velocities to very low values (< 0.01 m/s). The lack of tidal circulation is of course one of the reasons high concentration of fecal indicator bacteria that are regularly found during water quality monitoring of these areas.
The City of Newport Beach created its Water Quality Division in 2001 and began a program to address the poor circulation in the Bay specifically at Newport Dunes and the Newport Island Channels. Table 1 highlights the studies completed under the Circulation Improvement Program including testing of various circulation devices such as the InStreem (2002) and the Oloid (2004). Though not initially anticipated, we are finding that a successful circulation project requires:

- A deep understanding of the hydrodynamics of Newport Bay,
- Active participation with equipment suppliers to test and develop an effective circulation device, and
- Community support especially in regard to swimmer safety, navigation safety, noise and visual impacts.

The circulation program has successfully accomplished several milestones, and with the help of our cooperative partners, especially the State Water Resources Control Board and the County of Orange, we think we are close to implementing a full-scale circulation project in the Newport Harbor Channels.

Table 1: City of Newport Beach – Summary of Circulation and Water Quality Improvement Studies

2002	March	InStreem Demonstration at Newport Dunes Lagoon: A one-week demonstration testing the operation of the InStreem at Newport Dunes including a 1-day measurement of the flow generated by the unit using an ADCP mounted on a boat.
2002	September	InStreem Demonstration at Newport Island Channels: A 10-day demonstration of the operation of a reduced size InStreem unit at Newport Island Channels
2002	October	Circulation Improvement Study for Newport Dunes Lagoon and Newport Island Channels: Hydrodynamic and water quality modeling to evaluate InStreem or Tornado circulation units in different configurations to improve water circulation and water quality at Newport Dunes Lagoon and Newport Island Channels.
2003	March	Circulation Improvement Study for Newport Island Channels: Hydrodynamic and water quality modeling to evaluate the effectiveness of different configurations of submerged nozzles (driven by pumps) placed along the channel bed to improve water circulation and water quality at Newport Island Channels.
2004	August	Oloid Demonstration at Newport Island Channel: A one-week demonstration to test the operation of an Oloid unit at Rivo Alto (East) Channel including field measurements of the flow generated by Oloid
2004	August	Storm Drain Diversion Study: Flow and bacterial samples collected at five storm drains for two weeks to define bacteria loadings from the storm drains into Newport Bay. Based on the loadings, hydrodynamic and water quality modeling performed to evaluate the relative impacts of each storm drain loading to water quality in Newport Bay.
2004	December	Oloid Circulation Unit Flow Measurement (for West Technology System Inc.): A two-day field program using an ADCP to measure flows generated by two different Oloid designs operating at various submerged depths.
2005	March	Oloid Circulation Units Alternative Evaluation: As a final study, hydrodynamic and water quality models determined a preferred Oloid deployment toward improving water circulation and water quality at Newport Island Channels.

APPENDIX E

Beach Case Studies

APPENDIX E. BEACH CASE STUDIES

The workshop was comprised of two breakout sessions, followed by presentations from the breakout groups and discussion. Six breakout groups were formed and given two assignments:

(1) Brainstorm potential solutions and develop recommendations for future CBI proposals for case-study beaches.
(2) Identify the greatest sources of uncertainty and impediments to preparing and implementing a successful CBI project.

The three case-study beaches considered by six breakout groups (two breakout groups were assigned to each beach) were Campbell Cove, Cabrillo Beach, and Kiddie Beach. These three beaches were chosen to represent a range of source, circulation, and resource characteristics.

Key points to emerge from the symposium were (i) the uncertainty associated with characterizing sources and how best to mitigate FIB contamination, and (ii) the existence of several significant impediments to successful mitigation projects. Clearly, uncertainty can become a significant barrier to developing a plan and implementing a project that successfully results in achievement of water quality standards. To further characterize these impediments to the implementation of effective CBI projects, the breakout groups were charged with identifying greatest site-specific sources of uncertainty and other impediments in addition to developing recommendations for future mitigation work at case-study beaches. An overview of uncertainties is given in the main report, e.g., Table 1, as well as an overview of other impediments. In this appendix, the beach specific results and suggestions are summarized.

The results of the case studies are presented below. For each case study, a synopsis of the water quality problem is provided in addition to the breakout group findings and recommendations. For each case-study beach, the results of the two breakout groups have been combined.

Kiddie Beach

Synopsis of Water Quality Problem

Routine monitoring conducted at Kiddie Beach since 1998 has recorded frequent exceedances of the recreational water quality standards. A source study completed in 2001 found that several sources were likely responsible for the exceedances. A number of mitigation measures recommended by the study have been implemented, including diversion of dry-weather urban runoff, improved trash management, feral cat management and installation of bird deterrents.

Despite these mitigation efforts, bacteria densities continue to frequently exceed recreational water quality standards. A circulation enhancement feasibility analysis was completed for the site. Three alternatives were analyzed: (i) removal of various seaward portions of the sheet-pile groin; (ii) replacement of the sheet-pile groin with a rubble-mound groin; and (iii) installation of mechanical circulation devices. Modeling indicated that installation of mechanical devices would be the alternative most likely to result in compliance with recreational water quality standards at the beach.

Recommendations

A two-pronged approach was recommended: (1) completion of source identification and mitigation, and (2) Increase water circulation while minimizing sand loss by reconfiguring Kiddie Beach to increase the width of the beach, and modify and/or remove groins.

1. Complete identification and mitigation of sources
    - Ensure all sources have been identified.
    - Sources that may need further investigation and/or mitigation include restroom infrastructure, restroom cleaning practices, storm drain diversion effectiveness, wrack and kelp management, sediment, boats, old and/or existing septic systems, groundwater, abandoned pipes, and visitor activity.
    - Ensure all human sources have been removed and all other sources reduced as much as possible.
    - Improve public education and involvement, including improved signs regarding trash, diapers, pets, seagulls, etc.
2. Enhance circulation through beach and groin reconfiguration
    - Short-term – Reconfigure beach and groins in a manner that will not shift O&M responsibilities from the Army Corps of Engineers (ACE) to Ventura County. It would be very beneficial to work with the ACE (Vicksburg), which would require a cooperative R & D agreement between the ACE and the County. Short-term efforts would include more comprehensive modeling and analyses of reconfiguration options.
    - Long-term – Work with the ACE to investigate feasibility of modifying outer breakwater and entrance channel configuration to improve harbor safety and reduce wave action during storms on the beach to reduce beach erosion.
    - Runoff – relocate wet weather stormdrain discharges.

Site-specific Uncertainties and Impediments

Significant uncertainties include:
- Quantitative relationship between different reconfiguration scenarios and likely exceedances of health standards in ankle-to-knee depth water.
- Impact of reconfiguration scenarios on sand loss and channel maintenance.

- Contribution to bacteria densities in ankle-to-knee depth from sand and sediment

Potential Impediments include:
- Reconfiguration project must be conducted jointly with the ACE. ACE support of this project, and their willingness to continue to operate and maintain the harbor channels is essential.
- Time frame of available CBI funds is short relative to time needed to coordinate with the ACE, and to conduct adequate regulatory review of a reconfiguration project.
- Multiple beneficial uses – Some users of the beach fear a clean beach will result in more visitors, traffic, and noise. Reconfiguration project cannot disrupt harbor activities.

Cabrillo Beach

Synopsis of Water Quality Problem

Cabrillo Beach exhibits some of the highest bacteria densities recorded at any enclosed beach, and has a very high exceedance frequency. Unique characteristics of this beach that may affect bacteria densities at ankle-depth include an extensive eelgrass bed parallel to the shoreline of the recreational beach, a significant fraction of fine-grain sediment in beach sands, and a flat beach topography that results in the formation of pools of water on the beach following high tide (in which birds deposit fecal bacteria). These pools contain high bacteria densities and slowly drain and/or infiltrate back into the harbor.

Extensive source investigations of the beach have been conducted and some source mitigation efforts have already been implemented. Landside source investigations led to the discovery and mitigation of faulty sewer and storm drain lines. A partial bird exclusion structure was constructed and past monitoring data shows a measurable reduction in bacteria densities after the structure was erected (although recreational water quality standards are still consistently exceeded). Hydrodynamic modeling enhanced by a comprehensive circulation study, plus offshore monitoring data, indicate offshore sources (such as a nearby sewage outfall and a saltwater marsh) are not contributing to the shoreline problem.

Recommendations

A phased implementation approach comprised of source reduction and enhanced water circulation is recommended. Start with removal of identified sources and follow with circulation enhancement. Following the first two phases, address the large eelgrass beds, which may exacerbate the high bacteria densities along the shoreline through two mechanisms: (i) decreasing shoreline circulation, and (ii) acting as a proximal source of FIB.

1. Removal of sources.
    - Finish sewer close-off (leaking sewers, old infrastructure).
    - Repair and extend bird exclusions.
    - Control feral cat population in nearby breakwater.
    - Modify beach topography to increase slope and eliminate high-tide pools.
    - Pilot project on sand removal and replacement: replace fine-grain material with coarse grain sand.
2. Circulation enhancement
    - Pilot deployment of infusion pump to evaluate impact of very nearshore, shallow water circulation enhancement on FIB densities in the water column.
    - Feasibility study. If enhanced circulation proves effective, conduct feasibility study to determine whether a passive approach to water circulation is possible through a change in beach topography, a change in beach shape (elimination of hard corners), a change in orientation of beach to wind, or reconfiguring beach and the jetty. Alternatively develop an active approach such as pumps to enhance circulation.
3. Eelgrass beds
    - Consider modification or removal of eelgrass beds

Site-specific Uncertainties and Impediments

Significant uncertainties include:

- The optimal method for improving water circulation in the ankle-depth water.
- Relationship between ankle-depth bacteria densities and increased circulation.
- Effects of eelgrass bed reduction to shoreline FIB densities.
- Contribution of the fine-grain portion of the beach sand to water column bacteria densities.

Potential impediments include:

- Multiple beneficial uses – benefits of existing habitat (eelgrass) and harbor uses (configurations that may lead to poor circulation) may restrict the types of solutions acceptable to other stakeholders.
- Large number of stakeholders may require more time in the project to allow adequate input.
- Time frame of available CBI funding is shorter than time required to test circulation improvement methods and to construct the optimal circulation project. In particular, passive circulation improvement is preferred and

would likely require reconfiguration of the beach face, boat launch and jetty.

- Involvement of multiple agencies with overlapping jurisdictions and responsibilities could slow the project.

Campbell Cove

Synopsis of Water Quality Problem

Campbell Cove State Beach is a 0.2 mile-long beach area within the Sonoma Coast State Beach. It is protected from the rough northern surf and typically has water temperature 10 degrees warmer than open coastal waters. About 75,000 people visit the beach annually. Routine monitoring started in 1999 and has revealed a regular seasonal fluctuation with elevated bacteria densities of all three types of indicator bacteria (enterococcus, fecal and total coliform) occurring August through November. Preliminary sanitary surveys failed to determine the source of the seasonal elevated levels of bacteria. Subsequent CBI funded activities have included a tidal circulation study, fecal bacteria source identification, and a source abatement project. Despite these efforts, the source(s) of pollution have not been identified, however, the studies provide findings that further characterize the problem. The circulation study showed that the source of the bacteria is mostly likely coming from onshore or from nearby tidal flats, both of which have large shorebird populations. Offshore sources are not likely. Dye released near the shore tended to remain close to the shoreline, dispersing alongshore, but not offshore. A bacteria source at or near the shoreline could cause elevated levels of bacteria to persist in the boundary layer for longer than one tidal cycle. Sediment sampling indicates elevated bacteria in sediment underlying knee-deep water, in the creek discharging to the ocean, and around the discharge point.

Recommendations for Campbell Cove

A three-pronged approach is recommended:

1. Investigate whether further bacterial source typing may provide more conclusive data on the dominant source of bacteria:
    - o Verify accuracy of ribotyping work completed to date.
    - o Investigate whether speciation of enterococci strains would help identify specific types of birds and marine mammals
    - o Consider temporarily eliminated potential sources (e.g., birds) and measure the response in the system

2. Investigate seasonality of bacteria densities in the sand, sediment and eelgrass:

- Enlarge existing transects to include comprehensive eelgrass bed sampling
- From May to October sample:
    - Biomass of eelgrass
    - Organic matter in sediment
    - Detritus matter
    - Temperature
    - Nutrients
    - Bacteria densities

3. Encourage and/or collaborate in investigations of human health risks associated with FIB densities in natural systems.

Site-specific Uncertainties and Impediments for Campbell Cove

Significant uncertainties include:

- Is significant human health risk associated with elevated FIB in the natural system of Campbell Cove given few potential human sources of FIB.
- The ecological impacts of removing natural sources such as eelgrass beds or birds on the beach are unknown.
- Uncertainty associated with the analytical method used to measure total coliform. This method may provide false positives under certain conditions.
- The ecological impacts of increased nearshore circulation is unknown, particularly impacts on the eelgrass.

Potential impediments include:

- Multiple beneficial uses must be considered. Elimination of birds and marine mammals may not be desirable. Stakeholders may have opposing views on which resources are more important to protect.
- CBI funding timeline much shorter than the time necessary to adequately assess the seasonal fluctuation of bacteria densities observed at Campbell Cove.

APPENDIX F

Speaker Biographies

DAVID G. CANNON, M.C.E., P.E.
David Cannon grew up in Delaware attending college at the University of Delaware where he earned both a Bachelor's of Science in Civil Engineering as well as a Master's of Civil Engineering with a concentration in coastal engineering and coastal processes. After completing his coursework in 1988, David moved to Long Beach, California and took a job with an engineering consulting company where he specialized in the planning and design of coastal projects. After five years, David took a job with a biological consulting firm where he served as manager for biological monitoring and habitat restoration projects. In 1997, he left the biological consulting firm to return to the engineering profession where he focuses on shoreline protection, habitat restoration, and water quality improvement projects. David is currently the president and a principal engineer of Everest International Consultants, Inc., which is a small, engineering consulting company located in Long Beach, California.

JOE CHESLER, M.A.
Mr. Chesler currently serves as Chief of Planning for the County of Los Angeles Department of Beaches & Harbors, providing management and planning oversight for public beach and marina facilities along 31 miles of public beach and waterfront area in the County, including Marina del Rey. Prior to his arrival in 2000, Mr. Chesler was employed as Environmental Compliance Manager for The Walt Disney Company and Walt Disney Imagineering from 1990 to 2000, where he provided environmental compliance oversight and technical advice for worldwide Disney operations and served as project manager on various special research and design projects. He also served as Manager of Master Planning for the Port of Long Beach from 1978 to 1989. Mr. Chesler holds a Masters in Urban and Regional Planning and a B.S. in Park Administration, with significant course work in landscape architecture. He and his wife have resided in Long Beach since 1977.

DONNA FERGUSON, M.S.
Donna Ferguson is a Supervising Microbiologist for the Water Quality Department of the Orange County Public Health Laboratory in Newport Beach, California. She received her B.S. in Microbiology from California State University Long Beach and M.S. in Epidemiology from UCLA. She has worked as a microbiologist for 12 years in the Public Health (PH) field and for 7 years conducting research at Metropolitan Water District (MWD) of Southern California. As a senior PH microbiologist, she specialized in Parasitology. At MWD she worked on developing Cryptosporidium, Giardia and Microsporidium detection/infectivity methods using cell culture and in situ hybrization methods, participated in EPA methods 1622 and 1623 validation studies, conducted waterborne pathogen monitoring and watershed protection studies. Currently, she supervises the Water Quality Laboratory and is working on characterizing enterococci to the species and strain level to gain a better understanding on the ecology and source of these organisms to the marine environment.

KIM GARVEY, M.S.
Kimberly (Kim) Garvey is a coastal scientist at Moffatt & Nichol. Since joining Moffatt & Nichol in 2003, Ms. Garvey has worked on a variety of coastal projects involving coastal impact studies, beach nourishment, wetlands restoration, port development, and water quality. Prior to joining Moffatt & Nichol, Ms. Garvey was an Engineering Director at Boeing, where she managed several large, technically complex projects. Ms. Garvey has a B.S. in Mechanical Engineering from University of California, Santa Barbara, an M.S. in Aerospace Engineering from Purdue University, and has completed several coastal engineering courses at Old Dominion University and California State University of Long Beach.

VINCENT GIN, P.E.
Vincent Gin is a Senior Civil Engineer with the County of Orange, Watershed & Coastal Resources Division. He received his B.S. in Civil Engineering from the University of California, Irvine and has 15 years of experience in engineering and project management.

MARK GOLD, D.Env.
Mark has been the Executive Director of the environmental group, Heal the Bay, for eleven years. Heal the Bay is an environmental group dedicated to making Santa Monica Bay and Southern California coastal waters safe and healthy again for people and marine life. Mark received his Bachelors and Masters in Biology and his doctorate in Environmental Science and Engineering from UCLA. He was recently inducted into the UCLA School of Public Health Hall of Fame. Mark has worked extensively over the last 17 years in the field of coastal protection and water pollution. In particular he has worked on research projects on urban runoff pollution, DDT and PCB contamination in fish, and the health risks of swimming at runoff contaminated beaches. He created Heal the Bay's Beach Report Card. Mark has authored or co-authored numerous California coastal protection, water quality and environmental education bills. He served on the USEPA Urban Stormwater Federal Advisory Committee. Currently, Mark is a vice chair of the National Estuary Program's Santa Monica Bay Restoration Commission, and he sits on numerous other environmental and water quality boards and task forces including the California Ocean Science Trust.

PATRICK KINNEY, Ph.D.
Patrick Kinney holds his Ph.D. in Chemical Engineering and a Post-Doctorate in Oceanography/Marine Sciences at the Scripps Institution of Oceanography where he conducted research with the Food Chain Research Group working on organic carbon flux to deep ocean food chains. He served as a tenured faculty member in Marine Sciences at the University of Alaska where he taught graduate programs in hydrodynamics, and physical and chemical oceanography. He also conducted interdisciplinary coastal oceanographic and habitat studies that formed a basis for determining impacts of coastal developments. For the last 35 years, Dr. Kinney has been a Principal of Kinnetic Laboratories, Inc., an environmental science consulting firm with operations on the west coast and in

Alaska. He has specialized in scientific studies necessary to solve environmental problems. This work has included coastal/estuarine habitat and contaminant studies, several hundred sediment quality studies, and over 20 major urban watershed and storm water monitoring studies. Specifically he has also carried out bacterial investigations on numerous storm water programs, including a two-year study of bacterial contamination in San Diego Bay, Cowells Beach/Neary Lagoon in Santa Cruz, Marina Beach in Marina del Rey, and Inner Cabrillo Beach in San Pedro.

RUTH KOLB

Ruth Kolb is a Biologist III – Storm Water Specialist for the City of San Diego. She is the Monitoring Section Supervisor. Ms. Kolb has 23 years of experience in the environmental field with projects ranging from land development oversight in Texas, to pesticides, air quality and water quality projects. Currently, she oversees Municipal Storm Water Permit monitoring, Total Maximum Daily Load coordination, contaminated sediment oversight, grants, beach posting reduction program, Areas of Special Biological Significance, and other special projects as needed.

JEFF LEWIN

Jeff Lewin is a Registered Environmental Health Specialist and worked for the City of Long Beach Public Health Department for 8 years. For the past 26 years he has worked for the County of Sonoma Department of Health Services and is now the Environmental Health Program Manager of the Waste Management and Water Quality Programs for the County of Sonoma.

JOHN LARGIER, Ph.D.

John Largier has over 20 years experience in coastal oceanography in the USA and South Africa. He is a professor at UC Davis, resident at the Bodega Marine Laboratory, where he works on developing an “environmental oceanography” perspective, linking oceanography to environmental issues. Largier’s specific expertise is in the movement of water in coastal (nearshore, bay, estuary) environments and the importance of this to ecological and environmental systems. His work pertains to issues as diverse as marine reserves, fisheries, mariculture, coastal water quality, wastewater discharge, desalination, land runoff, kelp forests, wetlands, marine mining, dredging, coastal zone management and the impacts of coastal development. In addition to research and teaching, Largier maintains an active dialogue that extends well beyond academia, such as serving on the state Clean Beach Task Force. He is an Aldo Leopold Leadership Fellow, in recognition of his role in linking science with society. Dr Largier obtained his PhD from the University of Cape Town (South Africa) in 1987.

JOHN NORTON, P.E.

John Norton is Chief of the Office of Statewide Initiatives at the State Water Resources Control Board. The mission of the Office is to develop methods to coordinate State and Regional Board activities to achieve measurable environmental results and to improve internal operations. A major focus is to assure implementation of the State and Regional Boards' Strategic Plan. The Strategic Plan charts a new course for the Boards to achieve significant results in the face of expanding population pressures and limited funding.Mr. Norton has over 25 years experience in water quality control and 10 years of experience in the private sector. Immediately prior to his assignment to the new Office, Mr. Norton was Chief of the Compliance Assurance and Enforcement Unit. Mr. Norton has also served as acting Executive Officer at the Los Angeles Regional Water Quality Control Board and the San Diego Regional Water Quality Control Board. Mr. Norton is a registered professional engineer and received his Bachelor of Science degree from the University of California at Davis.

LISA MARIE KAY

Ms. Kay has over 20 years of experience in water quality assessments relating to the Clean Water Act, primarily involving project development, study design, project management, and quality assurance oversight. She assists her municipal clients in NPDES compliance; TMDL studies, watershed management planning, and the development of grant funded projects. She co-designed the NPDES storm water monitoring program for the 22 municipal copermittees in San Diego County. She has been managing the implementation of this urban runoff program since 2000. She assisted the City of San Diego with numerous grant proposals and project studies, including both the Mission Bay Source Identification Study and the San Diego River/Dog Beach Water Quality Improvement Project. For both Prop. 13 and CBI grants, she assisted the City in writing the grant applications. Subsequently, she led the study designs and led the Weston technical teams implementing both studies. Lisa is the Water Resource Practice Leader for Weston Solutions, Inc. leading teams in the Carlsbad and Los Angeles offices of Weston.

YING POON, Ph.D.

Dr. Poon is a Vice President and Principal Engineer of Everest International Consultants, Inc., located at the City of Long Beach. He is a registered Professional Engineer in California and has over fifteen years of experience in coastal engineering, wetland design, hydraulic and hydrology studies, as well as water quality improvement studies. In the last couple of years, he has worked on several Clean Beach Initiative (CBI) projects in Ventura County, City of Newport Beach and Dana Point Harbor, seeking solutions to improve beach water quality at these locations. His presentation today is based on his experience on these CBI projects. Dr. Poon has a Master of Science Degree in Water Resources and Environmental Engineering from the State University of New York, Buffalo, and a Doctor of Science Degree in Hydrodynamics and Coastal Engineering from MIT. He enjoys teaching, in the last few years, he has taught classes in the area of Hydrology, Watershed Management, Hydraulic Design and Coastal Engineering at the University of California, Irvine, and California State University, Long Beach.

LINDA RASMUSSEN, Ph.D.
Linda (Raz) Rasmussen came to Scripps Institution of Oceanography, UCSD, as Postdoctoral Researcher in 2003 after receiving her Ph.D. from the MIT-Woods Hole Oceanographic Institution Joint Program. Her work focuses on modeling and observations of circulation in inner coastal waters to address both environmental and ecological issues, such as the transport and dispersion of pollutants, marine larvae, nutrients and phytoplankton.

BOB STEIN, M.S., P.E.
Bob Stein has been designing civil engineering projects for 25 years in the public and private sectors. As a principal civil engineer for the City of Newport Beach Public Works Department, he manages the Newport Coast Watershed Program which includes protecting and renovating the City's coastal canyons and sensitive marine life areas. Important current projects include the Morning Canyon Stabilization Project, Buck Gully Erosion Control Project, Newport Coast Flow and Water Quality Assessment and Newport Coast Groundwater Seepage Study. He also provides support to Dave Kiff, Assistant City Manager, in promoting the City's water quality program for Newport Bay. He is a registered civil engineer and has a Masters of Science from the UCI School of Civil Engineering where he is currently a struggling student in the doctoral program. In his spare time he writes grant proposals.

MITZY TAGGART, D.Env.
Dr. Mitzy Taggart is a staff scientist with Heal the Bay, a non-profit organization with more than 10,000 members dedicated to improving water quality in Southern California. For the past 7 years, Mitzy has advocated at local and national levels to improve water quality, monitoring, and public notification at marine beaches. Her doctoral research investigated the transport of bacteria indicators in the surf zone from urban runoff discharge. Mitzy also works on TMDL's, structural BMP implementation, and contaminated sediments. Prior to joining Heal the Bay, Mitzy worked as an environmental engineer in consulting and private industry for 8 years. She holds a B.S. in Fluid and Thermal Engineering from Case Western Reserve University, an M.S. in Environmental Engineering from The University of Southern California, and a Doctorate from UCLA's Environmental Science and Engineering program.

STEPHEN B. WEISBERG, Ph.D.
Dr. Stephen Weisberg is Executive Director of the Southern California Coastal Water Research Project (SCCWRP) where he specializes in the design and implementation of environmental monitoring programs. He serves as chair of the Southern California Bight Regional Monitoring Steering Committee, which is responsible for developing integrated regional coastal monitoring for the Southern California Bight. He also serves on the Steering Committee for the US Global Ocean Observing System (GOOS), the National Oceanographic Partnership Program's Ocean Research Advisory Panel, the Alliance for Coastal

Technology Stakeholder’s Council, the State of California’s Clean Beaches Task Force and on Technical Advisory Committees for the University of Southern California Sea Grant Program and the Southern California Wetlands Recovery Program. Dr. Weisberg received his undergraduate degree from the University of Michigan and his Ph.D. from the University of Delaware.

RICHARD WHITMAN, Ph.D.
Richard Whitman is the Chief of the Lake Michigan Ecological Research Station, Biological Resources Division, U.S. Geological Survey in Porter, Indiana. Dr. Whitman received a Ph.D. from Texas A&M University in 1979 in Wildlife and Fisheries Sciences. He went on to teach at Indiana University NW for 10 years as Associate Professor of Biology. His research interests focuses on non-point sources and background levels of E. coli. Currently, he is studying the sources and occurrence of bacteria contamination in sands and waters of Lake Michigan and coastal streams. Dr. Whitman is active in modeling E. coli occurrence locally and regionally in the Lake Michigan area. He has authored numerous national and international articles and reports on beach water quality. He is past president of the Great Lakes Beach Association.