

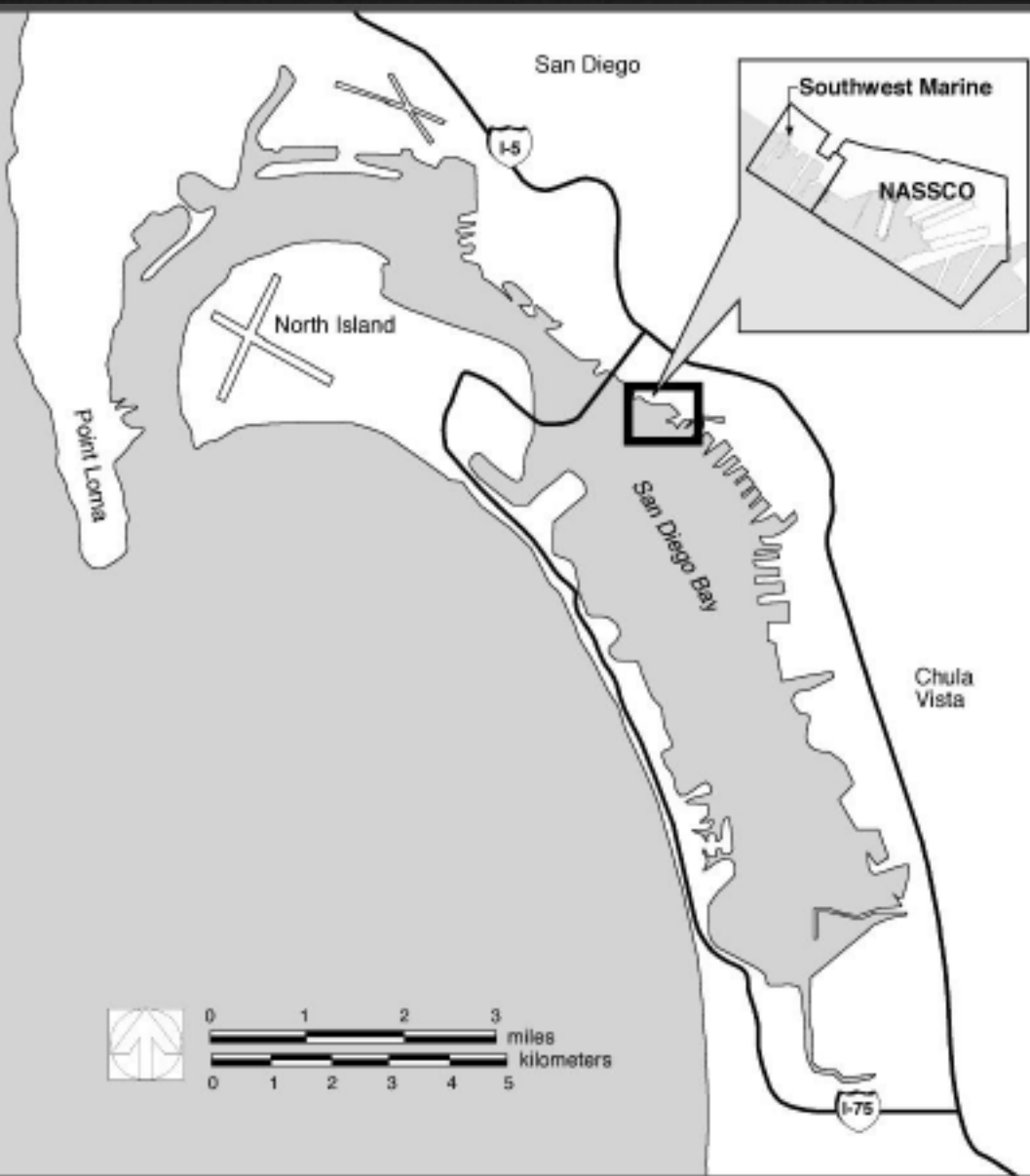


NASSCO and Southwest Marine Sediment Investigation Preliminary Results

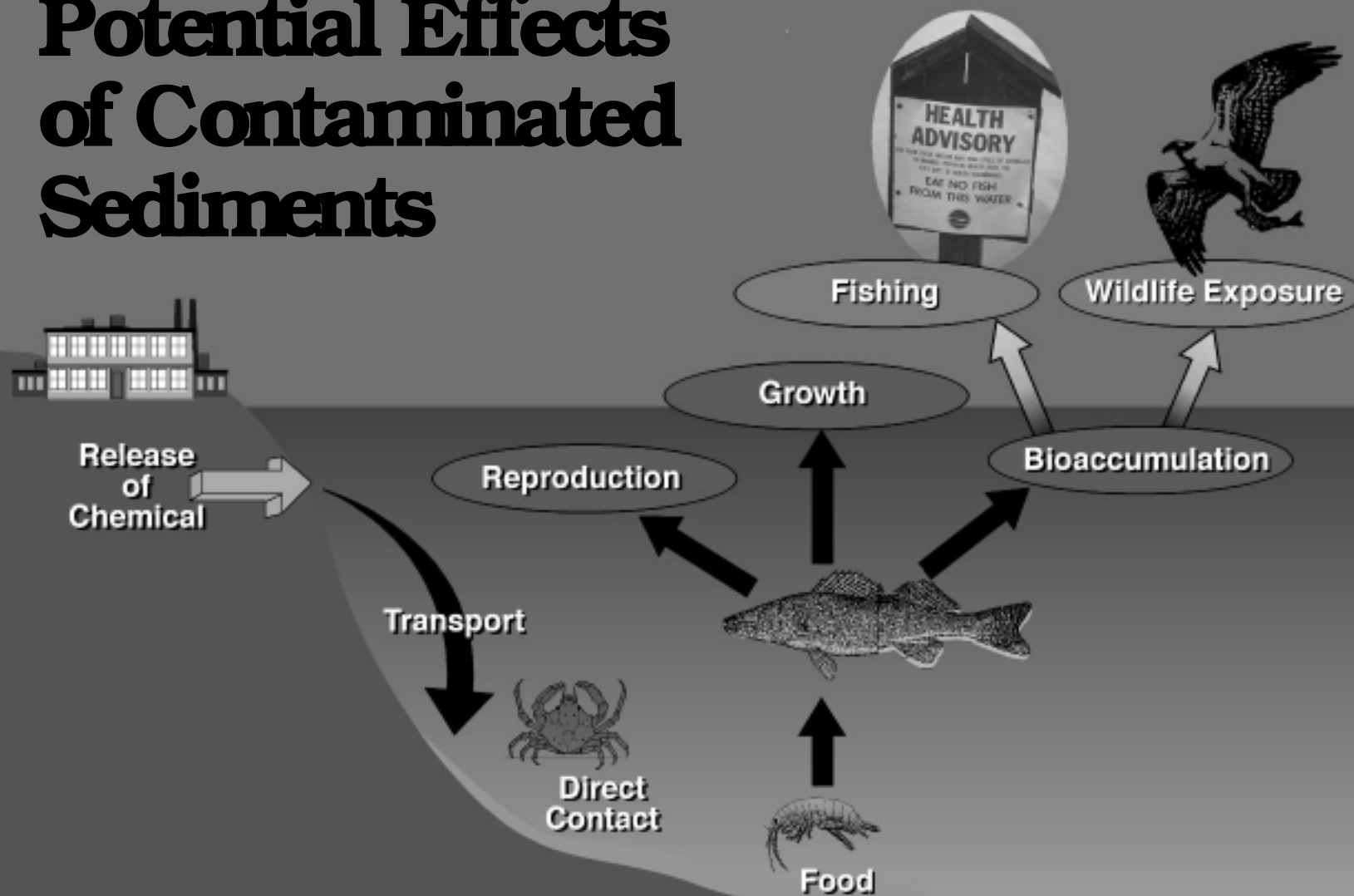
**Thomas Ginn, Ph.D.
Dreas Nielsen**

June 18, 2002

Site Location



Potential Effects of Contaminated Sediments



Study Goals

Develop cleanup levels that are protective of:

- **Aquatic life**
- **Aquatic-dependent wildlife**
- **Human health**

Study Components

Standard assessment methods used to conduct:

- **Sediment chemistry analyses**
- **Toxicity tests**
- **Bioaccumulation tests**
- **Sediment profile image analysis**
- **Benthic community analysis**
- **Fish histopathology**
- **Bioaccumulation by resident biota**
- **Ecological risk assessment**
- **Human health risk assessment**
- **Technological feasibility analysis**
- **Economic feasibility analysis**

Study Overview

ACTIVITY

Design Sediment Investigation

Conduct Surface Sediment Sampling (Phase 1)

- Sediment profile imaging
- Sediment chemistry
- Toxicity testing
- Benthic infauna
- Laboratory bioaccumulation testing

Evaluate Phase 1 Data

- Determine indicator chemicals
- Assess need for field sampling of fish and shellfish tissue
- Refine Phase 2 study design

Conduct Subsurface Sediment and Supplemental Tissue Sampling (Phase 2)

- Sediment cores
- Pore water
- Tissue sampling
- Fish histopathology
- Eelgrass sampling

Develop Cleanup Levels

- Background
- Protect aquatic life
- Protect human health
- Protect wildlife

Delineate Area of Concern, Cleanup Volumes

Identify Candidate Cleanup and Remedial Alternative

Conduct Economic and Feasibility Analysis

Recommend Cleanup and Remedial Alternative

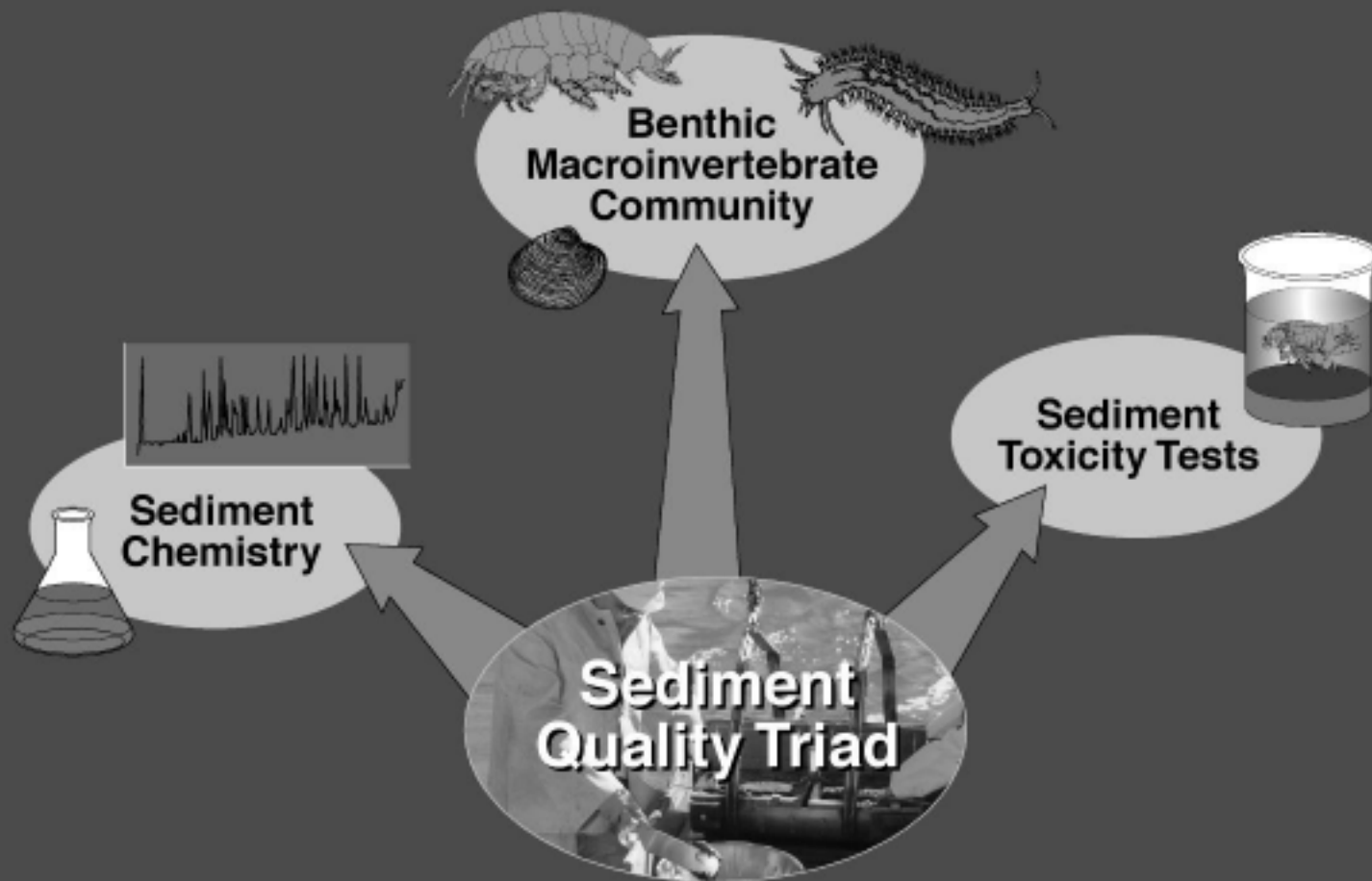
Phase 1 Study Design

- **Sediment profile images**
 - 101 shipyard stations
 - 5 reference stations
- **Sediment triad study**
 - Chemistry, toxicity, and benthic community analysis
 - 30 shipyard stations
 - 5 reference stations
- **Supplemental sediment chemistry**
- **Bioaccumulation tests**
 - 9 shipyard stations
 - 5 reference stations

Phase 1 Target Chemicals

- **Metals (10)**
- **Acid-volatile sulfide and simultaneously extractable metals**
- **Tributyltin**
- **Polychlorinated biphenyls**
 - Aroclor® mixtures (8)
 - Congeners (41)
- **Polychlorinated terphenyls (3)**
- **Polycyclic aromatic hydrocarbons (17)**
- **Petroleum hydrocarbons**

Sediment Quality Triad



Phase 1 Toxicity Tests

- **Amphipod survival**
- **Echinoderm fertilization**
- **Bivalve larval development**

Phase 1 Sampling Locations

- **Shipyards stations**
 - Based on previous shipyard data
 - Range of concentrations
 - Located throughout shipyards
- **Reference stations**
 - Recommended by SCCWRP and Board staff based on Bight '98 data
 - Data demonstrate low toxicity, low chemical concentrations, and healthy benthic communities

Phase 1 Sediment Stations

Southwest Marine
Shipyard

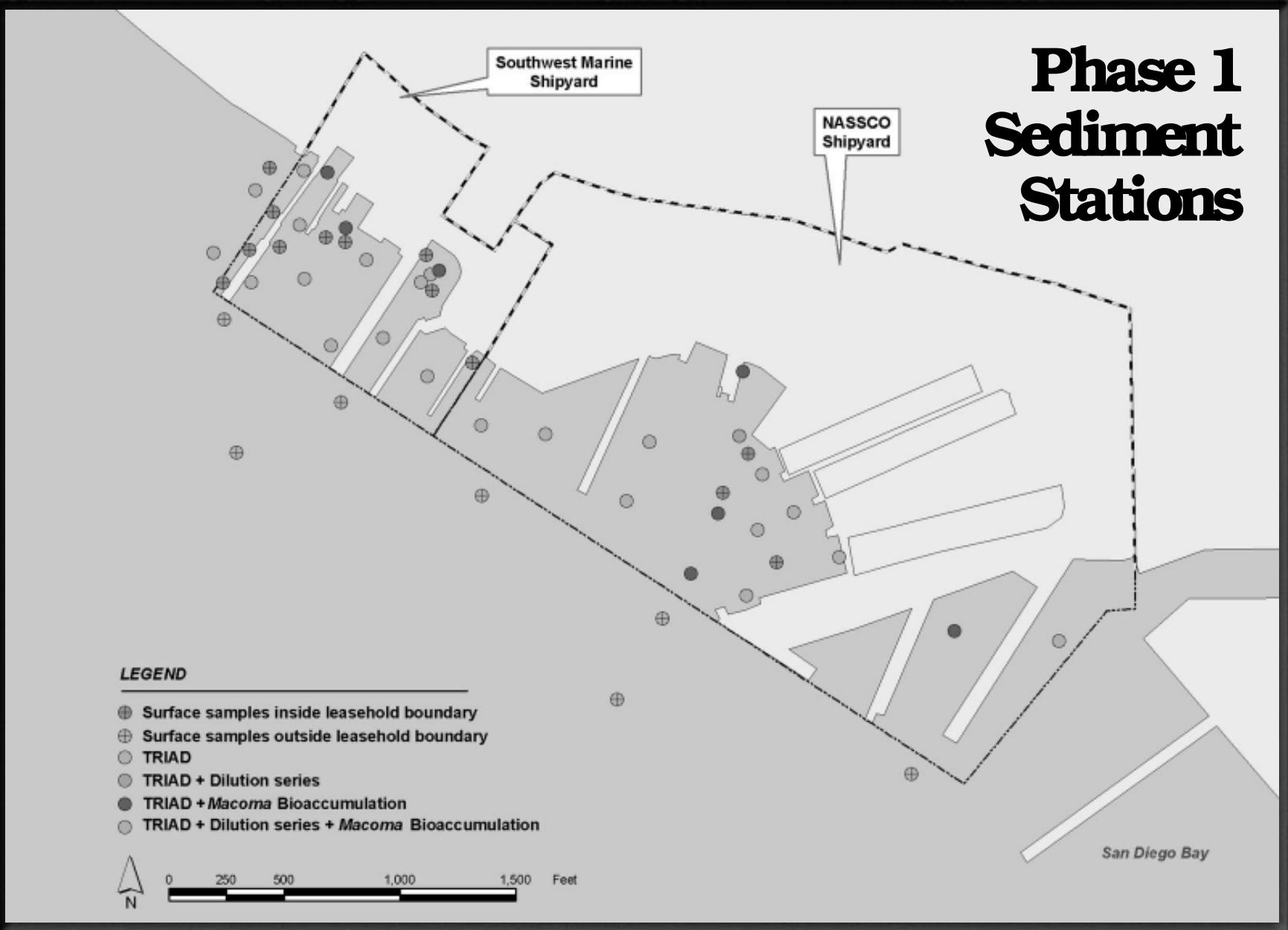
NASSCO
Shipyard

LEGEND

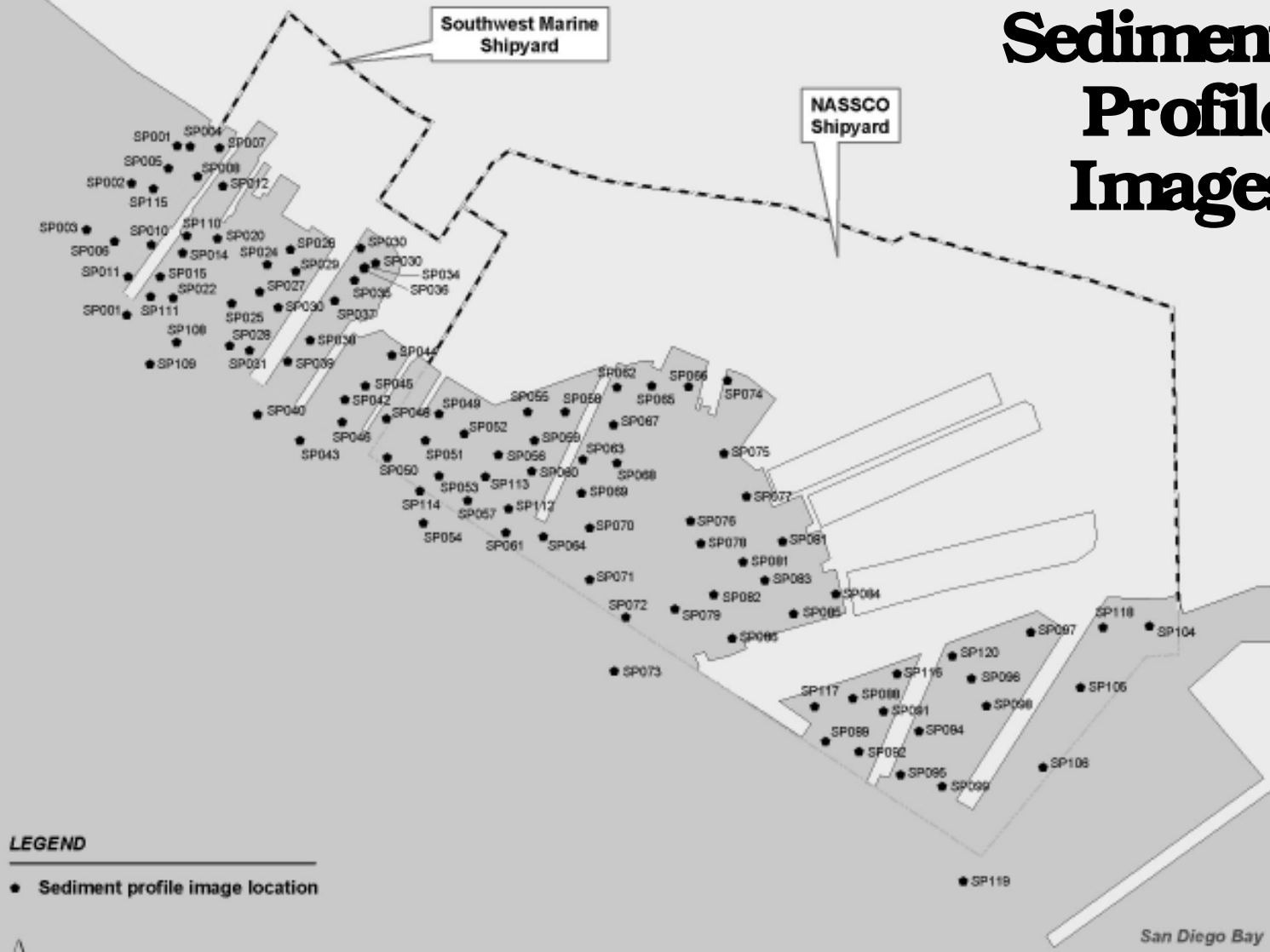
- ⊕ Surface samples inside leasehold boundary
- ⊕ Surface samples outside leasehold boundary
- TRIAD
- TRIAD + Dilution series
- TRIAD + *Macoma* Bioaccumulation
- TRIAD + Dilution series + *Macoma* Bioaccumulation



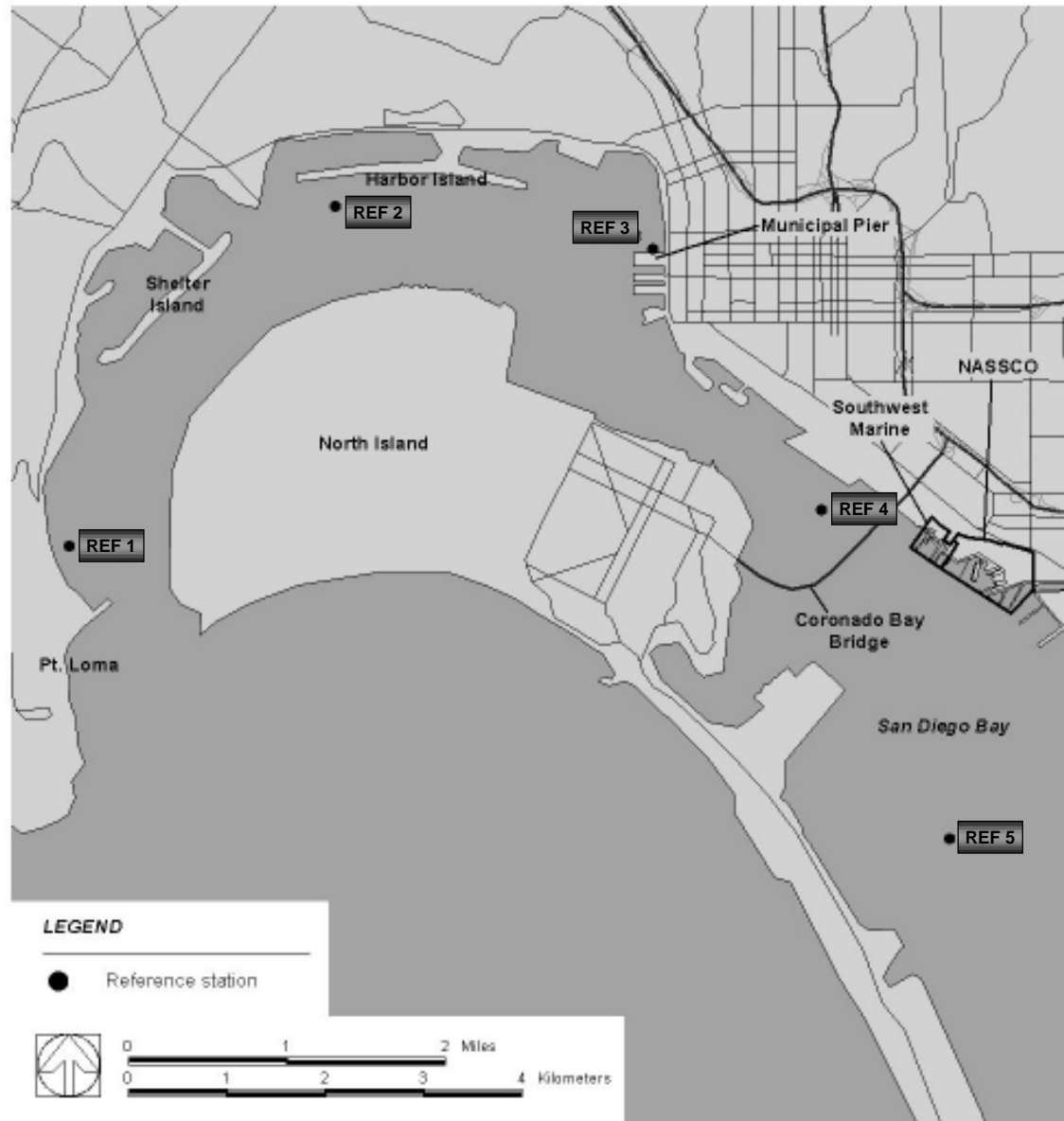
San Diego Bay



Sediment Profile Images



Reference Station Locations



Phase 1 Samples

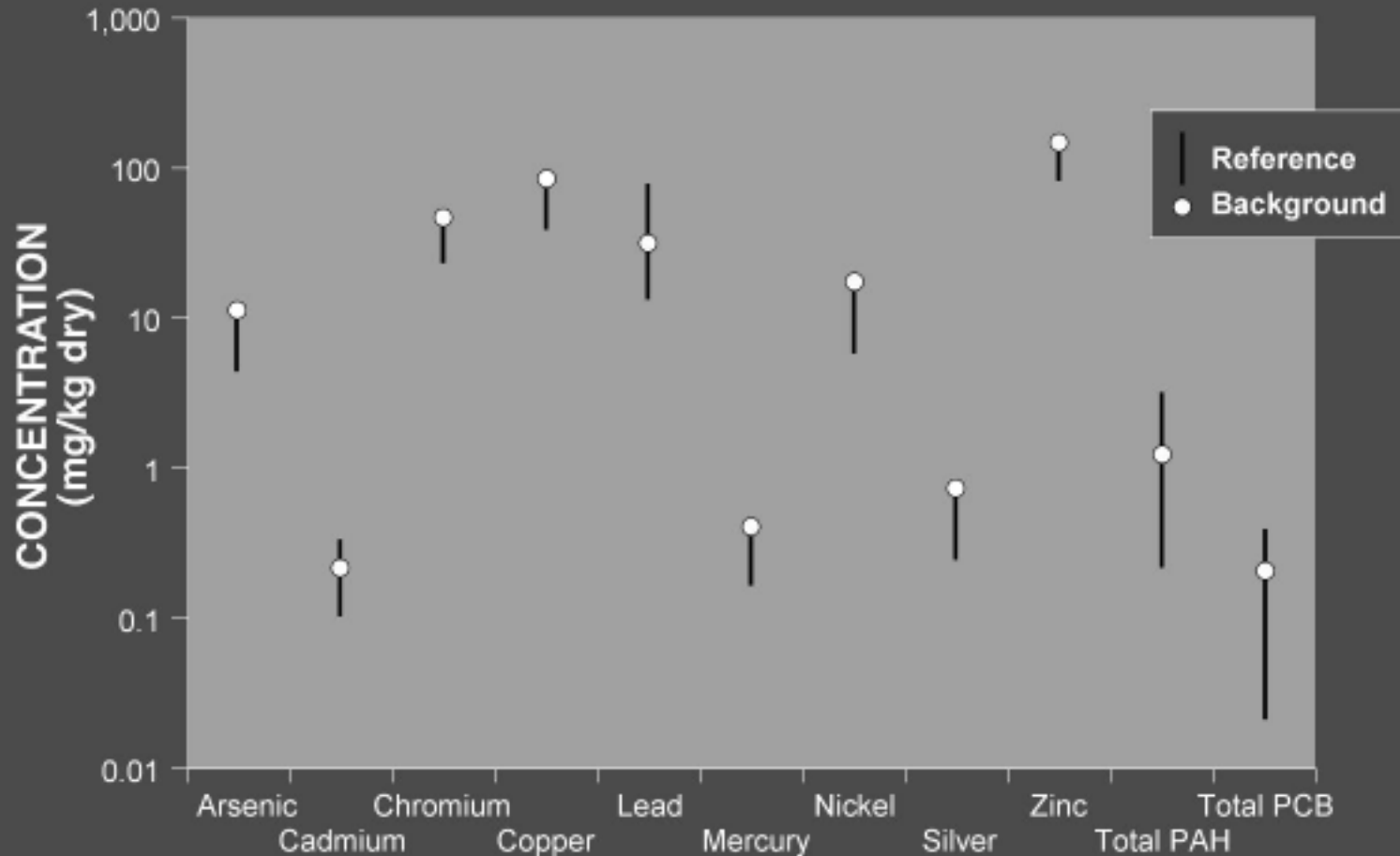
Type of sample	Shipyard stations	Reference stations	Replicates	Samples
Sediment profile image	101	5	3*	325
Sediment chemistry	49	5	1	54
Amphipod toxicity test	30	5	5	175
Echinoderm toxicity test	30	5	5	175
Bivalve toxicity test	30	5	5	175
Bioaccumulation test	9	5	5	70
Benthic community	30	5	5	175
Total				1,149

*Target number

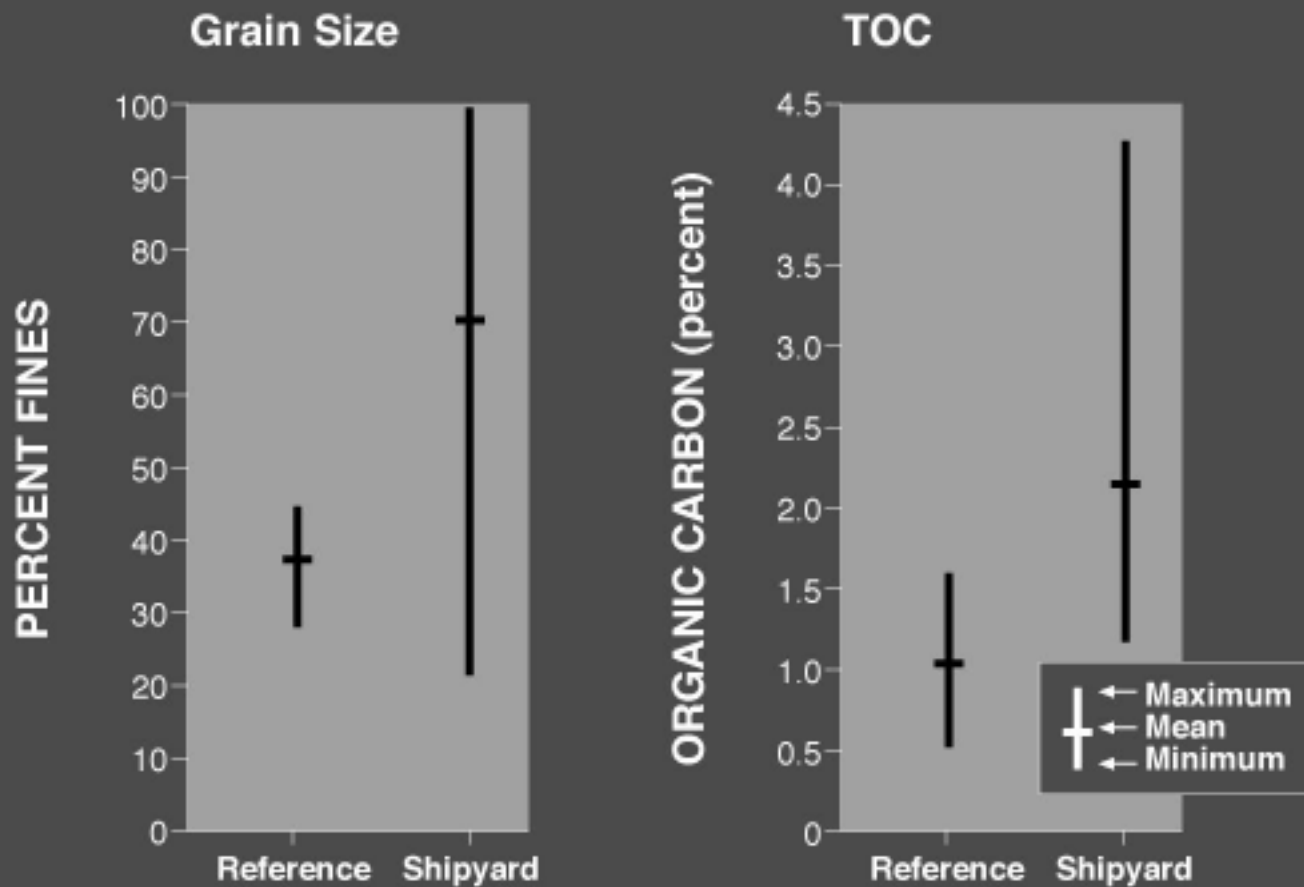
Phase 1 Results

- **Sediment chemistry**
- **Amphipod survival test**
- **Echinoderm fertilization test**
- **Bivalve larva development test**
- **Bioaccumulation test**
- **Benthic macroinvertebrate community**

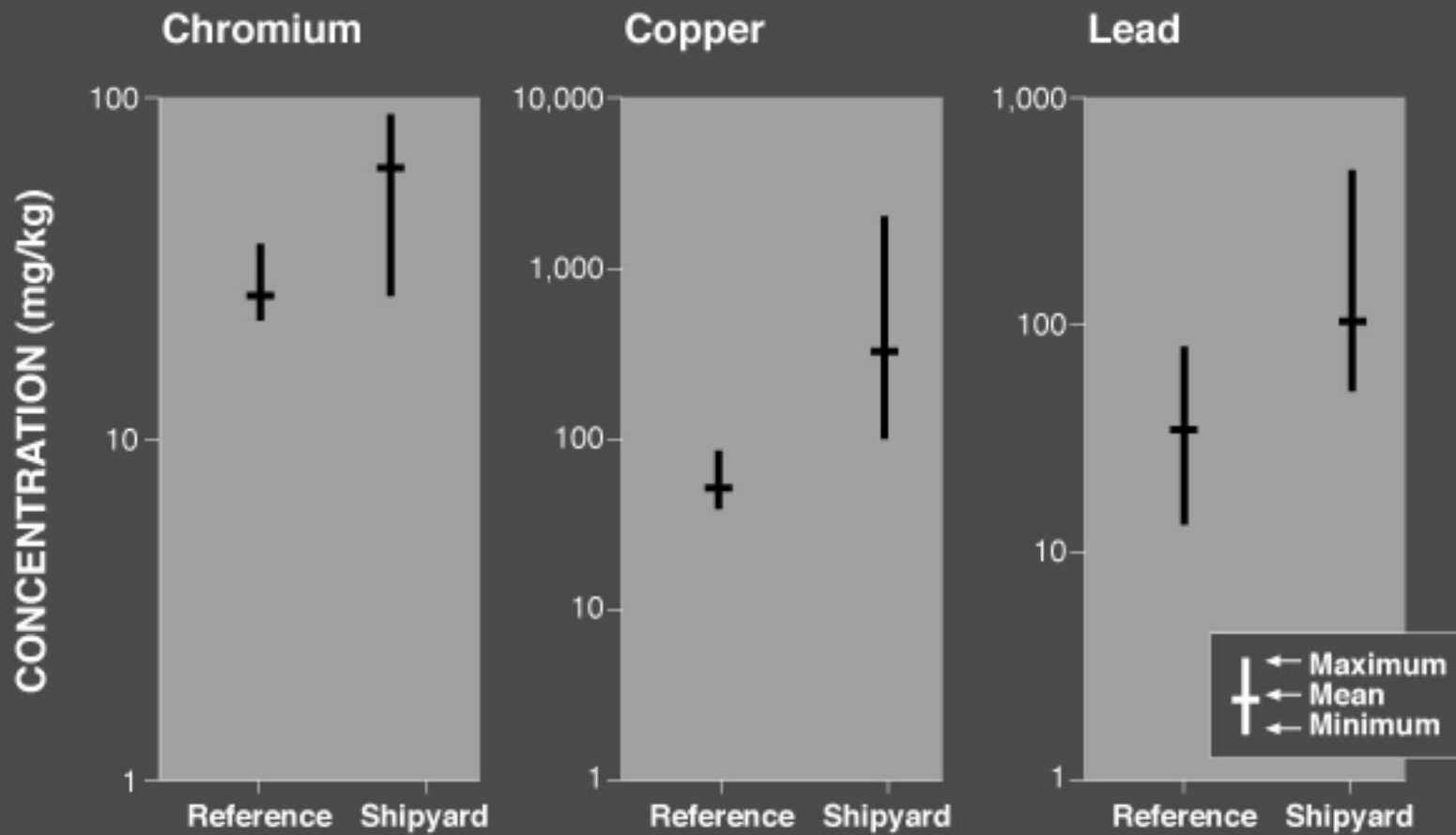
Sediment Chemistry: Phase 1 Reference Stations and Background (Robertus 2002)



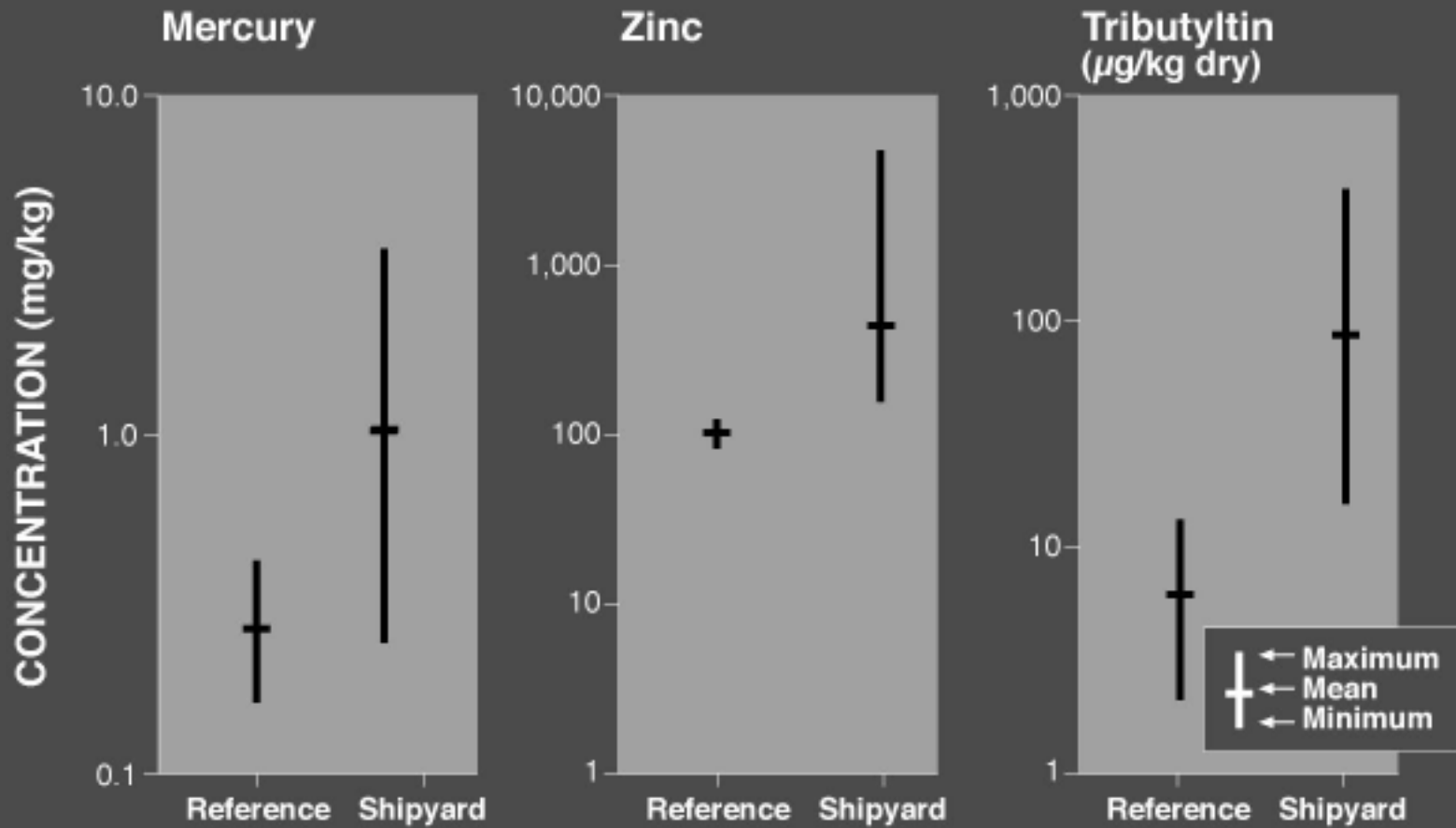
Sediment Data



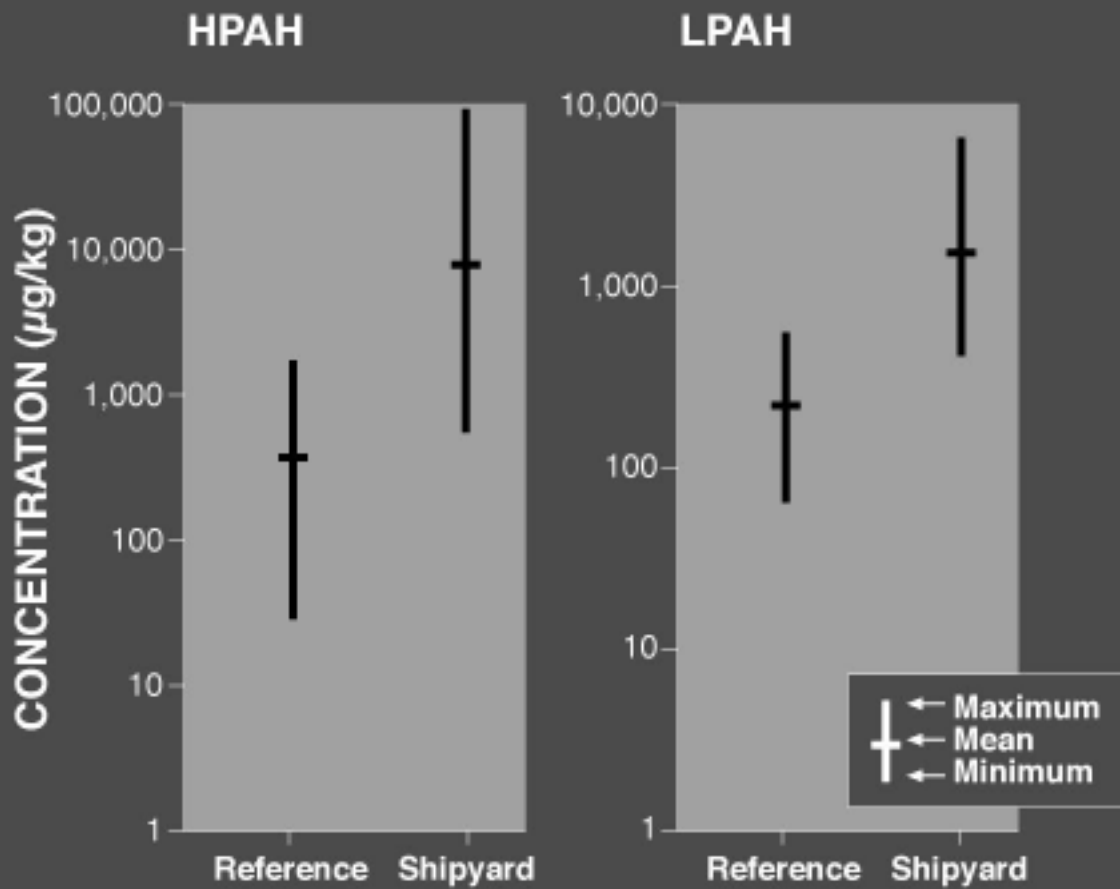
Sediment Concentrations *(continued)*



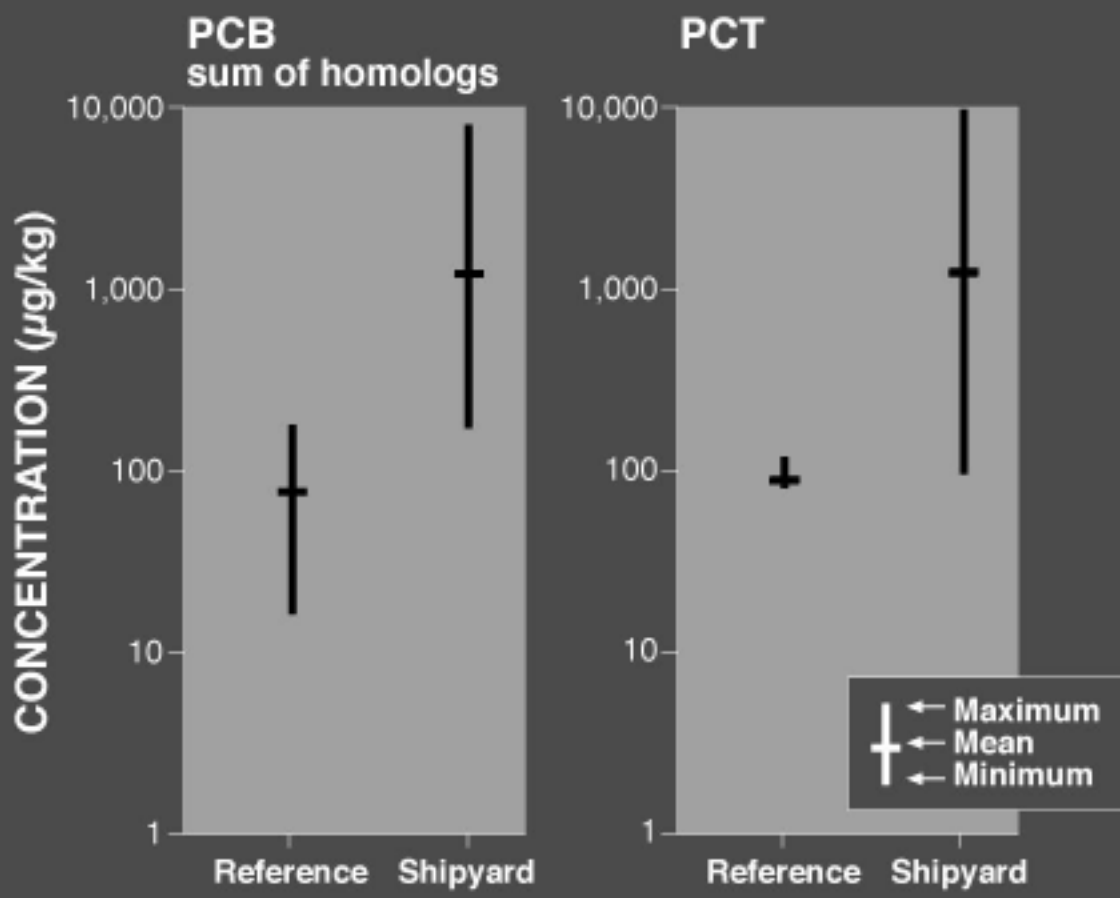
Sediment Concentrations *(continued)*



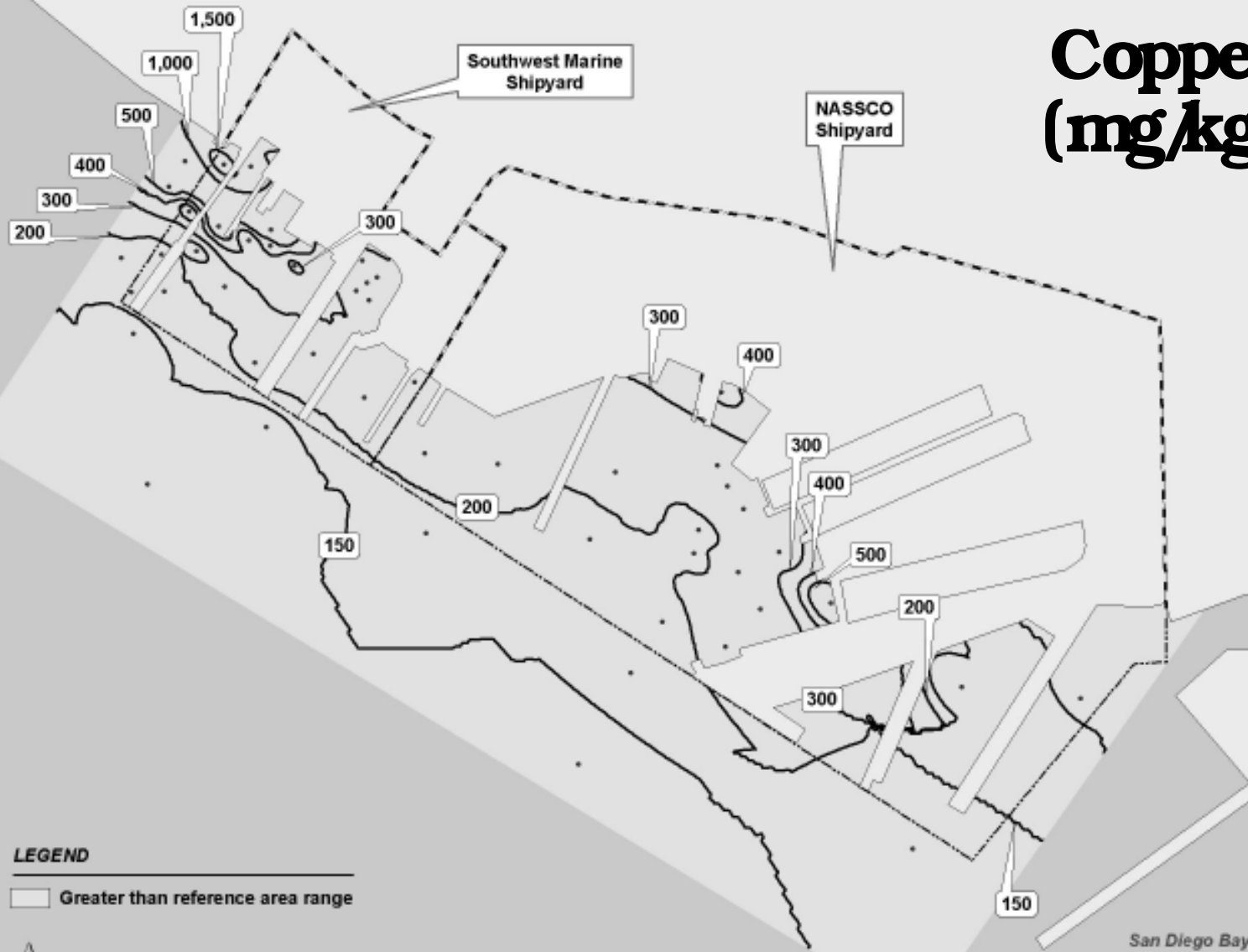
Sediment Concentrations *(continued)*



Sediment Concentrations *(continued)*



Copper (mg/kg)

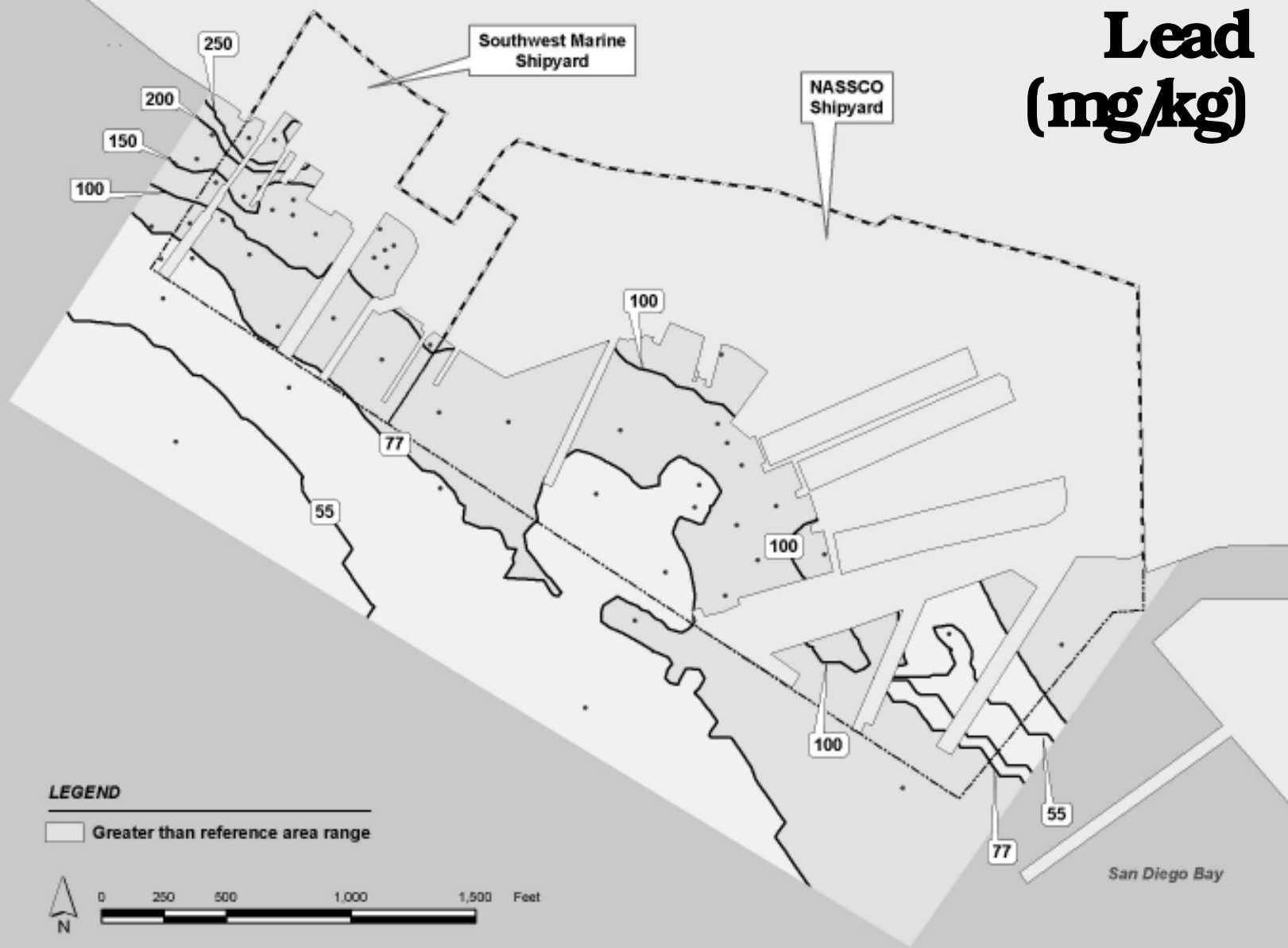


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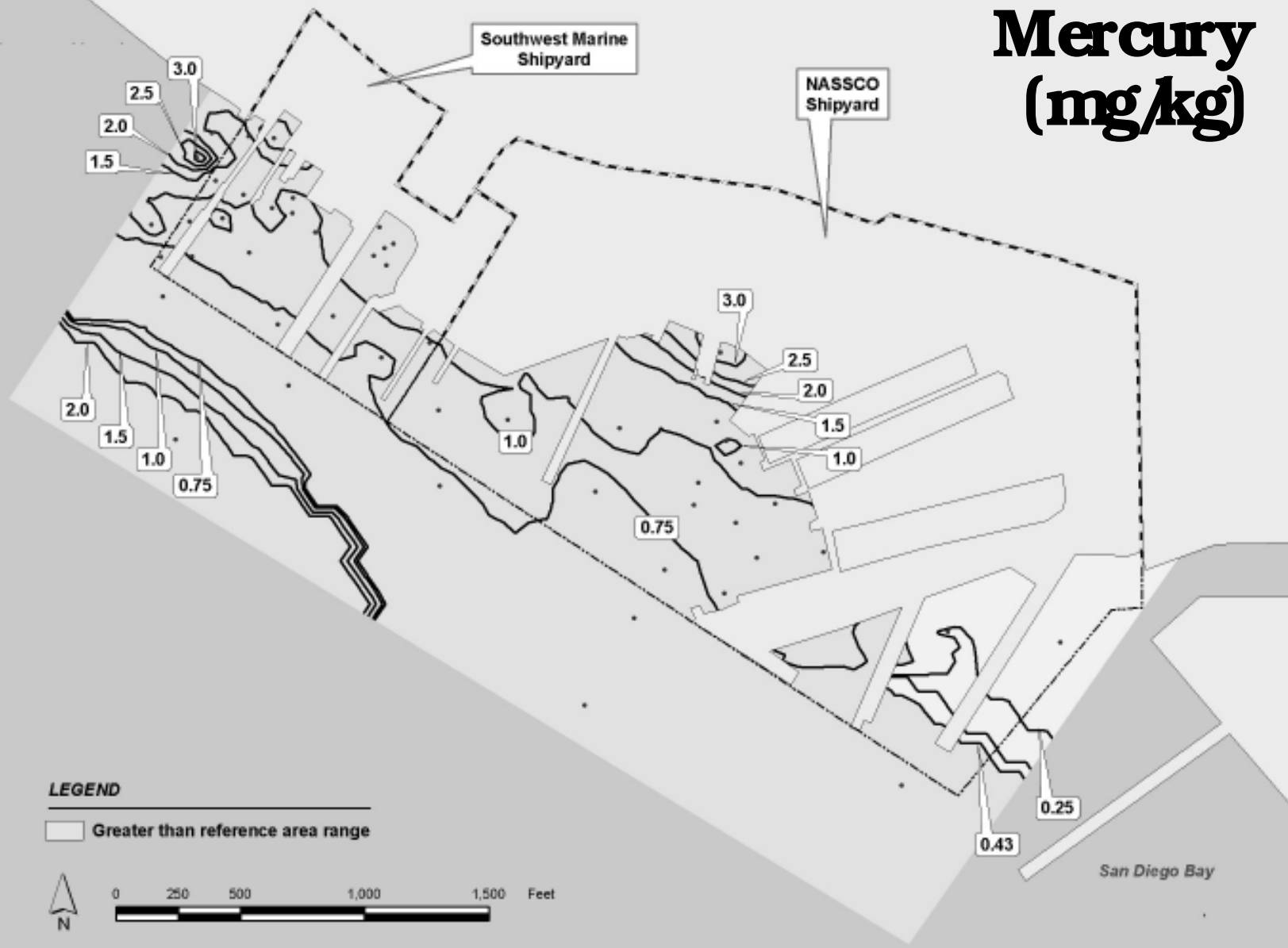
Greater than reference area range



Lead (mg/kg)



Mercury (mg/kg)



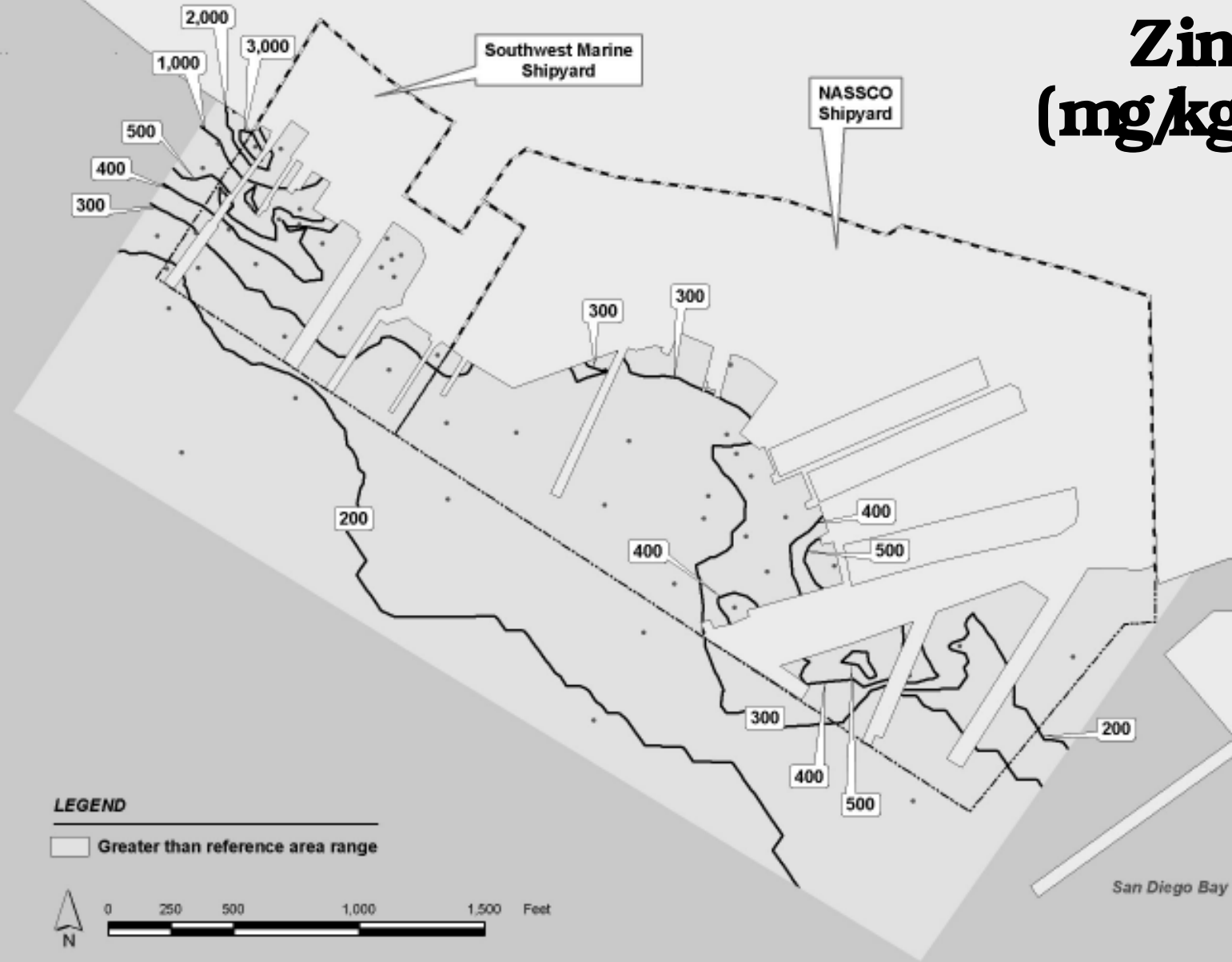
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Greater than reference area range

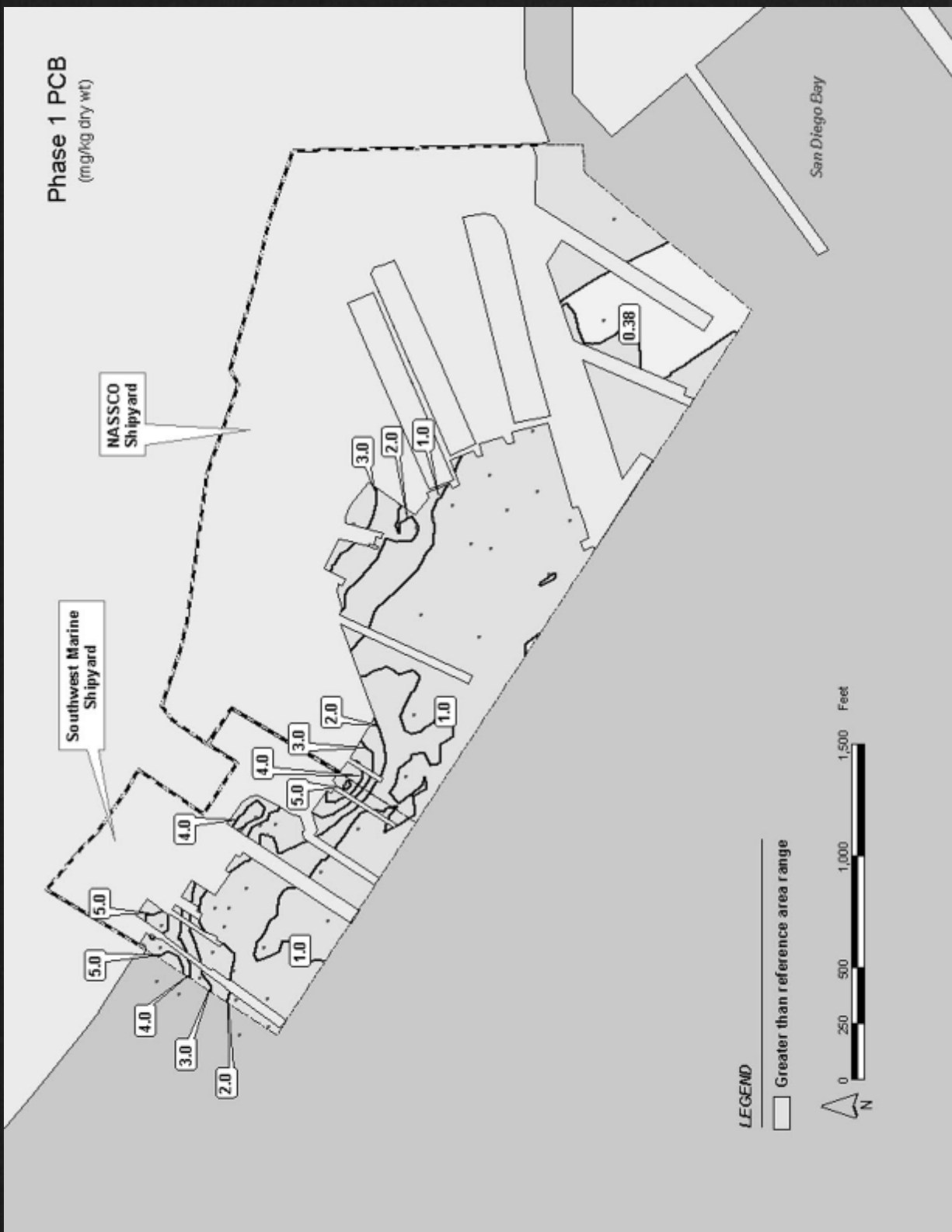


0 250 500 1,000 1,500 Feet

Zinc (mg/kg)



Phase 1 PCB
(mg/kg dry wt)

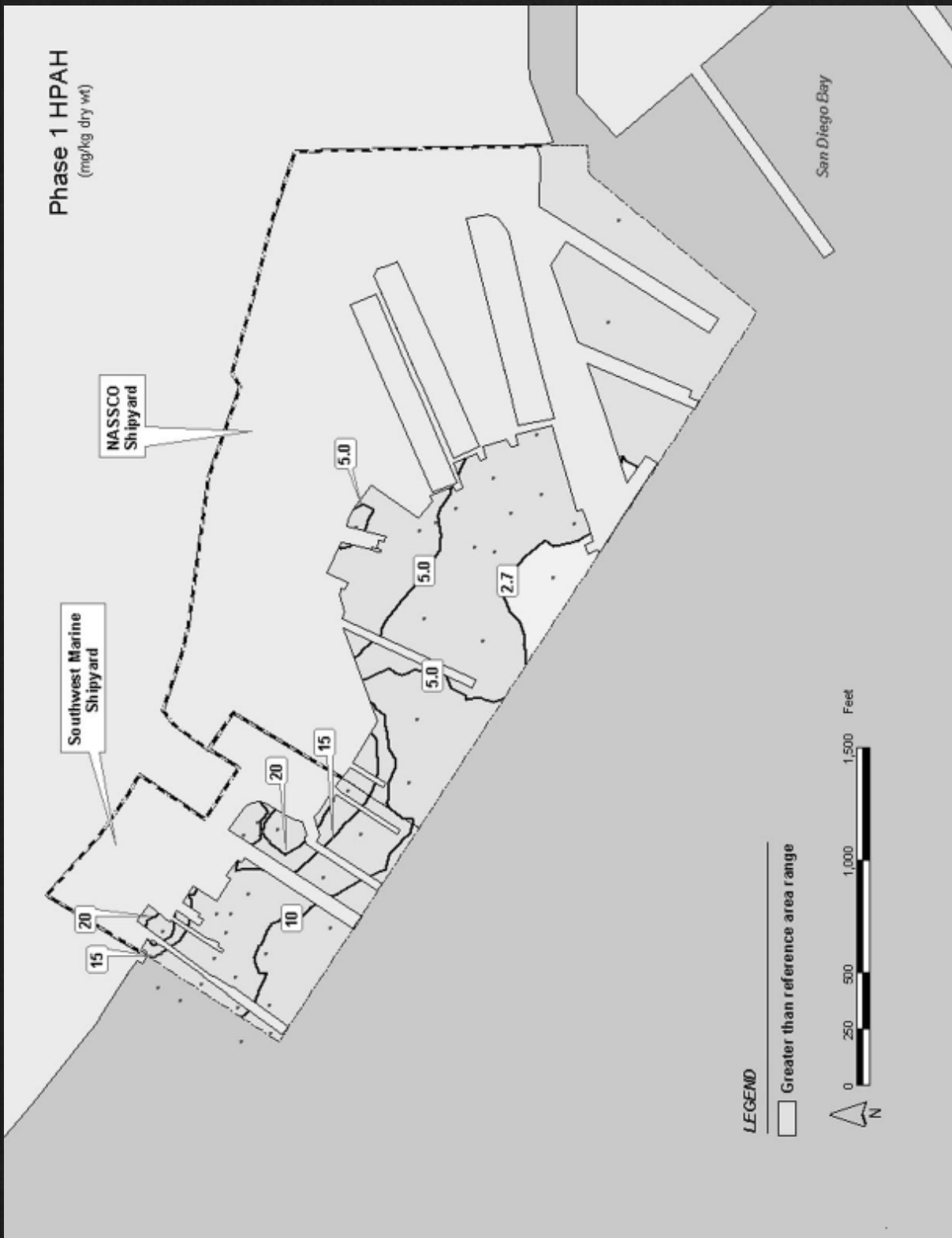


LEGEND

Greater than reference area range



Phase 1 HPAH (mg/kg dry wt)



LEGEND

Greater than reference area range



San Diego Bay

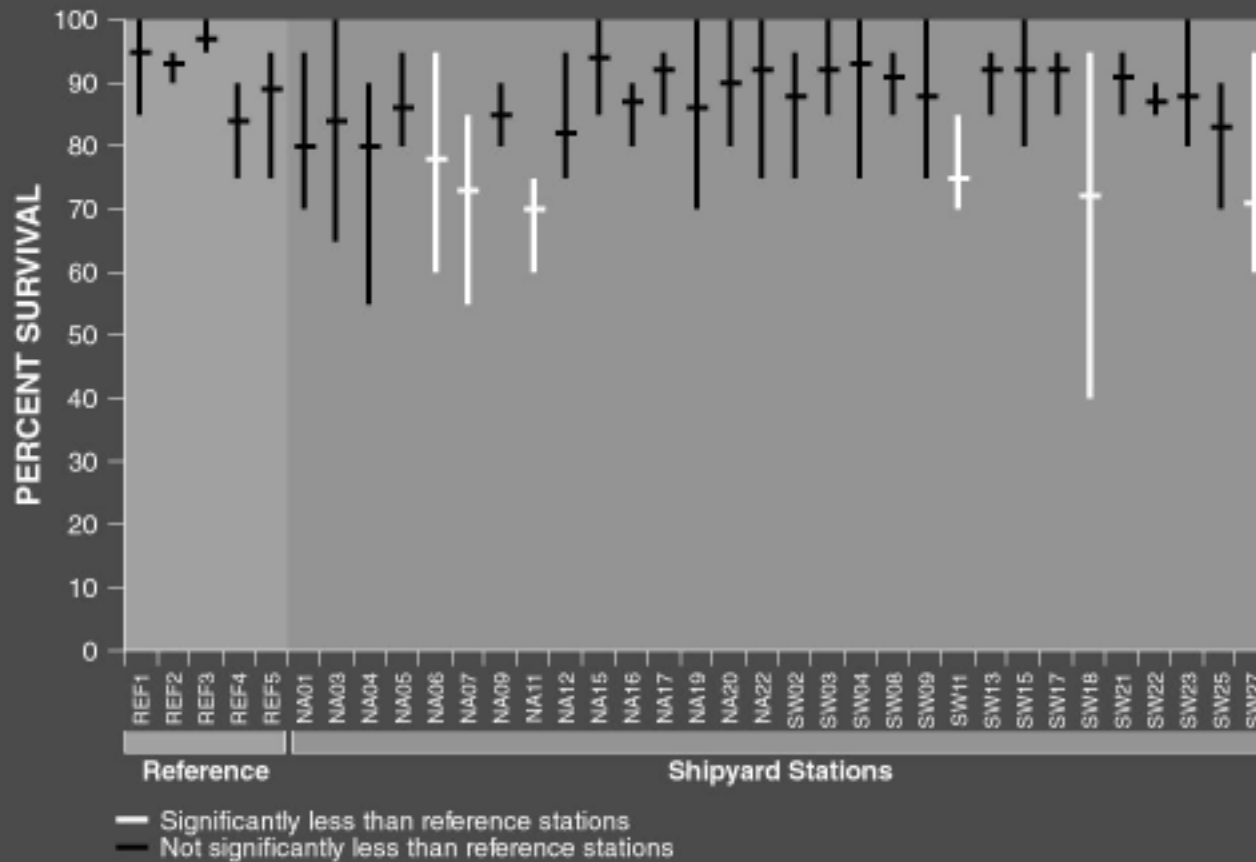
Sediment Chemistry Summary

- **Footprints show concentration gradients at both shipyards**
- **Highest concentrations found near shore**
- **Reference range exceeded at some location for all chemical groups (metals, butyltins, PAH, PCBs, PCTs, petroleum hydrocarbons)**

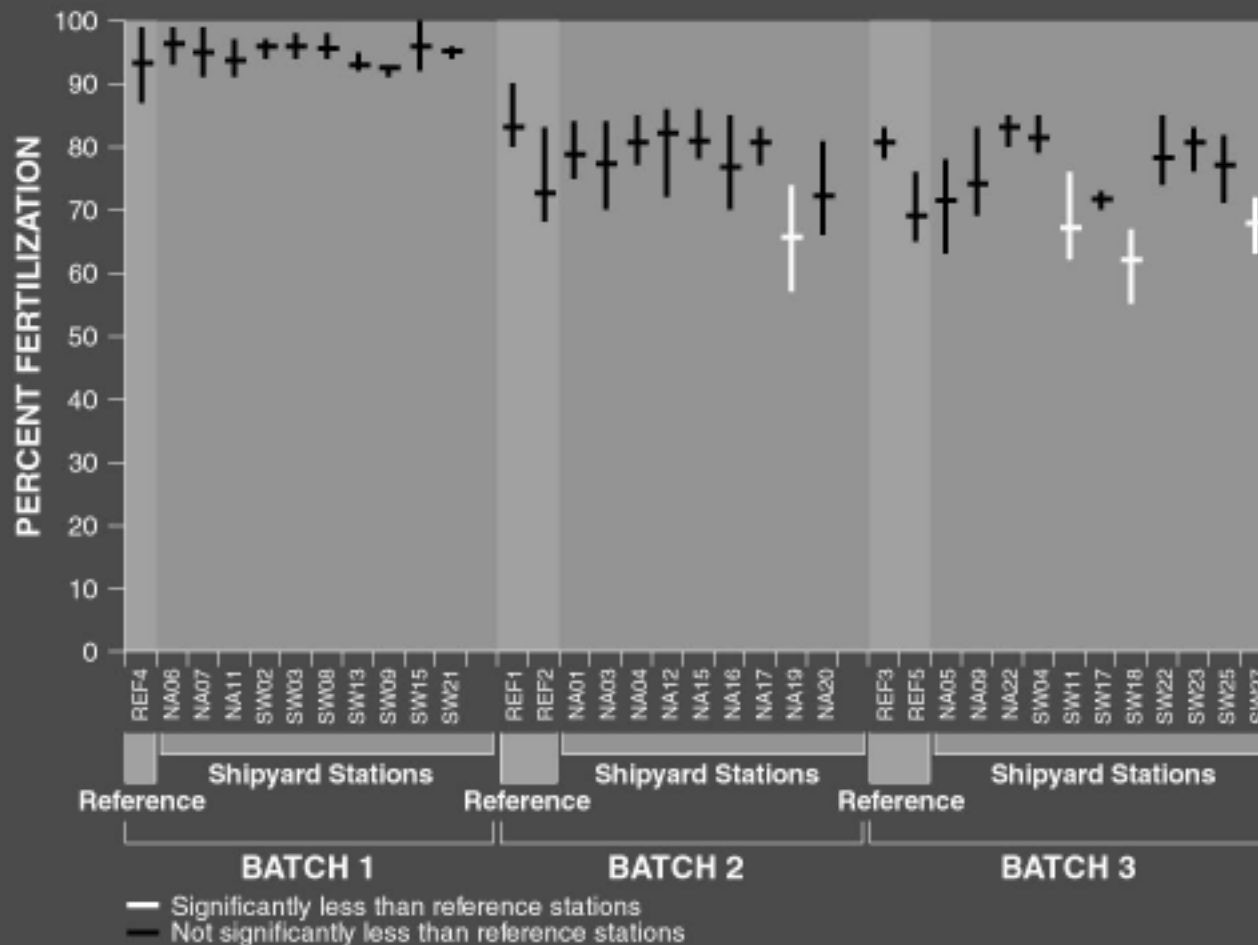
Sediment Toxicity Tests

- **Amphipod survival**
 - Whole sediment tested
- **Echinoderm fertilization**
 - Pore water tested
- **Bivalve larva development**
 - Sediment-water interface tested

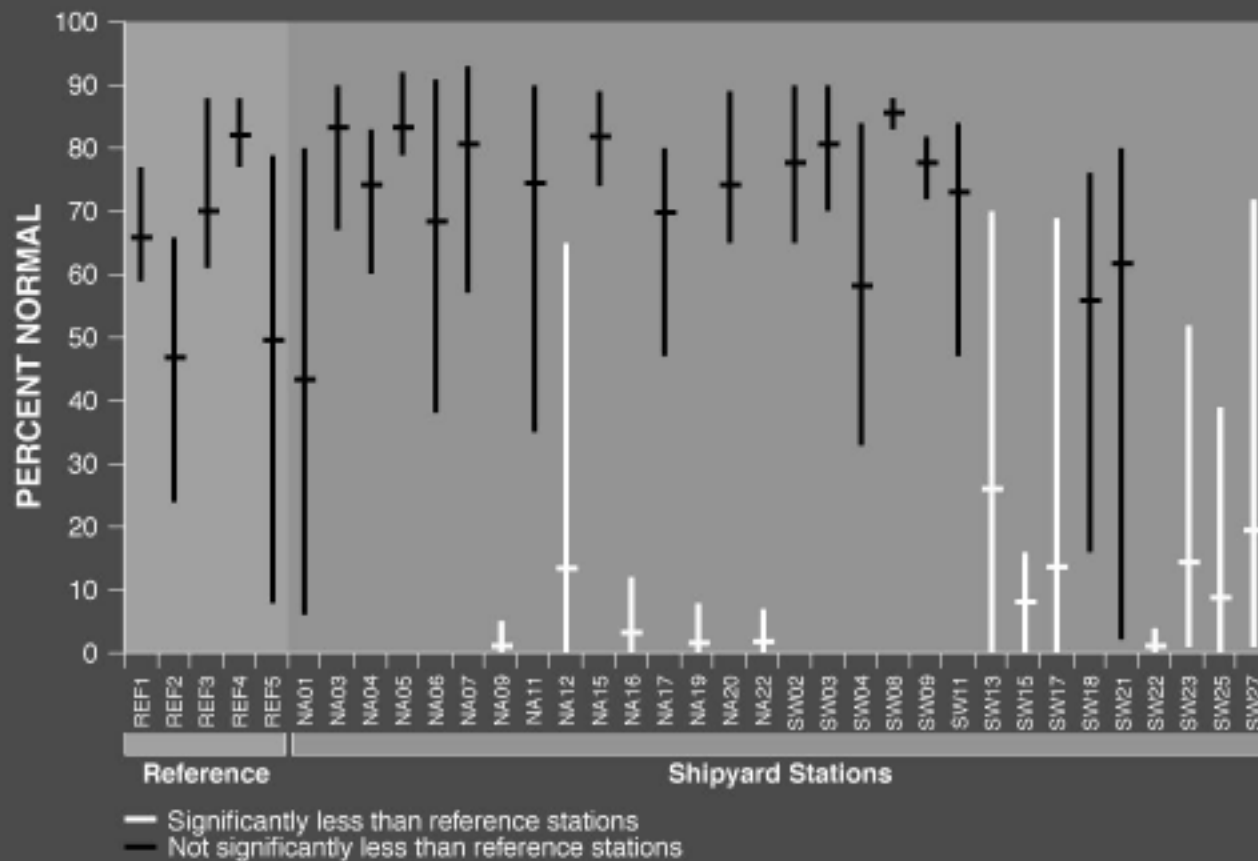
Amphipod Survival Response by Station



Echinoderm Fertility Response by Station



Bivalve Normality Response by Station



Summary of Toxicity Tests

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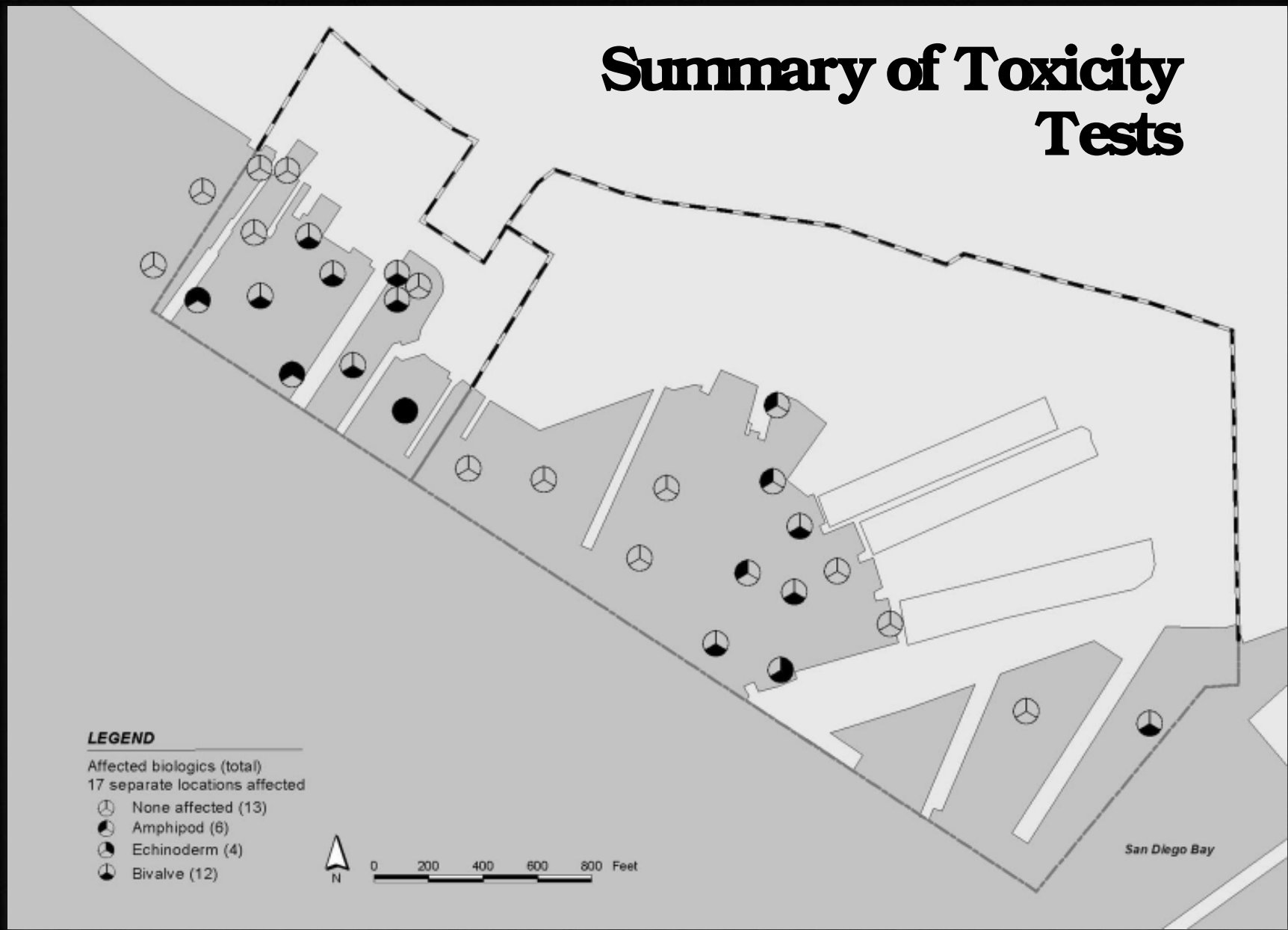
Affected biologics (total)
17 separate locations affected

- None affected (13)
- Amphipod (6)
- ◐ Echinoderm (4)
- ◑ Bivalve (12)

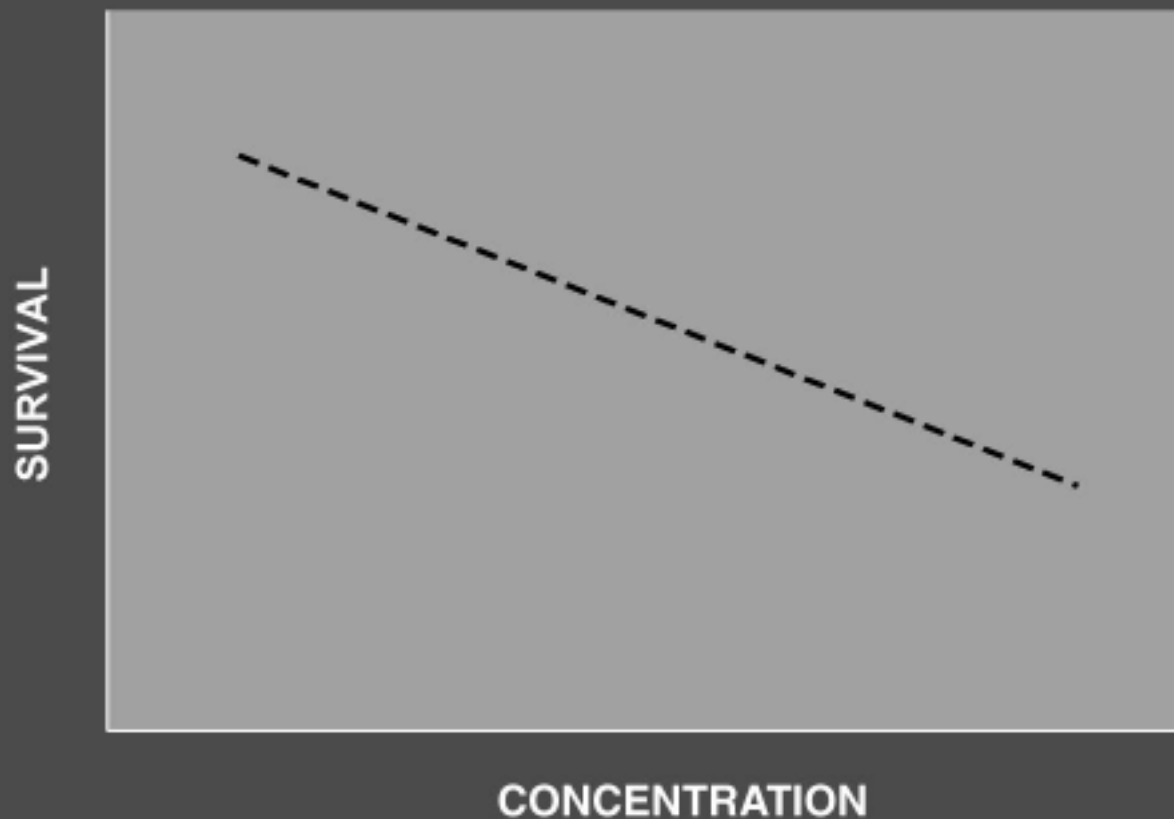


0 200 400 600 800 Feet

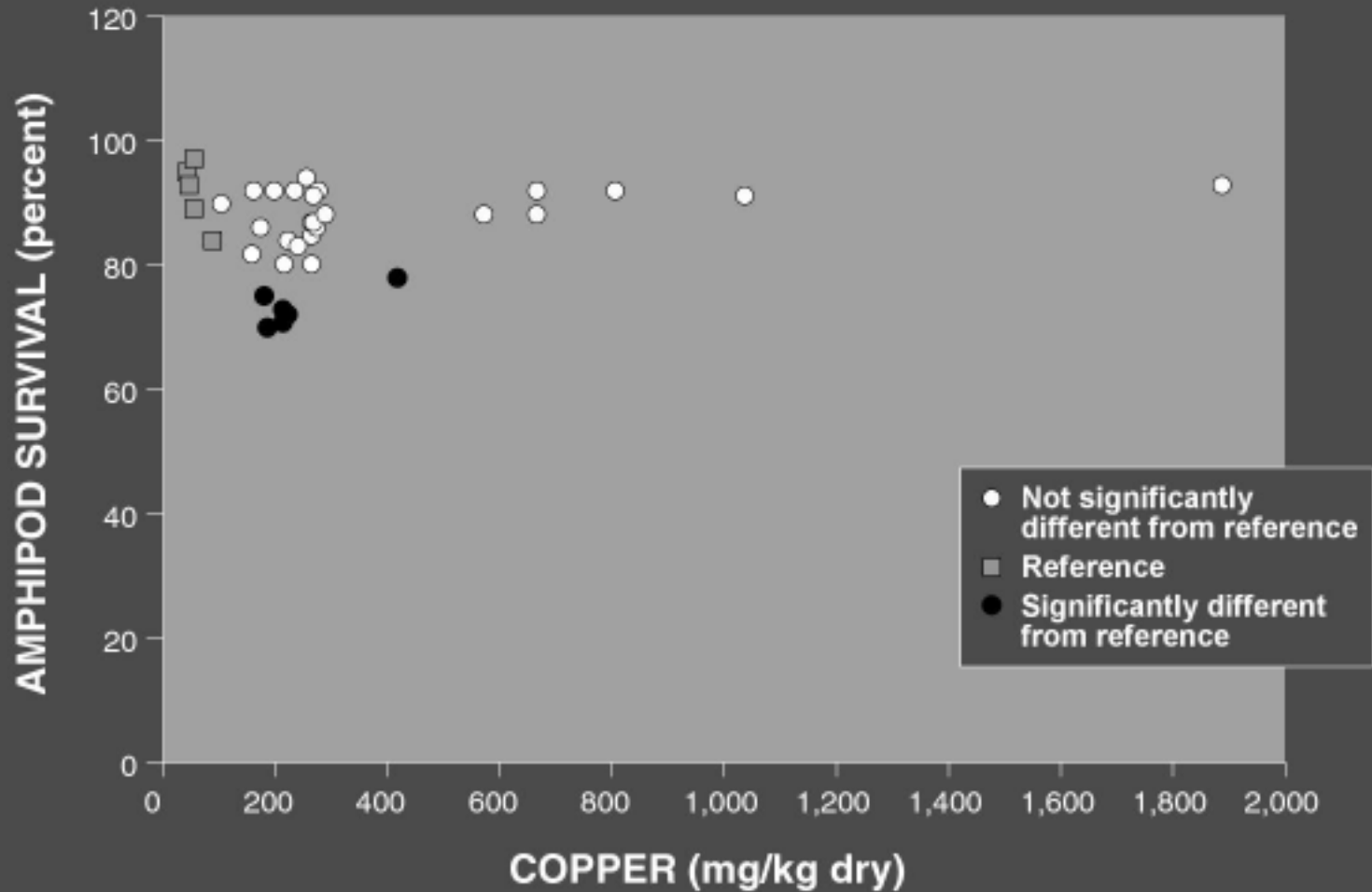
San Diego Bay



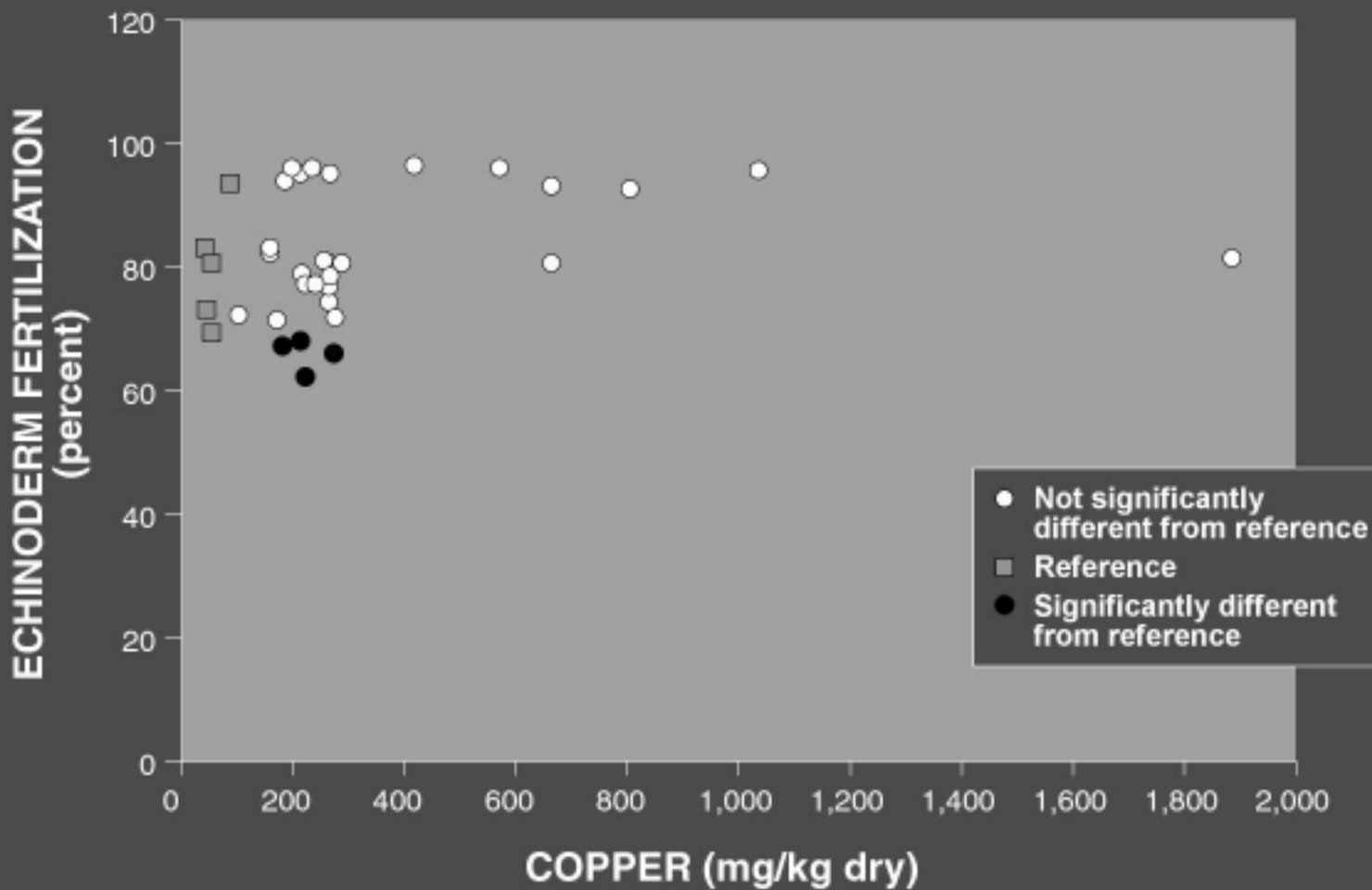
Causation: Use of Chemistry and Toxicity Relationships



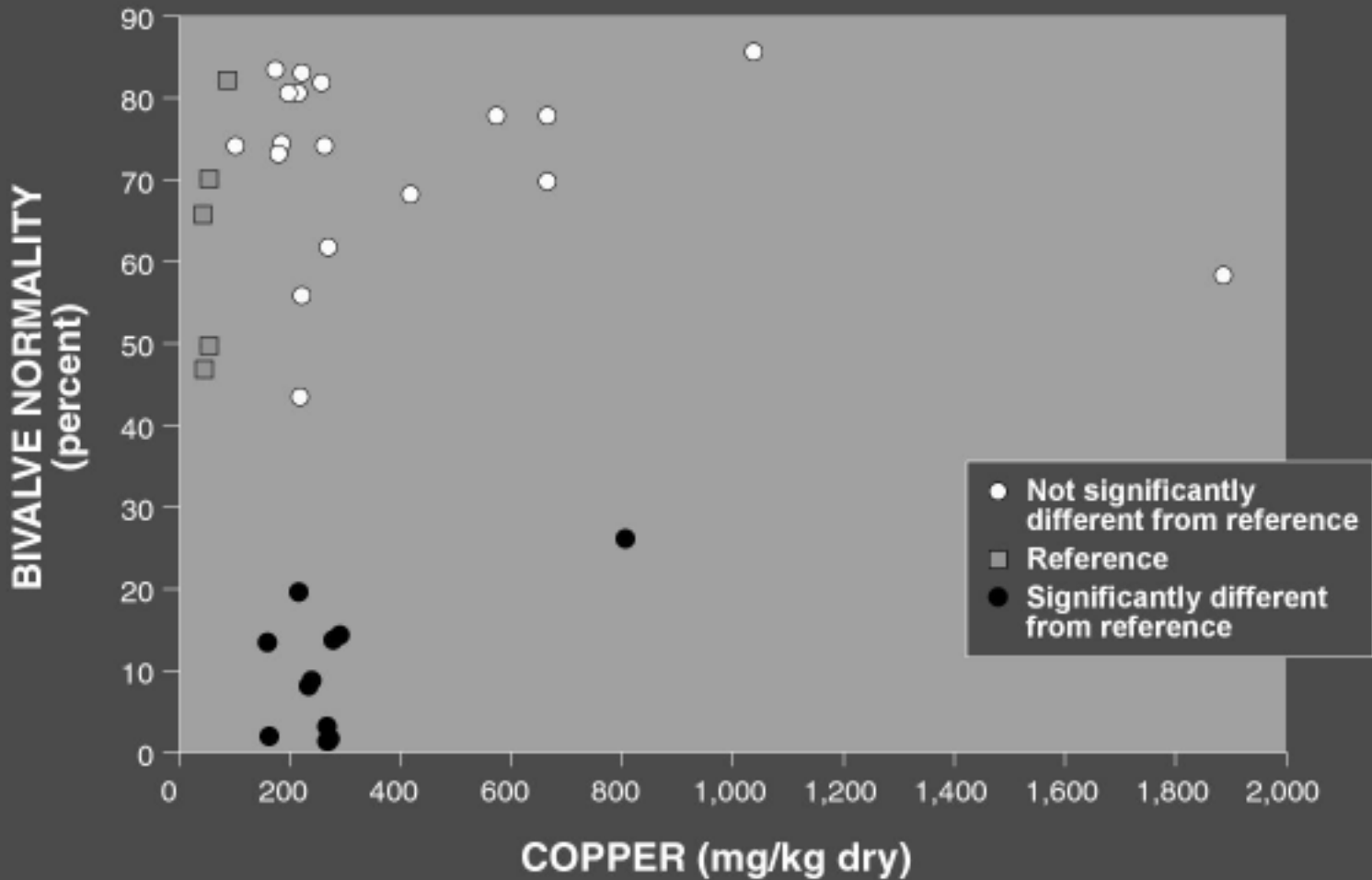
Amphipod Survival vs. Copper



Echinoderm Fertility vs. Copper



Bivalve Development *vs.* Copper



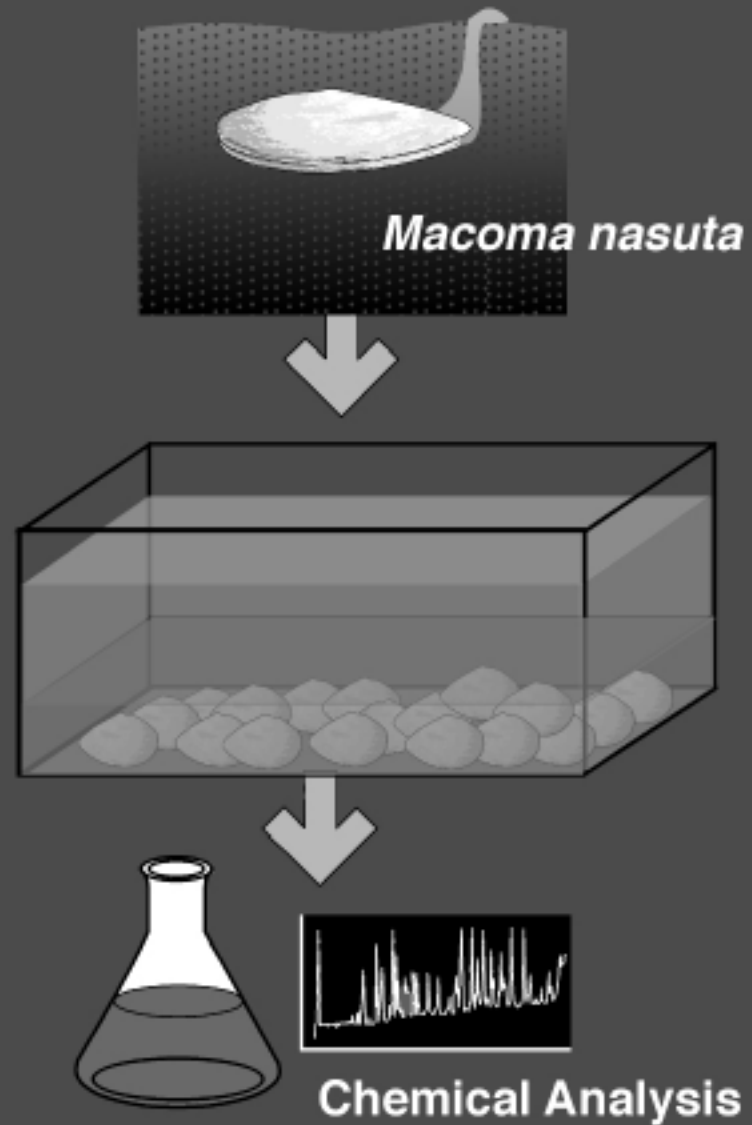
Sediment Toxicity Test Summary

- **Three toxicity tests at each of 30 shipyard stations**
- **Statistical comparisons to reference**
 - 13 stations had no effect
 - 17 stations had one or more types of effect
- **No effects seen at stations with highest concentrations of most shipyard chemicals**

Bioaccumulation Testing— Laboratory (Phase 1)

Purpose:

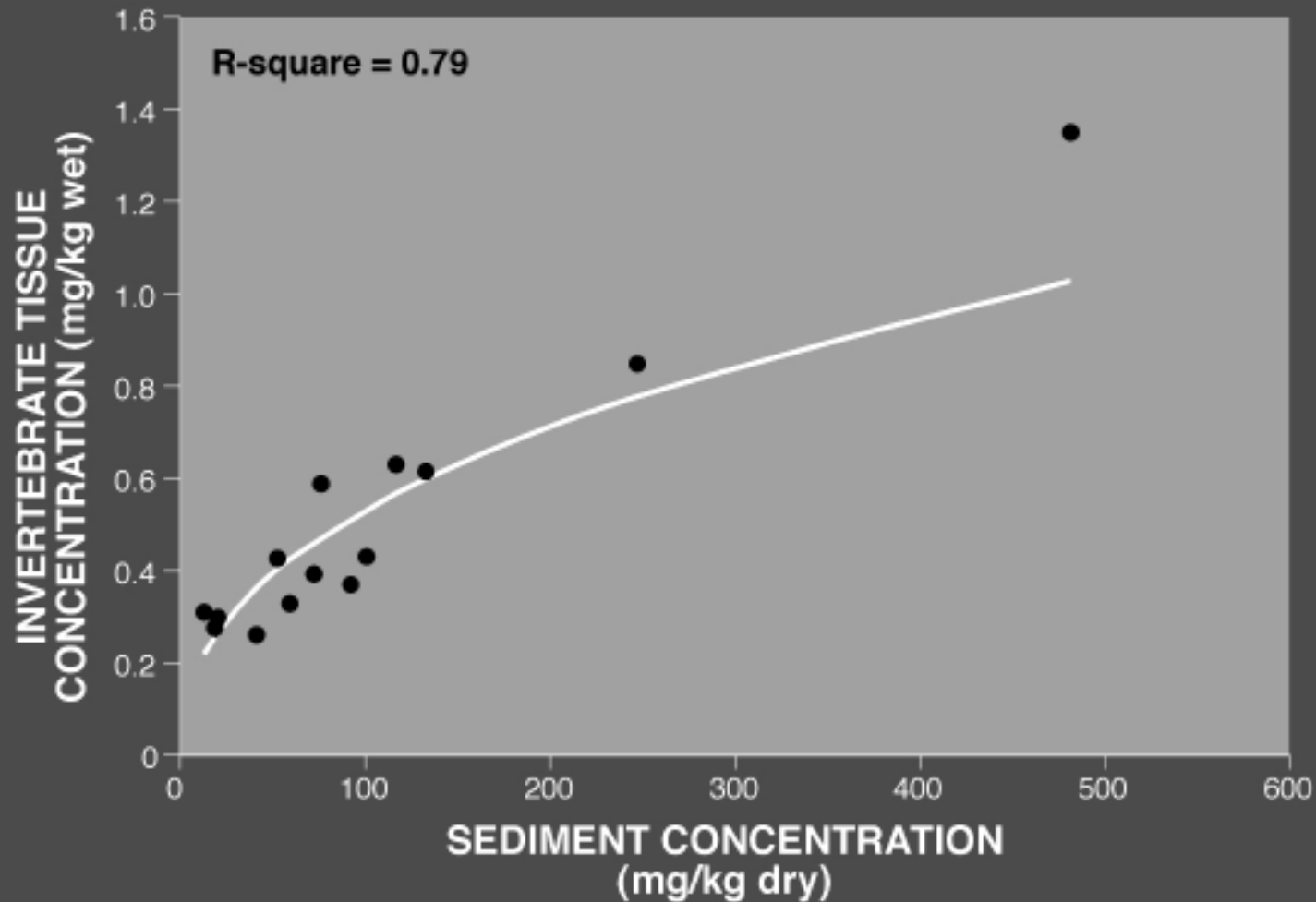
Evaluate
bioaccumulation
potential, and the need
to sample resident biota



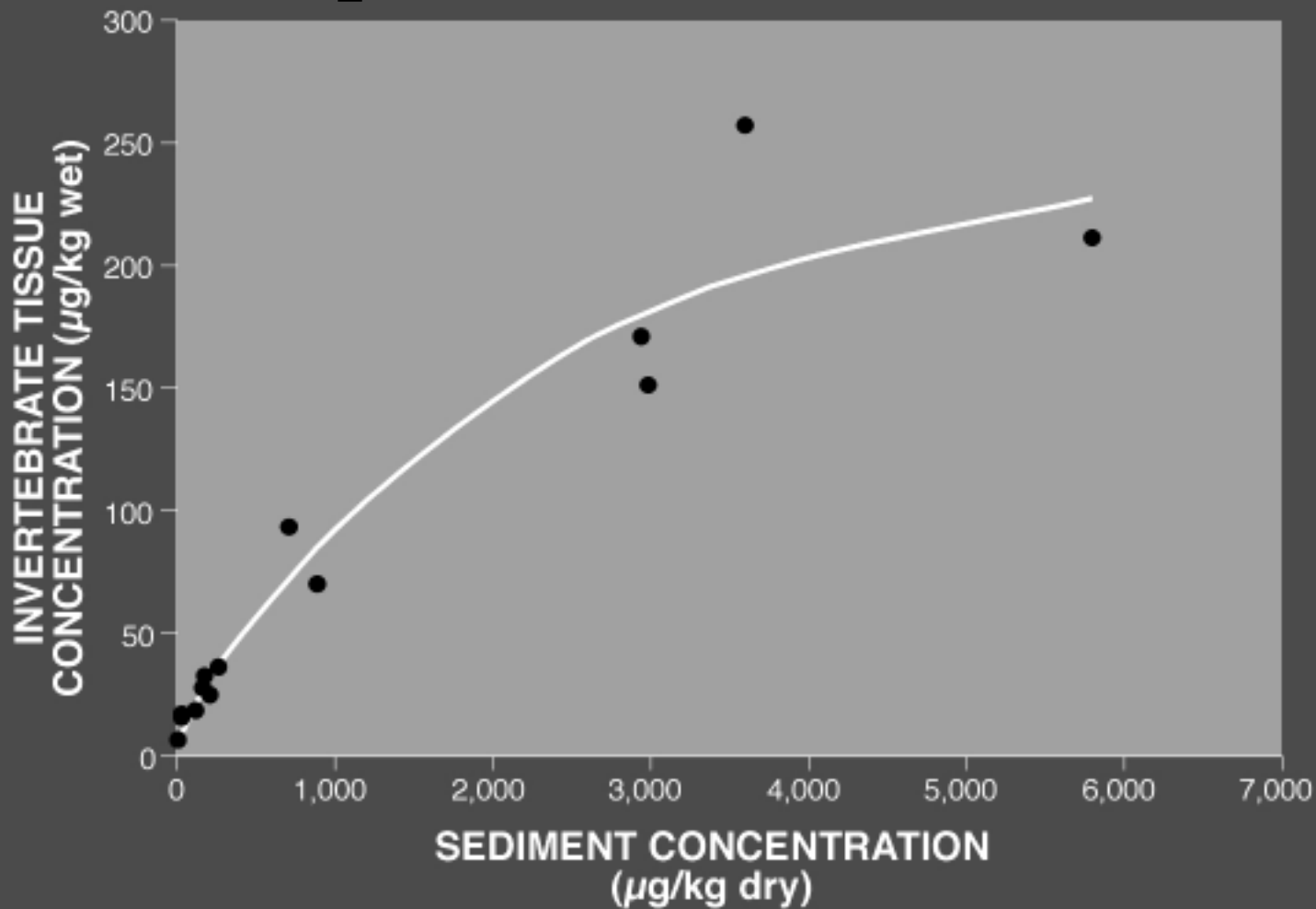
Bioaccumulation Tests

- 28-day test using a surface deposit feeding clam (*Macoma nasuta*)
- Tissues tested for all chemicals measured in sediments
- Tests conducted at 9 shipyard stations and 5 reference stations
- Five replicate tests conducted at each station

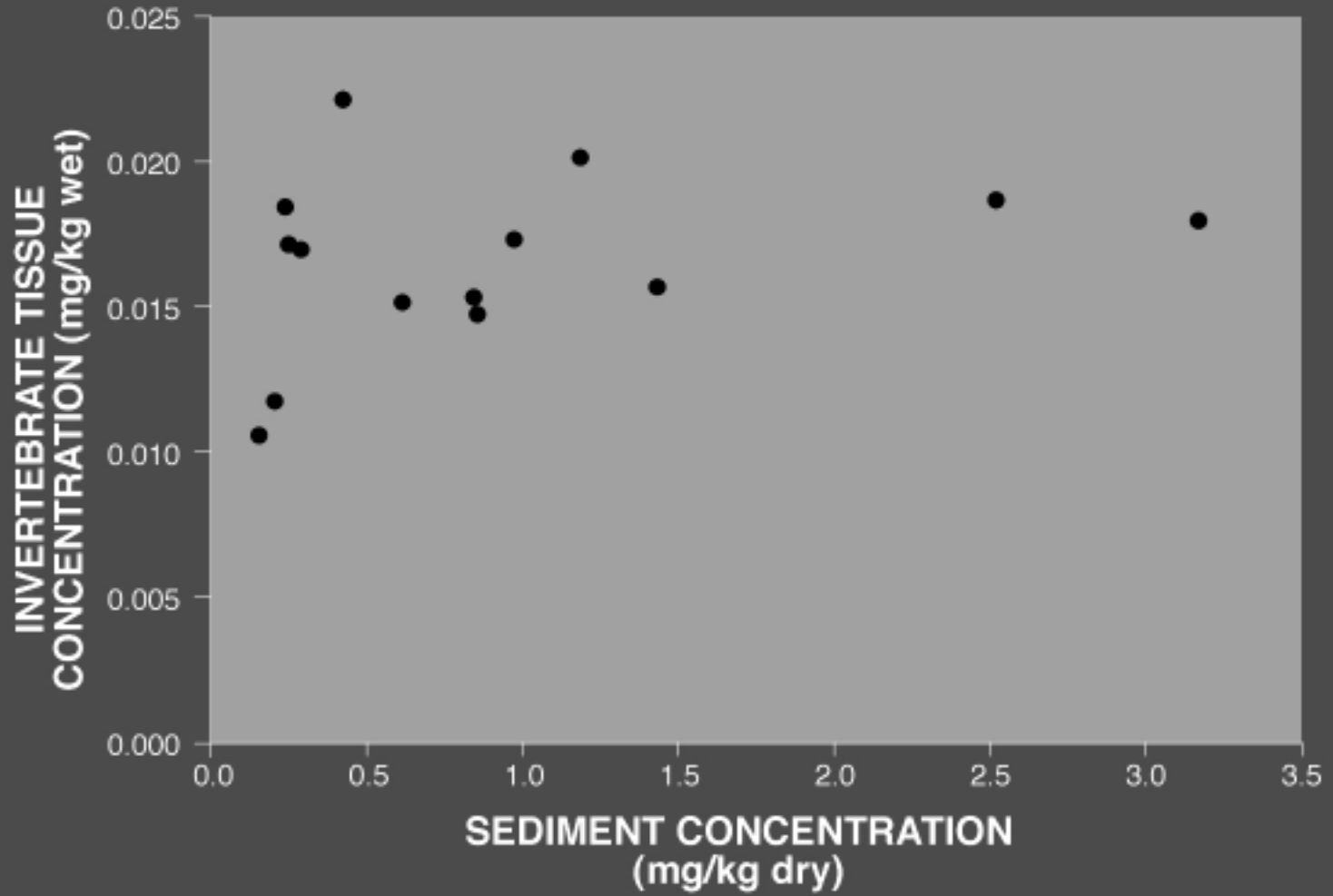
Bioaccumulation Exposure-Response Relationship for Lead



Bioaccumulation Exposure-Response Relationship for PCBs



Bioaccumulation Exposure-Response Relationship for Mercury



Bioaccumulation Test Summary

- **Statistically significant bioaccumulation exposure-response relationship observed for most chemicals**
- **No significant bioaccumulation exposure-response relationship for cadmium, chromium, mercury, or PCTs**

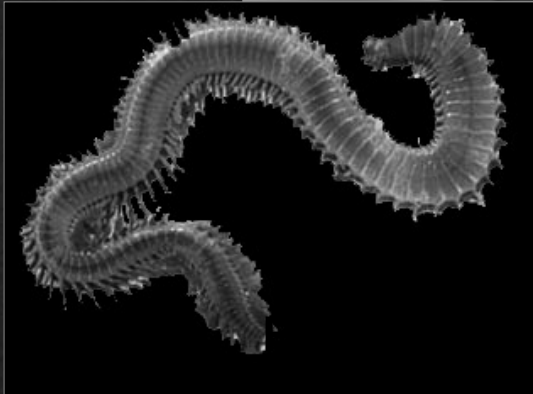
Benthic Macroinvertebrates



Polychaete



Crab



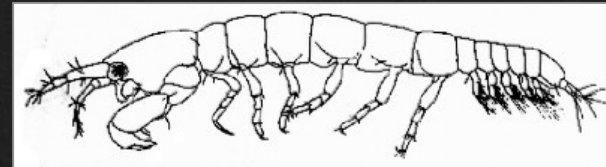
Sand Shrimp

Benthic Macroinvertebrate Community Metrics

- **Total abundance**
- **Total richness (number of species)**
- **Major taxa abundances**
 - Crustaceans, polychaetes, molluscs
- **Schwartz' Dominance Index (SDI)**
- **Percent dominance**
- **Shannon-Wiener diversity index**

Benthic Macroinvertebrates: Reference Communities

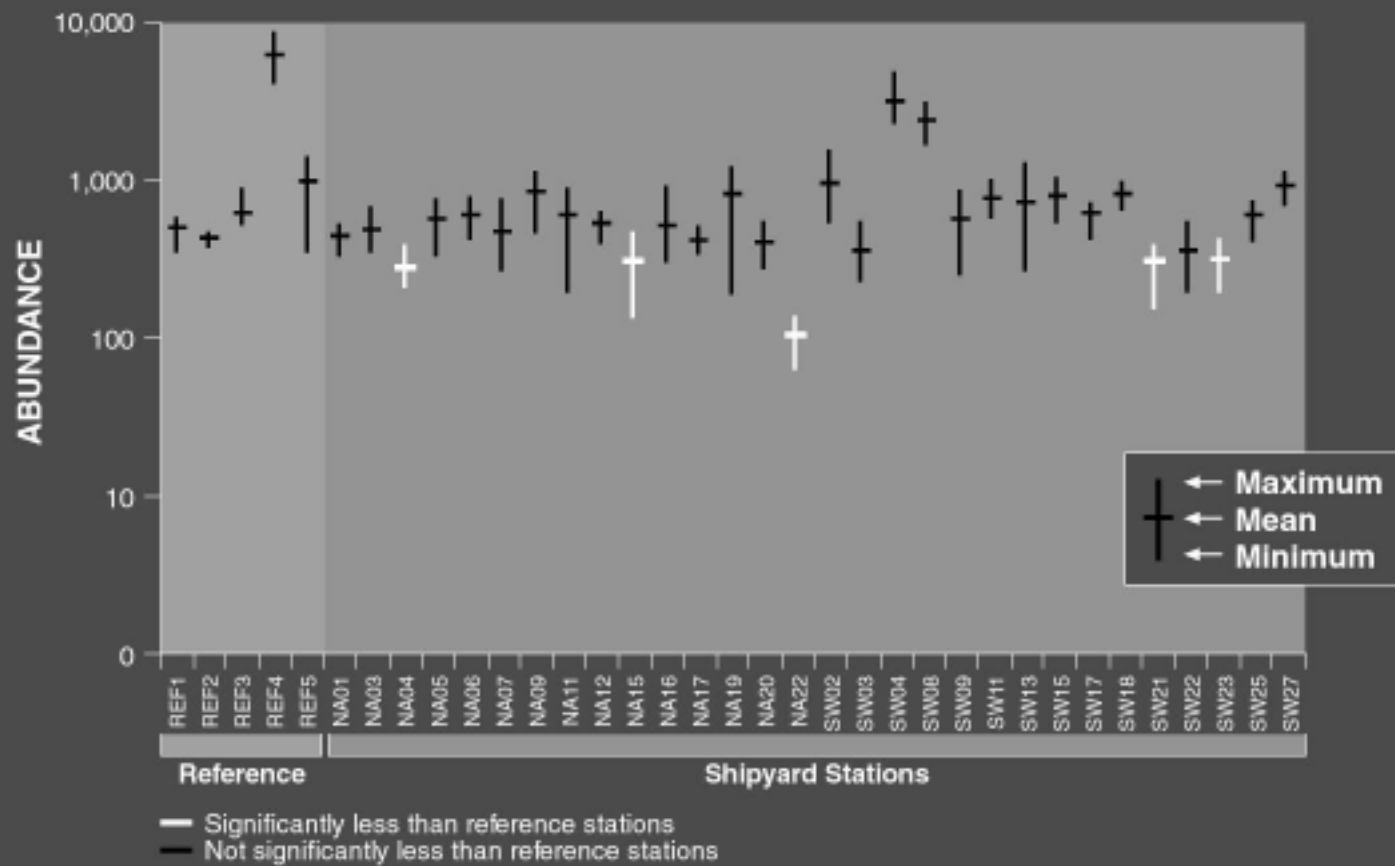
- **Similar abundances—total and major taxa**
 - 30–50 species
 - 400–1,000 organisms per sample
- **Species change away from mouth of bay**
- **REF4 dominated by invasive crustacean**
 - Total abundance: 6,000 to 8,000



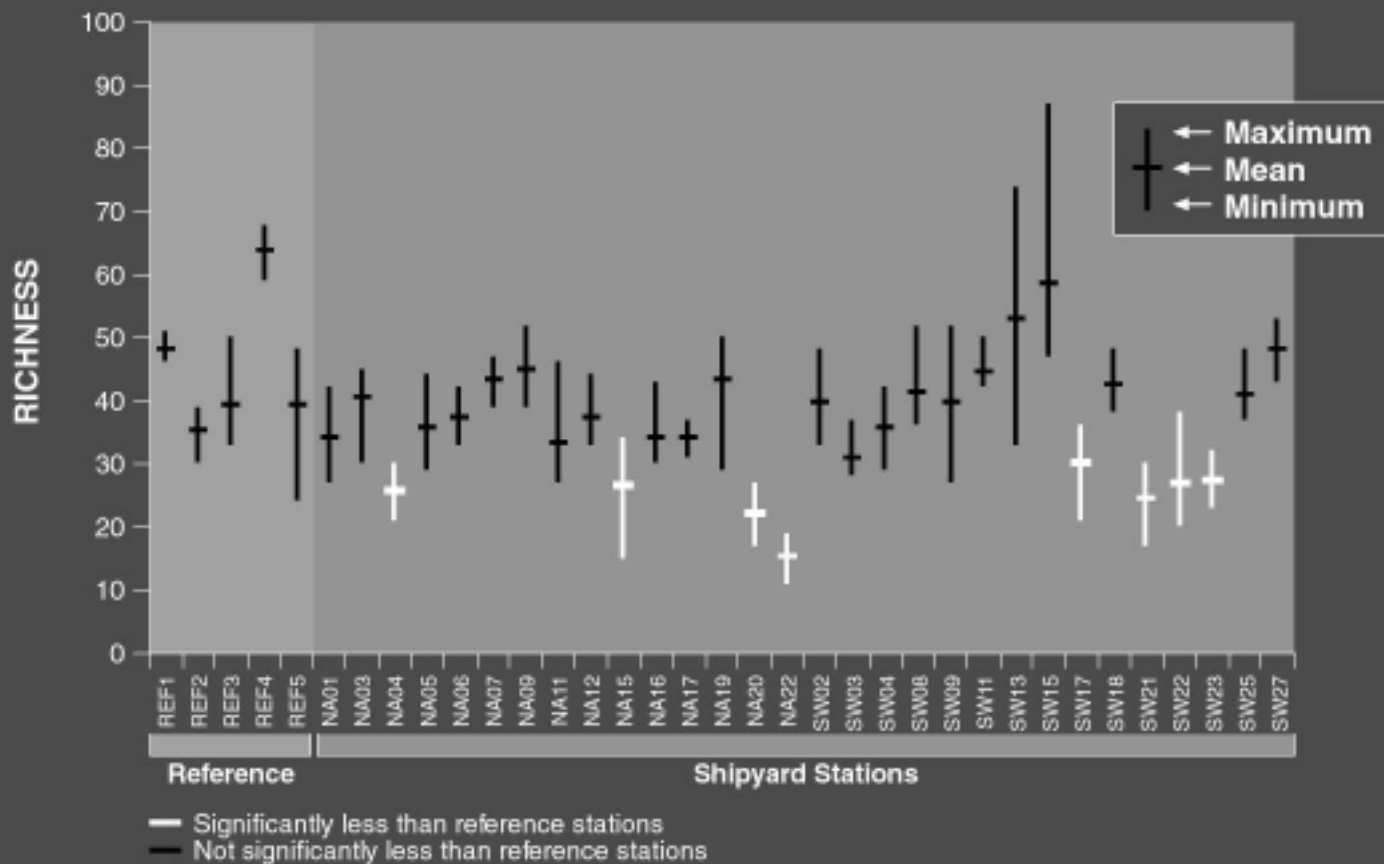
Benthic Macroinvertebrates: Shipyard Communities

- **Statistical analysis of all 8 metrics**
- **Multivariate analyses of similarities among stations**
- **Differences from reference stations**
 - Major differences: 8 stations
 - Moderate differences: 2 stations
 - Minor differences: 3 stations
 - No differences: 17 stations

Total Abundance



Total Number of Taxa



Benthic Community Results

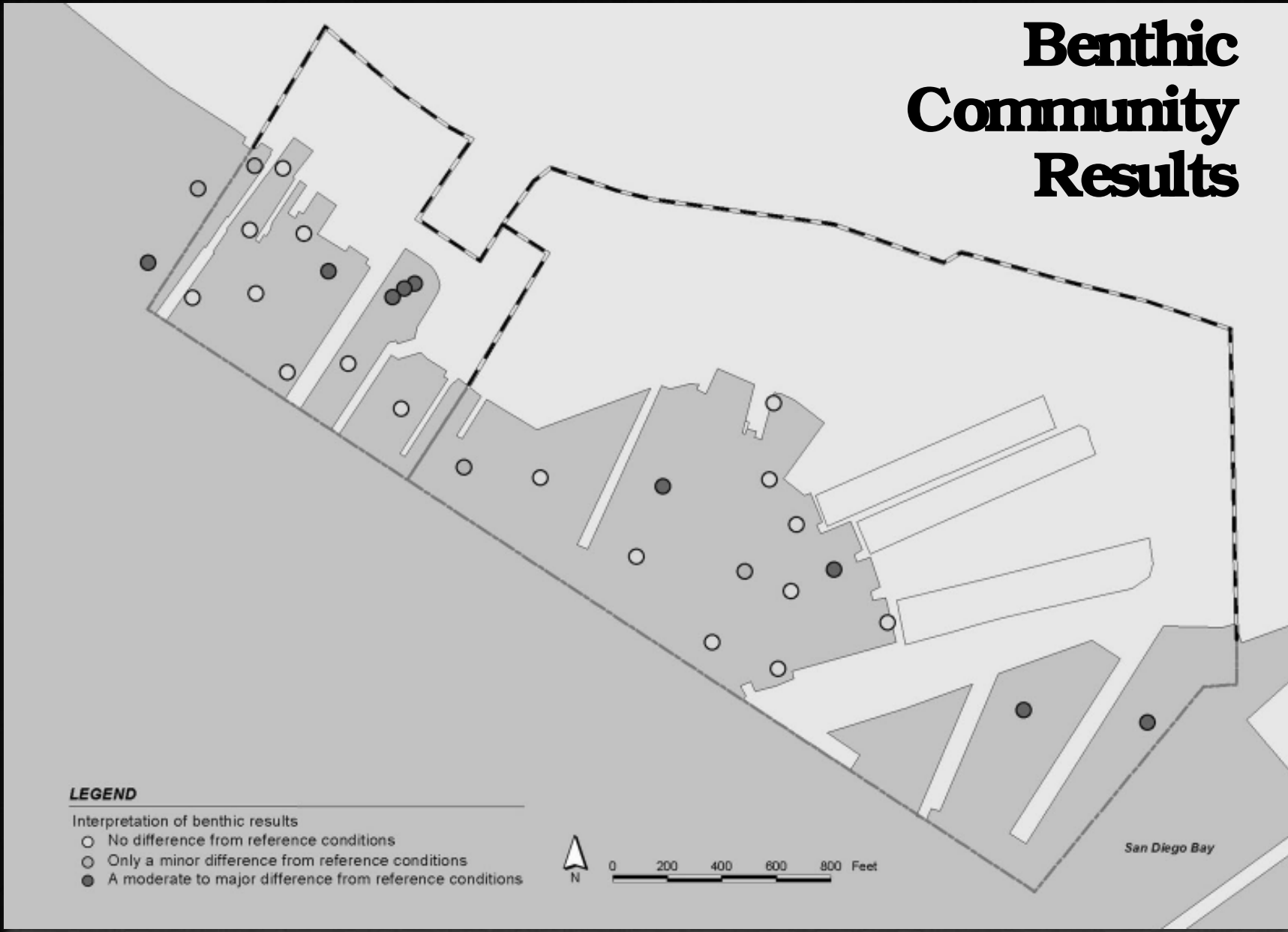
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Interpretation of benthic results

- No difference from reference conditions
- ◐ Only a minor difference from reference conditions
- A moderate to major difference from reference conditions



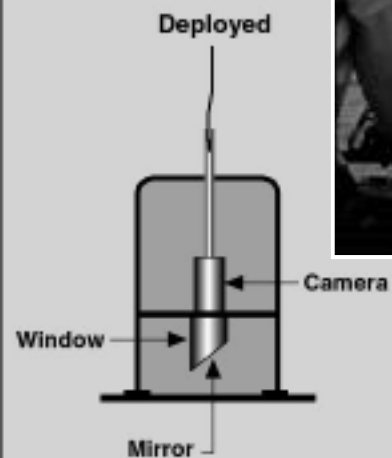
San Diego Bay



Benthic Macroinvertebrates: Notable Conditions

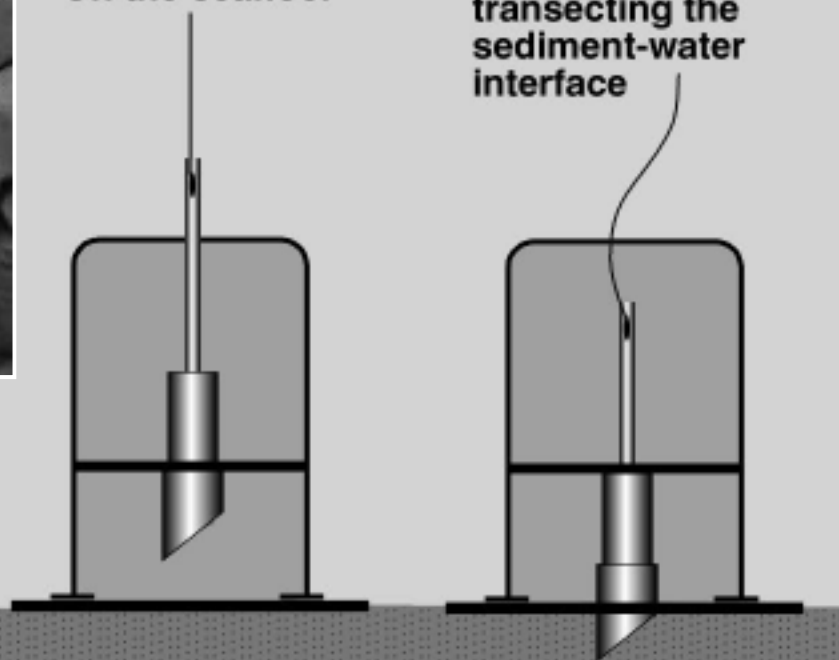
- **Northwest end of Southwest Marine (Stations SW02 and SW04)**
 - Different from all other stations
 - Higher abundances of crustaceans and polychaetes
- **Chollas Creek outlet (Station NA22)**
 - Very different from all other stations
 - Seven of 8 metrics are different from reference

Sediment Profile Camera

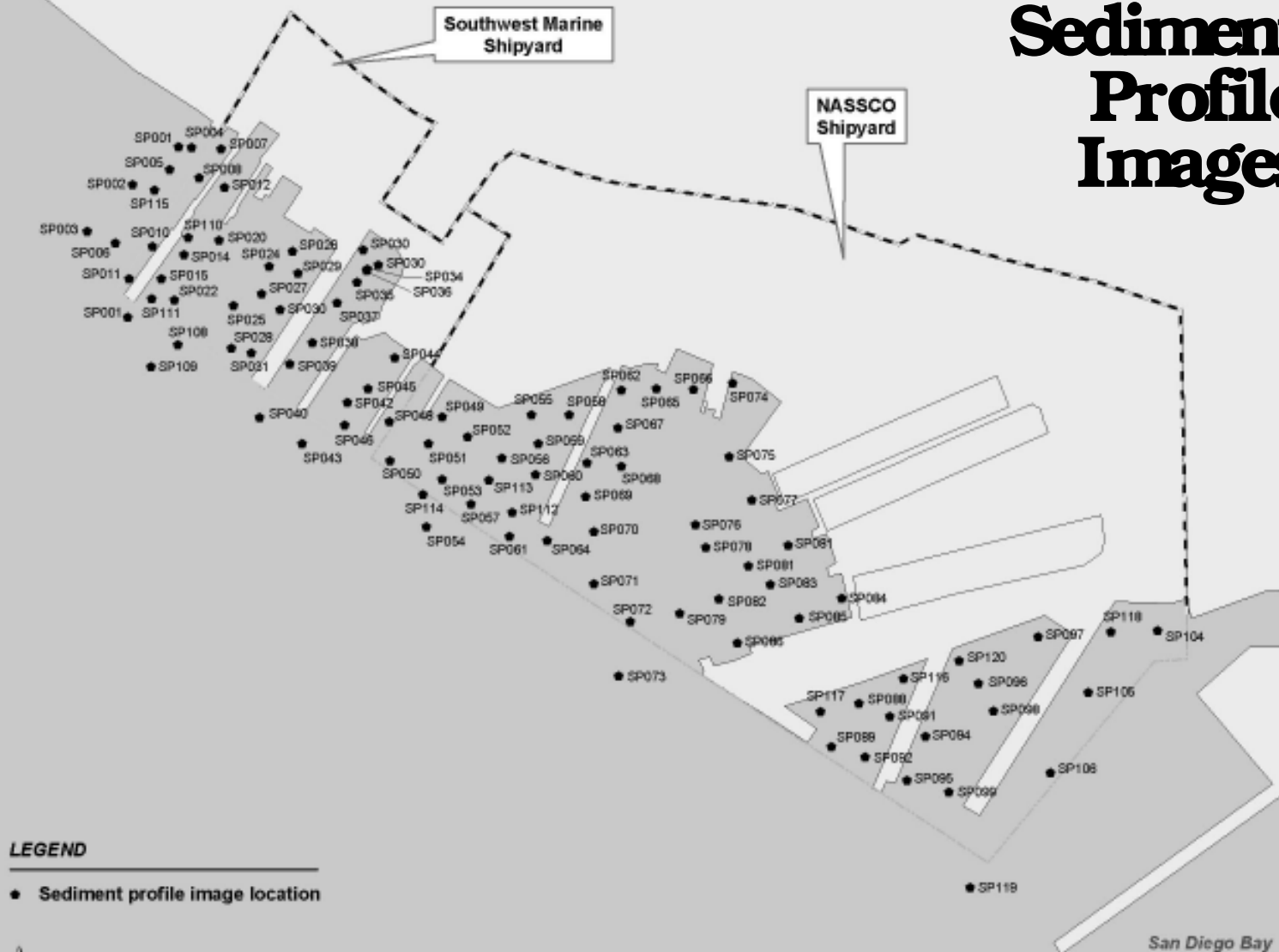


On the seafloor

"Down" position
transecting the
sediment-water
interface



Sediment Profile Images

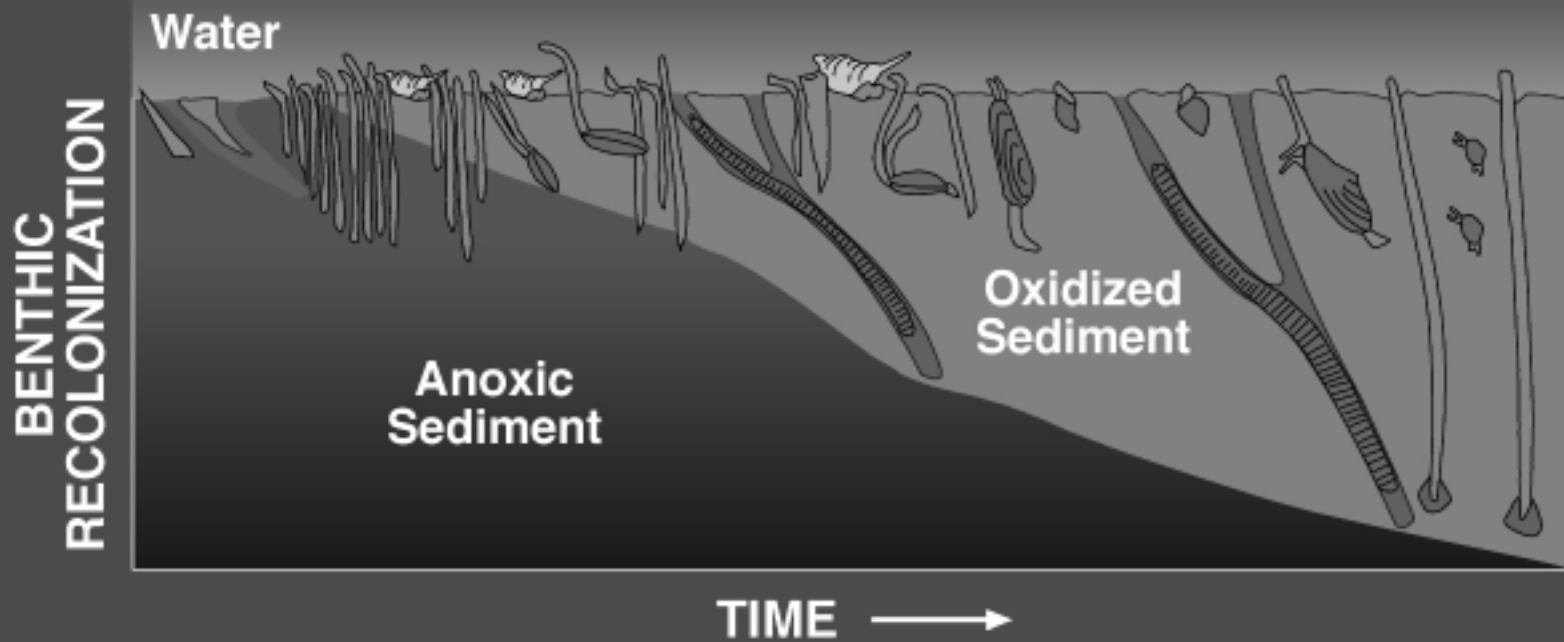


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- Sediment profile image location



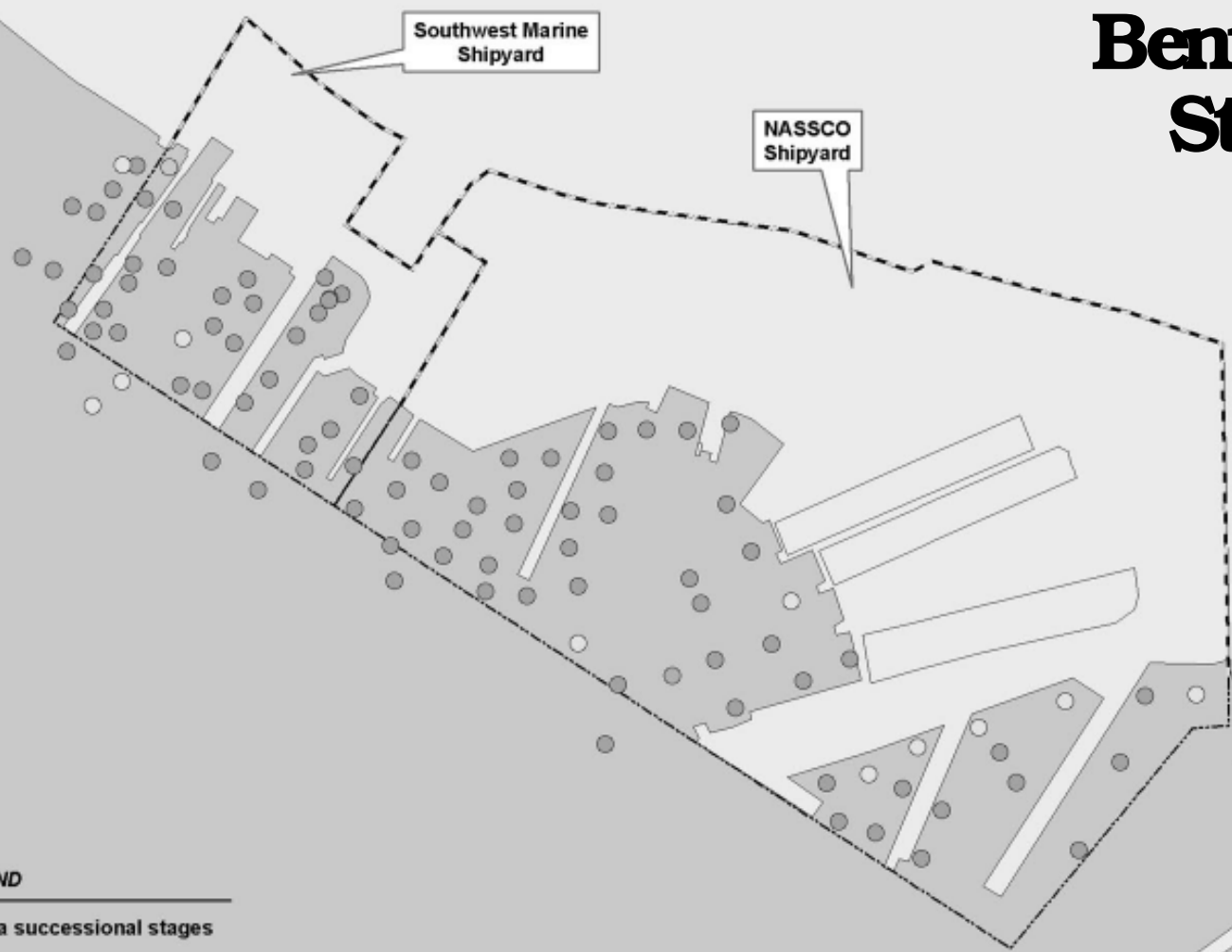
Typical Pattern of Benthic Recolonization



Sediment Profile Image Summary

- **Mature communities at reference stations**
- **Early communities at 11 shipyard stations**
- **Mature communities at 88 shipyard stations**

Benthic Stage



Southwest Marine Shipyard

NASSCO Shipyard

LEGEND

Infauna successional stages

- Stage 1
- Up to Stage 2
- Up to Stage 3
- Indeterminate



San Diego Bay

Human Health and Ecological Risk Assessments



Planned Phase 2 Fieldwork

- Pore water
- Supplementary surface sediment sampling
- Sediment coring
- Chemical analyses of resident biota to:
 - Perform risk assessments
 - Assess adverse effects on fish
- Fish histopathology
- Sampling of eelgrass to:
 - Assess adverse effects on sea turtles
 - Assess adverse effects on eelgrass

Cleanup Alternatives Analysis

- **Cleanup levels and areas chosen to protect:**
 - Aquatic life
 - Aquatic-dependent wildlife
 - Human health
- **Technical feasibility analysis**
- **Economic feasibility analysis**
- **Alternative remedial designs**
- **Selection of a cleanup alternative**

Summary

- **Phase 1 results**
 - Standard evaluation methods used
 - Obtained all planned data
 - Shipyard conditions contrasted with reference conditions
- **Phase 2 sampling will address:**
 - Effects on fish
 - Effects on aquatic-dependent wildlife
 - Effects on human health
- **Feasibility analyses and selection of a cleanup alternative will follow**