California Regional Water Quality Control Board
San Diego Region

Total Maximum Daily Load for Dissolved Copper In Shelter Island Yacht Basin, San Diego Bay

Resolution No. R9-2005-0019
Basin Plan Amendment and

Technical Report

February 9, 2005

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
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Technical Report

Adopted by the
California Regional Water Quality Control Board
San Diego Region
on February 9, 2005

Approved by the
State Water Resources Control Board
on _______________, 2005
and the
Office of Administrative Law
on _______________,2005
and the
United States Environmental Protection Agency
on _________________. 2005

Cover Photograph: Shelter Island Yacht Basin, San Diego Bay (2004) by David T. Barker

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List of Tables and Figures

List of Acronyms and Abbreviations

Basin Plan	Water Quality Control Plan for the San Diego Basin – Region 9
BIOL	Preservation of biological habitats of special significance
CAC	San Diego County Agricultural Commissioner
CalEPA	California Environmental Protection Agency
CCC	California Coastal Commission
CCR	California Code of Regulations
CDFA	California Food and Agriculture Code
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
City	City of San Diego
COMM	Commercial and sport fishing
CTR	California Toxics Rule
Cu	Copper
CWA	Clean Water Act
CWC	California Water Code
DBW	California Department of Boating and Waterways
DPR	California Department of Pesticide Regulation
EMC	Event mean concentration
ERL	Effects range low
ERM	Effects range medium
EST	Estuarine habitat
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
IND	Industrial service supply
LA	Load allocations
LC	Loading capacity
MAA	Management Agency Agreement
MP	Management practice
MAR	Marine habitat
MIGR	Migration of aquatic organisms
MLLW	Mean lower low water
MM	Management measures
MOS	Margin of safety
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer Systems
NAV	Navigation
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge and Elimination System
OAL	Office of Administrative Law
Port	San Diego Unified Port District
PRC	PRC Environmental Management, Inc.
RARE	Rare, threatened, or endangered species
REC1	Water contact recreation
REC2	Non-contact water recreation
Regional Board	California Regional Water Quality Control Board, San Diego Region

SCCWRP	Southern California Coastal Water Research Project
Sea Grant	University of California Sea Grant Extension Program
SHELL	Shellfish harvesting
SIYB	Shelter Island Yacht Basin
SPAWAR	US Navy's Space and Naval Warfare Systems Command
SQG	Sediment quality guidelines
SSO	Site-specific objective
State Board	State Water Resources Control Board
TBT	Tributyltin
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
WDR	Waste discharge requirements
WER	Water effects ratio
WILD	Wildlife habitat
WLA	Wasteload allocation
WQC	Water quality criteria

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN DIEGO REGION

RESOLUTION NO. R9-2005-0019

A RESOLUTION ADOPTING AN AMENDMENT TO THE WATER QUALITY CONTROL PLAN FOR THE SAN DIEGO REGION TO INCORPORATE A TOTAL MAXIMUM DAILY LOAD FOR DISSOLVED COPPER IN SHELTER ISLAND YACHT BASIN, SAN DIEGO BAY

WHEREAS, The California Regional Water Quality Control Board, San Diego Region (hereinafter, Regional Board), finds that:

1. **BASIN PLAN AMENDMENT**: The proposed amendment of the Water Quality Control Plan for the San Diego Basin – Region 9 (Basin Plan) described in the recitals below was developed in accordance with California Water Code (CWC) section 13240 et seq.

2. **NECESSITY STANDARD** [Government Code section 11353(b)]: This regulatory action meets the "Necessity" standard of the Administrative Procedures Act, Government Code, section 11353, subdivision (b). Amendment of the Basin Plan to establish and implement a Total Maximum Daily Load (TMDL) for Shelter Island Yacht Basin (SIYB) is necessary because the existing water quality does not meet applicable numeric water quality objectives for copper, or narrative water quality objectives for toxicity and pesticides. The federal Clean Water Act (CWA) section 303(d) requires the Regional Board to establish and oversee the implementation of a TMDL under the water quality conditions that exist in SIYB. This TMDL for dissolved copper is necessary to ensure attainment of applicable water quality objectives and restoration of beneficial uses designated for SIYB.

3. **CLEAN WATER ACT SECTION 303(d)**: The SIYB portion of San Diego Bay was placed on the Clean Water Act section 303(d) list of impaired waters in 1996 due to elevated levels of dissolved copper in the water column.

4. **BENEFICIAL USE IMPAIRMENTS**: SIYB supports the same suite of beneficial uses as San Diego Bay. The most sensitive beneficial uses are those designated for protection of marine aquatic life and aquatic dependent wildlife as described in the Basin Plan definition of the marine habitat (MAR) and wildlife habitat (WILD) beneficial uses. The MAR and WILD beneficial uses of SIYB are threatened or impaired due to elevated levels of dissolved copper.

5. **WATER QUALITY OBJECTIVES**: The water quality objectives for copper in SIYB specify that concentrations in seawater for dissolved copper should not exceed 3.1 micrograms/liter (µg/L) for continuous or chronic exposures (not to be exceeded over a four-day average), and 4.8 µg/L of copper for brief or acute exposures (not to be exceeded over a one-hour average). These water quality objectives are based on, and equal, to the California Toxics Rule (CTR) water quality criteria for dissolved copper promulgated by United States Environmental Protection Agency (USEPA). The USEPA's CTR criteria are

the legally applicable water quality standards in the State of California for inland surface waters, enclosed bays, and estuaries for all purposes and programs under the CWA.

In addition, the Basin Plan establishes the following narrative water quality objectives for "toxicity" and "pesticides" to ensure the protection of the MAR and WILD beneficial uses.

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

The survival of aquatic life in surface waters subjected to a waste discharge or other controllable water factors, shall not be less than that for the same water body in areas unaffected by the waste discharge or, when necessary, for other control water that is consistent with requirements specified in USEPA, State Water Resources Control Board (State Board) or other protocol authorized by the Regional Board. As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour acute bioassay.

In addition, effluent limits based upon acute bioassays of effluents will be prescribed where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged.

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

Meeting the numeric water quality objectives for copper will ensure that the narrative toxicity and pesticides objectives are met in the water column with respect to copper.

6. **NUMERIC TARGETS**: TMDL Numeric Targets interpret and implement water quality standards (i.e., numeric and narrative water quality objectives and beneficial uses) and are established at levels necessary to achieve water quality standards. The Regional Board has set the copper TMDL Numeric Targets for both the numeric and narrative water quality objectives equal to the numeric water quality objectives for copper cited in Finding 5. The numeric targets for dissolved copper are 3.1 µg/L for continuous or chronic exposure (4-day average) and 4.8 µg/L (1-hour average) for brief or acute exposures. Attainment of the TMDL numeric targets will result in attainment of water quality standards in SIYB.

7. **SOURCES OF DISSOLVED COPPER**: Approximately 98 percent of the total copper loading to SIYB originates from copper-based antifouling paints applied to the hulls of recreational vessels moored in SIYB marinas. Of this total, 93 percent is attributable to copper entering the water column through passive leaching of copper from antifouling paints.

The remaining five percent enters the water column during periodic underwater hull cleaning of recreational vessel hulls in the marinas. Four other insignificant sources of copper were identified in the TMDL source analysis including urban runoff, direct atmospheric deposition, marine sediment and background.

8. **WATER QUALITY OBJECTIVE VIOLATIONS**: Elevated dissolved copper concentrations in SIYB have been sustained over time through continuous passive leaching of copper from antifouling paints. The effects of these discharges on water quality are exacerbated by factors such as a) the large number of vessels congregated in SIYB marinas (approximately 2,200 vessels); b) the large combined surface area of vessel hulls leaching copper; and c) reduced tidal flushing caused by the configuration of the enclosed basin. Furthermore, since recreational vessels spend most of their time moored in marinas, most of the copper from antifouling paints on the vessel hulls is released in the marinas. Sampling surveys conducted by the Regional Board in SIYB during 1994 and 2000 documented water column concentrations as high as12 μg/L and 8 μg/L of copper, respectively.

9. **ADVERSE EFFECTS OF COPPER**: Copper is used as the bioicide in antifouling paints because of its known toxicity to marine aquatic life. At relatively low concentration levels, copper is toxic to aquatic organisms. Copper toxicity to aquatic life varies between species and within individual species life stages. The early life stages of fish, bivalves and echinoderms are especially vulnerable to copper contamination. Copper tends to accumulate in sediment, threatening the benthic life at SIYB. Copper in the sediment may need to be removed through human intervention, such as dredging which can be very costly. Because of these adverse affects of copper, the use of copper-based antifouling paints is restricted or banned in parts of Europe.

10. **TOTAL MAXIMUM DAILY LOAD**: [40 Code of Federal Regulations (CFR), section 130.2(i)] The TMDL for copper discharges into SIYB is calculated to be 1.6 kilograms of copper per day (kg/day), or 567 kilograms of copper per year (kg/year). The TMDL is defined as the maximum amount of copper that SIYB can receive and still attain water quality objectives and protection of designated beneficial uses. The TMDL is comprised of the sum of all individual Wasteload Allocations (WLAs) for point source discharges of copper, the sum of all Load Allocations (LAs) for nonpoint source discharges of copper, and background. The TMDL includes a margin of safety (MOS) that takes into account any uncertainties in the TMDL calculation. (i.e. TMDL = WLAs + LAs + MOS). The TMDL calculations also account for seasonal variations and critical conditions.

11. **ALLOCATIONS AND REDUCTIONS**: A 76 percent overall reduction of residual copper loading to SIYB is required to meet the TMDL of 567 kg/year. The assigned allocations from each source translate into a percent reduction of dissolved copper from current loading. Loading due to passive leaching must be reduced by 81 percent from current loading. Loading due to underwater hull cleaning must be reduced by 28 percent from current loading. From an overall perspective, passive leaching loading must be reduced by 75 percent from the combined total loading of all sources to SIYB. Underwater hull cleaning loading must be reduced by one percent from the combined total loading of all sources to SIYB.

12. **DISCHARGERS**: The San Diego Unified Port District (Port), SIYB marina owners/operators, persons owning boats moored in SIYB, and SIYB underwater hull cleaners are accountable for the discharges of copper from boat hull antifouling paints to SIYB. To a much lesser extent, the City of San Diego (City) also discharges copper from its Municipal Separate Storm Sewer Systems (MS4s).

13. **IMPLEMENTATION ACTIONS**: Strategies that the Regional Board could take to implement the TMDL are described in the Basin Plan Amendment and Technical Report for *Total Maximum Daily Load for Dissolved Copper in Shelter Island Yacht Basin, San Diego Bay,* dated February 9, 2005.

14. **SAMPLING PROTOCOL**: Future sampling should be done in accordance with the best current protocols to reduce sample bias regarding low concentrations of metals in marine waters.

15. **COMPLIANCE MONITORING**: Water quality monitoring will be required to assess compliance in SIYB with the copper load and wasteload reductions specified in this TMDL and with the water quality objectives for copper.

16. **COMPLIANCE SCHEDULE**: Copper load and wasteload reductions are required over a 17-year staged compliance schedule period. The first stage consists of an initial 2-year orientation period during which no copper load and wasteload reductions are required. The subsequent 15-year reduction period is comprised of three stages during which incremental copper load and wasteload reductions are required.

17. **SCIENTIFIC PEER REVIEW**: The scientific basis of this TMDL has undergone external peer review pursuant to Health and Safety Code section 57004. The Regional Board has considered and responded to all comments submitted by the peer review panel.

18. **STAKEHOLDER PARTICIPATION**: Interested persons and the public have had reasonable opportunity to participate in review of the amendment to the Basin Plan. A California Environmental Quality Act (CEQA) scoping meeting was held on March 19, 2003. Efforts to solicit public review and comment included three public workshops held between May 2000 and December 2003; a public review and comment period of 90 days preceding and following the Regional Board public hearing; a second public comment period of 30 days following the release of the revised TMDL Technical Report dated October 14, 2004; and written responses from the Regional Board to oral and written comments received from the public.

19. **ECONOMIC ANALYSIS**: The Regional Board has considered the costs of reasonably foreseeable methods of compliance with the load and wasteload reductions specified in this TMDL.

20. **CEQA REQUIREMENTS**: The basin planning process has been certified as functionally equivalent to the CEQA requirements for preparing environmental documents and is,

therefore, exempt from those requirements (Public Resources Code section 21000 et seq.). The required environmental documentation (Basin Plan amendment, technical report, and environmental checklist) has been prepared.

The Regional Board finds that the analysis contained in the TMDL Technical Report, the CEQA checklist, and the responses to comments comply with the requirements of the State Board's certified regulatory CEQA process, as set forth in the California Code of Regulations, title 23, section 3375 et seq. Furthermore, the Regional Board finds that the analysis fulfills the Regional Board's obligations attendant with the adoption of regulations "requiring the installation of pollution control equipment, or a performance standard treatment or requirement", as set forth in section 21159 of the Public Resources Code.

21. **DE MINIMIS ENVIRONMENTAL EFFECTS**: This Basin Plan amendment will result in no potential for adverse effect, either individually or cumulatively, on wildlife.

22. **PUBLIC NOTICE**: The Regional Board has notified all known interested parties and the public of its intent to consider adoption of this Basin Plan amendment in accordance with CWC section 13244.

23. **PUBLIC HEARING**: The Regional Board has, at a public meeting on December 10, 2003, held a public hearing and heard and considered all comments pertaining to this Basin Plan amendment.

24. **BASIN PLAN ORGANIZATION**: Basin Plan Chapter 4, Implementation needs to be reorganized to create a subsection in which to include the Shelter Island Yacht Basin Dissolved Copper TMDL, and the Chollas Creek Diazinon TMDL Basin Plan amendments, and any future TMDL Basin Plan amendments.

NOW, THEREFORE, BE IT RESOLVED that

1. **AMENDMENT ADOPTION**: The Regional Board hereby adopts this amendment to the Basin Plan to incorporate the Shelter Island Yacht Basin Dissolved Copper TMDL, and to reorganize Chapter 4 as set forth in Attachment A hereto.

2. **TECHNICAL REPORT APPROVAL**: The Regional Board hereby approves the Technical Report for *Total Maximum Daily Load for Dissolved Copper In Shelter Island Yacht Basin, San Diego Bay*, dated February 9, 2005.

3. **CERTIFICATE OF FEE EXEMPTION**: The Executive Officer is authorized to sign a Certificate of Fee Exemption.

4. **AGENCY APPROVALS**: The Executive Officer is directed to submit this Basin Plan amendment to the State Board in accordance with CWC section 13245. The Regional Board requests that the State Board approve the Basin Plan amendment and forward it to Office of Administrative Law (OAL) and the USEPA for approval.

5. **NON-SUBSTANTIVE CORRECTIONS**: If, during the approval process for this amendment, the State Board or OAL determines that minor, non-substantive corrections to the language of the amendment are needed for clarity or consistency, the Executive Officer may make such changes, and shall inform the Regional Board of any such changes.

I, John H. Robertus, Executive Officer, do hereby certify the foregoing is a full, true and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, San Diego Region, on February 9, 2005.

Original signed by
JOHN H. ROBERTUS
Executive Officer

ATTACHMENT A
TO RESOLUTION NO. R9-2005-0019

AMENDMENT TO THE WATER QUALITY CONTROL PLAN FOR THE SAN DIEGO REGION TO INCORPORATE A TOTAL MAXIMUM DAILY LOAD FOR DISSOLVED COPPER IN SHELTER ISLAND YACHT BASIN, SAN DIEGO BAY

This Basin Plan amendment establishes a Total Maximum Daily Load (TMDL) and associated wasteload allocations for dissolved copper in the Shelter Island Yacht Basin portion of San Diego Bay. This amendment includes a program to implement the TMDL and monitor its effectiveness. This amendment also reorganizes portions of Chapter 4 of the Basin Plan dealing with TMDLs and creates a new subsection in which to include the Chollas Creek Diazinon TMDL, the Shelter Island Yacht Basin Dissolved Copper TMDL, and any future TMDL Basin Plan amendments. Chapters 2, 3, and 4 of the Basin Plan are amended as follows:

Chapter 2, Beneficial Uses
Table 2-3. ***Beneficial Uses of Coastal Waters, San Diego Bay***

Add the following footnote 3 to San Diego Bay

> [3]The Shelter Island Yacht Basin portion of San Diego Bay is designated as an impaired water body for dissolved copper pursuant to Clean Water Act section 303(d). A Total Maximum Daily Load (TMDL) has been adopted to address this impairment. See Chapter 3, Water Quality Objectives for Pesticides, Toxicity and Toxic Pollutants and Chapter 4, Total Maximum Daily Loads.

Chapter 3, Water Quality Objectives
Inland Surface Waters, Enclosed Bays and Estuaries, Coastal Lagoons, and Ground Waters

Water Quality Objectives for Pesticides:
Add a third paragraph as follows:

> The Shelter Island Yacht Basin portion of San Diego Bay is designated as an impaired water body for dissolved copper pursuant to Clean Water Act section 303(d). A Total Maximum Daily Load (TMDL) has been adopted to address this impairment. See Chapters 2, Table 2-3, *Beneficial Uses of Coastal Waters, San Diego Bay, Footnote 3* and Chapter 4, Total Maximum Daily Loads.

Water Quality Objectives for Toxicity:
Add a fourth paragraph as follows:

> The Shelter Island Yacht Basin portion of San Diego Bay is designated as an impaired water body for dissolved copper pursuant to Clean Water Act section 303(d). A Total Maximum Daily Load (TMDL) has been adopted to address this

impairment. See Chapters 2, Table 2-3, *Beneficial Uses of Coastal Waters, San Diego Bay, Footnote 3* and Chapter 4, Total Maximum Daily Loads.

Water Quality Objectives for Toxic Pollutants:
Add a second paragraph as follows:

The Shelter Island Yacht Basin portion of San Diego Bay is designated as an impaired water body for dissolved copper pursuant to Clean Water Act section 303(d). A Total Maximum Daily Load (TMDL) has been adopted to address this impairment. See Chapters 2, Table 2-3, *Beneficial Uses of Coastal Waters, San Diego Bay, Footnote 3* and Chapter 4, Total Maximum Daily Loads.

Chapter 4, Implementation
Change the second order subsection "***California Water Quality Assessment (WQA)***" to a first order section by removing it from and placing it before the section "***Other Programs***."

Change the second order subsection "***California's 303(d) Process***" to a first order section by removing it from the section "**Other Programs**" and placing it after the section "***California Water Quality Assessment (WQA)***." Change the name of the section "***California's 303(d) Process***" to "***Clean Water Act Section 303(d) Requirements for Impaired Waterbodies***." Move the sixth paragraph (which begins with "The 303(d) list of WQLS…") to the position after the first sentence in the second paragraph. Begin a new paragraph with the second sentence of paragraph 2 (which begins with "Section 303(d) requires…").

Remove "***(TMDL)***" from the title of the subsection "***Total Maximum Daily Load (TMDL) for Diazinon, Chollas Creek Watershed, San Diego County***" and move this subsection from "***Other Programs***" into the section "***Clean Water Act Section 303(d) Requirements for Impaired Waterbodies***."

After the subsection on the Chollas Creek Diazinon TMDL add the following subsection:

Total Maximum Daily Load for Dissolved Copper, Shelter Island Yacht Basin, San Diego Bay

On February 9, 2005, the Regional Board adopted Resolution No. R9-2005-0019*, A Resolution Adopting an Amendment to the Water Quality Control Plan for the San Diego Region to Incorporate a Total Maximum Daily Load for Dissolved Copper in the Shelter Island Yacht Basin, San Diego Bay*. The TMDL Basin Plan Amendment was subsequently approved by the State Water Resources Control Board on [Insert Date], the Office of Administrative Law on [Insert Date], and the United States Environmental Protection Agency on [Insert Date]. The TMDL is described in the *Total Maximum Daily Load for Dissolved Copper in Shelter Island Yacht Basin, San Diego Bay*, Technical Report dated [insert date].

Problem Statement

Dissolved copper levels in Shelter Island Yacht Basin (SIYB) waters violate water quality objectives for copper, toxicity, and pesticides. Dissolved copper concentrations in SIYB threaten and impair the designated beneficial uses of marine habitat (MAR), and wildlife habitat (WILD).

Numeric Target

The TMDL Numeric Targets for copper, toxicity and pesticides are set equal to the numeric water quality objectives for dissolved copper as defined in the California Toxics Rule (CTR) and shown below.

Table 4-10. TMDL Numeric Targets.

Exposure	Water Quality Objective*	Numeric Target*
Continuous or Chronic (4 day average)	3.1 µg/L** of copper (Cu)	3.1 µg/L** of Cu
Maximum or Acute (1 hour average)	4.8 µg/L** of Cu	4.8 µg/L** of Cu

* Concentrations should not be exceeded more than once every three years.
** micrograms/liter (µg/L)

If the water quality objectives for dissolved copper in SIYB are modified in the future, as in the case of a site-specific objective, then the numeric targets will be set equal to the new water quality objectives.

Source Analysis

Approximately 98 percent of all copper loading to SIYB is attributable to copper-based antifouling paints applied to the hulls of recreational boats. The passive leaching of copper from antifouling paint is 93 percent of the total loading. The remaining five percent of total copper loading results from underwater hull cleaning operations in SIYB.

Table 4-11. Summary of Dissolved Copper Sources to SIYB.

Source	Mass Load (kg/year)	Percent Contribution (% Cu)
Passive Leaching	2,000	93
Hull Cleaning	100	5
Urban Runoff	30	1
Background	30	1
Direct Atmospheric Deposition	3	<1
Sediment	0	0
Combined Sources	**2,163**	**100**

Total Maximum Daily Load

The TMDL or loading capacity for dissolved copper discharges into SIYB is 1.6 kilograms/day (kg/day) or 567 kilograms/year (kg/year).

Margin of Safety

The TMDL includes an explicit and implicit margin of safety (MOS). Ten percent of the loading capacity was reserved as an explicit MOS and calculated to be 57 kg/year. The implicit MOS was incorporated into the TMDL source analysis through numerous conservative assumptions.

Allocations and Reductions

A 76 percent overall reduction of residual copper loading to SIYB is required to meet the TMDL of 567 kg/year as shown in the table below. The assigned allocations from each source translate into a percent reduction of dissolved copper from current loading. Loading due to passive leaching must be reduced by 81 percent from current loading. Loading due to underwater hull cleaning must be reduced by 28 percent from current loading. From an overall perspective, passive leaching loading must be reduced by 75 percent from the combined total loading of all sources to SIYB. Underwater hull cleaning loading must be reduced by one percent from the combined total loading of all sources to SIYB.

Table 4-12. TMDL and Allocation Summary.

Source	Current Load (kg/year of Cu)	Percent Contribution (% Cu)	Allocation (kg/year of Cu)	Percent Reduction From Current Source Load (%)	Percent Reduction from Total Loading to SIYB (%)
Passive Leaching	2,000	93	375	81	75
Hull Cleaning	100	5	72	28	1
Urban Runoff	30	1	30	0	0
Background	30	1	30	0	0
Direct Atmospheric Deposition	3	<1	3	0	0
Sediment	0	0	0	0	0
Current Mass Load	2,163	100			0
Margin of Safety			57		0
TMDL			567		0
Total Load Reduction				76	76

Recalculations if Water Quality Objectives Change

If the water quality objectives for dissolved copper in SIYB are changed in the future, then the MOS, TMDL and allocations will be recalculated using the method shown in Appendix D of the Basin Plan.

TMDL Implementation Plan

The TMDL will be implemented as follows:

- The Regional Board will coordinate with governmental agencies having legal authority over the use of copper-based antifouling paints to protect water quality from the adverse effects of copper-based antifouling paints in SIYB; and

- The Regional Board will regulate discharges of copper to SIYB through the issuance of Waste Discharge Requirements (WDRs), Waivers of WDRs (waivers), or adoption of Waste Discharge Prohibitions. WDRs could build upon pollution control programs developed by discharger organizations or the Port. Likewise, waivers or prohibitions could be conditioned on implementation of pollution control programs through third party agreements between the Regional Board and discharger organizations, and/or other agencies.

- The Regional Board will amend Order No. 2001-01, "Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm /Sewer Systems" to require that discharges of copper into SIYB waters via the City's municipal separate storm/sewer system not exceed a 30 mg/kg wasteload for copper.

The dischargers will be required to monitor SIYB waters and provide monitoring reports to the Regional Board for the purpose of assessing the effectiveness of the alternatives implemented.

Compliance Schedule

Copper load and wasteload reductions are required over a 17-year staged compliance schedule period. The first stage consists of an initial 2-year orientation period during which no copper load reductions are required. The subsequent 15-year reduction period is comprised of three stages during which incremental copper load and wasteload reductions are required as shown below.

Table 4-13. Interim Loading Targets for Attainment of the TMDL.

Stage	Time Period	Percent Reduction from Current Estimated Loading	Reduction to be Attained by End of Year	Estimated Interim Target Loading (kg/year of dissolved Cu)
Stage 1	Years 1-2	0%	N/A	N/A
Stage 2	Years 2-7	10%	7	1,900
Stage 3	Years 7-12	40%	12	1,300
Stage 4	Years 12-17	76%	17	567

At the end of the Basin Plan, add the following Appendix D:

APPENDIX D
METHOD FOR RECALCULATION OF THE TOTAL MAXIMUM DAILY LOAD FOR DISSOLVED COPPER IN THE SHELTER ISLAND YACHT BASIN, SAN DIEGO BAY

This appendix describes the method for recalculating the Shelter Island Yacht Basin TMDL for dissolved copper if the water quality objectives for dissolved copper are modified in the future.

Numeric Target

The numeric targets are set equal to the new water quality objectives.

Margin of Safety

The explicit margin of safety (MOS) equals ten percent of the loading capacity. The equation to calculate the loading capacity is given below.

Total Maximum Daily Load

The TMDL or loading capacity is recalculated using equations 1 through 4 below.

The loading capacity is recalculated according to equation 1 below:

$$(1) \quad R_S = C_2\left(\frac{KA_c}{\Delta x} + k_L V_2\right) - A_c C_1\left(\frac{eA_s}{A_c} + \frac{K}{\Delta x}\right)$$

where C_1 = average background concentration of copper measured in the area of San Diego Bay adjacent to SIYB, expressed as total copper, (0.05 μg/L)

C_2 = average target concentration for copper in the SIYB (expressed as total copper) when the maximum concentration of copper in SIYB is equal to or less than the numeric target (mass/volume)

K = dispersion coefficient calculated from salinity measurements and mixing length approximation (15.3 m^2/sec)

A_c = cross-sectional area of entrance to SIYB (1,000 m^2)

A_s = surface area of SIYB (740,000 m^2)

Δx = average mixing length between SIYB and adjacent area; estimated distance between the endpoints for S_1 and S_2 (2,000 m)

V_2 = volume of SIYB (31,000,000 m^3)

e = evaporation rate (0.43 cm/day)

k_l = rate of total copper loss to sediment (7%/day)

R_S = loading capacity, expressed as total copper (mass/time); R_S is calculated iteratively to find the maximum possible value that does not cause C_2 to exceed the numeric target.

The dispersion coefficient K is calculated using equation 2 below:

(2) $$K \cong \frac{eA_s S_1 \Delta x}{A_c (S_2 - S_1)}$$

where S_1, S_2 = salinity data obtained in SIYB and San Diego Bay adjoining SIYB (33.62 practical salinity units (psu) and 33.46 psu, respectively).

The average target concentration, C_2, must be lower than the numeric target concentration to ensure that the loading capacity will not cause an exceedance of the numeric target anywhere in SIYB. C_2 is calculated by multiplying the numeric target for chronic exposure by the ratio of the average measured concentration of copper in SIYB to the maximum measured concentration as expressed in equation 3 below:

(3) C_2 = numeric target [average measured concentration/maximum measured concentration]

Or,

C_2 = numeric target * [5.45 µg/L / 8 µg/L]

To convert C_2 from dissolved copper concentration to total copper concentration, the number calculated from equation 3 is multiplied by the ratio of dissolved copper to total copper in seawater. If site-specific data are not available, the ratio of 0.83 can be used. This is the USEPA's conversion factor for saltwater acute criteria.[1]

Finally, the TMDL is calculated according to equation 4 below:

(4) TMDL = Rs - MOS

Allocations

Equation 5 is used to determine the new allocation for passive leaching. In equation 5, the only variable is the allocation for passive leaching (Ap), while the other source allocations are constants. The allocation for hull cleaning remains the same, since it was based on the assumption that all of the divers will use Management Practices (MPs) to clean boat hulls that have copper bottom paints. Allocations for the other sources, namely urban runoff, background and sediment will not be recalculated because these sources of copper are insignificant.

(5) TMDL = Wasteload Allocation + Load Allocations + MOS

TMDL = Au + Ap + Ah + As + Ab + Aa + MOS

where:

Au = allocation for urban runoff = 30 kg/year
Ap = allocation for passive leaching
Ah = allocation for hull cleaning = 72 kg/year
As = allocation for sediment = load from sediment = 0 kg/year
Ab = allocation for background = load from background = 30 kg/year

[1] USEPA. 2000. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule. 40 CFR Part 131. May 18, 2000.

Aa = allocation for direct atmospheric deposition = load from direct atmospheric deposition = 3 kg/year.

I. EXECUTIVE SUMMARY

Shelter Island Yacht Basin (SIYB) is a semi-enclosed popular recreational yacht basin located at the north end of San Diego Bay, in southern California. SIYB is comprised of recreational marinas and yacht clubs[2] that support a high density of recreational vessels in an area of low tidal flushing. Recreational vessels at SIYB are typically painted with copper-based antifouling paints to slow down the buildup of marine organisms on the vessels' hulls. The copper in antifouling paints is designed to leach into the environment to prevent marine fouling, in a process known as passive leaching. At relatively low concentrations copper is toxic to a wide range of aquatic organisms, not just fouling organisms, and is persistent in the environment.

The copper from antifouling paints on vessels at SIYB has resulted in elevated dissolved copper concentrations that have been sustained over time through continuous passive leaching. Since recreational vessels spend much of their time moored in marinas, most of the copper from antifouling paints on the vessel hulls is released in the marinas at SIYB. The effects of these discharges on water quality are exacerbated by factors such as the high density of recreational vessels congregated in SIYB marinas, the extensive combined surface area of vessel hulls leaching copper, and reduced tidal flushing caused by the configuration of the enclosed basin.

Section 303(d) of the federal Clean Water Act (CWA) requires that each state identify waterbodies within its boundaries for which the effluent limitations are not stringent enough to meet applicable water quality standards (i.e., water quality objectives and beneficial uses). Section 303(d) also requires states to establish a priority ranking for these impaired waters, known as the List of Impaired Water Bodies, or Section 303(d) list, and to establish Total Maximum Daily Loads (TMDLs) for such waters. The purpose of a TMDL is to restore the beneficial uses and to attain the water quality objectives in the waterbody. A TMDL represents the maximum amount of the pollutant of concern that the waterbody can receive and still attain water quality standards. Once this maximum pollutant amount has been calculated, it is then divided up and allocated amongst all of the contributing sources in the watershed. In order to meet the TMDL, an Implementation Plan is also developed that describes the pollutant reduction actions that must be taken by various dischargers to meet the allocations. The Implementation Plan includes a time schedule for meeting the required pollutant reductions and requirements for monitoring to assess the effectiveness of the load reduction activities in attaining water quality objectives and restoring beneficial uses. When the TMDL is fully implemented, i.e., all of the contributing sources have reduced their current loading of the pollutant to their assigned allocation, water quality standards are expected to again be achieved in the receiving water.

The California Regional Water Quality Control Board, San Diego Region (Regional Board) is responsible under the California Water Code (CWC) for protecting the beneficial uses of the waters of the State in the San Diego Region by regulating the discharge of pollutants to those waters, as required under the CWA. Due to high concentrations of dissolved copper, in 1996 the Regional Board placed SIYB on the list of impaired waterbodies, i.e. not meeting applicable water quality standards. Dissolved copper concentrations at SIYB exceed the numeric water quality objectives for copper and the narrative water quality objectives for toxicity and pesticides

[2] In this TMDL document, the term "marina" refers to marina facilities and yacht club facilities.

as defined in the Water Quality Control Plan for the San Diego Basin – Region 9 (Basin Plan). These exceedances threaten the wildlife habitat and marine habitat beneficial uses of SIYB. High levels of copper in the water column at SIYB are also a concern because of the increased potential to contaminate sediment, and adversely impact aquatic benthic life. A TMDL was developed to meet water quality objectives at SIYB and protect beneficial uses.

Technical TMDL

In this TMDL, the numeric targets were set equal to water quality criteria (WQC) for dissolved copper as set forth by the United States Environmental Protection Agency (USEPA) in the California Toxics Rule (CTR) (USEPA, 2000b). The CTR's WQC serve as legally applicable numeric water quality objectives for dissolved copper in the state of California. WQC are established by the USEPA at levels necessary to ensure the protection of aquatic life from acute and chronic toxicity. When the numeric targets are met, both the numeric water quality objective and the narrative water quality objectives for toxicity and pesticides due to dissolved copper in the water column are expected to be met at SIYB. The numeric target for dissolved copper is 3.1 micrograms/liter (µg/L) for continuous or chronic exposure (4-day average) and 4.8 µg/L (1-hour average) for maximum or acute exposures, not to be exceeded more than once every three years. Sampling surveys conducted at SIYB by the Regional Board demonstrate that levels exceed the numeric target (and numeric water quality objectives) by two to threefold, with concentrations as high as 8.0–12.0 µg/L of copper.

The analysis of the sources of dissolved copper to SIYB shows that the vast majority (98 percent) of copper enters the Basin from copper-based antifouling paints (Table i.). The greatest source of loading results from passive leaching of copper antifouling paints applied to the vessels moored in SIYB, accounting for approximately 93 percent (2,000 kilograms/year (kg/year) of copper) of total loading. The second most significant source results from underwater hull cleaning of the copper antifouling paints on vessel hulls in the marinas, accounting for approximately five percent (100 kg/year of copper) of total loading. Dissolved copper also enters SIYB from urban runoff, although the contribution is marginal compared to the other anthropogenic sources, at approximately one percent (30 kg/year) of the total load. In addition, copper is found naturally in seawater, and background loading accounts for approximately one percent (30 kg/year). Direct atmospheric deposition was also determined to be a relatively insignificant contributor of dissolved copper, accounting for less than one percent (3 kg/year) of the total load. Lastly, sediment was found to act primarily as a sink, rather than a source, of dissolved copper under current loading conditions to SIYB. This is of concern due to the likelihood of long-term contamination of sediment by copper.

Table i. Summary of Dissolved Copper Sources to SIYB.

Source	Mass Load (kg/year of Cu*)	Percent Contribution (% Cu*)
Passive Leaching	2,000	93
Hull Cleaning	100	5
Urban Runoff	30	1
Background	30	1
Direct Atmospheric Deposition	3	<1
Sediment	0	0
Combined Sources	2,163	100

* Copper (Cu)

A copper fate and transport model based on mass-balance principles was developed for SIYB to calculate the loading capacity or TMDL for copper discharges to SIYB. Using this model, the TMDL for dissolved copper at SIYB was calculated to be 567 kg/year (Table ii). An overall 76 percent reduction in loading is required from the sources to SIYB to achieve the TMDL. Most of the load reduction will be required from the most significant anthropogenic source, passive leaching, as well as to a lesser extent from the second most significant source, hull cleaning. No reductions will be required from the other much less significant sources. In terms of the total reduction necessary from all sources to meet the TMDL, 75 percent of the necessary reduction will be required from passive leaching, amounting to an 81 percent reduction from current passive leaching loading (Table ii). Furthermore, one percent of the necessary total reduction will be required from hull cleaning, amounting to a 28 percent reduction from current hull cleaning loading.

Reductions from passive leaching and hull cleaning are expected to be achieved through implementation of Management Practices (MPs), such as the use of nontoxic or less toxic antifouling paints in place of copper-based paints. Switching to nontoxic and less toxic antifouling paints will result in load reductions from both passive leaching and underwater hull cleaning. Achievement of the required copper load and wasteload reductions should result in the attainment of water quality objectives and restoration of beneficial uses in SIYB. As required by the basin planning process, the scientific basis for this TMDL has undergone external peer review pursuant to Health and Safety Code section 57004.

Table ii. TMDL and Allocation Summary.

Source	Current Load (kg/year)	Allocation (kg/year)	Percent Reduction from Current Loading (%)	Percent Reduction from Total Loading (%)
Passive Leaching	2,000	375	81	75
Hull Cleaning	100	72	27	1
Urban Runoff	30	30	0	0
Background	30	30	0	0
Direct Atmospheric Deposition	3	3	0	0
Sediment	0	0	0	0
Margin of Safety		57		
Combined Sources	2,163			76
TMDL		567		

Implementation Plan

Copper-based antifouling paints are legally registered pesticides subject to regulation by the USEPA under regulation pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the California Department of Pesticide Regulation (DPR) regulation pursuant to the California Food and Agriculture Code. In this TMDL document, the “discharge of copper” refers to “residual copper” which is defined as any molecule of copper that leaches, dissolves, ablates, or erodes from boat hull antifouling paints into SIYB surrounding waters and does not reach a target fouling organism. This includes residual copper that results from legally registered hull antifouling paints used in accordance with label instructions in compliance with the FIFRA.

The Regional Board has the authority to use its administrative tools to regulate the San Diego Unified Port District, SIYB marina owners and operators, persons owning boats moored in SIYB, and hull cleaners operating in SIYB to reduce copper discharges to SIYB to reduce copper discharges to SIYB. To a much lesser extent, the City of San Diego also discharges copper from its Municipal Separate Storm Sewer Systems (MS4s). There are several strategies and management practices available to the dischargers to reduce copper loading to SIYB. They include:

- Transition to nontoxic and less toxic hull coatings;
- Reduce effects of copper-based paints through management practices;
- Conduct boater education programs;
- Conduct commercial demonstrations and scientific studies;
- Impose controls on SIYB boat owners;
- Implement financial incentives;

- Impose controls on SIYB marina owners and operators to limit use of copper-based hull paints; and

- Implement financial incentives to encourage the use of alternative antifouling strategies.

The TMDL will be implemented as follows:

- The Regional Board will coordinate with governmental agencies having legal authority over the use of copper-based antifouling paints to protect water quality from the adverse effects of copper-based antifouling paints in SIYB; and

- The Regional Board will regulate the discharge of copper to SIYB waters through the issuance of Waste Discharge Requirements (WDRs), Waivers of WDRs (waivers), or adoption of Waste Discharge Prohibitions. WDRs could build upon pollution control programs developed by discharger organizations or the Port. Likewise, waivers or prohibitions could be conditioned on implementation of pollution control programs through third party agreements between the Regional Board and discharger organizations, and/or the Port.

- The Regional Board will amend Order No. 2001-01, "Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm /Sewer Systems" to require that discharges of copper into SIYB waters not increase via the City's municipal separate storm /sewer system from existing loadings.

The dischargers will be required to monitor SIYB waters for the purpose of assessing the effectiveness of the alternatives implemented.

Compliance Schedule
Copper load reductions are required over a 17-year staged compliance schedule period. The first stage consists of an initial 2-year orientation period during which no copper load reductions are required. The subsequent 15-year reduction period is comprised of three stages during which incremental copper load reductions are required as shown below.

Table iii. Interim Loading Targets for Attainment of the TMDL.

Stage	Time Period	Percent Reduction from Current Estimated Loading	Reduction to be Attained by End of Year	Estimated Interim Target Loading (kg/year of dissolved Cu)
Stage 1	Years 1-2	0%	N/A	N/A
Stage 2	Years 2-7	10%	7	1,900
Stage 3	Years 7-12	40%	12	1,300
Stage 4	Years 12-17	76%	17	567

Environmental and Economic Analysis
The Regional Board is the lead agency for evaluating the environmental impacts of this Basin Plan amendment pursuant to the California Environmental Quality Act (CEQA). The Basin Planning process has been certified as functionally equivalent to CEQA requirements for

preparing environmental documents and is, therefore, exempt from those requirements (Public Resources Code section 21000 et seq.). The required environmental documentation (Basin Plan amendment, technical report, and environmental checklist) has been prepared. The Regional Board has identified environmental impacts, reasonable alternatives, and mitigation measures to minimize any significant adverse environmental impacts of the proposed Basin Plan amendment. The Regional Board has also considered the costs of reasonably foreseeable methods of compliance with the TMDL through an economic analysis.

As required by the Basin Planning process, the Regional Board has encouraged and provided numerous opportunities for stakeholder participation, including CEQA scoping meeting, stakeholder meetings, public workshops, a formal public review and comment period, and a public hearing. The Regional Board will hold a public hearing to consider adopting Resolution No. R9-2005-0019amending the Basin Plan to incorporate this TMDL. Once adopted, the Basin Plan amendment will be submitted to the State Board, the Office of Administrative Law, and the USEPA for subsequent approvals.

II. TECHNICAL ANALYSIS

Shelter Island Yacht Basin (SIYB) is a recreational yacht basin comprised of marinas and yacht clubs,[3] an anchorage, a fuel dock and other facilities that support the marine industry. SIYB is located near the mouth of San Diego Bay, California. Levels of dissolved copper in SIYB exceed numeric water quality objectives for copper and narrative water quality objectives for toxicity and pesticides, and threaten and impair the wildlife habitat and marine habitat beneficial uses in SIYB. Due to this exceedance, SIYB was placed on the list of impaired waterbodies compiled pursuant to federal Clean Water Act (CWA) section 303(d). This TMDL was developed to address and resolve this impairment.

1. Introduction

Section 303(d)(1)(A) of the federal CWA requires that "[e]ach State shall identify those waters within its boundaries for which the effluent limitations…are not stringent enough to implement any water quality standard applicable to such waters." Section 303(d) also requires states to establish a priority ranking for waters on the List of Impaired Waterbodies, or the Section 303(d) list, and to establish Total Maximum Daily Loads (TMDLs) for such waters.

The purpose of a TMDL is to attain water quality objectives and restore and protect the beneficial uses of an impaired waterbody. The TMDL represents a strategy for meeting water quality objectives by allocating quantitative limits for point and nonpoint pollution sources. A TMDL is defined as the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background (40 Code of Federal Regulations (CFR), section 130.2) such that the capacity of the waterbody to assimilate pollutant loading (i.e., the loading capacity) is not exceeded.

The TMDL process began with the development of this technical report which includes the following 7 components: (1) a **Problem Statement** describing which water quality objectives are not being attained and which beneficial uses are impaired; (2) identification of **Numeric Targets** which will result in attainment of the water quality objectives and protection of beneficial uses; (3) a **Source Analysis** to identify all of the point and nonpoint sources of the impairing pollutant in the watershed and to estimate the current pollutant loading for each source; (4) a **Linkage Analysis** to calculate the **Loading Capacity** of the waterbody for the pollutant; i.e., the maximum amount of the pollutant that may be discharged to the waterbody without causing exceedances of water quality objectives and impairment of beneficial uses; (5) a **Margin of Safety** (MOS) to account for uncertainties in the analysis; (6) the division and **Allocation** of the TMDL among each of the contributing sources in the watershed, wasteload allocations (WLA) for point sources and load allocations (LA) for nonpoint and background sources; (7) a description of how **Seasonal Variation and Critical Conditions** are accounted for in the TMDL determination. The document containing the above components is generally referred to as the technical TMDL report.

[3] In this TMDL document, the term "marina" refers to marina facilities and yacht club facilities.

This report also includes an **Implementation Plan** that describes the pollutant reduction actions that must be taken by various responsible parties to meet the allocations specified in the technical report. A time schedule for meeting the required pollutant reductions is included in the Implementation Plan. In addition, the Implementation Plan also includes requirements for a Monitoring Plan that must be implemented to assess the effectiveness of the load reduction activities in attaining water quality objectives and restoring beneficial uses. Public participation is a key element of the TMDL process, and stakeholder involvement was encouraged and required.

Once established, the regulatory provisions of the TMDL, Implementation Plan, and Monitoring Plan are incorporated into the Water Quality Control Plan for the San Diego Basin – Region 9 (Basin Plan) via a formal action by the California Regional Water Quality Control Board, San Diego Region (Regional Board) to amend the Basin Plan in a public hearing. Additional requirements of the Basin Plan amendment process also include an evaluation of economic and environmental considerations. As with any Basin Plan amendment involving surface waters, a TMDL adopted by the Regional Board will not take effect until it has undergone subsequent agency approvals by the State Water Resources Control Board (State Board), the Office of Administrative Law (OAL), and the United States Environmental Protection Agency (USEPA).

Following these approvals, the Regional Board is required to incorporate the regulatory provisions of the TMDL into all applicable regulatory mechanisms. Numeric limits for the impairing pollutant in the subject watershed may be added to the appropriate waste discharge requirements to implement and make the TMDL enforceable.

The final and most important step in the process is the implementation of the TMDL by the responsible parties. Per the governing waste discharge requirement (WDR) order (or other regulatory mechanism), each responsible party must reduce its current loading of the pollutant to its assigned allocation of the pollutant in accordance with the time schedule specified in the technical report (and implementing order). When each responsible party has achieved its required load reduction, water quality standards for the impairing pollutant are expected to be restored in the receiving waters.

2. Problem Statement

Levels of dissolved copper at SIYB, a recreational yacht basin in San Diego Bay, exceed numeric water quality objectives for copper and narrative water quality objectives for toxicity and pesticides in the water column. These exceedances threaten and impair the wildlife habitat and marine habitat beneficial uses in SIYB. In this analysis, the majority of dissolved copper entering SIYB was found to come from copper-based antifouling paints on the vessels moored in the Yacht Basin.

SIYB is a popular recreational yacht basin comprised of marinas and yacht clubs numerous marinas, yacht clubs, an anchorage, a fuel dock and other facilities that support the marine industry located in the north end of San Diego Bay. SIYB supports a high density of recreational vessels in an area of reduced tidal flushing. The vast majority of recreational vessels in SIYB are painted with copper-based antifouling paint coatings. Antifouling paints are applied to vessel hulls to discourage attachment and growth of aquatic organisms, such as barnacles, which results in increased corrosion and drag, reduced safety and maneuverability, and decreased fuel efficiency and economy. Copper is typically the toxic component added to antifouling paints to prevent the attachment of these organisms. Copper is toxic to a wide range of aquatic organisms, however, not just to fouling organisms. The most common toxicant in copper-based paints used on recreational vessels is cuprous oxide, which acts as a preventative biocide by leaching into the water column. Copper in antifouling paints also enters the marine environment through underwater hull cleaning, a common practice used to help prevent the buildup of marine organisms on vessel hulls. Copper from these paints enters the water column, and is largely responsible for the high dissolved copper concentrations that persist in the Basin. Elevated copper levels in the water column also increase the likelihood of contamination of the sediment. Not surprisingly, copper is the most common pollutant found at toxic levels in marinas nationwide (USEPA, 1993).

Under the California Water Code (CWC), the Regional Board is responsible for protecting beneficial uses in the Region's surface waters, by regulating the discharge of pollutants to those waters, as required under the CWA. The Regional Board designated SIYB as an impaired waterbody on the Section 303(d) list due to elevated levels of dissolved copper in 1996. Current concentrations at SIYB exceed numeric water quality objectives for copper, which are equal to federal water quality criteria designed to protect marine aquatic life from toxicity to dissolved copper. Concentrations at SIYB also do not meet the narrative water quality objectives for toxicity and pesticides as defined in the Basin Plan. Elevated levels of dissolved copper threaten the designated beneficial uses of SIYB, including wildlife and marine habitat. A TMDL and Implementation Plan were developed to meet water quality objectives at SIYB and protect beneficial uses.

Watershed Characteristics

San Diego Bay is a semi-enclosed, crescent-shaped estuary that opens to the Pacific Ocean. The Bay is located in southern California, north of the Mexican border. San Diego Bay extends approximately 24 kilometers (km) in length and varies from about 0.4 to 5.8 km in width (State Board *et al.*, 1996). Extensive dredging of channels and near-shore filling has significantly altered the Bay in terms of depth and width (State Board *et al.*, 1996). Depths vary from less than one meter in the southern portion of the Bay to 18 meters near the mouth, with an average depth of 12 meters (State Board *et al.*, 1996).

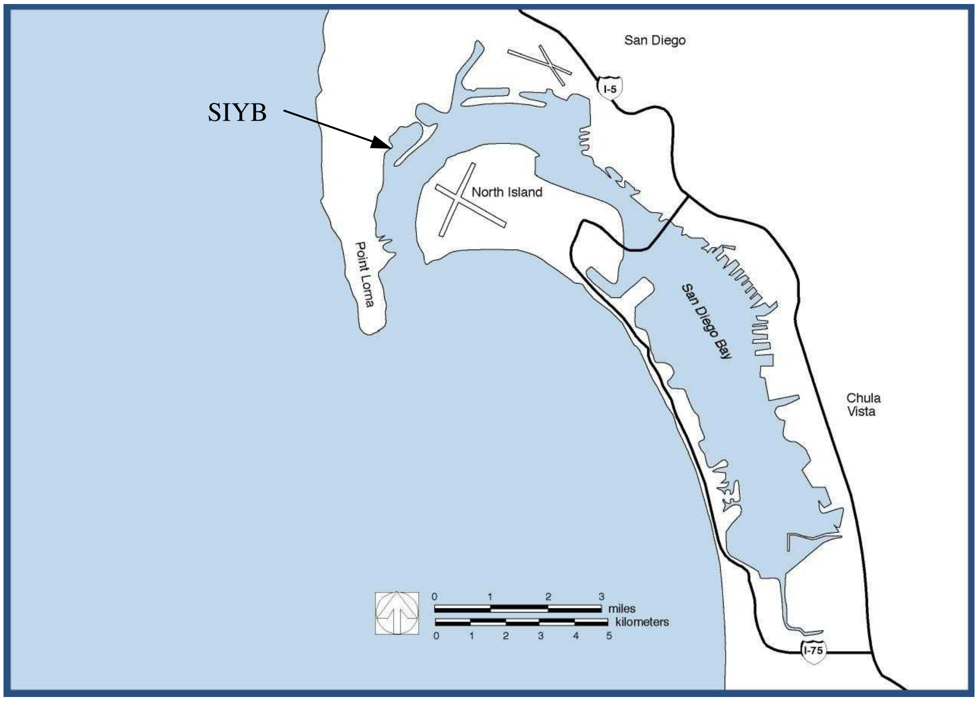

Figure 2.1. Map of San Diego Bay and Shelter Island Yacht Basin.

San Diego Bay may be divided into northern, central and southern portions that differ in hydrologic characteristics. High current velocities and rapid tidal flushing characterize the northern reaches of the Bay, and tidal currents primarily control surface water mixing. These characteristics decrease into the central and southern reaches of the Bay, which are characterized by lower current velocities and longer contaminant residence times (Valkirs *et al*., 1994). The semi-enclosed marinas and commercial basins located throughout the Bay also experience reduced tidal flushing and increased contaminant residence times (Seligman and Zirino, 1998).

The climate in the area is Mediterranean-like and may be characterized as semi-arid with little precipitation, and an annual rainfall of about 25 centimeters/year (Largier, 1995). There is very little freshwater input to the Bay and its salinity approaches that of seawater, especially closer to the mouth. During the dry season, the Bay may be characterized as hypersaline, particularly in the southern reaches of the Bay (Largier, 1995). Both temperature and salinity values increase from the Bay's entrance into the southern reaches (Katz, 1998).

The San Diego Bay watershed is composed of three main sub-watersheds that include Sweetwater, Otay and Pueblo San Diego for a total land area of 1,144 square kilometers (km^2). Runoff from the watersheds feed into the Bay. The San Diego Bay watershed is highly urbanized and industry dominates the shoreline around the Bay. Much of the bayside is owned and operated by the U.S. Navy. Industries located along the Bay may be divided into maritime, including boatyards and shipyards, aerospace, and various industries, such as power generating plants. San Diego Bay is also valued as a wildlife habitat and refuge for migratory and estuarine birds, endangered species, marine mammals, and as a spawning area for near-shore marine fishes. In addition, San Diego Bay supports many recreational uses including swimming, sport fishing, and recreational boating. Numerous marinas are located throughout San Diego Bay, and according to the Port's annual pleasure craft survey, approximately 7,295 recreational vessels have a confirmed occupancy in San Diego Bay (Harbor Police, 1999). The major designated beneficial uses of San Diego Bay (and SIYB) include commercial, recreational, wildlife and industrial uses (Regional Board, 1994). Further discussion of beneficial uses is provided in Section 2.2.

SIYB is a semi-enclosed, human-made yacht basin located in the north end of San Diego Bay near the Bay's mouth, which opens to the Pacific Ocean (Calwater ID # 4912.000000). There are approximately ten popular recreational marinas and yacht clubs located in SIYB. SIYB supports the greatest number of moored vessels of all the yacht basins in San Diego Bay. Approximately 2,242 recreational boats are moored at SIYB (Harbor Police, 1999). The SIYB watershed is comprised of a portion of the Pueblo San Diego sub-watershed. There is a total drainage area of 2.64 km^2 directly to the SIYB by way of nine outfalls (City of San Diego, 2003). Land uses are classified as exclusively single family residential (City of San Diego, 2003). The average depth in SIYB is approximately 6 meters. A map of the Basin is provided in Figure 2.2.

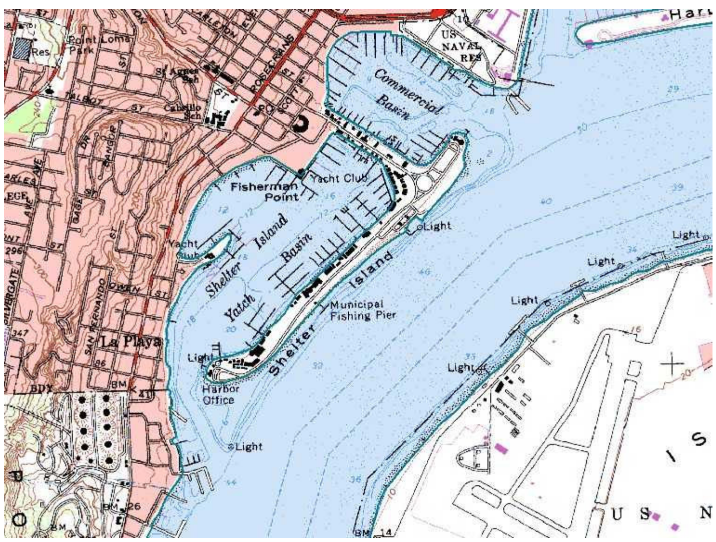

Figure 2.2. Map of the Shelter Island Yacht Basin in San Diego Bay.

Water Quality Standards

Water quality standards consist of water quality objectives and beneficial uses. Water quality objectives are defined under CWC section 13050(h) as "limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water." Under section 304(a)(1) of the CWA, the USEPA is required to publish water quality criteria that incorporate ecological and human health assessments based on current scientific information (USEPA, 1997). Water quality objectives must be based on scientifically sound water quality criteria (WQC), and be at least as stringent as those criteria.

The USEPA promulgated numeric water quality criteria for priority toxic pollutants, including dissolved copper, in the California Toxics Rule (CTR) (USEPA, 2000b). The passage of the CTR creates "legally applicable water quality standards in the State of California for inland surface waters, enclosed bays and estuaries for all purposes and programs under the CWA" (USEPA, 2000b). Water quality criteria contained in the CTR for dissolved copper are the same as the national recommended criteria concentration values (USEPA, 1998). Numeric water quality objectives for copper in California are equal to federal water quality criteria as defined in the CTR (USEPA, 2000b).

In accordance with numeric water quality objectives, dissolved copper concentrations in seawater should not exceed 3.1 micrograms/liter (μg/L) for continuous or chronic exposures (not to be exceeded over a four-day average), and 4.8 μg/L for brief or acute exposures (not to be exceeded over a one-hour average). These concentration limits must not be exceeded more than once every three years (USEPA, 1994). The numeric water quality objectives for copper are shown in the table below:

Table 2.1. Numeric Water Quality Objectives for Dissolved Copper.

Exposure	***Water Quality Objective****
Chronic	3.1 μg/L
Acute	4.8 μg/L

*Concentrations should not be exceeded more than once every three years.

In December 2003, the USEPA issued the *Draft Update of Ambient Water Quality Criteria for Copper* (EPA-822-R-03-026), containing updated freshwater and saltwater aquatic life criteria for copper. These criteria revisions are based in part on new data that have become available since the USEPA's last comprehensive criteria updates for copper. In accordance with the CWA, the USEPA must develop, publish, and periodically revise criteria for water quality that accurately reflect the latest scientific knowledge. The USEPA's recommended water quality criteria provide guidance for states and authorized tribes to establish water quality standards under the CWA to protect human health and aquatic life.

For marine organisms, the proposed criteria are more stringent than the current water quality objectives shown in Table 2.1. Should the criteria be adopted and eventually promulgated as numeric water quality objectives in the CTR, the new values would be those shown in Table 2.2.

Table 2.2. Proposed Numeric Water Quality Criteria for Dissolved Copper.

Exposure	**Water Quality Objective***
Chronic	1.9 μg/L
Acute	3.1 μg/L

*Concentrations should not be exceeded more than once every three years.

In addition to numeric water quality objectives, the Basin Plan contains narrative water quality objectives for toxicity and for pesticides. These objectives are applicable to all inland surface waters, enclosed bays and estuaries, coastal lagoons, and ground waters of the San Diego Region (Regional Board, 1994), and are described below:

> **Toxicity Objective**: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by

use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Board.

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

Water quality objectives must protect the most sensitive beneficial uses of a waterbody. Beneficial uses of San Diego Bay, all of which apply to SIYB, are described in the Basin Plan (Regional Board, 1994), and are listed below:

- Industrial service supply (IND)
- Navigation (NAV)
- Water contact recreation (REC1)
- Non-contact water recreation (REC2)
- Commercial and sport fishing (COMM)
- Preservation of biological habitats of special significance (BIOL)
- Estuarine habitat (EST)
- Wildlife habitat (WILD)
- Marine habitat (MAR)
- Migration of aquatic organisms (MIGR)
- Shellfish harvesting (SHELL)
- Rare, threatened, or endangered species (RARE)

Copper Speciation

Copper is a naturally occurring crustal metal that is ubiquitous in the environment and is found in water, sediment and biota. Copper also tends to be present in both industrial and urban discharges from anthropogenic sources.

Copper exists as a variety of chemical species, or forms, in natural waters that include particulate and dissolved forms (Figure 2.3). The particulate form of copper tends to become bound up in sediment where it may not be bioavailable, and therefore not toxic, to organisms, at least temporarily. Dissolved copper species are comprised of inorganic forms and organic complexes. Organic complexes are formed through complexation with organic molecules naturally found in the environment, such as humic substances and phytoplankton complexes. Copper has a strong affinity for organic molecules, and the predominant form of copper in seawater and estuaries is an organic complex. Inorganic forms include the ionic form (Cu^{2+}) and inorganic complexes, such as hydroxy- and carbonate-copper complexes. Inorganic complexation is fast and can effectively be considered an equilibrium process. The various copper species present in water, and thus toxic to aquatic life, is affected by factors such as pH, alkalinity, and the presence of organic ligands. For example, toxicity decreases with increased organic carbon and alkalinity.

Copper Forms
↙ ↘
Dissolved Particulate
↙ ↘
Inorganic Forms Organic Complexes
↙ ↘
Ionic Form (Cu^{2+}) ↔ Inorganic Complexes

Figure 2.3. Speciation of Total Copper in Seawater.

Copper Toxicity to Aquatic Life

Aquatic life toxicity to copper is influenced by the copper species and complexes it forms. Dissolved copper is more readily available and toxic to aquatic organisms than the particulate form. Of the dissolved copper species, the inorganic or ionic forms tend to be substantially more toxic than organic complexes (USEPA, 1999). Free copper ions and weak inorganic complexes are the forms that most readily assimilate from the water. Copper toxicity can be most closely related to the concentration of free ions and weak inorganic complexes, as compared to the total copper concentration.

Copper concentrations considered protective of human health are much higher than for aquatic life. Copper is a minor nutrient for plants and animals at very low concentrations, however at concentrations not much higher, copper can be toxic to aquatic organisms. Toxicity to aquatic life varies between species and within individual species life stages. The early life stages of fish, bivalves and echinoderms are especially vulnerable to copper contamination (Seligman and Zirino, 1998). Phytoplankton and zooplankton, including bivalve larvae, are the most sensitive organisms to copper toxicity. Saltwater algae have been shown to be adversely affected by exposures of total copper ranging between 5 and 100 µg/L (USEPA, 1986). Aquatic organisms mainly take up copper through dietary exposure. Acute toxicity to saltwater animals has been documented to range from 5.8 µg/L to 600 µg/L total copper for the green crab (EPA, 1986). Oysters and mussels bioaccumulate copper and oysters can become bluish-green through exposure (USEPA, 1986). Under chronic exposure, the bay scallop was killed at 5 µg/L total copper (USEPA, 1986). There does not seem to be evidence of biomagnification up the food chain.

Copper Levels in San Diego Bay

Dissolved copper concentrations are elevated in many locations throughout San Diego Bay, particularly in the southern reaches and enclosed yacht basins (Katz, 1998; VanderWeele, 1996; McPherson and Peters, 1995; Valkirs *et al*., 1994). In a 1998 US Navy study designed to evaluate dissolved copper concentrations throughout San Diego Bay, over half of the samples taken exceeded the numeric water quality objective of 3.1 µg/L (Katz, 1998). In another study that sampled dissolved copper concentrations in the Bay from 1991 to 1993, levels ranged from 2.8 to 5.8 µg/L, with an average of 3.8 µg/L (Valkirs *et al*., 1994). Levels tended to be highest in south San Diego Bay and in the enclosed yacht basins.

Marinas tend to have elevated levels of pollutants in the water column and sediments, including copper. For example, results from the Southern California Bight 1998 regional monitoring study demonstrated that sediment from marinas throughout southern California had consistently elevated copper levels, and demonstrated the highest toxicity of all harbor and ocean strata in the Southern California Bight (Bay *et al.,* 2000). In another study conducted by the Regional Board in 1993 and 1994, dissolved copper concentrations were consistently higher in marina areas than in or near the main channel of San Diego Bay (McPherson and Peters, 1995). Elevated copper levels in marinas may be attributed to a number of factors. High densities of vessels and low hydrologic flushing characterize most marinas, and contribute to significant water quality problems, including increased pollutants in the water column, sediments, and tissues of aquatic organisms.

Sources of copper loading to San Diego Bay were investigated in two comprehensive analyses, one conducted by the US Navy and one by environmental consulting firms, PRC Environmental Management, Inc. (PRC), and Woodward-Clyde (Johnson *et al.,* 1998; PRC, 1997). PRC and Woodward-Clyde were contracted by the TMDL committee of the San Diego Bay Interagency Water Quality Panel to estimate copper loading to the Bay through funding provided under section 205(j) of the CWA. In both the Navy and PRC/Woodward-Clyde studies, the majority of dissolved copper loading to the Bay was attributed to copper-based antifouling paints, specifically from passive leaching and underwater hull cleaning. Antifouling paints are discussed in further detail in Section 4. Additional, but less significant sources of copper to the Bay include urban runoff and direct atmospheric deposition. In the past, waste discharges from boatyards and shipyards were known to be significant sources of copper to San Diego Bay. However, increasing regulations and controls over the past years has dramatically reduced the contribution of copper in boatyard and shipyard discharges.

Copper Levels in Shelter Island Yacht Basin

SIYB supports a high density of recreational vessels in a semi-enclosed, relatively shallow-water area. Concentrations of dissolved copper have been found to be consistently elevated over many years in SIYB (McPherson and Peters, 1995; Valkirs *et al.,* 1994; Johnston, 1990; Krett, 1980). Concentration levels were measured in 1991 through 1993 at SIYB as part of an US Navy study (Valkirs *et al.,* 1994). Researchers found that the mean concentration at SIYB over this time frame was 6.9 μg/L of copper. In another study conducted by the Regional Board in 1994, dissolved copper concentrations were found to be as high as 12 μg/L (McPherson and Peters, 1995). Recent surveys conducted by the Regional Board (2000) documented concentrations averaging as high as 8.0 μg/L of copper (Appendix 6). Elevated dissolved copper concentrations at SIYB are sustained over time through continual source loading mainly from copper-based antifouling paints, poor tidal flushing and low water circulation.

Elevated copper levels in SIYB have been associated with adverse effects on the biota at SIYB in a number of studies. In a 1980 study, investigators found that phytoplankton genera considered sensitive to copper were absent at SIYB, while copper tolerant genera were present (Krett, 1980). Another study documented a decrease in species diversity at SIYB that paralleled an increase in copper levels from the Basin's entrance towards the moored vessels (Johnston, 1990). In 1996, a study was conducted in which mussels were transplanted from a less contaminated site in San Diego to SIYB (VanderWeele, 1996). Researchers found that the mussels rapidly accumulated copper in tissues to a degree that was proportional to concentration levels in the water column. Results from the State Mussel Watch Program also documented elevated copper levels in transplanted mussels at SIYB in 1987 and 1993 (State Board, 1995). Mussels are commonly used as biological indicators of water quality.

In order to provide more information about the levels of dissolved copper and the potential for toxicity to aquatic life in SIYB, the Regional Board conducted a sampling survey in the spring of 2000. Water column samples were obtained and analyzed for dissolved copper in May and June of 2000. Samples were analyzed using low detection methods of analysis. Results clearly demonstrate a copper concentration gradient at SIYB, with levels increasing from the entrance into the inner reaches (Appendix 6). The higher concentrations were associated with areas of greater boat density and reduced tidal flushing, as was expected. Concentration levels in north San Diego Bay near the mouth of SIYB (station G) averaged 1.5 µg/L of copper. Concentrations increased in the inner reaches of SIYB (station A) to average 8.0 µg/L of copper consistently over both sampling dates. These levels exceed the CTR water quality criterion for dissolved copper in seawater of 3.1 µg/L. As part of the study, developmental toxicity testing also was performed on the mussel, *Mytilus edulis*, using one water column sample taken from the inner portion of SIYB (station A) and one sample from the Bay near the entrance of SIYB (station G). Toxicity was observed in the laboratory on samples taken from the high concentration station A, but toxicity was not seen on the low concentration station G (toxicity testing was not preformed on the other stations). While the results of this test showed that toxicity did occur at the high concentration station, the test does not identify the cause of the toxicity. A diagram of the sampling stations and results of the water column survey are presented in Appendix 6.

3. Numeric Target

When calculating TMDLs, numeric targets are established to meet water quality objectives and ensure the protection of beneficial uses. The numeric targets for the SIYB TMDL were set equal to numeric water quality objectives for dissolved copper, as defined by the USEPA in the CTR to protect marine aquatic life from toxicity. These numeric targets should also ensure that the narrative water quality objectives for toxicity and pesticides due to copper exposures are met in the water column. The numeric target for dissolved copper is 3.1 µg/L for continuous or chronic exposure (4-day average) and 4.8 µg/L (1-hour average) for brief or acute exposures.

Table 3.1. Numeric Targets.

Exposure	Water Quality Objective*	Numeric Target*
Chronic	3.1 µg/L	3.1 µg/L
Acute	4.8 µg/L	4.8 µg/L

* Concentrations should not be exceeded more than once every three years.

As discussed in Section 2, the USEPA is considering adopting new aquatic life criteria for dissolved copper that are more stringent for marine organisms than the current values. Should the proposed aquatic criteria be adopted and eventually promulgated in the CTR in the form of legally applicable numeric water quality objectives, the numeric targets used in this TMDL would also be changed. If the water quality objectives for copper change in the future, as in the case of a site-specific objective for copper in SIYB, then the TMDL would be recalculated and the new numeric target would be equal to the new water quality objective for chronic exposure.

4. Source Analysis

The source analysis section describes and quantifies the sources of dissolved copper to SIYB. In this analysis, dissolved copper was determined to enter SIYB primarily from passive leaching of copper-based antifouling paints applied to the hulls of recreational vessels moored in the Basin. Additional, albeit less significant sources of copper include boat hull cleaning of copper-based antifouling paint, natural background, urban runoff and direct atmospheric deposition. Passive leaching and hull cleaning are currently unregulated sources of pollution to surface waters. Urban runoff is regulated as a point source under one or more National Pollutant Discharge and Elimination System (NPDES) orders. In the source analysis sediment was determined to have a tendency to bind copper from the water column and act as a sink rather than a source of copper.

In quantifying source loading estimates, a number of assumptions were made throughout the source analysis, and are detailed in Appendix 1. The calculations used to generate current mass loading estimates are contained in Appendix 2. Figure 4.1 diagrams the sources and directions of flow of dissolved copper into and out of SIYB.

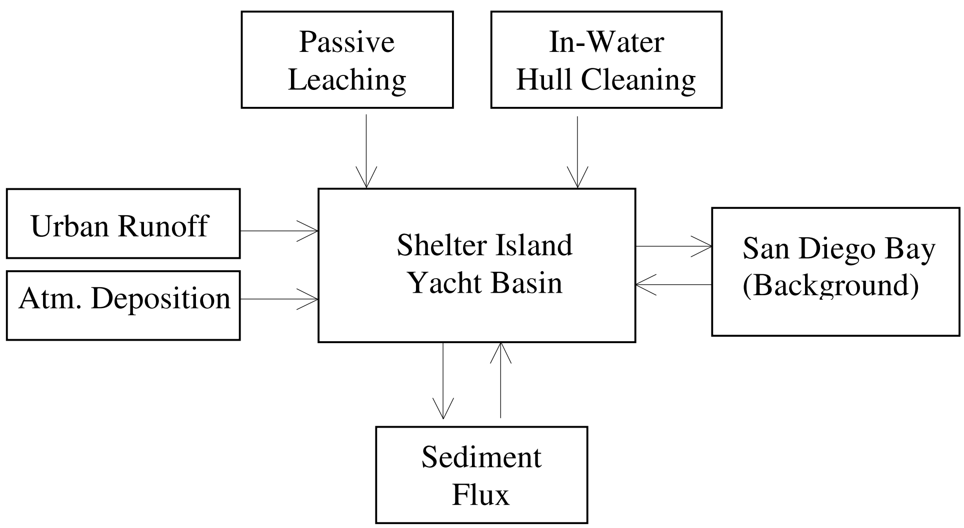

Figure 4.1. Sources of Dissolved Copper to Shelter Island Yacht Basin.

Passive Leaching

Antifouling paints applied to recreational vessels throughout California and the nation typically rely on copper as the toxic component to prevent marine fouling. While less toxic alternatives to copper antifoulants are available on the market, their use tends to be limited. Copper-based antifoulants are registered as pesticides with the California Department of Pesticide Regulation (DPR). These paints act as pesticides by leaching copper from vessel hulls directly into the water column to slow marine fouling. Copper from the paints generally enters the water column through two routes: passive leaching and underwater hull cleaning. Passive leaching from copper-based antifouling paints is by far the most significant source of dissolved copper to both San Diego Bay (PRC, 1997) and SIYB (as determined in this analysis).

Conventional copper-based antifouling paints fall into two general categories: ablative paints and contact leaching paints (Conway and Locke, 1994). Ablative paints, also known as soft sloughing paints, are designed to erode when a vessel is moving and leach copper into the water column when a vessel is docked. The rate ablative paints leach copper is designed to be constant over the life of the paint. Contact leaching paints, or hard paints such as epoxy, however, are designed to have much higher copper release rates following initial application in order to preserve effectiveness and increase the longevity of the paint. Over the lifetime of the two paint types, leaching rates of ablative paints are estimated to be higher than contact leaching paints, by as much as 50 percent (Conway and Locke, 1994). According to representatives at a large-scale boating store located in Southern California, hard antifouling paints may be best suited for boats that are regularly moored in the water, which includes the majority of vessels at SIYB (West Marine, 2001). Furthermore, due to restrictions on air emissions of volatile organic carbons, ablative (soft-sloughing) paints are typically not applied to recreational vessels in boatyards in California. The vast majority of antifouling paint used on recreational vessels in San Diego Bay is hard paint, such as epoxy and vinyl (Johnson and Miller, 2002a).

Passive leaching rates from copper-based antifouling paints are dependent on a number of factors, including the type of paint, copper content, age of the paint, time since last hull cleaning, and frequency of painting. In San Diego Bay, painting frequency of recreational vessels generally ranges from one to three years, with most boats repainted on average every two years (Johnson *et al.,* 1998; Conway and Locke, 1994; Carson report*.,* 2002). Leaching rates also vary with environmental conditions such as pH, temperature and existing slime layer.

Rates of passive leaching of dissolved copper from copper antifoulants on recreational vessels were investigated in studies conducted in Southern California by the US Navy. Researchers with the US Navy conducted *in situ* studies on seven recreational vessels in San Diego Bay in October 1999 using a re-circulating dome system to estimate passive leaching rates (Valkirs *et al*., 2003).[4] All of the boats were painted with epoxy copper antifouling paints. The release rates of copper were estimated to range from 2-14 micrograms/square centimeters/day ($\mu g/cm^2$/day), with an average leaching rate of approximately 8.2 $\mu g/cm^2$/day. Neither the frequency of hull cleaning, nor the type nor age of the paint was known in the study. These factors may affect passive leaching rates from the vessels (Valkirs *et al*., 2003).

In another study conducted in Southern California, researchers with the Southern California Coastal Water Research Project (SCCWRP) investigated the environmental impacts associated with the use of copper-based antifouling paints. Funding for this research was provided by the State Board through the USEPA's 319(h) Nonpoint Source Implementation Grant Program, as well as through funds provided by the DPR. The study objective was to measure the mass emissions of dissolved copper from both passive leaching and underwater hull cleaning of copper-based antifouling paints on recreational vessels. In order to estimate emission rates,

[4] In the 2002 draft version of the Technical TMDL Report, the Valkirs *et al*., 2003 study was not yet available. However, the data from the study was available, and was referenced as Seligman *et al*., 2001.

fiberglass panels were painted with copper-based antifouling paints and immersed in seawater in a harbor environment. The fiberglass panels were designed to simulate recreational vessel hulls, and passive leaching rates were estimated from the panels over time (Schiff *et al*., 2003). Measurements were made using the re-circulating dome system developed by the US Navy (Schiff *et al*., 2003). This was the same measurement technique used in the Valkirs *et al.* study to measure passive leaching rates on recreational vessels. SCCWRP researchers determined the average monthly flux rates for epoxy and hard vinyl copper antifouling paints to be approximately 4.3 and 3.7 $\mu g/cm^2/day$, respectively. Epoxy and hard vinyl copper antifouling paints are the two paint types most commonly applied to recreational vessels in San Diego Bay (Johnson and Miller, 2002a).

Both the US Navy (Valkirs *et al*., 2003) and SCCWRP (Schiff *et al*., 2003) studies estimated passive leaching rates for copper-based antifouling paints. Identical analytical techniques (*in situ* measurements using a re-circulating dome system) were used in the studies to measure passive leaching rates, and for this reason the studies were considered comparable in this analysis. However, the studies differ in a number of ways. In the SCCWRP study, fiberglass panels were used to simulate boat hulls, whereas in the US Navy study, data was collected on actual boat hulls. The behavior of epoxy paints may be different on the fiberglass panels compared to boat hulls. Also, in the SCCWRP study, the rate of passive leaching was measured several times over a one-month time period, beginning one day after hull cleaning. Over the course of the month, the passive leaching rate was defined by integrating the area under the curve generated from all the data points. In contrast, the US Navy looked at a “snapshot” of passive leaching rates for epoxy paints. An overall leaching rate was estimated by averaging the instantaneous rates measured on seven different boats. In addition, in the SCCWRP study, time since hull cleaning was known and factored into the analysis, whereas it was not in the US Navy study. Furthermore, the US Navy study estimated rates of leaching for epoxy copper antifouling paints, whereas the SCCWRP study estimated rates for both epoxy and vinyl paints.

In the SCCWRP study, the authors provided a discussion about the comparability of the results from the US Navy and SCCWRP studies (Schiff *et al*., 2003). According to the authors, the range of passive leaching measurements from the US Navy study was within the range of measurements from the SCCWRP study (Schiff *et al*., 2003). Therefore, the passive leaching rates determined in the two studies were concluded to be comparable, despite the fact that the US Navy study reported the rate as approximately twice the rate determined in the SCCWRP study.

After consultation with the principal authors of both studies, results from the US Navy and SCCWRP studies were combined to calculate a passive leaching rate for use in this analysis (Schiff, 2003a and Valkirs, 2003a) (Appendix 2). The results were combined to maximize the use of available data. Combining the data was considered appropriate since the analytical techniques used to measure emission rates were identical in the two studies. However, combining the data also increases the margin of error associated with the final value. Nonetheless, that the benefits of combining the results of the two studies outweigh the limitations. The passive leaching rate for vessels at SIYB was determined to be 6.5 $\mu g/cm^2/day$. This rate was used to calculate the annual loading of 2,000 kg/year of dissolved copper into SIYB from passive leaching (Appendix 2).

Underwater Hull Cleaning

Underwater hull cleaning of copper antifoulants is the second greatest source of dissolved copper to SIYB, although it is much less significant in magnitude than passive leaching, as determined in this analysis. Underwater hull cleaning is a common maintenance practice designed to remove the buildup of marine organisms on a vessel's hull. Although antifouling paints are effective at slowing growth, some growth does occur which will build up over time. This growth may be removed from recreational vessel hulls either through haul-out at a boatyard, or manually while the boat is in the water using underwater hull cleaning techniques. The majority of the pleasure crafts in the Bay are estimated to undergo periodic underwater hull cleaning (Conway and Locke, 1994). Similar to passive leaching, underwater hull cleaning is not currently subject to waste discharge requirements, and is an unregulated source of surface water pollution. Both underwater hull cleaning and passive leaching are sources of copper to SIYB that result from the use of copper antifoulants on recreational vessels in the Basin.

The physical process of removing marine growth on a vessel's hull while underwater results in a release of dissolved copper into the environment from copper-based antifouling paints. The amount of copper released is dependent on cleaning frequency, method of cleaning, type of paint, and frequency of painting. For regularly maintained recreational boats underwater hull cleaning takes place in San Diego Bay about once a month, or 14 times a year (Carson report., 2002). Painting frequency varies from one to three years, with most vessels repainted every two years (Conway and Locke, 1994 Johnson *et al.,* 1998). A recent study found that more abrasive cleaning techniques tend to release more copper into the environment, depending on the paint type (Schiff *et al*., 2003). In 1999, the state of Washington, through the departments of Natural Resources and Ecology, issued an advisory prohibiting underwater hull cleaning of ablative paints (Washington State Department of Ecology, 1999a). The prohibition was based on findings that soft paints contribute to contaminated sediments, dissolve quickly and do not last as long as hard paints (Washington State Department of Ecology, 1999a; Washington State Department of Ecology 1999b). Currently, there are no known published studies that quantitatively compare release rates based on paint age. That more frequently painted vessels with higher copper content paints will release more copper during hull cleanings is a reasonable assumption.

A study was conducted by US Navy researchers to investigate the environmental impacts associated with underwater hull cleaning of Navy vessels in San Diego Bay (Valkirs *et al.,* 1994). Researchers found that underwater hull cleaning resulted in elevated total copper (both dissolved and particulate) concentrations near the vicinity of the operation. Dissolved copper was released during and shortly after hull cleaning. Smaller amounts of dissolved copper also leached from debris and sediments after the cleaning ended. The particulate form of copper was rapidly incorporated into the bottom sediment, likely rendering it unavailable to water column organisms. The biologically active species of copper complexed rapidly, and dissolved copper levels returned to pre-cleaning conditions within minutes to hours after the hull cleaning ended. The authors concluded that potential adverse effects of hull cleaning on water column organisms from the increased dissolved copper concentrations were relatively short-term and pulsed in nature. Another conclusion was that the potential adverse effects of increased particulate copper were probably long-term in nature, and dependent on re-suspension or sediment uptake from benthic organisms.

The Regional Board also conducted a study on the effects of underwater hull cleaning on copper water column concentrations and aquatic life toxicity (McPherson and Peters, 1995). In the study, an underwater hull cleaning operation was performed in SIYB using Management Practices (MPs) that involve less abrasive techniques (i.e., hand-wiping with a soft cloth) to remove fouling growth. The operation was performed on one vessel that was considered representative of those in SIYB in terms of size and degree of fouling growth. However, neither the type (hard versus soft paints) nor age of the paint was known. The majority of copper released during the cleaning was found to be in the form of dissolved copper. Prior to the hull cleaning, dissolved copper concentrations in the vicinity of the boat averaged 12 μg/L. During the hull cleaning, average concentrations increased from 12 μg/L to 56 μg/L of copper. Concentration levels decreased to 17 μg/L of copper within five minutes after the cleaning ended, and returned to pre-cleaning levels within ten minutes. Researchers found that the copper contaminant plume moved with the current, and that the degree of plume contamination was dependent upon fouling extent and exertion by the diver (McPherson and Peters, 1995). Based on the results, the authors concluded that underwater hull cleaning generates elevated concentrations in the vicinity of the operation, which return to background levels within minutes. The researchers did not identify the type of antifouling paint (ablative or contact leaching paint) or age of the antifouling paint on the vessel, or the time since last hull cleaning. While the study provided important information regarding impacts of underwater hull cleaning on water quality, it did not provide copper emission rates associated with hull cleaning.

A more recent study was conducted by SCCWRP in Southern California to estimate dissolved copper emissions rates associated with underwater hull cleaning. Fiberglass panels were painted with copper antifoulants to simulate the hulls of recreational vessels (Schiff *et al*., 2003). The study objective was to estimate the flux rates of dissolved copper from underwater hull cleaning of two commonly used types of copper-based antifouling paints in San Diego Bay. Researchers found that hull cleaning using MPs generated 8.6 micrograms/square centimeter/event ($\mu g/cm^2$/event) of copper for epoxy paint, and 3.8 $\mu g/cm^2$/event of copper for hard vinyl paint (Schiff *et al*., 2003). For epoxy paints, cleaning without MPs doubled the dissolved copper flux, from 8.6 $\mu g/cm^2$/event to 17.4 $\mu g/cm^2$/event. The flux rate from hard vinyl paints remained about the same, from 3.8 $\mu g/cm^2$/event with MPs to 4.2 $\mu g/cm^2$/event of copper without MPs. The study concluded that on the days when vessels are cleaned, underwater hull cleaning results in a greater daily load of copper to the environment than passive leaching. However, since hull cleaning is performed only once a month on average, passive leaching results in a much greater flux of dissolved copper into the environment. In terms of mass loading, the authors concluded that approximately 95 percent of dissolved copper from antifouling paint enters the environment via passive leaching, and only five percent enters from hull cleaning. The underwater hull cleaning rates from this study were used to determine the copper load to SIYB from hull cleaning, calculated to be roughly 100 kg/year. (Appendix 2).

Urban Runoff

Urban runoff is another source of dissolved copper to SIYB. Urban runoff discharges are regulated by the Regional Board through the issuance of waste discharge requirements subject to NPDES regulations. Urban runoff is regulated as a point source discharge due to its release from channelized, discrete conveyance pipe systems, or outfalls (Regional Board, 2000a). The City is responsible for urban runoff discharges into its storm water conveyance system and into SIYB under Regional Board Order No. 2001-01, "Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm Sewer Systems." Furthermore, the City is responsible for meeting NPDES discharge requirements and conditions for urban runoff discharges from its storm water conveyance system.

Urban runoff is comprised of wet weather flow, or storm water, and dry weather flow. Wet weather flow is the result of runoff from precipitation events. As runoff travels along its drainage path, it serves to convey untreated pollutants that are discharged into surface waters through storm drains. On the other hand, dry weather flows occur in the absence of storm events, and are often referred to as nuisance or base flows. Dry weather flows may result from irrigation runoff, car washing activities, groundwater seepage into the storm water conveyance system, indirect connections, and direct illicit connections (Regional Board, 2000b; USEPA, 1983). Sources of copper in urban runoff discharge to San Diego Bay include brake pads, tires, water pipe leaching, architectural structures, and industrial sources (Woodward Clyde, 1997). Brake pads may account for up to 63 percent of the copper in urban storm water runoff (Woodward Clyde, 1997).

The watershed or drainage area of SIYB was characterized and mapped by the City, as shown in Figure 4.2 (City of San Diego, 2000a; City of San Diego, 2003). Total drainage area was determined to be approximately 3.15 km^2 (753 acres), while land use was classified as approximately 95 percent single-family residential (City of San Diego, 2003). . The runoff coefficient varied between 0.55 and 0.85, depending on land-use type (City of San Diego, 2003). In general, runoff coefficients represent the degree of imperviousness of the watershed, or the fraction of rainfall that is converted into runoff (Schueler, 1987). A map of the drainage area for the SIYB watershed is shown in Figure 4.2. The map depicts the drainage areas to each of the nine outfalls draining directly to the Basin.

Source: City of San Diego (2003).

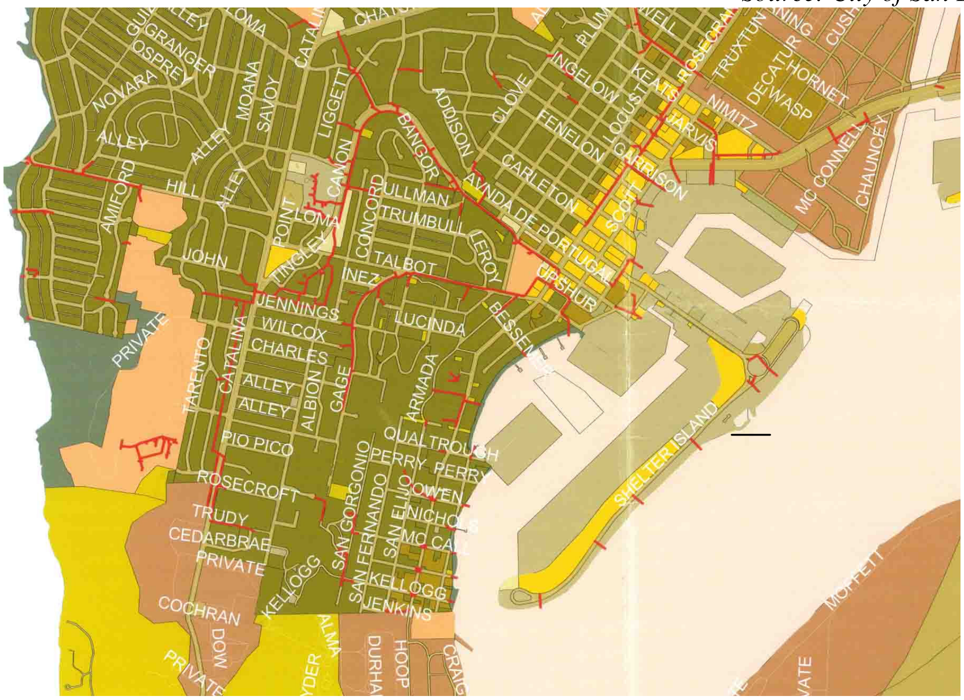

Figure 4.2. Drainage Area of the Shelter Island Yacht Basin.

Information regarding wet weather flow was obtained through data provided by the City in their annual Storm Water Monitoring Report, pursuant to Regional Board Order No. 2001-01 (City of San Diego, 2000a). The average measured concentration of an urban pollutant in runoff from a storm event is known as the event mean concentration (EMC) (Schueler, 1987). The EMC is defined as the total pollutant load divided by the total runoff volume generated by a storm (Woodward Clyde, 1999). EMC values were determined based on direct measurements of pollutant concentrations in flow-weighted composite samples from residential land use monitoring stations located throughout the county of San Diego. The average five-year residential land use EMC was calculated by averaging storm event EMCs from monitoring data collected from 1994/95 to 1998/99. This monitoring data included sampling results taken from the first two storm events of each wet weather season. Using this information, the average total copper EMC for runoff from residential land uses within the County of San Diego was determined to be 34 μg/L (City of San Diego, 2000a). After applying a dissolved copper conversion factor of 0.96 to the total copper EMC, the average dissolved copper EMC was determined to be approximately 32.6 μg/L (see Appendix 2 for calculations) (USEPA, 1996; USEPA, 2000b).

Information on pollutant concentrations in dry weather flows throughout California is limited. Not surprisingly, information on illegal discharges is essentially absent (Woodward Clyde, 1997). That dry weather flow can be a significant contributor of pollutants to receiving waters however, is known. In a 1987 study in Sacramento, California, close to half of the runoff from storm drains could not be attributed to precipitation (USEPA, 2000a). More information is needed on dry weather flows to better estimate dissolved copper concentrations.

Based on the limited data currently available and the knowledge that dry weather flows may contribute approximately half of the total flow discharged from storm water conveyance systems, dry weather flows to the SIYB were conservatively estimated to be equal to wet weather flows.

The dissolved copper load from urban runoff to SIYB was estimated to be roughly 30 kg/year (Appendix 2).

Background

All sources of dissolved copper into SIYB were considered in the analysis, including natural background sources of dissolved copper found in ambient seawater. SIYB is located in north end of San Diego Bay near its mouth, which opens to the Pacific Ocean. San Diego Bay water serves to flush SIYB and decrease the concentration of dissolved copper. Measurements of dissolved copper concentrations in San Diego Bay taken by the US Navy were used to characterize background conditions, and averaged 0.5 µg/L (Chadwick, 2002b). In order to estimate loading from ambient seawater and background conditions, a "box model" was developed based on mass balance principals to describe the fate and transport of copper into and out of SIYB (Chadwick, 2002b). The model was used to estimate background loading as well as the assimilative capacity of copper in the Basin (Section 5.0). The model and its derivation, including a discussion of the model's assumptions and limitations, are provided in Appendix 3.

The copper load from background to SIYB was estimated to be roughly 30 kg/year (Appendix 3).

Direct Atmospheric Deposition

Atmospheric deposition is another potential source of copper to SIYB. Copper in the atmosphere enters SIYB via direct and indirect deposition. Indirect atmospheric deposition occurs when dissolved copper enters the watershed that drains to SIYB. Indirect deposition is a component of urban runoff to SIYB, and is already accounted for in the urban runoff source analysis. Therefore, this section will only address direct atmospheric deposition. Direct atmospheric deposition results from both wet and dry deposition directly to the surface of the waterbody.

Direct atmospheric deposition rates of trace metals have been investigated in limited studies in California. Atmospheric deposition rates of trace metals, including copper, were determined for the San Francisco Estuary in a pilot study conducted in 1999 and 2000 (Tsai *et al.,* 2001). Direct wet and dry atmospheric deposition of copper to the estuary was found to represent a minor contribution to the total copper load (less than ten percent). In a study in southern California, atmospheric deposition of copper was calculated for Santa Monica Bay and the Santa Monica Bay watershed (Stolzenbach *et al.,* 2001). Copper atmospheric deposition was determined through a combination of direct and indirect methods to determine contaminant loading. Researchers found that atmospheric deposition, primarily through daily dry deposition, was a significant contributor of nonpoint source pollutant loading to Santa Monica Bay.

Information on atmospheric deposition of metals to the San Diego Region is not currently available, and more research is needed to characterize this source of loading. In an analyses of copper source loading to San Diego Bay, direct atmospheric deposition of dissolved copper was determined to be negligible compared to other sources (Johnson *et al*., 1998; PRC, 1997). Direct atmospheric deposition of copper is expected to be insignificant to SIYB compared to other sources, in part due to the small surface area of the Basin. Direct atmospheric deposition to SIYB was calculated based on the results of the Santa Monica Bay study, and was found to be approximately 3 kg/year of copper to SIYB (Appendix 2). Therefore, direct atmospheric deposition of dissolved copper to SIYB was concluded to be negligible compared to estimations of copper loading from all other sources.

The total copper load from direct atmospheric deposition to SIYB was estimated to be roughly 3 kg/year (Appendix 2).

Sediment

Copper in the water column will tend to settle and can accumulate in sediment through adsorption or by partitioning in pore water. In this way, sediment acts as a "sink" for copper in the water column, and concentration levels can build up and persist over time. The rate of contamination of sediment is dependent on a variety of factors including sediment type and quality, organic matter content and the degree of contamination in the water column and associated sediment. Some of the copper adsorbed to sediment or sequestered in pore water may not be bioavailable for uptake by organisms in the water column, however, and may be rendered essentially nontoxic to these organisms. Nonetheless, as sediment copper concentrations increase, so does the potential for adverse impacts to aquatic benthic life. Copper in sediment may buildup to levels toxic to aquatic life such that costly remediation, i.e., dredging, is required to remove the contamination.

Sediment can also act as a source for copper in the water column. For example, copper associated with sediment can become re-suspended into the water column, such as through ship movements or by becoming stirred up by benthic organisms. Furthermore, as sediment concentration levels of copper increase, so does the potential for flux out of the sediment into the surrounding water column, leading to elevated dissolved copper concentrations.

Information on sediment flux rates is available throughout San Diego Bay, although rates are limited for SIYB. In a copper loading analysis study on San Diego Bay, average flux rates from sediment to the water column were estimated to be about six percent of the total load (PRC, 1997). However, this analysis did not take into account the flux rate from the water column to the sediment. The US Navy has collected more extensive data on net flux rates throughout the Bay. Using an instrument known as a "Benthic Flux Chamber," investigators evaluated the net exchange rate of copper between the sediment and water column. Analyses showed that, on average, the net loss of copper from the water column to the sediment is approximately four to seven percent per day throughout the Bay (Chadwick, 2002). Flux rates vary from this average depending on site-specific environmental conditions. Based on US Navy research, sediment generally acts as a sink for copper in San Diego Bay. Additionally, researchers concluded that approximately half of the copper load in San Diego Bay is flushed to the ocean, and half is deposited to the sediment (Chadwick, 2002).

There is direct evidence that suggests that sediment at SIYB acts a sink for copper from the water column. Sediment at SIYB is composed of a relatively high percentage of clay, which has a tendency to bind copper (Valkirs *et al*., 1994). The US Navy has gathered some sediment flux data in the SIYB using the Benthic Flux Chamber, and documented negative flux rates. In other words, under current conditions of high anthropogenic copper loading at SIYB, copper is highly likely to move from the water column to the underlying sediment (Valkirs *et al.*, 1994).

Copper contamination to sediment at SIYB is a concern due to the potential for adverse effects on aquatic benthic life. In order to evaluate chemicals of concern such as copper, sediment quality guidelines (SQGs) have been developed by the National Oceanic and Atmospheric Administration (NOAA) to help identify concentration levels that may warrant further study (Long and MacDonald, 1998). These informal guidelines are based on empirical analyses of chemical and biological data from a nationwide database. SQG are used throughout the nation to help rank and prioritize sites and chemicals of concern (NOAA, 1999). They include an Effects Range Low (ERL), identified as the lower 10th percentile of available sediment data for toxic samples, and an Effects Range Medium (ERM), or the 50th percentile (median) of available sediment data for toxic samples (NOAA, 1999, Buchmann, 1999). Concentrations below the ERL represent a range where adverse effects are rarely observed, or may be observed in sensitive organisms (NOAA, 1999). Concentrations above or equal to the ERL, but below the ERM, represent a range where adverse effects occasionally occur (NOAA, 1999). Concentrations above the ERM are frequently toxic (NOAA, 1999). ERLs/ERMs were developed for a variety of constituents, including copper sediment contamination in seawater. The ERL for copper is 34 milligrams/kilogram (mg/kg), which corresponds to a 29 percent incidence of adverse biological effects, as shown in Table 4.1 (NOAA 1999). The ERM for copper is 270 mg/kg, which corresponds to an 84 percent incidence of adverse biological effects, as shown in Table 4.1 (NOAA 1999).

Table 4.1. Sediment Quality Guidelines for Copper.

ERL	**Incidence of Probable Biological Effects**	**ERM**	**Incidence of Probable Biological Effects**
34 mg/kg	29%	270 mg/kg	84%

There have also been some limited investigations into copper sediment concentrations at SIYB. US Navy researchers measured copper concentrations in sediment at SIYB, and found that they were relatively high compared to other areas in San Diego Bay (Valkirs *et al*., 1994). In the sample analysis conducted on two occasions in 1991 and one in 1993, sediment levels at a station in SIYB were between the ERL and ERM, from 133 to 212 mg/kg. In another study conducted as part of the Bay Protection and Toxic Cleanup Program (BPTCP), copper sediment chemistry levels and toxicity were evaluated at SIYB (SWRCB *et al.,* 1996). Three stations were sampled for sediment chemistry at SIYB from 1993 to 1994, and levels were found to range from 86 mg/kg to 150 mg/kg. In addition, toxicity testing was performed on sediment from SIYB, and the results yielded observed toxicity. Additional data on copper concentrations at SIYB was gathered and analyzed by researchers at the Scripps Institute of Oceanography, in conjunction with the US Navy, and presented in a preliminary report (Gieskes *et al.,* 2002). In this study, copper sediment concentrations collected at four stations in SIYB were found to range from just over the ERL, to levels greater than the ERM. No data was obtained in any of the studies on benthic community structure at SIYB. While reducing copper in the water column at SIYB is expected to also reduce the rate of sediment contamination, copper in the sediment tends to buildup and persists over time. More information is needed to accurately assess the impacts of copper contamination on sediment and benthic life at SIYB.

Furthermore, although sediment is believed to act as a net sink for copper under current conditions, sediment could become a net source of copper during a period of low loading at SIYB. When copper in the water column is decreased, the net exchange of copper to the water column from historically contaminated sediments may prove to be significant. If copper in sediment is re-suspended and acts as a net source to the water column, meeting the numeric target at SIYB may take longer than anticipated.

Due to the tendency of sediment to act as a sink for copper under current external loading conditions, the copper load from sediment to the water column was assumed to be zero in this analysis. The contribution of sediment to copper concentrations in the water column will probably need to be reassessed in the future to determine if sediment will act as a more significant source, once primary sources such as copper-based antifouling paints have significantly decreased.

The current copper load from sediment to SIYB was assumed to be 0 kg/year (Appendix 2).

Summary of Loading Estimates

In summary, approximately 98 percent, or 2,100 kg/year, of dissolved copper loading to SIYB was determined to originate from copper-based antifouling paints applied to recreational vessels moored in the marina. The most significant individual source of dissolved copper is from passive leaching of copper-based paints, accounting for approximately 2,000 kg/year or 93 percent of total loading. The second most significant source comes from underwater hull cleaning, accounting for approximately 100 kg/year of copper, or five percent of loading. Urban runoff (including indirect atmospheric deposition) accounts for approximately 30 kg/year of copper, or one percent of total loading. Background loading amounts to approximately 30 kg/year of copper, or one percent of total loading. In addition, direct atmospheric deposition was determined to contribute approximately 3 kg/year of copper or less than one percent of total loading. Furthermore, sediment was found to act as a sink, rather than a source of dissolved copper to SIYB. No other sources of dissolved copper to the SIYB were identified. A summary of the results of the source loading analysis is presented in Table 4.2 and Figure 4.3. The values are presented as rough approximations to reflect the degree of uncertainties and assumptions in the calculations. These calculations are contained in Appendices 2 and 3.

Table 4.2. Summary of Dissolved Copper Sources to SIYB.

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

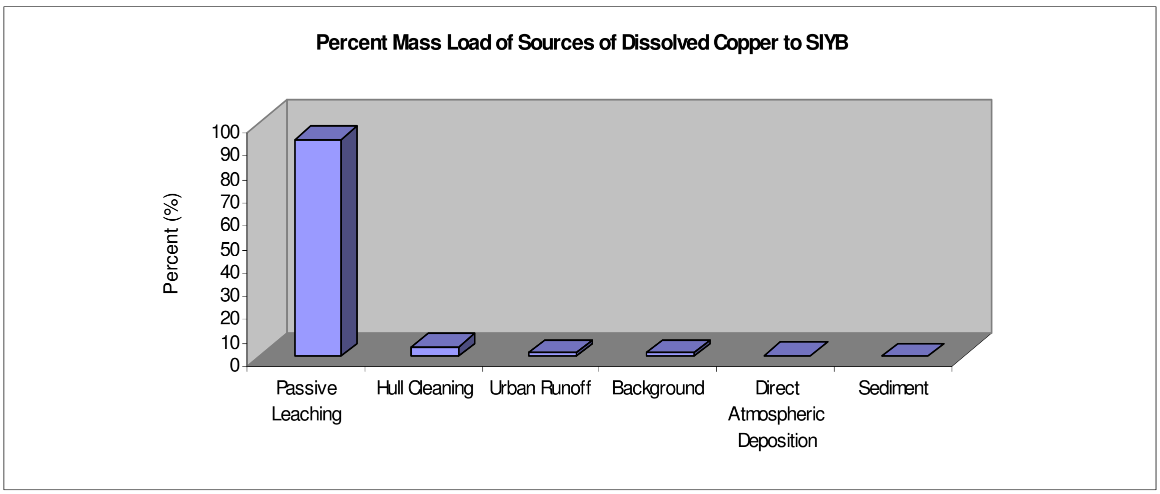

Figure 4.3. Percent Mass Load of Sources of Dissolved Copper to SIYB.

5. Linkage Analysis

The technical analysis of copper loading to SIYB and the waterbody response to this loading is referred to as the linkage analysis. The analysis results in the calculation of the total allowable copper loading to SIYB and the associated reductions in current loading from individual sources needed to meet water quality standards. Because the TMDL numeric targets are set equal to the numeric water quality objectives for copper, attainment of the numeric targets will result in attainment of water quality standards the water column at SIYB.

The linkage analysis describes the relationship between the numeric target and attainment of water quality standards by defining the waterbody's total assimilative capacity, or loading capacity, for the pollutant. The loading capacity is equal to the TMDL and represents the maximum amount of pollutant loading the waterbody can support and still maintain water quality standards. The linkage analysis therefore is the critical quantitative link between the TMDL and attainment of water quality standards.

At SIYB, the loading capacity is the maximum amount of dissolved copper that can enter the Basin and remain in the water column without exceeding the numeric target. Loading capacity at SIYB is a function of the different hydrodynamic processes that affect the environmental fate and transport of dissolved copper as it moves through the system. These processes include the circulation in SIYB, tidal flushing, chemical reactions, biological uptake, and sediment flux.

An accurate determination of loading capacity is dependent upon an understanding of the relationship between mass loading and movement of copper in these various hydrodynamic processes. In order to determine the loading capacity, a "box model" was developed for SIYB based on general mass-balance principles describing copper fate and transport. This model was developed by the US Navy's Space and Naval Warfare Systems Command (SPAWAR) for use by the Regional Board (Chadwick, 2000b). The box model was used to generate a theoretical maximum loading capacity, or TMDL, for the system to meet the numeric target, and hence attain water quality standards. If the water quality objectives for copper change in the future, as in the case of a site specific objective for copper in SIYB, the numeric target would be equal to the new water quality objective, and a new loading capacity would be calculated to meet the new numeric target. The TMDL was allocated among the various identified sources, as discussed in Section 7.

The box model results are dependent on certain input values, such as numeric targets, measured copper concentrations inside and outside SIYB, and salinity measurements to quantify local dispersion. In the model, the numeric target was set equal to water quality criteria designed to protect marine aquatic life from chronic exposures to dissolved copper (3.1 µg/L). Water quality criteria are intended to protect the most sensitive species throughout the year. Therefore, once the numeric targets are met, water quality objectives for dissolved copper are expected to be met, and associated beneficial uses in SIYB will be attained.

The derivation of the governing equations used in the box model, as well as a discussion of the model's input parameters and limitations is provided in Appendix 3. The box model also has several built-in assumptions, which are also discussed in Appendix 3.

6. Margin of Safety

The TMDL must contain a margin of safety (MOS) to account for uncertainty in the analysis. The MOS for the SIYB TMDL is both explicit as well as implicit. The explicit MOS was calculated by taking ten percent of the total loading capacity as generated by the box model. This was done to account for uncertainty associated with the calculations in the source analysis and linkage analysis. The explicit ten percent MOS was determined to be 57 kg/year of copper (Appendix 4). If the water quality objectives for copper should change in the future, as in the case of a site specific objective for copper in SIYB, then the TMDL would be recalculated and the new explicit MOS would be equal to 10 percent of the recalculated loading capacity.

In addition to an explicit MOS, an implicit MOS was incorporated into the TMDL through conservative assumptions made in the source analysis (Section 4, Appendix 1). For example, in the source estimates for passive leaching and underwater hull cleaning, a conservative assumption was made that all of the slips in marinas are always occupied. Furthermore, the dry weather flow component of urban runoff to the SIYB was conservatively estimated to be equal to wet weather flows. These assumptions are conservative in that they were designed to be protective of water quality.

7. Total Maximum Daily Load and Allocations

In order to attain the numeric target, the loading must be less than or equal to the TMDL. The TMDL is divided into a total wasteload allocation (WLA) that specifies the amount of allowable loading for all point sources subject to waste discharge requirements in an NPDES order, and a total load allocation (LA) that specifies the allowable loading for all other sources including nonpoint, natural background, and unregulated point sources, and a margin of safety, as shown below:

TMDL = Wasteload Allocations + Load Allocations + MOS

Using the box model, the TMDL for SIYB was calculated to be 567 kg/year for copper. In order to achieve this TMDL, a 76 percent reduction from the current loading of approximately 2,163 kg/year is required. The value of 567 kg/year of copper is dependent on the numeric target, currently set at 3.1 µg/L. Should the USEPA's proposed aquatic criteria (discussed in Section 2.2) be adopted and eventually promulgated in the CTR in the form of legally applicable numeric water quality objectives, the numeric targets represented in this TMDL would also be changed. Since the proposed values are more stringent, the result would be a lower TMDL in SIYB, and a higher percent reduction required from current loading. The calculations and box model used to generate the loading capacity are shown in Appendix 3.

In order to assign allocations, a review of available management practices (MPs) was conducted for controlling pollution from marinas (USEPA, 1993; USEPA, 1999; USEPA, 2001; Johnson and Miller, 2002b). MPs to reduce pollution from copper antifouling paints in marinas include switching to nontoxic and less toxic antifouling paints, cleaning hulls underwater with less abrasive techniques, storing boats out of water when not in use, and public education. For example, if all underwater hull cleaners use less abrasive MPs to clean hulls with copper-based antifouling paints at SIYB, emissions from hull cleaning could drop by 28 percent (assuming that in the source analysis calculations, approximately 50 percent of divers use MPs at SIYB). Switching to nontoxic and less toxic antifouling paints would also essentially eliminate copper loading from both passive leaching and underwater hull cleaning to SIYB.

Copper load reductions were assigned to sources based on current loading contributions. The most significant anthropogenic source of copper, passive leaching, was assigned the largest required reduction of 81 percent in current loading, or a decrease from 2,000 kg/year to 375 kg/year. Hull cleaning, the second largest source, was assigned a reduction in current loading of 28 percent, or a decrease from 100 kg/year to 72 kg/year of copper. The other sources, including sediment, were not assigned reductions in loading due to the relatively insignificant magnitude of their contributions.

If, in the future, studies indicate that other potential sources such as sediment are indeed significant, then the TMDL and load allocations can be recalculated. As discussed in the source analysis, there is limited data indicating that under current equilibrium conditions, the sediment acts as a net sink for dissolved copper in the water column. Further studies are necessary to better understand this phenomenon. If studies demonstrate that sediment is, or could become, a significant source once primary sources, such as copper-based antifouling paints have been reduced, then the TMDL and allocations could be amended at a later date. An allocation for sediment loading could be assigned to the dischargers responsible for the sediment contamination.

In terms of the total reduction necessary from all sources to meet the TMDL, 75 percent of the required reduction (a reduction of 76 percent total) should come from dischargers responsible for passive leaching, and one percent should come from dischargers responsible for hull cleaning.

Reductions in loading from copper antifouling paint discharges via passive leaching and hull cleaning will result in the achievement of the TMDL. The loading estimates and allocations for all sources are shown in Table 7.1.

Table 7.1. TMDL and Allocation Summary.

Source	Current Load (kg/year)	Allocation (kg/year)	Percent Reduction from Current Loading (%)	Percent Reduction from Total Loading (%)
Passive Leaching	2,000	375	81	75
Hull Cleaning	100	72	27	1
Urban Runoff	30	30	0	0
Background	30	30	0	0
Direct Atmospheric Deposition	3	3	0	0
Sediment	0	0	0	0
Margin of Safety		57		
Combined Sources	2,163			76
TMDL		567		

8. Seasonal Variation and Critical Conditions

Critical conditions that have the potential to affect the determination of the TMDL and alter estimates in loading and/or allocations, such as seasonal variation and anticipated future growth, must be considered in the TMDL. A number of critical conditions relevant to SIYB were incorporated into development of the TMDL. The numeric targets are based on water quality criteria designed to be protective of beneficial uses throughout the year. Boating in San Diego Bay is popular year round, and boats tend to be moored in SIYB throughout the year. According to the Port, there are no current plans for future marina expansions, nor is there likely to be an increase in the slip number in SIYB (Brown, 2001). Furthermore, in the source analysis, both wet and dry weather flows were included in calculating loading estimates for urban runoff. While future growth may occur within the watershed that drains to SIYB, leading to increased pollutant loading from urban runoff and direct atmospheric deposition, any increase is likely to be insignificant due to the small current contribution of these sources. Therefore, there is no need to include further allocations into the TMDL to account for critical conditions.

9. Assumptions

A number of assumptions were made throughout the technical analysis, particularly in the source analysis and linkage analysis, in order to calculate current copper loading and the loading capacity. Assumptions were based on the best available information at the time when the technical TMDL was developed. When faced with uncertainty, assumptions were designed to be conservative, or protective of water quality and associated beneficial uses. Assumptions may affect estimates of source loading, and could result in an over- or under-estimation of the contributions from individual sources. Assumptions may also affect proposed estimates of the loading capacity of the Basin. To address uncertainties associated with the analysis, the effectiveness of the allocations in meeting the numeric target should be monitored and evaluated over time. Assumptions are detailed in Appendices 1 and 3.

III. LEGAL AUTHORITY FOR TMDL IMPLEMENTATION PLAN

This section describes the legal authority for the TMDL Implementation Plan. The regulatory agencies and laws governing copper antifouling paint in California are also described. The Regional Board's authority to regulate the residual discharge of copper[5] to SIYB from legally applied hull bottom antifouling paints is established.

10. Copper Antifouling Paint Regulation

Pesticides,[6] including copper antifouling paints, are industrial chemicals produced specifically for the purpose and intent of killing target pest[7] organisms. They are designed to be toxic to target pests and must be purposely introduced into the environment to do their job. However, once introduced in the environment, the pesticide may also adversely affect non-target organisms.

Copper antifouling paints, like all pesticides, are subject to regulation under several state and federal laws. The laws which apply at any given time depend on whether copper, the pesticide active ingredient, is acting on target fouling organisms or on non-target aquatic organisms.

Regulation of Pesticides Acting on Target Organisms: FIFRA and California Food and Agriculture Code

Copper-based antifouling paints are legally registered pesticides subject to United States Environmental Protection Agency (USEPA) regulation pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the California Department of Pesticide Regulation (DPR) regulation pursuant to the California Food and Agriculture Code.

USEPA

The USEPA is the federal government agency responsible for registering pesticides for sale or distribution within the United States pursuant to FIFRA. A pesticide cannot be legally used in the United States if it has not been registered with the USEPA's Office of Pesticide Programs. Pesticide registration is the process through which the USEPA examines the ingredients of a

[5] In this TMDL, "discharge of copper" refers to "residual copper" which is defined as any molecule of copper that leaches, dissolves, ablates, or erodes from boat hull antifouling paints into SIYB surrounding waters and does not reach a target fouling organism. This includes residual copper that results from legally registered hull antifouling paint used in accordance with label instructions in compliance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). (Finding 5, *Water Quality Order No. 2001-12-DWQ Statewide General National Pollutant Discharge Elimination System (NPDES) Permit for Discharges of Aquatic Pesticides to Surface Waters of the United States (General Aquatic Pesticides Permit)).*

[6] A pesticide is any substance or mixture of substances intended to control, destroy, repel, or attract a pest. Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. Under U.S. and California law, a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. *(Regulating Pesticides: The California Story, California Department of Pesticide Regulation, October 2001)*

[7] A target pest is defined as any living organism that causes damage or economic loss or transmits or produces disease. Pests can be animals (like insects, mice, or boat hull fouling organisms), unwanted plants (weeds), or microorganisms (like plant diseases and viruses). *(Regulating Pesticides: The California Story, California Department of Pesticide Regulation, October 2001)*

pesticide; the site or crop on which it is to be used; the amount, frequency and timing of its use; and storage and disposal practices. Through the registration process, the USEPA evaluates the pesticide to ensure that it will not have unreasonable adverse effects on humans, the environment, or non-target species when used in accordance with label specifications.

Under FIFRA, the USEPA establishes a nationally uniform labeling system to regulate pesticide use. Pesticide label language is under the sole jurisdiction of the USEPA.

California Department of Pesticide Regulation

The California Department of Pesticide Regulation (DPR) is the lead state agency for regulating the registration, sales, and use of pesticides in California. Local administration and enforcement is provided by County Agricultural Commissioners (see next section). The legal authority for California's pesticide regulatory program is found primarily in the Food and Agricultural Code.

Before a pesticide may be marketed and used in California, the DPR evaluates it to ensure that it will not harm human health or the environment. The DPR is required by law to protect the environment, including surface waters, from environmentally harmful pesticides by prohibiting, regulating, or controlling the uses of such pesticides. This is accomplished through a licensing process called "registration." As part of the pesticide registration process, the DPR evaluates data submitted by registrants to ensure that a product used according to label instructions will cause no harm (or "adverse impact") on non-target organisms that cannot be reduced (or "mitigated") with protective measures or use restrictions. Registrants are required to submit data on the effects of pesticides on target pests (efficacy) as well as non-target effects. Data on non-target effects include plant effects (phytotoxicity), fish and wildlife hazards (ecotoxicity), impacts on endangered species, effects on the environment, environmental fate, breakdown products, leachability and persistence. Pesticides that pass this scientific, legal, and administrative process are granted a license that permits their sale and use according to requirements set by the DPR to protect human health and the environment in California.

Pesticides must be registered both by the USEPA and the DPR before distribution in California. Because the USEPA has sole responsibility for label language, the DPR cannot require a manufacturer to make changes to its labels. However by refusing to allow registration and hence the possession, sale and use of any pesticide not meeting California standards, the DPR can place more restrictive requirements on pesticides than the USEPA.

County Agricultural Commissioner

The San Diego County Agricultural Commissioner (CAC) serves as the DPR's primary enforcement agent for pesticide laws and regulations in San Diego County. The CAC registers licensed pest control businesses, pest control aircraft pilots, and agricultural pest control advisers (these businesses and individuals must obtain statewide licenses from the DPR, and register in each county where they operate). The CAC conducts compliance inspections and takes enforcement actions if violations are found. The CAC also conducts pesticide incident and illness investigations and provides training to pesticide users. The San Diego CAC has the authority to adopt local regulations governing pest control operations in San Diego County, including additional more stringent use restrictions. Each regulation however must be approved by the DPR before it becomes effective.

Regulation of Residual Pesticides Acting on Non-Target Organisms: Clean Water Act and California Water Code

The USEPA, Office of Water, has responsibility on a federal level for regulating the discharge of "pollutants" to waters of the United States pursuant to the federal Clean Water Act. The USEPA has authorized the State Water Resources Control Board (State Board) and the Regional Water Quality Control Boards (Regional Boards) to implement and administer the provisions of the Clean Water Act in the State of California. The State Board and the Regional Boards also have primary responsibility for regulating the discharge of "waste" to waters of the State pursuant to the state statute, the California Water Code.

"Residual" Pesticide

A residual pesticide is defined as any molecule of pesticide that does not reach a target organism. This includes residual pesticides that result from the legally registered use in accordance with label instructions and in compliance with FIFRA and the California Food and Agriculture Code. A residual pesticide is a "waste" under the California Water Code as provided below.

11. Regional Board's Authority to Regulate Residual Copper Discharges

This TMDL is required because residual copper discharges from copper antifouling paints cause the water quality objectives for copper to be violated in SIYB. The residual copper discharges are the result of the legal use of copper antifouling paints in accordance with label instructions and in compliance with FIFRA.

The Regional Board has the authority to regulate the discharge of residual copper from boat hull antifouling paints in SIYB by way of waste discharge requirements (WDRs)[8], waivers of WDRs (waivers), Basin Plan prohibitions (prohibitions), or enforcement orders. The Regional Board's legal authority is found in the California Water Code, Division 7, Water Quality (a.k.a. Porter-Cologne Water Quality Control Act) and the federal Clean Water Act.

California Water Code (Porter-Cologne Water Quality Control Act)

To establish the applicability of the California Water Code's WDRs, discharge prohibitions, and enforcement remedies, a person must be shown to be (1) discharging or proposing to discharge (2) a waste (3) that could affect the quality of waters of the State.

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8 WDRs include those issued for discharges of pollutants from point sources to navigable waters of the United States that implement federal NPDES regulations. While nearly everyone refers to the orders containing WDRs that implement NPDES regulations in California as "NPDES permits," in fact they are not NPDES permits. Technically, such WDRs are issued by the state pursuant to independent state authority (not authority delegated to the state by the USEPA or derived from the Clean Water Act). Pursuant to Chapter 5.5 of the Porter-Cologne Act, in order to avoid the issuance by the USEPA of separate and duplicative NPDES permits for discharges in California that would be subject to the Clean Water Act, the State's WDRs for such discharges implement the NPDES regulations and entail enforcement provisions that reflect the penalties imposed by the Clean Water Act for violation of NPDES permits issued by the USEPA.

Due to the fact that NPDES requirements serve in lieu of NPDES permits, and, contain all the substantive terms and conditions necessary for an NPDES permit, many people refer to NPDES requirements as "NPDES permits" and to the dischargers as "permittees." The prevalence of this common shorthand usage does not, however, alter the underlying legal reality that NPDES requirements are just a particular subset of WDRs for discharges that would be subject to NPDES permits in the absence of State regulation that is, at least, equivalent to what would be required by NPDES permitting.

Passive Leaching of Residual Copper is a Discharge of Waste

Any discharge of a chemical that affects water quality in a manner that detracts from the suitability of water for a beneficial use is a discharge of waste. California Water Code section 13050 defines "waste" as including sewage and any and all other waste substances, liquid, solid, gaseous, or radioactive, associated with human habitation, or of human or animal origin, or from any producing, manufacturing, or processing operation, including waste placed within containers of whatever nature prior to, and for purposes of disposal. This broad definition encompasses any substance whose formation was caused by human activity or whose path through the ecosystem is controlled or affected by human agency.

The passive leaching (i.e., discharge) of "residual copper" from antifouling paints is a "waste" pursuant to California Water Code section 13050(d). A discharge of waste (residual copper) occurs as a consequence of properly using copper-based antifouling paints on boat hulls. Copper-based antifouling paint is a registered pesticide applied to vessel hulls for the purpose and intent of killing target fouling aquatic organisms. The pesticide is designed to poison the entire aquatic environment of a vessel hull surface in order to discourage or prevent the growth of marine fouling organisms. However, the impacts of copper antifouling paint are not limited to target fouling organisms–other aquatic life in the vicinity of the boat hull may also be impacted. Due to water movement in the vicinity of the boat hulls, residual copper (the active pesticide ingredient) can be carried to adjacent areas in concentrations high enough to cause adverse effects to non-target aquatic organisms. Every molecule of copper poison that does not reach a target organism is "waste". Every molecule of copper poison that affects water quality necessary to support a non-target organism is "pollution." Violations of the copper water quality objectives throughout SIYB provide ample evidence that discharges of residual copper are occurring.

Regional Board May Issue Waste Discharge Requirements or Other Appropriate Mechanism

The Porter-Cologne Water Quality Control Act provides that "All discharges of waste into the waters of the State are privileges, not rights."[9] Furthermore, all discharges are subject to regulation under the Porter-Cologne Act including both point and nonpoint source discharges.[10] In obligating the State Board and Regional Boards to address all discharges of waste that can affect water quality the legislature provided the State Board and Regional Boards with authority in the form of administrative tools (WDRs, waivers, and prohibitions) to address ongoing and proposed waste discharges. Hence, all current and proposed discharges must be regulated under WDRs, waivers, or a prohibition, or some combination of these administrative tools.

Pursuant to California Water Code section 13260, the Regional Board may require any person discharging a waste, such as residual copper in SIYB, to file a report of waste discharge in application for waste discharge requirements. Pursuant to California Water Code section 13263,

[9] See CWC section 13263(g).

[10] See CWC sections 13260 and 13376.

the Regional Board may issue waste discharge requirements[11] to SIYB dischargers to regulate the discharges of residual copper. Alternatively, the Regional Board may issue waivers or adopt prohibitions to regulate the discharges of residual copper.

Residual Copper Discharge is a Violation of a Basin Plan Discharge Prohibition

The Basin Plan contains the following discharge prohibition that is applicable to any person (as defined by section 13050(c) of the California Water Code) whose activities could affect the quality of waters of the State:

> *The discharge of waste to waters of the state in a manner causing, or threatening to cause, a condition of "pollution", contamination or nuisance as defined in California Water Code section 13050, is prohibited.*

"Pollution" is defined under California Water Code section 13050(l), in part, to mean an alteration of the quality of the waters of the state by waste to a degree which unreasonably affects beneficial uses. A condition of pollution exists when applicable water quality objectives are violated as a result of the discharge of waste.

A condition of pollution exists in SIYB because the discharge of residual copper from copper antifouling paints, applied in accordance with label instructions in compliance with FIFRA, is causing exceedances of the applicable water quality objectives for copper.

[11] Discharges of pollutants from point sources to waters of the United States are regulated under WDRs that implement National Pollutant Discharge Elimination System (NPDES) regulations. There are plausible arguments that passive leaching of copper from copper-based antifouling paints on boats in marinas constitutes a discharge of pollutants from point sources, and should be regulated under WDRs that implement NPDES regulations. However, to develop and apply appropriate numeric effluent limits and other conditions needed for NPDES requirements for passive leaching of copper to marinas or individual boat owners would be complex and controversial. Regardless of whether the copper discharge comes from a point source or nonpoint source, the requirements would essentially be the same.

Nothing in Resolution No. R9-2005-0019, or the Basin Plan amendment promulgated by the Resolution, precludes any person who may be aggrieved by a subsequent determination by the Regional Board to regulate copper discharges to SIYB through the issuance of WDRs that implement NPDES regulations, from seeking review of that determination by the State Board.

IV. DISCHARGERS ACCOUNTABLE FOR COPPER LOAD AND WASTELOAD REDUCTIONS

Persons discharging copper to SIYB (hereafter, dischargers) are accountable for achieving compliance with the copper load and wasteload reductions specified in this TMDL. The Port, SIYB marina owners/operators, persons owning boats moored in SIYB, and underwater hull cleaners operating in SIYB are accountable for the discharge of copper waste from boat hull antifouling paints to SIYB waters. To a much lesser extent, the City also discharges copper from its MS4s.

12. San Diego Unified Port District

The Port is a special government entity, created in 1962 by the San Diego Unified Port District Act, California Harbors and Navigation Code in order to manage San Diego Harbor, and administer the public lands along San Diego Bay. The Port holds the tidelands and the submerged lands occupied by marinas in SIYB in trust for the State of California. Approximately 2,200 boats are congregated by seven marina owners/operators in the semi-enclosed SIYB. Copper leaches, dissolves, ablates, or erodes from the paint on the hulls of these boats into the surrounding water. The high density of boats combined with reduced tidal flushing has resulted in elevated levels of copper in SIYB.

The Port Can Control Discharges

The Regional Board has discretion to hold persons accountable for discharges of waste which occur or occurred on their property based on three criteria: (1) ownership of the land on which an activity occurs that results in a discharge of waste; (2) knowledge of the activity causing the discharge; and (3) the ability to control the activity.[12] The Port meets all three of these criteria.[13] As trustee, the Port exercises the rights and responsibilities of land ownership for the lands occupied by SIYB marina facilities in which residual copper discharges occur. The Port has land use authority on these lands. In exercising this authority, the Port controls decisions regarding the citing and sizing of all marinas in SIYB. The Port has full knowledge of the copper discharges from antifouling paint and the effects of these discharges on the water quality of San Diego Bay. In fact the Port co-sponsored an alternative hull paint demonstration study, is currently investigating the effectiveness of several types of paint that demonstrate innovative antifouling strategies, and is systematically repainting its entire vessel fleet with these new coatings. Finally, the Port has the ability under its lease agreements with the SIYB marina

[12] These principles on the issue of landowner liability under both waste discharge requirements and enforcement orders were established in a series of orders adopted by the State Water Resources Control Board (State Board) and in memoranda issued by the State Board Office of Chief Counsel. (See e.g., State Board Order Nos. WQ 87-6, 87-5, 86-18, 86-16, 86-15, 86-11, 84-6, 90-03; Memorandum dated May 8, 1987 from William R. Attwater to Regional Board Executive Officers entitled “Inclusion of Landowners in Waste Discharge Requirements and Enforcement Orders”.)

[13] State Board Order No. WQ 90-3 specifically addressed the Regional Board’s authority to hold the Port accountable for discharges of pollutants from its tenant’s facility operations. In 1989 the Regional Board adopted an addendum to six NPDES orders previously issued to certain boatyards and shipyards that were tenants of the Port. The Addenda added the Port as a responsible party to those ordered. The Port appealed the Regional Board’s action contending that the Port was a “non-operating” landowner and therefore not subject to NPDES order requirements. The State Board upheld the Regional Board’s action concluding that the Regional Board has the discretion to name non-operating landowners such as the Port in waste discharge requirements and NPDES orders because landowners may properly be considered “dischargers” under the CWA and CWC.

owners/operators, to impose controls that could prevent or reduce copper discharges.

The Port Can Be Held Accountable for Discharges

These facts establish that the Port is accountable for discharges of copper waste from antifouling paints to SIYB. Therefore, the Regional Board can hold the Port accountable for meeting load reductions specified in this TMDL.

The Port is also in the unique position to eliminate any competitive advantage other marinas, not subject to this TMDL, may gain by their location outside of SIYB. The Port has the ability under its lease agreements to impose the same controls needed for SIYB marinas, on all marinas in San Diego Bay. This would “level the playing field” bay-wide and significantly reduce copper loads from marinas throughout San Diego Bay.

13. Marina Owners/Operators

The Regional Board has the discretion to hold SIYB marina owners/operators accountable for discharges of waste which occur or occurred within the marina leasehold based on three criteria: (1) status as owner or operator of the marina facility on which an activity occurs that results in a discharge of waste; (2) knowledge of the activity causing the discharge; and (3) the ability to control the activity. The SIYB marina owners/operators meet all three of these criteria.

Marina Owners/Operators Congregate Boats

That the marina owners/operators own or operate the SIYB marina facilities where copper discharges from antifouling paints occur is undisputed. The marina owners/operators congregate boats and thereby cause or contribute to the discharge of copper from the large number of boat hulls in SIYB.

Approximately 2,200 boats are congregated by seven major marina owners/operators in the semi-enclosed SIYB. Copper leaches, dissolves, ablates, or erodes from the paint on the hulls of these boats into the surrounding water. The high density of boats combined with reduced tidal flushing has resulted in elevated levels of copper in SIYB. Furthermore, because recreational boats are moored in marinas most of the time, the majority of copper is discharged within the marina environment.

Marina Owners/Operators have Knowledge of Discharges

The SIYB marina owners/operators have knowledge of the copper discharges from antifouling paint and the effects of these discharges on the water quality of San Diego Bay through their participation in various conferences, workshops, studies, and outreach efforts related to antifouling coatings. These include Regional Board public workshops on the SIYB Copper TMDL (May 2000, March 2003, November 17, 2003); the International Congress on Marine Corrosion and Biofouling (San Diego, July 2002); the Alternative Antifouling Strategies for Recreational Boats Conference (San Diego, September 2000); the San Diego Advisory Committee for Environmentally Superior Antifouling Paints and subsequent report to legislature pursuant to Senate Bill 315 (Carson report. 2002); Regional Board and Port Tenants Association workshops related to the tentative Marina NPDES Order No. R9-2003-0215; and participation in other related conferences and workshops.

In addition, for the past several years the University of California's Sea Grant Extension Program (Sea Grant) has been actively involved in educating the San Diego boating community (including SIYB marina owners/operators) about alternative antifouling strategies through numerous outreach efforts, including the conduct of the July 2000 conference mentioned above, the conduct of a "Nontoxics Bottom Paint Demonstration Project", and the development of educational booklets.[14] There are also several efforts and advisory groups dedicated to addressing nonpoint source pollution problems associated with marinas and recreational boating and implementing the State of California's "Nonpoint Source Program Strategy and Implementation Plan" (State Board and CCC, 2000).[15] The California Coastal Commission has published the California Clean Marina Guidebook (2nd Draft). The Boating Clean and Green Campaign and the California Clean Boating Network are examples of other educational programs designed to promote environmentally sound boating practices to marine businesses and boaters in California.

Marina Owner/Operators Can Control Discharges

Finally, the SIYB marina owners/operators have the ability to control discharges of copper to SIYB. Marina owners/operators exercise control and enforcement over boat owners and their discharges by way of conditional lease or license agreements with owners of boats moored within the marina leasehold. The conditions written into these contract agreements are the key to the marina's legal authority to exercise control over residual copper discharges from boat hulls within the marina leasehold. By way of these conditions, the marina owners/operators can control the number of moored boats, the types of hull coatings used, and hull cleaning activities allowed within the leasehold. Marina owners/operators can also require the use of MPs by boat owners and hull cleaners and require boat owners to provide proof of hull coating composition.

Marina Owner/Operators can be Held Accountable for Discharges

Taken together, these facts establish that the Regional Board can hold marina owners/operators accountable for discharges of copper waste from boat hull antifouling paints to SIYB. Therefore, the Regional Board should hold the marina owners/operators accountable for meeting load reductions specified in this TMDL.

Regulating Marina Owners/Operators is Appropriate

The naming of the marina owners/operators as dischargers responsible for residual copper discharges emanating from individual boats moored within their leaseholds is consistent with, and analogous to, the Regional Board's regulation of other dischargers within the Region. Analogous examples include Concentrated Animal Feeding Operations (CAFOs), Municipal Separate Storm Sewer Systems (MS4s), and roads built by Caltrans. Another important analogy involves the regulation of outdoor shooting ranges.

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[14] *What you Need to Know About* Nontoxic Antifouling Strategies *For Boats* (Johnson and Miller, 2002); A Change is in the Wind for Antifouling Strategies - And It's Blowing Your Way (Report No. T-049)

[15] For example, the Statewide Interagency Coordinating Committee and the Marinas and Recreational Boating Workgroup.

In each of the analogous examples discussed below, the facility owner/operator congregates, concentrates, channels and directs waste directly to surface waters. Although the individual users of the facility generate the waste, the owner/operator of the facility is held accountable because it collects, congregates, concentrates, channels, and directs waste to surface waters. Furthermore it is more practicable for the Regional Board to regulate the owner/operator of the facility than to regulate each individual user of the facility. Similarly it is more practicable for the Regional Board to regulate marina owner/operators than to regulate each individual boat owner mooring a boat within the marina leasehold.

Concentrated Animal Feeding Operations (CAFOs) Analogy

Concentrated Animal Feeding Operations (CAFOs) are regulated because they congregate large numbers of animals at a single location resulting in the cumulative and concentrated discharge of significant volumes of animal waste. The CAFO owner/operator is the named discharger accountable for the discharge of animal wastes. As previously described, marina owners/operators similarly congregate large numbers of boat hulls in a single leasehold resulting in the cumulative and concentrated discharge of significant amounts of residual copper. A small number of boats, like a small number of animals, may not necessarily result in a water quality problem. However a large number of boats, like a large number of animals, when congregated in a single location such as SIYB has resulted in a significant water quality problem.

MS4 Analogy

The concept of holding marina owners/operators accountable for discharges from boat hulls in their leaseholds is also analogous to the Regional Board holding municipal MS4 copermittees responsible for all discharges resulting from all land uses within their jurisdiction. Although other persons in the land use areas generate the pollutants, the municipal copermittees are held responsible because they own or operate the MS4, which collects, congregates, concentrates and conveys the waste to receiving waters. Municipal copermittees have ample legal authority to control waste discharges from land uses and to enforce these controls. It would be impracticable for the Regional Board to directly regulate individual persons contributing waste to the discharges from each land use area. Similarly although the residual copper discharges originate from boats owned by other persons, the marina owner/operators can be held accountable because they own or operate the marina that congregates and concentrates large numbers of boat hulls continuously discharging copper. Marina owners/operators have ample legal authority to control residual copper discharges from boats moored within their leasehold and to enforce these controls. It would be impracticable for the Regional Board to directly regulate individual persons owning the approximate 2,200 boats moored in SIYB.

Caltrans MS4 Highway Analogy

In the statewide MS4 Caltrans NPDES Permit, the SWRCB names Caltrans as the discharger responsible for waste discharges from roads and highways owned or controlled by Caltrans. Caltrans is held responsible despite the fact that the majority of waste discharges originate from vehicles owned by persons other than Caltrans. Waste discharges include oil, gas, and metals resulting from tire, brake and engine wear. The road or highway is an MS4 point source, which collects, congregates, and concentrates large numbers of vehicles and conveys the vehicle pollutants to receiving waters. Similarly marina owners/operators congregate and concentrate large numbers of boat hulls, which continuously discharge copper as described above.

Outdoor Shooting Ranges Analogy
In the 1994 case, New York Coastal Fisherman's Association v. New York Athletic Club, the United States District Court for the Southern District of New York specifically found that shooting ranges act to systematically channel pollutants into waters of the United States and that mechanized target throwers convey pollutants directly into waters of the United States. Individuals at the shooting range stand on concrete platforms, facing Long Island Sound, from which they fire lead and steel shot at clay targets launched over the water. The Court determined that the concrete shooting platforms could either be seen as separate point sources under the Clean Water Act or as one facet of the shooting range that systematically delivers pollutants into waters of the United States. The Court concluded that the shooting range operated by Defendant which is designed to concentrate shooting activity from a few specific points and systematically direct it in a single direction over Long Island Sound is an identifiable source from which spent shot and target fragments are conveyed into waters of the United States. As such, the shooting range constitutes a point source within the meaning of the Clean Water Act. The Court found that the owner/operator of the shooting range, rather than the individual club members firing shot over Long Island Sound, is responsible for the discharge of pollutants to waters of the United States. The owner/operator of the shooting range, rather than the individual club members, was required to obtain an NPDES permit under the Clean Water Act.

The holdings of the Court in New York Coastal Fisherman's Association v. New York Athletic Club are directly analogous to the SIYB marinas and residual copper discharges. The marinas are analogous to the shooting range and the individual boat owners are analogous to the individual club members firing shot from individual concrete shooting platforms within the shooting range. The individual boat hulls, like individual concrete shooting platforms, are individual sources of waste to surface waters. The marinas, like the shooting range, concentrate and congregate the individual sources of waste (boat hulls) and direct the discharges (residual copper) into surface waters (SIYB). The marina leaseholds themselves are an identifiable cumulative source from which residual copper discharges are conveyed into surface waters. The marina owner/operators like the shooting range owner/operator are responsible for the cumulative discharge of waste. Thus, these discharges are appropriately regulated through the Regional Board's administrative tools.

14. Individual Boat Owners

Persons owning boats moored in SIYB are responsible for discharges of copper waste because hull coating leachate containing copper is continuously generated whenever a vessel hull is exposed to water. Some individual boat owners also engage in underwater hull cleaning activities which result in the additional release of dissolved copper into the surrounding waters from copper antifouling paints applied to boat hulls. Therefore, the Regional Board can hold each individual person owning a boat moored in SIYB accountable for meeting load reductions specified in this TMDL.[16]

[16] It is more practicable for the Regional Board to appropriately regulate individual boat owners indirectly via prohibitions, or WDRs or waivers issued to the Port of San Diego and/or the SIYB marina owners/operators.

15. Underwater Hull Cleaners

Underwater hull cleaners cleaning boat hulls coated with copper antifouling paint in SIYB are responsible for discharges of copper waste. Underwater hull cleaning is performed by divers using various manual and mechanical means to remove fouling organisms that have adhered to a vessel and its appendages. The physical process of removing fouling organisms from a vessel's hull painted with copper-based antifouling paints while underwater, results in the release of dissolved copper into surrounding SIYB waters. Therefore, the Regional Board can hold persons engaged in underwater hull cleaning activities in SIYB accountable for meeting load reductions specified in this TMDL.

16. City of San Diego

Because urban runoff is a source of dissolved copper to SIYB, the City is responsible for these discharges from its storm water conveyance system into SIYB under NPDES Order No. 2001-01, "Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm Sewer Systems." The City is responsible for meeting the WDRs. For this reason, the Regional Board can hold the City responsible for meeting wasteload reductions specified in this TMDL. However, the source analysis showed that discharges of copper from urban runoff account for less than one percent of the total loading into SIYB.

V. TMDL IMPLEMENTATION PLAN FOR SHELTER ISLAND YACHT BASIN

This Implementation Plan describes the strategies and management practices available to dischargers to reduce copper loading to SIYB. The Implementation Plan also describes the regulatory options available to ensure the dischargers comply with the copper reductions. The Implementation Plan describes:

- Alternative strategies and management practices that can be developed and implemented by the dischargers to reduce dissolved copper loading into SIYB;

- Regional Board coordination with governmental agencies having legal authority over the use of copper-based antifouling paints; and

- Regulation by the Regional Board.

The Implementation Plan also includes a schedule to achieve compliance with the copper reductions specified in the TMDL over a 17-year period. This section also describes how dischargers can participate in compliance monitoring of SIYB waters to measure the effectiveness of the TMDL and Implementation Plan in attaining water quality objectives over time.

17. Discharger Strategies to Reduce Dissolved Copper Loading to SIYB

The following strategies and management practices (MPs) can be developed and implemented by the dischargers to achieve compliance with the copper reductions specified in this TMDL.

Transition to Nontoxic and Less Toxic Hull Coatings

Given the fact that copper-based antifouling paints have been approved by the USEPA for nationwide use under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), and are relied upon throughout the state and region by boaters and boat maintenance enterprises, the ultimate resolution for the copper pollution associated with such use depends on review of registration for toxic antifouling paints by the USEPA and radical restriction or prohibition of the use of such paints. Meanwhile, the most reasonable foreseeable strategy to promote compliance with the required load reductions for copper in SIYB is promotion of a gradual transition to the use of nontoxic or less toxic antifouling coatings and maintenance strategies.

A transition to nontoxic coatings could be accomplished in 15 years without substantial economic hardship because nontoxic antifouling coatings are more cost-effective than copper-based antifouling paints over the long term. While it is currently less expensive to re-apply copper-based paint to existing boats when the paint must be replaced, nontoxic epoxy antifouling coatings last longer, which makes them more cost-effective over the life of a boat (Carson *et al.*, 2002). Additionally, some nontoxic coatings may provide other benefits, such as reduced fuel consumption due to the lower friction associated with some silicon-based coatings. The success of the transition would depend on a clear deadline for the elimination of copper-based antifouling paints that would compel boat owners and boat maintenance enterprises to promote the use of nontoxic or less toxic alternatives.

Subsequent to the release of the Carson report, the University of California Sea Grant Extension Program conducted a poll of 10 boat repair yards in San Diego and Orange Counties in fall 2003 (comment letter to Regional Board, dated 1/21/04). These boatyards reported a range of 8-20 years before stripping is required, although one (Driscoll Boatworks) mentioned 30 years. Thus, the Sea Grant poll supports the Carson report conclusion that boats are stripped on average every 15 years. Nonetheless, for owners who never strip their boats, the conversion to non-toxic epoxy coatings would cost an additional $5,200 to $6,000 compared to a boat owner who includes stripping as part of routine boat maintenance (assuming an average boat length of 40 feet and a stripping cost between $130 to $150 per foot).

Most of the measures involved in this transition would take place at the level of the most direct discharge of copper: boat owners and hull cleaners, and would require vigorous outreach by governmental and non-governmental organizations involved in the implementation of the TMDL for SIYB.

Measures that SIYB boat owners could take include:

- Replacement of copper-based paints with nontoxic or less toxic coatings during routine hull bottom stripping and coating replacement; and

- Selection of new boats that are "factory-equipped" with a nontoxic or less toxic hull coating.

Several features of this Implementation Plan are based on the recommendations of an important investigation and report entitled "Transitioning to Non-Metal Antifouling Paints On Marine Recreational Boats in San Diego Bay," prepared by Dr. Richard Carson, Ph.D., et al., of the University of California, San Diego in response to Section 13366 of the Water Code (added by Chapter 469, Statutes of 2001, also known as Senate Bill 315). The Carson report identified nontoxic alternatives to toxic metal-based antifouling paints, compared the costs of using these alternatives to the cost of using traditional copper-based antifouling paints, and identified economic incentives for a transition to the use of alternatives.

The key findings of the Carson report are summarized below:

- Converting all boats in San Diego Bay from copper-based paints to nontoxic coatings in 15 years is possible without substantial economic hardship to the boating community. This finding assumes that all newly manufactured boats are sold with nontoxic coatings and that all existing boats are converted to nontoxic coatings at the time of routine stripping, i.e., every 15 years;

- To effect this conversion to nontoxic coatings, policy makers must announce a future ban on copper paints and set a specific compliance date;

- Copper paint is more cost effective over the short term but nontoxic epoxy coatings are more cost effective over the long-term life of the boat;

- Boater education, commercial demonstrations and scientific studies should be conducted to support the conversion from copper paints to nontoxic coatings; and

To determine factors that would be useful to policy makers in creating incentives for boat owners to convert from copper-based paints to nontoxic coatings, a survey was conducted of San Diego Bay boaters (Carson *et al*., 2002). The top four factors rated by the boaters surveyed as extremely or very important in deciding whether to convert were: (1) the greater longevity of nontoxic paint (77 percent surveyed); (2) laws requiring nontoxic paint (76 percent surveyed); (3) nontoxic paints will make San Diego Bay cleaner (71 percent surveyed); and (4) marina requires nontoxic paint (62 percent surveyed).

In summary, the Carson report established that converting to nontoxic strategies is possible and economically feasible if sufficient time is provided. For this reason, the Regional Board has established a 15-year timeframe to accommodate such a conversion, as discussed in the TMDL staged compliance schedule.

Appendix 9 provides a description of some of the nontoxic antifouling strategies available on the market, including durable epoxy and ceramic-epoxy, easy-clean silicone and siloxane, fiber-epoxy, polymer, water-based urethane, and bottom wax.[17]

Appendix 10 provides an overview of other important global and regional efforts to address the water quality problems resulting from copper antifouling paints and describes current laws, restrictions and recommendations pertaining to the gradual phase-out of copper-based antifouling paint.

Reduce Effects of Copper-Based Paints through Management Practices

Efforts should be made to reduce the amount of copper discharged from boat hulls with copper-based paints by implementing the MPs listed below.

- Boat owners could use slip liners to isolate boat hulls from SIYB waters;

- Boat owners could use dry storage (e.g., hoists, lifts) or landside boat storage facilities for smaller boats;

- Hull cleaners could use less abrasive hull cleaning methods and materials on boats with copper-based antifouling paints; and

- Hull cleaners could train in the maintenance of nontoxic and less toxic hull coatings and purchase the necessary special equipment.

[17] This information was provided from a brochure published by Sea Grant, in: Johnson, Leigh T. and Jamie A. Miller. 2002. Nontoxic Antifouling Strategies Sampler. What You Need to Know about Nontoxic Antifouling Strategies for Boats. California Sea Grant College Program Technical Report T-049:6-7.

Conduct Boater Education Programs

In order to build a consensus supporting the need and rationale for the transition from traditional toxic antifouling paints to nontoxic alternatives that will entail higher costs for initial application, the Port and the marina owner/operators should conduct boater education programs. The education programs would be designed to educate the SIYB boating community about the water quality problem associated with copper leaching in SIYB and the nontoxic or less toxic coatings and strategies that can be implemented by individual boaters to resolve the problem. The education programs should include information on the economics and tradeoffs between the use of copper-based paints and nontoxic or less toxic alternatives.

Commercial Demonstrations and Scientific Studies

The Port and marina owners/operators in SIYB could coordinate and oversee commercial and scientific studies to confirm and demonstrate the efficacy and longevity of available nontoxic and less toxic boat hull coating products. The demonstrations and studies would also allow boat repair yards and underwater hull cleaners the opportunity to develop expertise and acquire special equipment needed for the application and maintenance of nontoxic and less toxic boat hull coatings. The Regional Board may support efforts by the Port to seek grant funding for the commercial demonstrations and scientific studies from a variety of sources including the State Board, the USEPA, and the California Department of Boating and Waterways (DBW). Scientific research work should be conducted by qualified scientific or academic organizations.

Impose Controls on SIYB Boat Owners

Marina owners/operators in SIYB could impose and enforce controls on boat owners via conditions in lease or license agreements. For example: restrictions on the use of copper-based paints, such as a requirement that all new boats have nontoxic or less toxic coatings, or a requirement that boat owners convert to nontoxic or less toxic coatings during routine stripping; proof of hull coating composition; restrictions on hull cleaning; restrictions on number of boats; and requirements that hull cleaners use MPs.

Implement Financial Incentives

Marina owners and operators in SIYB could implement financial incentives to encourage the use of nontoxic and less toxic hull coatings. For example, the marina owner/operators could impose differential lease fees for individual boat owners which consider the hull coating composition of boats within the marina leaseholds with higher fees for traditional copper-based antifouling paints and lower fees for less toxic hull bottom coatings.

Impose Controls on SIYB Marina Owners and Operators to Limit Use of Copper-Based Hull Paints

The Port could impose and enforce controls on SIYB marinas via conditions in lease agreements and ordinances. For example, the Port could require restrictions on the use of copper-based paints, such as requiring that all new boats have nontoxic or less toxic coatings and requiring conversion to nontoxic or less toxic coatings during routine stripping; proof of hull coating composition; restrictions on hull cleaning; and/or restrictions on the number of boats.

Implement Financial Incentives to Encourage the Use of Alternative Antifouling Strategies

The Port could implement financial incentives to encourage the use of nontoxic and less toxic hull coatings. For example, the Port may impose differential lease fees for SIYB marina owners/operators which control the hull coating composition of boats within the marina leaseholds: higher fees for traditional copper-based antifouling paints and lower fees for less toxic hull bottom coatings. Additionally, the Port could impose the same types of controls and financial incentives on marinas throughout San Diego Bay to "level the economic playing field."

18. Coordination with Governmental Agencies Having Legal Authority Over the Use of Copper-Based Antifouling Paints

Copper-based antifouling paints are legally registered pesticides subject to registration and regulation by the USEPA pursuant to the FIFRA (7 U.S.C. 136) and by the California Department of Pesticide Regulation (DPR) pursuant to Division 7, commencing with section 12500, of the California Food and Agriculture Code (CDFA). The Regional Board, in conjunction with the State Board, will pursue regulatory solutions with these and other agencies having legal authority over the registration, sale, and use of copper-based antifouling paints in California to address the problem in SIYB. These agencies have authority to take direct regulatory actions that could include the imposition of additional restrictions on the sale and use of copper-based antifouling paints in SIYB, up to, and including cancellation of particular uses or registration. A relevant example of regulatory action related to water quality concerns is discussed in Appendix 9 pertaining to legislative and regulatory restrictions that were imposed on the use of tributyltin antifouling paints.

United States Environmental Protection Agency

The Regional Board will formally ask the State Board to use its legal authority over the registration, sale, and use of copper-based antifouling paints in California to address the violations of copper water quality objectives in SIYB. Potential actions that the USEPA may consider include amendments to label language, cancellation of uses, pesticide re-registration, and cancellation of registration. The USEPA is scheduled to review registration for all copper-based pesticides beginning in 2007.

California Department of Pesticide Regulation

Section 13247 of the California Water Code requires state agencies to comply with water quality control plans (basin plans) "in carrying out activities which may affect water quality." Under this provision, the DPR has an obligation to ensure that registration and use conditions for copper-based antifouling paints would not violate the TMDL for SIYB.

The Regional Board will continue to coordinate with the DPR pursuant to the 1997 Management Agency Agreement (MAA) between the State Board and the DPR. Under the MAA, the State Board, Regional Boards and the DPR are committed to working together to use their respective authorities to resolve water quality problems that are related to pesticide use. The Regional Board will formally ask the State Board to request that the DPR use its legal authority over the registration, sale, and use of copper antifouling paints in California to address the violations of copper water quality objectives in SIYB. Potential actions that the DPR may consider include pesticide re-evaluation (requirements for additional data from registrants), adoption of regulations, designation of a pesticide as a restricted material, refusal to register, cancellation of registration, and suspension of registration.

San Diego County Agricultural Commissioner

The San Diego County Agricultural Commissioner (CAC) serves as the DPR's primary enforcement agent for State pesticide laws and regulations in San Diego County. The Regional Board will continue to coordinate with the CAC pursuant to the MAA between the State Board and the DPR. The Regional Board will request that the CAC use its legal authority over the use of copper antifouling paints in San Diego County to address the violations of copper water quality objectives in SIYB. Potential actions that the CAC may consider include the issuance of conditional use permits, adoption of local regulations and additional, more stringent local use restrictions.

California Coastal Commission

The California Coastal Commission (CCC) is a State regulatory agency responsible for protecting, conserving and restoring California's coastal and ocean resources. Under a Memorandum of Understanding (MOU) between the CCC and the State Board, the CCC is committed to implementing the jointly authored Plan for California's Nonpoint Source Pollution Control Program (Nonpoint Source Program Plan) (State Board and CCC, 2000). The Nonpoint Source Program Plan presents a 15-year strategy for dealing with nonpoint source pollution, including pollution from marinas and recreational boating, through implementation of management measures. Management measures for marinas and recreational boating include boater education, training and certification for underwater hull cleaners, promotion of nontoxic and less toxic products, and development of legislation that prohibits the sale and use of toxic hull paints as necessary after a thorough analysis. The CCC also supports a number of outreach programs and projects that work to promote clean boating and decrease boating-related pollution, including the Boating Clean and Green Campaign and the California Clean Boating Network. The Regional Board could coordinate with the CCC to address the violations of water quality objectives in SIYB through their education and outreach programs.

California Department of Boating and Waterways

The mission of the DBW is to provide access to navigable waterways for recreational boaters and to protect the public's right to safe and enjoyable boating. The DBW plays an important role in boater safety and education and in funding public projects related to boating including the Carson study and resulting report (Carson *et al.*, 2002). The Regional Board could coordinate with the DBW to educate boaters on the environmental impacts of copper-based antifouling paints and the nontoxic and less toxic available alternatives.

Legislative Initiatives

The Regional Board will consult with the State Board regarding the need to consider legislative solutions to address water quality problems caused by copper antifouling paints. Following this determination, the State Board could solicit legislation to address this issue. Potential legislative solutions would be developed in coordination with the USEPA and the DPR. A two-stage process would be appropriate: (1) a statewide investigation of water quality problems associated with copper antifouling paint to develop an action plan; and (2) subsequent phase-out of copper-based paints. If the State Board agrees with the need for the legislation, the State Board may draft proposed legislation and forward it to the California Environmental Protection Agency (CalEPA) for consideration. If CalEPA agrees with the need, the proposed legislation may be forwarded to the Governor's Office for approval. If approved by the Governor's Office, the State Board may seek a sponsor to introduce the legislation. No State agency can take a position on, support, or promote a bill unless it has been approved by the Governor's office.

19. Regulation by the Regional Board

The Porter-Cologne Water Quality Control Act provides that "All discharges of waste into the waters of the State are privileges, not rights."[18] Furthermore, all discharges are subject to regulation under the Porter-Cologne Act including both point and nonpoint source discharges.[19] In obligating the State Board and Regional Boards to address all discharges of waste that can affect water quality, the legislature provided the State Board and Regional Boards with authority in the form of administrative tools (waste discharge requirements (WDRs), waivers of WDRs, and Basin Plan waste discharge prohibitions) to address ongoing and proposed waste discharges. Hence, all current and proposed discharges must be regulated under WDRs, waivers of WDRs, or a prohibition, or some combination of these administrative tools.

With the exception of persons discharging into community sewer systems, any person discharging or proposing to discharge waste that could affect water quality must file a report of waste discharge (RoWD) with the appropriate Regional Board, unless the Regional Board waives the filing.[20] A RoWD also is required if a discharger proposes a material change in the character, volume, or location of a discharge.[21] The Regional Board must then determine the appropriate action to take, either issuing WDRs to the discharger, or conditionally waiving the requirements.[22] WDRs can prohibit the discharge of waste or certain types of waste, either under specific conditions or in specified areas. As an alternative, the Regional Board may prohibit the discharge of waste or certain types of waste in a water quality control plan.[23]

The residual copper passively leached from antifouling paints is a waste pursuant to CWC section 13050(d), as discussed in Chapter III, Section 11. The Regional Board is responsible for regulating the discharge of residual copper waste through the issuance of WDRs,[24] waivers, or

[18] See CWC section 13263(g).

[19] See CWC sections 13260 and 13376.

[20] See CWC sections 13260 and 13269.

[21] See CWC section 13264.

[22] See CWC section 13263 and 13269.

[23] See CWC section 13243.

[24] Discharges of pollutants from point sources to waters of the United States are regulated under WDRs that implement National Pollutant Discharge Elimination System (NPDES) regulations. There are plausible arguments that passive leaching of copper from copper-based antifouling paints on boats in marinas constitutes a discharge of pollutants from point sources to navigable waters of the United States, and should be regulated under waste discharge requirements that implement NPDES regulations. However, to develop and apply appropriate numeric effluent limits and other conditions needed for NPDES requirements for passive leaching of copper to marinas or individual boat owners would be complex and controversial. Regardless of whether the copper discharge comes from a point source or nonpoint source, the WDRs would essentially be the same.

prohibitions. All three can be structured upon third party pollution control programs developed by the dischargers.

Issuance of Waste Discharge Requirements

The Regional Board could issue individual or general WDRs that would require that the dischargers meet the copper reductions specified in the TMDL. Since numeric effluent limits for dissolved copper from boat hulls would be difficult to achieve through conventional treatment methods without derogating from the antifouling effectiveness of copper-based paints, WDRs would emphasize the development and implementation of MPs to reduce the impact of copper leaching on waters of the State. WDRs may be used during an interim transition period to nontoxic or less toxic antifouling coatings. WDRs for discharges of copper from antifouling paints could require the following MPs:

- *Boater Education Programs*
  The Port and the marina owner/operators could conduct boater education programs. The purpose of the education programs would be to educate the SIYB boating community about the copper water quality problem in SIYB and the nontoxic or less toxic coatings and strategies that can be implemented by individual boaters to resolve the problem. The education programs could also include information on the economics and tradeoffs between the use of copper-based coatings and nontoxic or less toxic alternatives.

- *Coordinate and Oversee Commercial Demonstrations and Scientific Studies Investigating Alternative Antifouling Strategies*
  The Port could coordinate and oversee the conduct of commercial demonstrations and scientific studies. The purpose of the demonstrations and studies would be to confirm the efficacy and longevity of available nontoxic and less toxic boat hull coating products. The demonstrations and studies could also allow boat repair yards and underwater hull cleaners the opportunity to develop expertise and acquire special equipment needed for the application and maintenance of nontoxic and less toxic boat hull coatings.

- *Coordinate and Oversee Scientific Studies Investigating the Movement of Copper in Water Column / Sediment Dynamic Equilibrium*
  The Port and the marina owners/operators could oversee the conduct of scientific studies designed to investigate the movement of copper in the water column / sediment equilibrium. As discussed in the source analysis, there is limited data indicating that under current equilibrium conditions, the sediment acts as a net sink for dissolved copper in the water column. Further studies are probably necessary to better understand this phenomenon. If studies demonstrate that sediment is, or could become a significant source once primary sources, such as copper-based antifouling paints have been reduced, then the TMDL and allocations could be amended at a later date. An allocation for sediment loading could be assigned to the dischargers responsible for the sediment

Nothing in Resolution No. R9-2005-0019, or the Basin Plan amendment promulgated by the Resolution, precludes any person who may be aggrieved by a subsequent determination by the Regional Board to regulate copper discharges to SIYB through the issuance of WDRs that implement NPDES regulations, from seeking review of that determination by the State Board.

contamination. Depending on the severity of the contamination, sediment cleanup could be necessary.

The WDRs also could build upon third party pollution control programs, which are discussed below under the section entitled *Third Party Agreements*. These WDRs could, for example, require that the dischargers either participate in a third party program capable of achieving the required copper load reductions or, alternatively, require the dischargers to submit individual pollution control plans that detail how the discharger will comply with the WDRs.

Issuance of Conditional Waiver of Waste Discharge Requirements

The Regional Board could waive regulation of copper discharges based on the implementation of an adequate third party program that addresses the source of pollution, provided that certain conditions were met. An MOU or MAA between the Regional Board and discharger organizations/Port would be an appropriate mechanism to ensure implementation of the program and compliance with conditions of the waiver.

Adoption of Conditional Waste Discharge Prohibition

The Regional Board could adopt waste discharge prohibitions in the Basin Plan, which could include exceptions based on the implementation of an adequate third-party program that addresses the source of pollution. For example, the Regional Board could except from the discharge prohibition those discharges that are adequately addressed in a third-party pollution control program. An MOU or MAA between the Regional Board and discharger organizations/Port would be required to ensure implementation of the program.

Third Party Agreements

The dischargers could formulate and implement their own pollution control programs under third party agreements with the Regional Board. Under this alternative, an organization[25] of the marina owners/operators, an organization of the hull cleaners, an organization of boat owners, and/or the Port would formulate and submit pollution control programs to the Regional Board. The pollution control programs would be developed to comply with WDRs, waivers of WDRs, or basin plan prohibitions. If a pollution control program is likely to achieve the necessary copper load reductions, the Regional Board could enter into a MOU with the marina or hull cleaner organizations or an MAA with the Port to ensure implementation of the pollution control program. Pollution control programs should include some or all of the MPs described in section 15, *Discharger Strategies to Control Dissolved Copper Loading to SIYB*.

The Regional Board is responsible for regulating the discharge of residual copper with WDRs, waivers of WDRs, or basin plan prohibitions whether or not a third party agreement is in place. However, under third-party agreements the Regional Board can conditionally waive regulation of a particular pollution source based on the existence of an adequate pollution control program that addresses this source. Similarly, the Regional Board can adopt individual or general WDRs for discharges that build upon third-party programs. These WDRs can, for example, require that the dischargers either participate in an acceptable third party program or, alternatively, submit

[25] Though marina owners/operators and hull cleaners would participate in pollution control programs, organizationally, someone other than a discharger must manage the programs.

individual pollution control plans that detail how they will comply with the WDRs. Likewise, the Regional Board can adopt discharge prohibitions, which include exceptions based on third-party programs. For example, the Regional Board can except from the discharge prohibition those discharges that are adequately addressed in an acceptable third-party pollution control program.

Failure by any single discharger to participate in their respective organization/agency program could result in more stringent regulation of that discharger by the Regional Board through enforcement of WDRs, a conditional waiver of WDRs, or waste discharge prohibitions.

Copper Discharges Regulated Under Requirements for the Municipal Separate Storm/Sewer Systems

The Regional Board will amend Order No. 2001-01, "Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm /Sewer Systems" to require that discharges of copper into SIYB waters not increase from existing loadings. Since the source analysis showed that discharges of copper from urban runoff account for less than one percent of the total loading into SIYB, an amendment to Order No. 2001-01 would not contain required copper load reductions, but rather require that discharges of copper into SIYB not increase from existing loadings. The order could also be amended to require MPs designed to reduce copper loading into SIYB, and/or monitoring for copper in the runoff management plan pertinent to SIYB.

Issuance of Investigative Order Requiring Monitoring and Reporting

Pursuant to CWC section 13267, the Regional Board could issue an investigative order to any person who "discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge waste within its region," or has discharged waste to waters of the State that could affect the quality of the waters within its region. Section 13267 states that the discharger(s) shall furnish, under penalty of perjury, technical or monitoring program reports that the Regional Board requires in investigating the quality of waters of the State within its region.

The Regional Board could require any or all persons responsible for discharges of copper to SIYB, including those accountable for load reductions under the TMDL, to monitor and report on the status of the water column in SIYB to ensure that the required load reductions for copper discharges are met. At a minimum the monitoring would measure copper levels in SIYB water column and assess water column toxicity. Monitoring would use appropriate low detection methods of analysis to detect copper concentrations at or below the water quality objectives for copper. The Regional Board could require sediment monitoring in addition to water column monitoring.

The Port is participating in the development and implementation of a single coordinated Regional Harbor Monitoring Program covering all of the harbors in the San Diego Region, including San Diego Bay. The Regional Board could require that this program include compliance monitoring and reporting in SIYB. Alternatively, the Regional Board could submit a separate directive to the Port and/or other dischargers for monitoring and reporting specific to SIYB.

Issuance of Order to Investigate, Report and Enforce Water Quality in SIYB

Pursuant to CWC section 13225, the Regional Board can require as necessary any State or local agency to investigate and report on any technical factors involved in water quality control, or to obtain and submit analyses of the water column. The Regional Board can also request enforcement by appropriate federal, State and local agencies of their respective water quality control laws.

20. TMDL Staged Compliance Schedule

As with all TMDL projects, monitoring is a necessary component to ensure that water quality standards are gradually being met. Pursuant to CWC section 13225 and by letter dated July 24, 2003, the Regional Board directed the Port to participate in the development of a single coordinated Regional Harbor Monitoring Program covering all of the harbors in the San Diego Region, including San Diego Bay. A portion of the monitoring required under this program could be used to assess compliance in SIYB with the copper load reductions specified in this TMDL and with copper water quality objectives. At a minimum, the TMDL monitoring will measure copper levels in SIYB water column and will assess water column toxicity. Monitoring should use appropriate low detection methods of analysis to detect copper concentrations at or below the water quality objectives for copper. The Regional Board shall direct the Port, and may direct the SIYB marina owners/operators, to participate in TMDL monitoring in SIYB. This monitoring must show the effectiveness of the applied MPs.

The compliance schedule presented below is based on a timeline that will minimize the economic impact of the transition and has the following key features:

- Copper load reductions are required over a 17-year staged compliance schedule period. The first stage consists of an initial 2-year orientation period during which no copper load reductions are required. The subsequent 15-year reduction period is comprised of three stages during which incremental copper load reductions are required;[26]

- The schedule assumes that: (1) all new boats entering SIYB are provided with nontoxic or less toxic coatings; and (2) the copper coating on all existing boats is replaced by a nontoxic

[26] The Carson report (2002) found that all 7,000 boats in San Diego Bay could be converted from copper-based paints to alternative coatings over a 15-year period without economic hardship to the boating community. This finding assumed that (1) all new boats entering San Diego Bay are painted with nontoxic and less toxic coatings; and (2) the copper coating on all existing boats is replaced by a nontoxic or less toxic coating at the time routine hull stripping is required.

or less toxic coating at the next time routine hull stripping is scheduled;

- The schedule includes the conduct of education programs for the SIYB boating community and commercial demonstrations and scientific studies. These efforts will be initiated during the first two years and continued throughout the 17-year schedule as appropriate; and

- The formal mandate for copper load reductions will, in and of itself, increase the market demand for nontoxic and less toxic hull coating products. The gradual 17-year transition period will allow for the development and testing of these products.

2-Year Orientation Period

During Stage 1 of the schedule (Table 16.1), no reductions in dissolved copper emissions are required. This orientation period has two purposes:

- Initiation of an educational effort for boat owners and boating industries on the copper pollution problem, nontoxic and less toxic antifouling strategies, and short versus long-term costs of nontoxic and less toxic coatings relative to copper-based paints; and

- Initiation of commercial demonstration and scientific studies to confirm the efficacy and longevity of available nontoxic and less toxic boat hull coating products. The demonstrations and studies will also allow boat repair yards and underwater hull cleaners the opportunity to develop expertise and acquire special equipment needed for the application and maintenance of nontoxic and less toxic boat hull coatings.

15-Year Load Reductions (Conversion to Non Copper-based Coatings)

Stages 2-4 of the schedule (Table 20.1) require reductions in source loading of dissolved copper to SIYB. Each stage has an associated interim target loading.

The TMDL requires a final target loading of 567 kg/year, which represents a 76 percent overall reduction in copper loading to SIYB over 17 years. Table 20.1 shows the incremental percent reductions and interim loading targets. As discussed above, during Stage 1 (years 1-2), no reductions in loading are required. In Stage 2 (years 2-7), a ten percent reduction in current loading is required at the end of the seventh year. Greater reductions in copper loading are required during Stages 3 and 4 (years 7-12 and 12-17, respectively).

Table 20.1. Interim Loading Targets for Attainment of the TMDL.

Stage	Time Period	Percent Reduction from Current Estimated Loading	Reduction to be Attained by End of Year	Estimated Interim Target Loading (kg/year of dissolved copper)
Stage 1	Years 1-2	0%	N/A	N/A
Stage 2	Years 2-7	10%	7	1,900
Stage 3	Years 7-12	40%	12	1,300
Stage 4	Years 12-17	76%	17	567

Figure 20.1 shows the required reductions in copper loading as a function of time. The schedule commences upon final the USEPA adoption of this TMDL Basin Plan amendment.

21. Necessity Standard

The Office of Administrative Law (OAL) is responsible for reviewing administrative regulations proposed by state agencies for compliance with standards set forth in California's Administrative Procedure Act, Government Code §11340 et seq., for transmitting these regulations to the Secretary of State and for publishing regulations in the California Code of Regulations. Following State Board approval of this TMDL Basin Plan amendment, any regulatory portions of the amendment must be approved by OAL (Government Code §11352). The State Board must include in its submittal to OAL a summary of the necessity[27] for the regulatory provision.

This TMDL Basin Plan amendment meets the "necessity standard" of Government Code §11353(b). Amendment of the Basin Plan to establish and implement a TMDL for SIYB is necessary because the existing water quality does not meet applicable water quality objectives for copper. Applicable State and federal laws require the adoption of this Basin Plan amendment and regulations as provided below.

The State Board and Regional Boards are delegated the responsibility for implementing California's Porter Cologne Water Quality Control Act and the federal CWA. Pursuant to relevant provisions of both of those Acts, the State and Regional Boards establish water quality standards, including designated (beneficial) uses and criteria or objectives to protect those uses.

Section 303(d) of the CWA (33 USC § 1313(d)) requires the states to identify certain waters within their borders that are not attaining water quality standards and to establish the TMDL for certain pollutants impairing those waters. USEPA regulations in 40 CFR 130.2 provide that a TMDL is a numerical calculation of the amount of a pollutant that a water body can assimilate and still meet standards. A TMDL includes one or more numeric targets that represent attainment of the applicable standards, considering seasonal variations and a margin of safety, in addition to the allocation of the target or load among the various sources of the pollutant. These include wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background. TMDLs established for impaired waters must be submitted to the USEPA for approval.

CWA § 303(e) requires that TMDLs, upon the USEPA approval, be incorporated into the state's water quality management plans (Basin Plan). State law in turn, CWC §§ 13050(j) and 13242 require that Basin Plans have a program of implementation to achieve water quality objectives. The implementation program must include a description of actions that are necessary to achieve the objectives, a time schedule for these actions, and a description of surveillance to determine compliance with the objectives. State law requires that a TMDL include an implementation plan because the TMDL normally is, in essence, an interpretation or refinement of an existing water quality objective. The TMDL has to be incorporated into the Basin Plan under CWA § 303(e),

[27] "Necessity" means the record of the rulemaking proceeding demonstrates by substantial evidence the need for a regulation to effectuate the purpose of the statute, court decision, provision of law that the regulation implements, interprets, or makes, taking into account the totality of the record. For purposes of this standard, evidence includes, but is not limited to, facts, studies, and expert opinion. (Government Code §11349(a)).

and, because the TMDL supplements, interprets, or refines an existing objective, State law requires a program of implementation.

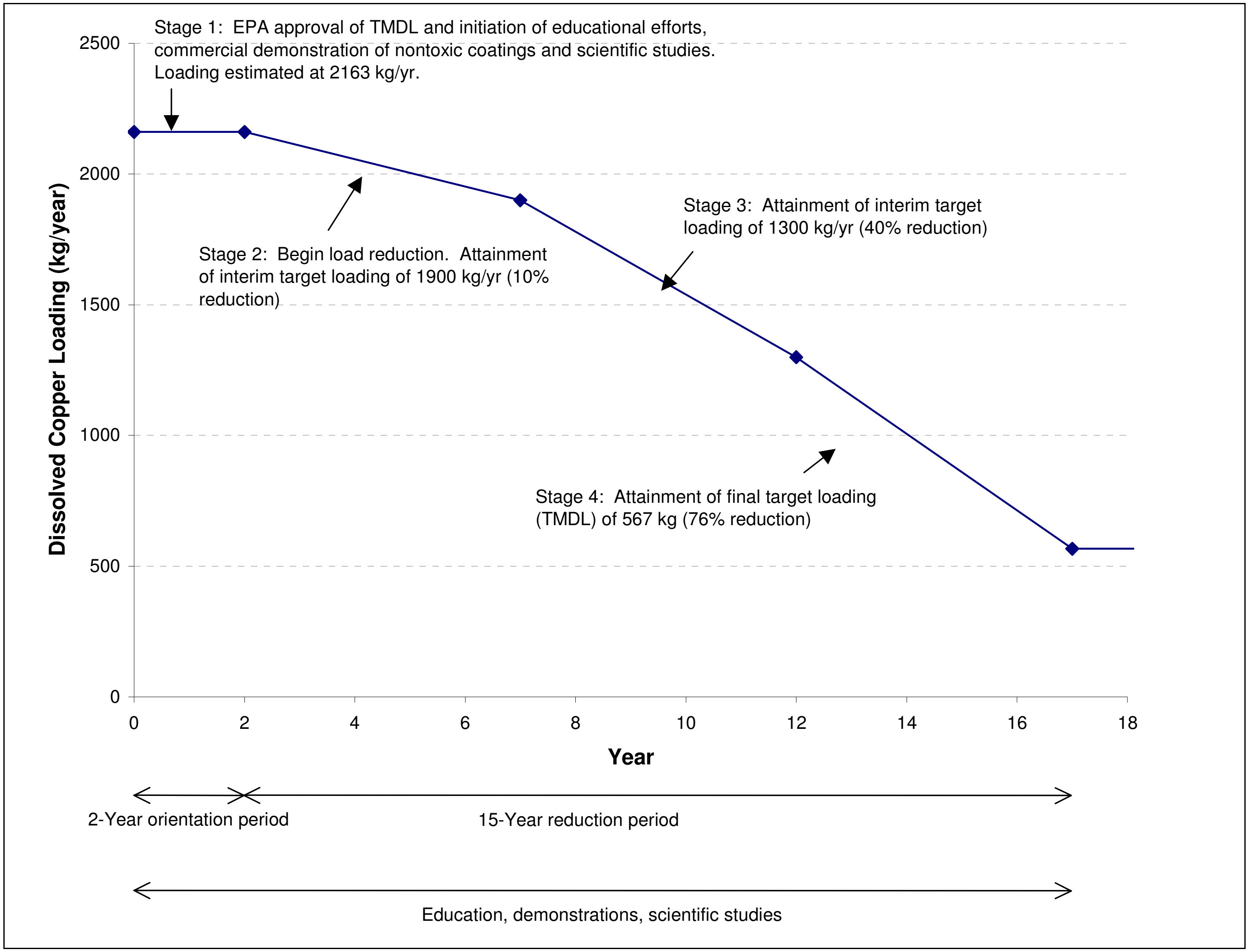

Figure 20.1. Compliance Schedule.

VI. ENVIRONMENTAL REVIEW

22. Introduction

This proposed amendment to the Basin Plan to incorporate a TMDL for dissolved copper in the SIYB is a "project" as defined by the California Environmental Quality Act (CEQA). The Regional Board is the Lead Agency for evaluating the environmental impacts of this Basin Plan amendment pursuant to CEQA. Although subject to CEQA, the Regional Board's basin planning process is certified by the Secretary for Resources as "functionally equivalent to," and therefore exempt from, CEQA's requirement for preparation of an environmental impact report or negative declaration and initial study [California Code of Regulations (CCR) Title 14, section 15251 (g)]. State Board regulations, "Implementation of the Environmental Quality Act of 1970" [23 CCR 3720 et seq.] describe the environmental documents required for Regional Board basin planning actions. These documents include a written report, an initial draft of the Basin Plan amendment, and an Environmental Checklist Form [23 CCR 3776]. Pursuant to 23 CCR 3777(a) the Regional Board must:

- Describe the proposed TMDL Basin Plan amendment;

- Identify reasonable alternatives to the proposed TMDL Basin Plan amendment;

- Identify the environmental impacts of the TMDL Basin Plan Amendment in the Environmental Checklist Form [23 CCR 3777]. Specifically, the Regional Board must identify the environmental impacts of the reasonably foreseeable methods to comply with the TMDL Basin Plan amendment; and

- Identify mitigation measures to minimize any significant adverse environmental impacts of the proposed Basin Plan amendment.

23. Description of Proposed TMDL Basin Plan Amendment

As required by section 303(d) of the CWA, the Regional Board has prepared a TMDL for dissolved copper in the SIYB portion of San Diego Bay. The purpose of the TMDL is to mandate copper mass load reductions to attain applicable water quality objectives for copper, toxicity and pesticides and to protect the wildlife and marine habitat beneficial uses. The major copper sources to SIYB are assigned numeric load and wasteload allocations, which translates to a percent reduction of current copper loading from each source. The Regional Board will amend the Basin Plan to include a TMDL for dissolved copper, an Implementation Plan, and a schedule for achieving compliance with the copper load and wasteload reductions.

The Regional Board could use its administrative tools to regulate the Port, SIYB marina owners/operators, persons owning boats moored in SIYB and underwater hull cleaners operating in SIYB to reduce the discharges of copper to SIYB. These parties are referred to as dischargers.

The copper discharges are a result of passive leaching from boat hulls painted with copper-based antifouling paints and underwater hull cleaning operations. Upon approval of the TMDL by the USEPA, the Regional Board will mandate compliance with copper load and wasteload reductions using its regulatory authority. The Regional Board will coordinate with other governmental agencies having regulatory authority to protect water quality from the adverse effects of copper-based antifouling paints in SIYB. The Regional Board will request that the USEPA, DPR, and CAC use their legal authorities to address the violations of water quality standards in SIYB caused by copper-based antifouling paints. Coordination with the DPR will be accomplished thorough the 1997 MAA between the State Board and the DPR. The Regional Board will also coordinate with CCC and DBW. These agencies may consider regulatory actions to restrict the use of copper antifouling paints in SIYB and encourage the use of nontoxic hull coatings.

The Regional Board will regulate discharges of copper to SIYB waters through the issuance of WDRs, waivers, or adoption of Waste Discharge Prohibitions. WDRs could build upon pollution control programs developed by discharger organizations or the Port. Likewise, waivers or prohibitions could be conditioned on implementation of pollution control programs through third party agreements between the Regional Board and discharger organizations, and/or the Port. The Regional Board also will amend Order No. 2001-01, “Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm /Sewer Systems” to require that discharges of copper into SIYB waters not increase from existing loadings.

The dischargers will be required to monitor SIYB waters and provide monitoring reports to the Regional Board for the purpose of assessing the effectiveness of the alternatives implemented.

24. Reasonable Alternatives to TMDL Basin Plan Amendment

This section describes reasonable alternatives to the proposed TMDL Basin Plan amendment and evaluates the comparative merits of the alternatives. The alternatives include:

- No action;
- Actions by other Agencies; and
- Actions by Regional Board;

No Action

Under the "no action" alternative the Regional Board would not adopt the proposed TMDL Basin Plan amendment and copper loading would likely continue at current levels. The no action alternative (1) does not comply with the CWA; (2) is inconsistent with the mission of the Regional Board; and (3) does not meet the purpose of the proposed TMDL Basin Plan amendment. Under CWA section 303(d), the Regional Board is obligated to adopt a TMDL for waters such as SIYB, which are not meeting water quality standards. The mission of the Regional Board is to ensure the protection of receiving water beneficial uses through attainment of applicable water quality objectives. Consistent with the Regional Board's mission, the purpose of the proposed TMDL Basin Plan amendment is to attain water quality objectives for copper, toxicity and pesticides and to restore and protect the wildlife and marine habitat beneficial uses of SIYB.

The proposed Basin Plan amendment mandates an overall 76 percent reduction of copper loading from current levels to SIYB in order to attain water quality standards. Water quality standards are comprised of designated beneficial uses, the applicable numeric and/or narrative water quality objectives to protect those uses, and the State Board's anti-degradation policy provisions (Resolution No. 68-16, Statement of Policy with Respect to Maintaining High Quality of Waters in California). In the absence of mandatory copper load reductions, violations of the copper water quality objective and impairment of beneficial uses will likely continue in SIYB.

Actions by Other Agencies

California Department of Pesticide Regulation

The DPR is the lead state agency, with local administration by San Diego County Agricultural Commissioners (CAC), for regulating the registration, sales and use of pesticides in California. The DPR is required by law to protect the environment, including surface waters, from environmentally harmful pesticides by prohibiting, regulating, or controlling the uses of such pesticides. Copper-based antifouling paints are legally registered pesticides subject to the DPR regulation pursuant to the California Food and Agriculture Code (CDFA).

In order to promote cooperation to protect water quality from the adverse effects of pesticides, the DPR and the State Board signed a MAA in 1997. The MAA, and its companion document, "*The California Pesticide Management Plan for Water Quality*," strives to coordinate interaction, facilitate communication, promote problem solving, and ultimately assure the protection of water quality.

Under the MAA, the State Board, Regional Board, and the DPR will work cooperatively to investigate copper-based antifouling paints and develop recommended use practices or restrictions designed to reduce or eliminate the impact of copper-based paints on surface water quality. This cooperative effort is not dependent on Regional Board adoption of the proposed TMDL Basin Plan amendment. However, an effort to address the issue solely through the MAA, without a TMDL Basin Plan amendment, would likely prolong the impaired state of SIYB waters.

Addressing excessive levels of copper in SIYB solely through the MAA (between State Board and the DPR) without a TMDL Basin Plan amendment is a viable alternative. However, proceeding with adoption TMDL Basin Plan amendment in conjunction with cooperative efforts through the MAA is a superior alternative. The TMDL Basin Plan amendment formally documents the significance and magnitude of the SIYB water quality problem and quantifies the specific copper loading reductions needed to attain water quality standards. This is accomplished by the Regional Board through a formal scientific peer review, and public review, comment and hearing process prior to Board adoption of the TMDL Basin Plan amendment. The

TMDL will serve as a catalyst to initiate action by the State Board and the DPR to address the water quality impacts from the legally applied copper-based antifouling paints. The TMDL also provides a sound technical basis for future actions by the DPR to consider restrictions on the use of copper based antifouling paints. The formal mandate for copper load reduction will increase the market demand for innovative solutions including nontoxic hull coatings. This in turn will create market incentives for the development of new products. Taken together these factors support the Regional Board's adoption of the TMDL Basin Plan amendment with concurrent coordination among the DPR, State Board and the Regional Board. The TMDL Basin Plan amendment will facilitate and expedite the DPR's consideration of solutions to the copper water quality problem in SIYB through the MAA.

United States Environmental Protection Agency
The USEPA is the federal government agency responsible for registering pesticides for sale or distribution within the United States pursuant to FIFRA. Under FIFRA, the USEPA has the authority to control the distribution and sale of pesticides, and to ensure that pesticides will not cause unreasonable harm to the environment when used in accordance with label specifications. Copper-based antifouling paints are legally registered pesticides subject to regulation by the USEPA pursuant to FIFRA.

The Regional Board will request that the USEPA investigate the environmental impacts associated with copper-based antifouling paints and develop recommended use practices or restrictions designed to reduce or eliminate the impact of copper-based paints on surface water quality. The State Board, Regional Board, and the DPR will work cooperatively with the USEPA towards this goal. This cooperative effort is not dependent on Regional Board adoption of the proposed TMDL Basin Plan amendment. However, a cooperative effort in the absence of the TMDL Basin Plan amendment would likely prolong the impaired state of SIYB waters. Proceeding with adoption of the TMDL Basin Plan amendment in conjunction with cooperative efforts with the USEPA is a superior alternative.

Other Actions by Regional Board

Discharge Prohibition

CWC section 13243 provides that the Regional Board, in a water quality control plan or in waste discharge requirements, may specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted. Accordingly the Regional Board could elect to amend the Basin Plan to prohibit the discharge of waste of copper at any concentration or load into SIYB waters.

Under this alternative, the dischargers (i.e., the Port, the SIYB marina owners/operators, SIYB individual boat owners and SIYB underwater hull cleaners) would need to take immediate action to eliminate all copper discharges to SIYB, including the passive leaching of copper from hull bottom paints.

Compliance with the prohibition would require the dischargers to achieve an immediate 100 percent copper load reduction. In contrast, the proposed TMDL Basin Plan amendment requires a 76 percent copper load reduction over a 17-year time frame. Both the copper discharge prohibition and the proposed TMDL Basin Plan amendment would result in attainment of the copper water quality objective and protection of beneficial uses in SIYB. Both alternatives require the same copper reduction activities which may include replacement of copper-based hull bottom paints with nontoxic or less toxic alternatives, use of vessel slip liners, increased use of land side boat storage facilities and other boat owner and hull cleaner MPs. As discussed in the economic study evaluating the long-term costs of both copper-based and nontoxic antifouling paints (Carson *et al*., 2002), a compressed compliance schedule would be cost prohibitive and present an unacceptable financial burden to the boating community.

In addition, recreational boating is a popular leisure time activity that is an integral part of life in San Diego, contributing many millions of dollars to the local economy annually. Implementation of an outright prohibition on copper discharges to SIYB would be unwarranted and extremely disruptive to the boating community. For these reasons, establishment of a copper discharge prohibition is not acceptable.

Development of Site-Specific Objectives

Developing a modified copper water quality objective for SIYB based on site-specific environmental conditions may be appropriate. A modified water quality objective is referred to as a site-specific objective (SSO).

The legally applicable water quality objective for copper in SIYB is 3.1 µg/L. Scientific studies could be conducted to examine the appropriateness of establishing a less stringent copper water quality objective (i.e., an SSO). A TMDL based on an SSO that is less stringent than 3.1 µg/L, would require a smaller reduction in copper loading than the 76 percent reduction required under the proposed Basin Plan amendment. An SSO for copper in SIYB could potentially eliminate the need for a TMDL, if the SSO is currently attained in the receiving waters. The SSO would need to (1) be based on sound scientific rationale; (2) protect the designated beneficial uses of SIYB waters; and (3) be adopted by the Regional Board in a Basin Plan amendment.

The 3.1 µg/L and 4.8 µg/L copper water quality objectives currently applicable in SIYB are based on the USEPA's numeric water quality criteria. The USEPA's California Toxics Rule (CTR) water quality criteria for copper are based on national criteria designed to be protective of aquatic organisms in all inland surface waters, enclosed bays, and estuarine waters in the United States.

The CTR criteria are based on the toxicity results of a large number of nationally representative species to a single pollutant in clean controlled laboratory waters. The physical and chemical characteristics of ambient water at a particular site may result in an increase or decrease in the bioavailability and/or toxicity of a given pollutant. Examples of potentially confounding water chemistry characteristics may include dissolved organic matter, particulate matter, other contaminants, pH, and hardness. Similarly the aquatic life community at a particular site may be more or less sensitive to a pollutant than the aquatic organisms used to develop the CTR criteria. Because (1) ambient water chemistry, and/or (2) the biological communities at SIYB may be different than the chemistry and biological communities upon which the CTR criteria were based, the CTR criteria may be over- or under- protective for SIYB.

If scientific studies demonstrate that the ambient water chemistry and/or biological communities at SIYB are significantly different from the chemistry and biological communities upon which the CTR criterion were based, an SSO for copper may be appropriate. However, the development of a copper SSO for SIYB waters, including the scientific studies necessary to support it, would be costly, time consuming and resource intensive. Dischargers or other interested parties would need to fund and initiate the scientific studies to develop the SSO.

Accounting for site-specific environmental conditions usually results in SSOs that are higher (less restrictive) than CTR criteria. However, the studies could reveal the presence of previously untested species and/or unusual water chemistry requiring the need for a more stringent copper water quality objective. The State Board's 2000 *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (SIP) provides further guidance on when SSOs may be used.

In 1998, the City of San Jose, in conjunction with the Santa Clara Basin Watershed Management Initiative, funded studies to investigate the toxic effects of copper and nickel in the Lower South San Francisco Bay. The studies demonstrated that the chemical features of Lower South San Francisco Bay reduce the toxicity and bioavailability of copper and nickel through a variety of mechanisms. Additionally, an impairment assessment demonstrated that the CTR water quality objectives for copper and nickel for Lower South San Francisco Bay could be relaxed while still fully protecting beneficial uses. As a result, in May 2002, the California Regional Water Quality Control Board, San Francisco Bay Region, adopted SSOs for dissolved copper and nickel for Lower South San Francisco Bay. The copper water quality objective for Lower South San Francisco Bay was relaxed from 3.1 μg/L to 6.9 μg/L (4-day average) and from 4.8 μg/L to 10.8 μg/L (one-hour average).

Maximum copper concentrations measured in SIYB range from approximately 8 μg/L to 12 μg/L. Current copper concentrations in SIYB would violate a copper SSO similar to the SSOs developed for Lower South San Francisco Bay. Under this scenario, the Regional Board would still be required to adopt a TMDL mandating copper load reductions in SIYB - although the copper load reductions needed would be smaller than those required under the proposed TMDL Basin Plan amendment.

25.Environmental Impacts of TMDL Basin Plan Amendment

The mission of the Regional Board is to preserve and enhance the quality of water resources in the San Diego Region for the benefit of present and future generations. All of the Regional Board's regulatory actions to implement its water quality protection programs are directed towards this end. The adoption of this TMDL and subsequent implementing actions by the Regional Board, other governmental agencies and dischargers are all designed to protect and restore beneficial uses currently impaired by elevated concentrations of copper in the SIYB portion of San Diego Bay.

Specifically, adoption of a Basin Plan amendment will require dischargers to meet copper load and wasteload reductions by implementing MPs, such as the use of nontoxic or less toxic hull bottom coatings. Although nontoxic or less toxic coatings are not widely used at this time, converting to such coatings is anticipated to be a viable solution to the copper pollution in SIYB. Should this eventually occur, the most significant environmental impact of this Basin Plan amendment would be the reduction of dissolved copper concentrations in SIYB and subsequent attainment of water quality standards. The implementation of the TMDL Basin Plan amendment will lead to an overall improvement in the water quality of SIYB and therefore the quality of the environment.

Since copper-based antifouling paints are currently the most widely used antifouling coatings, a decrease in usage and subsequent conversion to alternative coatings could lead to unforeseen adverse environmental impacts. However, the Regional Board intends that alternative coatings be used to both (1) allow for continued boating activities with minimal disruption, and (2) minimize possible adverse environmental impacts. The potential adverse impacts are described below, as well identified in and discussed following the Environmental Checklist form.

The most significant potential adverse impact resulting from the use of alternative antifouling coatings is that the alternative coatings could prove as toxic or more toxic than copper-based paints. This occurred in the late 1980s when copper paints replaced tributyltin paints on most recreational vessels following a legislative ban in the United States on the use of tributyltin on boat hulls less than 25 meters except for aluminum vessels. The universe of alternative coatings currently available consists of both "nontoxic" and "less toxic" coatings. In order to accurately evaluate the potential environmental impacts of these coatings, scientific studies are needed to accurately characterize the toxicity of the coatings. There are effective nontoxic alternatives to copper-based antifouling paints currently available, although not widely used (See "What you Need to Know about Nontoxic Antifouling Strategies for Boats", Johnson and Miller, 2002).

A less likely adverse environmental impact could occur if alternative coatings prove less effective than copper based paint. A less effective antifouling coating may lead to an increased growth of fouling organisms on vessel hulls; and the potential introduction of invasive species. The introduction of invasive species could have a significant adverse impact on indigenous ecosystems. The potential adverse impacts can be mitigated through more frequent underwater hull cleaning, particularly on vessels prior to leaving an area known or suspected to support species that could become invasive if brought into SIYB.

Another potential adverse impact of increased air pollution could occur if less effective alternative coating strategies are applied to vessel bottoms. As with all coatings, if an appropriate maintenance program is not followed for boat hulls painted with non-copper based paints, drag will increase, and consequently so will fuel consumption. In general, less toxic and non-toxic alternative coatings require more frequent cleaning in order to remove the buildup of fouling growth and prevent increased fuel consumption. If increased frequency of hull cleaning isn't adequate to prevent significant air pollution, additional measures such as putting pollution control devices on engines may be necessary.

26. Environmental Checklist Form

The proposed Basin Plan amendment does not prescribe any particular changes in watershed management. The analysis of potential environmental impacts is therefore based on the reduced use of copper-based antifouling paints, and the subsequent use of available alternatives.

1. ***Project title***
   Resolution R9-2005-0019, AMENDMENT TO THE WATER QUALITY CONTROL PLAN FOR THE SAN DIEGO REGION (9) TO INCORPORATE A TOTAL MAXIMUM DAILY LOAD FOR DISSOLVED COPPER IN THE SHELTER ISLAND YACHT BASIN

2. ***Lead agency name and address***
   California Regional Water Quality Control Board, San Diego Region 9174 Sky Park Court, Suite 100, San Diego, CA 92123-4340

3. ***Contact person and phone number***
   Lesley Dobalian, Environmental Scientist
   (858) 637-7139

4. ***Project location***
   Shelter Island Yacht Basin, San Diego Bay, California

5. ***Project sponsor's name and address***
   California Regional Water Quality Control Board, San Diego Region 9174 Sky Park Court, Suite 100, San Diego, CA 92123-4340

6. ***General plan designation***
   Not applicable

7. *Zoning*
Not applicable

8. *Description of project*
As required by section 303(d) of the federal Clean Water Act, the Regional Board has prepared a Total Maximum Daily Load (TMDL) for dissolved copper in the Shelter Island Yacht Basin (SIYB) portion of San Diego Bay. The purpose of the TMDL is to mandate copper mass load reductions to attain applicable water quality objectives for copper, toxicity and pesticides and to protect the wildlife and marine habitat beneficial uses. The major copper sources to SIYB are assigned a numeric load and wasteload allocation, which translates to a percent reduction of current copper loading from each source. The Regional Board will amend the Basin Plan to include a TMDL for dissolved copper, an Implementation Plan, and a schedule for achieving compliance with the copper load and wasteload reductions. The Implementation Plan will require dischargers to comply with the copper load and wasteload reductions pursuant to the TMDL Basin Plan amendment.

9. *Surrounding land uses and setting*
Urban.

10. *Other public agencies whose approval is required*
State Water Resources Control Board
Office of Administrative Law
U.S. Environmental Protection Agency

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED:

The environmental resource categories identified below are analyzed herein to determine whether the proposed TMDL Basin Plan amendment would result in adverse impacts to any of these resources. None of the categories below are checked because the proposed TMDL Basin Plan amendment is not expected to result in "potentially significant impacts" to any of these resources.

Aesthetics	Mineral Resources
Public Services	Utilities/Service Systems
Agriculture Resources	Biological Resources
Hazards & Hazardous Materials	Cultural Resources
Hydrology/Water Quality	Noise
Recreation	Mandatory Findings of Significance
Air Quality	Geology/Soils
Land Use Planning	Transportation/Traffic

On the basis of this initial evaluation:

☐ I find that the Proposed Project COULD NOT have a significant effect on the environment,

☒ I find that although the Proposed Project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the Project have been made by or agreed to by the Project proponent.

☐ I find that the Proposed Project MAY have a significant effect on the environment.

☐ I find that the Proposed Project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect: (1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and (2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An ENVIRONMENTAL IMPACT REPORT is required, but it must analyze only the effects that remain to be addressed.

☐ I find that although the Proposed Project could have a significant effect on the environment because all potentially significant effects (a) have been analyzed adequately in an earlier EIR or NEGATIVE DECLARATION pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier EIR or NEGATIVE DECLARATION, including revisions or mitigation measures that are imposed upon the Proposed Project, nothing further is required.

Original Signed by Art Coe for John H. Robertus January 27, 2005

John H. Robertus *Date*
Executive Officer

EVALUATION OF ENVIRONMENTAL IMPACTS

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
I. AESTHETICS Would the Project:				
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☒
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☐	☒
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☐	☐	☒
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☐	☐	☐	☒
II. AGRICULTURE RESOURCES: In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the Project:				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☐	☒
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☒
c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?	☐	☐	☐	☒
III. AIR QUALITY – Where available, the significance criteria established by the applicable air quality management or air pollution control the District may be relied upon to make the following determinations. Would the Project:				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☒
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☒		☐
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the Project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	☐	☐	☐	☒

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
d) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☐	☒
e) Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☒
IV. BIOLOGICAL RESOURCES – Would the Project:				
a) Have a substantial adverse effect, either directly, or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulators, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☐	☒
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?	☐	☒	☐	☐
c) Have a substantial adverse effect on federally protected wetlands as defined by section 404 of the Clean Water Act (including, but not limited to, marsh vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☐	☒
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☐	☒
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☒
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☒
V. CULTURAL RESOURCES – Would the Project:				
a) Cause a substantial adverse change in the significance of a historical resource as defined in section 15064.5?	☐	☐	☐	☒
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to section 15064.5?	☐	☐	☐	☒
c) Directly or indirectly destroy a unique paleontological resource of site or unique geological feature?	☐	☐	☐	☒
d) Disturb any human remains, including those	☐	☐	☐	☒

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
interred outside of formal cemeteries?				
VI. GEOLOGY AND SOILS – Would the Project:				
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:	☐	☐	☐	☒
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☒
ii) Strong seismic ground shaking?	☐	☐	☐	☒
Iii) Seismic-related ground failure,, including liquefaction?	☐	☐	☐	☒
iv) Landslides?	☐	☐	☐	☒
b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☐	☒
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	☐	☐	☐	☒
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☒
VII. HAZARDS AND HAZARDOUS MATERIALS – Would the Project:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☐	☒
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☐	☒
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☒
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☐	☒
e) For a Project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the Project result in a safety hazard	☐	☐	☐	☒

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
for people residing or working in the Project area?				
f) For a Project within the vicinity of a private airstrip, would the Project result in a safety hazard for people residing or working in the Project area?	☐	☐	☐	☒
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☐	☒
VIII. HYDROLOGY AND WATER QUALITY – Would the Project:				
a) Violate any water quality standards or waste discharge requirements?	☐	☒	☐	☐
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of preexisting nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted?	☐	☐	☐	☒
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?	☐	☐	☐	☒
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which results in flooding on- or off-site?	☐	☐	☐	☒
e) Create or contribute runoff water which exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☐	☒
f) Otherwise substantially degrade water quality?	☐	☐	☐	☒
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☒
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	☐	☐	☐	☒
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a	☐	☐	☐	☒

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
levee or dam?				
j) Inundation by seiche, tsunami, or mudflow?	☐	☐	☐	☒
IX. LAND USE AND PLANNING – Would the Project:				
a) Physically divide an established community?	☐	☐	☐	☒
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the Project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☐	☒
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☐	☐	☒
X. MINERAL RESOURCES – Would the Project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☒
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	☐	☐	☐	☒
XI. NOISE – Would the Project result in:				
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☐	☒
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☐	☒
c) A substantial permanent increase in ambient noise levels in the Project vicinity above levels existing without the Project?	☐	☐	☐	☒
d) A substantial temporary or periodic increase in ambient noise levels in the Project vicinity above levels existing without the Project?	☐	☐	☐	☒
e) For a Project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the Project expose people residing or working in the Project area to excessive noise levels?	☐	☐	☐	☒
f) For a Project within the vicinity of a private airstrip, would the Project expose people residing or working in the Project area to excessive noise levels?	☐	☐	☐	☒
XII. POPULATION AND HOUSING – Would the Project?				

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☒
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
XIII. PUBLIC SERVICES				
a) Would the Project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:				
Fire protection?	☐	☐	☐	☒
Police protection?	☐	☐	☐	☒
Schools?	☐	☐	☐	☒
Parks?	☐	☐	☐	☒
Other public facilities?	☐	☐	☐	☒
XIV. RECREATION				
a) Would the Project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☒
b) Does the Project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?	☐	☐	☐	☒
XV. TRANSPORTATION/TRAFFIC – Would the Project:				
a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio to roads, or congestion at intersections?	☐	☐	☐	☒
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion/management agency for designated roads or highways?	☐	☐	☐	☒
c) Result in a change in air traffic patterns,	☐	☐	☐	☒

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
including either an increase in traffic levels or a change in location that results in substantial safety risks?				
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☒
e) Result in inadequate emergency access?	☐	☐	☐	☒
f) Result in inadequate parking capacity?	☐	☐	☐	☒
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	☐	☐	☐	☒
XVI. UTILITIES AND SERVICE SYSTEMS – Would the Project?				
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☐	☒
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
d) Have sufficient water supplies available to serve the Project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☒
e) Result in a determination by the wastewater treatment provider which serves or may serve the Project that it has adequate capacity to serve the Project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☒
f) Be served by a landfill with sufficient permitted capacity to accommodate the Project's solid waste disposal needs?	☐	☐	☐	☒
g) Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☐	☒
XVII. MANDATORY FINDINGS OF SIGNIFICANCE				
a) Does the Project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number of restrict the range of a rare or endangered plant or animal or	☐	☐	☐	☒

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
eliminate important examples of the major periods of California history or prehistory?				
b) Does the Project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probably future projects)?	☐	☐	☐	☒
c) Does the Project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☐	☒

Discussion of Possible Environmental Impacts and Appropriate Mitigation Measures

Part III, b) - Question: Would the project violate any air quality standard or contribute substantially to an existing or projected air quality violation?
Answered "Potentially Significant Unless Mitigation Incorporation "

Increased growth of fouling organisms could occur as a result of boat owners converting from copper-based antifouling paints to alternative coatings and strategies which may prove to be less effective. Less effective antifoulant coatings may result in increased fouling community growth on boat hulls. Increased fouling community growth will resulted in increased hull bottom drag and corrosion, and a subsequent decrease in safety, maneuverability, and fuel efficiency. A decrease in fuel efficiency would lead to an increase in gasoline consumption for motorized boats, which in turn could have adverse effects on air quality because of increased gasoline combustion.

To avoid this potentially significant impact, effective alternatives to copper-based antifouling paints should be considered. At present, there are a number of available alternatives that have been demonstrated to be both nontoxic in nature and effective at reducing fouling growth. Examples include silicone hull coatings and hard smooth epoxy hull coatings, combined with more frequent underwater hull cleaning. In general, less toxic and non-toxic alternative coatings require more frequent cleaning in order to remove the buildup of fouling growth and prevent increased fuel consumption. If increased frequency of hull cleaning isn't adequate to prevent significant air pollution, additional measures such as putting pollution control devices on engines may be necessary.

Part IV, b) - Question: Would the project have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?
Answered "Potentially Significant Unless Mitigation Incorporation"

Increased growth of fouling organisms could occur as a result of boat owners switching from copper-based antifouling paints to alternative coatings, which may prove to be less effective. An increase in abundance and species diversity of fouling organisms on a boat previously moored in a different location could lead to the transport of invasive species into SIYB. In a recent study of this concept entitled "Fouling and Ship's Hulls: How Changing Circumstances and Spawning Events may Result in the Spread of Exotic Species" (Minchin and Goliasch, 2003), the authors propose that vessels having mature attached exotic biota can result in spawning and eventual development of invasive populations of organisms. Certain invasive species have been known to cause disruptions in ecosystems by a variety of mechanisms, such as through competition with native biota for food and resources. The natural community, if one exists in SIYB, could be negatively affected by the introduction and establishment of invasive species.

To avoid this potentially significant impact, effective alternatives to copper-based antifouling paints should be considered. At present, there are a number of available alternatives that have been demonstrated to be both nontoxic in nature and effective at reducing fouling growth. Examples include silicone hull coatings and hard smooth epoxy hull coatings, combined with more frequent underwater hull cleaning. Furthermore, underwater hull cleaning should be performed particularly on vessels prior to leaving an area known or suspected to support species that could become invasive if brought into SIYB.

Additionally, the formal mandate for copper load reduction in this TMDL Basin Plan amendment will in and of itself, increase the market demand for innovative solutions including nontoxic, effective hull coatings. This in turn will create greater market demand for the development of new products.

Part VIII, a) - Would the project violate any water quality standards or waste discharge requirements?
Answered "Potentially Significant Unless Mitigation Incorporation"

An increase in the use of alternatives coatings to copper-based antifouling paints is anticipated because of the required reduction in emissions of dissolved copper to SIYB. The alternative coatings could prove as toxic or more toxic than copper-based paints. This could potentially lead to violations of the water quality standards for the antifouling agent in the alternative coating. One example of this is the phase-out of tributyltin (TBT) that took place as a result of regulations and legislation passed in 1988 that prohibited the use of antifouling paint containing this agent in 1988. TBT is a highly toxic chemical to aquatic life that accumulates in sediment, bioaccumulates in shellfish, fish and sea otters and is extremely toxic to various aquatic invertebrates, fish, and plants (SWRCB 1998). Since prohibitions were imposed on the use of TBT in antifouling paints, copper has replaced its use as the toxic ingredient in antifouling paints on recreational vessels in the United States. Essentially one toxic antifouling coating was replaced by another toxic coating, both of which impair water quality.

Alternative coatings currently available consist of both “nontoxic” and “less toxic” coatings. In order to accurately evaluate the potential environmental impacts of these coatings, scientific studies are needed to accurately characterize the toxicity of the coatings. There are effective nontoxic alternatives to copper based antifouling paints currently available although not widely used (See “What you Need to Know About Nontoxic Antifouling Strategies for Boats”; Johnson and Miller, 2002).

Because of these potential implications, caution should be exercised when alternatives to copper-based antifouling paints are selected. At present, there are a number of available alternatives that have been demonstrated to be nontoxic in nature. Additionally, an increase in the demand for alternatives to copper-based antifouling paints will probably result. Copper pollution has been identified as a problem of concern in marinas and harbors across the nation, including California, Maryland, Washington and Florida, and is also of concern in countries in Europe, including Sweden and Denmark (Johnson and Miller, 2002). Furthermore, the formal mandate for copper load and wasteload reductions in the TMDL Basin Plan amendment will increase the market demand for innovative solutions including nontoxic hull coatings. This in turn will create market incentives for the development of new products.

If load and wasteload reductions required in SIYB are not required in other San Diego Bay marinas SIYB boaters owners may move relocate their boats from SIYB to other marinas. This may result in the copper loading from copper-based antifouling paint found in SIYB to be re-located to other marina areas. However, since copper-based antifouling paints are widely used, water quality impairments already potentially exist in other marinas. Movement of boats out of SIYB to other marinas would probably not increase the existing problem to a large degree.

In addition, there is a potential for the future transport of dissolved copper from sediment to the water column as a result of TMDL implementation. Although sediment may currently act as a net sink for copper in the water column, it has the potential to act as a net source in the future. During a period of low external loading, sediment that once acted as a net sink for copper can become a long-term net source through exchange with historically contaminated sediment that are re-suspended in the water column. As copper in sediment is re-suspended, it may act as a buffer to slow down the reductions in copper concentrations in the water column that would be expected from decreased loading of other sources to SIYB. However, the overall result of decreasing copper loading to SIYB should result in reductions in copper concentrations in both the water column and the sediment over time.

VII. ECONOMICS ANALYSIS

The California Environmental Quality Act (CEQA) has specific provisions governing the Regional Boards' adoption of regulations, such as the regulatory provisions of the Basin Plan that establish performance standards or treatment requirements. CEQA provides that the Regional Board must do an environmental analysis of the reasonably foreseeable methods of compliance with those standards or requirements.[28] The Regional Board must consider economic factors in this analysis.

CEQA does not define "performance standard"; however, the term is defined in the rulemaking provisions of the Administrative Procedure Act.[29] A "performance standard" is a regulation that describes an objective with the criteria stated for achieving the objective.[30] TMDLs will typically include performance standards. TMDLs normally contain a quantifiable numeric target that interprets the applicable water quality standard. They also include wasteload[31] allocations for point sources, and load allocations[32] for nonpoint sources and natural background to achieve the target.[33] The quantifiable numeric target together with the allocations may be considered a performance standard.

In summary, the economic analysis that is required for a TMDL consists of an estimate of the cost of the reasonably foreseeable methods of compliance with the load and wasteload and load reductions. The Regional Board can adopt TMDLs despite significant economic consequences. The Regional Board is not required to do a formal cost-benefit analysis.

This TMDL specifies an overall 76 percent reduction in copper loading from copper-based antifouling paints to SIYB. The most reasonably foreseeable method of compliance involves phasing out the use of copper-based antifouling paints and increasing the use of nontoxic and less toxic alternative coatings.

27. The Carson Report

An investigation mandated under California Water Code (CWC) section 13366 was recently completed for the purpose of identifying incentives necessary to ensure that nontoxic alternatives to metal-based antifouling hull coatings are used on recreational vessels in San Diego Bay. The investigation and resulting report, "Transitioning to Non-Metal Antifouling Paints On Marine

[28] Pub. Resources Code section 21159.

[29] Gov. Code section section 11340-11359.

[30] *Id.* section 11342(d).

[31] See 40 C.F.R. section 130.2(g). A wasteload allocation is the portion of the receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution.

[32] See *id*. section 130.2(g). A load allocation is the portion of the receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources.

[33] See *id*. section 130.2(i). A TMDL is the sum of the individual wasteload and load allocations.

Recreational Boats in San Diego Bay" was conducted by the University of California, San Diego, in conjunction with the California Department of Boating and Waterways (DBW) (Carson *et al.*, 2002). This report was prepared in response to CWC section 13366 created by California Senate Bill 315 (Alpert, 2001), which established the San Diego Advisory Committee for Environmentally Superior Antifouling Paints for the purpose of making recommendations and advising in the preparation of the report. The Carson report identified nontoxic alternatives, compared the costs of using these alternatives to the cost of using traditional copper-based antifouling paint and identified economic incentives for transitioning to the use of alternatives. This report considered economic impacts and incentives from a San Diego Bay-wide perspective.

Major Report Findings on Economic Factors Relating to Phase-In of Nontoxic Antifouling Coatings

The Carson report includes a rigorous cost comparison between the use of nontoxic hard epoxy and the use of traditional copper-based antifouling paint, including several findings concerning the economic impacts of transitioning paint types in all of San Diego Bay. Because the characteristics of copper paints differ from those of nontoxic epoxy coatings, the report found that cost comparisons should be based on costs over the entire life span of the boat. Important characteristics of each hull coating type including longevity, application and maintenance requirements are compared in the table below.

Table 27.1. Comparison of Copper-Based Antifouling Paints to Nontoxic Epoxy Coatings.[34]

Copper-Based Antifouling Paints	Nontoxic Epoxy Coatings
Initially less expensive to apply ($30 per foot)	Initially more expensive to apply ($30 - $50 per foot)
Do not need to be cleaned as often (14 times per year)	Need to be cleaned more often (22 times per year)
Need to be re-applied more often (every 2.5 years)	Do not need to be re-applied very often (every 5 years to 10 years)
Need to be stripped about every 6th application (every 15 years assuming paint is reapplied every 2.5 years)	Do not need to be stripped in first 30 – 60 years

The major findings of the report are summarized below and are based on the assumptions in the table above.

- Copper-based antifouling paints are more cost effective over the short-term, but nontoxic epoxy coatings are more cost effective over the long-term life of the boat.

- Although initial costs are greater, boat owners will likely realize small cost savings on nontoxic hull coatings and maintenance over the life of the boat compared to the costs

[34] Comparison is based on a typical "stylized" 40-foot long boat, 11-foot beam width, and 375 square feet of wetted hull surface.

associated with copper paint.

- To be cost effective, nontoxic epoxy coatings must be applied to new boat hulls or existing boat hulls that are in need of stripping. This is because of the high costs associated with labor-intensive hull stripping. New boats do not require hull stripping and existing boats are only required to convert to nontoxic coatings at the point in time when routine stripping will be required in any event (i.e. every 15 years).

- As shown in Figure 27.1 below, 100 percent reduction of boats painted with copper can be achieved in San Diego Bay with minimal economic impacts in approximately 15 years. This assumes that all new boats are painted with nontoxic coatings and that existing boats are converted to nontoxic coatings when they undergo routine stripping. (In 15 years all existing boats in San Diego Bay will have been stripped and repainted with nontoxic coatings and all new boats will have initially been painted with nontoxic coatings.) The report also found that a 66 percent reduction could likely be achieved in approximately 10 years.[35]

[35] The Carson report. examined a 66 percent copper reduction level because an earlier draft version of this TMDL called for a 66 percent reduction of copper loading to SIYB. The current draft TMDL requires a 76 percent reduction.

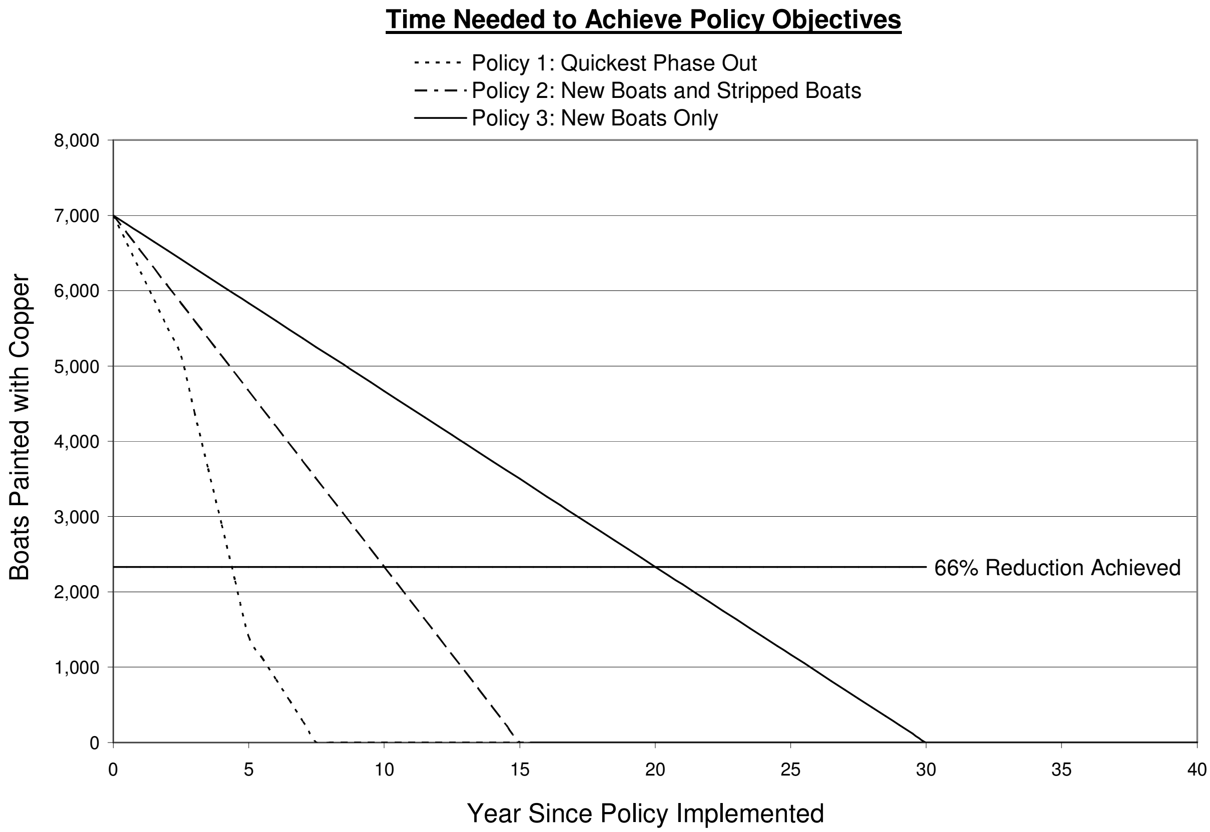

Figure 27.1. Time Needed to Achieve Policy Objectives.[36]

The report authors acknowledge variability in cost assumptions and that different conclusions result from different assumptions. For example under "best case" assumptions believed to be the most likely by the report authors, boat owners will save small amounts of money on nontoxic hull coatings and maintenance over the life of the boat. Under "worst case" assumptions, individual boat owners could spend slightly more money on nontoxic coating maintenance but the amount will be small compared to hull maintenance cost over the life of the boat. The variability in cost assumptions is further discussed below.

[36] The Carson. report evaluated three distinct policy options for phasing out the use of copper-based antifouling paints. Policy 1 looked at a "quickest phase out," with all boats converting to nontoxic coatings immediately. Under this policy, complete conversion to nontoxic coatings in San Diego Bay could take place in seven years and was estimated to cost approximately $15 million. Policy 2 looked at paint conversions for new and stripped boats (boats currently in need of new paint) and found that this could take place in San Diego Bay in 15 years at a cost of approximately $1.5 million. Policy 3 looked at converting new boats only to nontoxic coatings. Complete conversion in the Bay would take approximately 30 years and was discarded as not being a viable option due to the long time frame.

Report Findings on Cost Variability to Different Aged Boats

Boat hull maintenance costs vary significantly depending on the age of a boat. This is because stripping is required for boats older than a certain age, and the associated costs are significantly more expensive than other routine maintenance costs. For example, stripping costs can be approximated at $150/foot versus $30-$50/foot for a paint application. For the following analysis, all existing boats (not new) are assumed to be currently painted with copper-based paints.

In terms of comparing the costs associated with copper-based and nontoxic hard epoxy coatings, the need for stripping is key, since this is required for nontoxic hard epoxy application if copper-based paints were previously used. In the case of a new, unpainted boat, stripping costs are not a consideration. In the case of an older boat (approximately 15 years old), the effects of stripping on cost comparisons are identical since stripping is required for both application of nontoxic hard epoxy coatings, or continued application of copper-based paints. However, for boats that are in between these two age groups, the costs associated with stripping are much more pivotal. For example, a boat aged 2.5 years, if the costs of copper-based paints are considered, will not require stripping immediately. On the other hand, if a boat aged 2.5 years is currently painted with copper-based paints, and the owner is transitioning to nontoxic hard epoxy coatings, then stripping is required and the associated costs are much higher. Table 27.2 demonstrates the costs associated with hull maintenance for different aged boats, for both types of coatings. For each boat age considered, the remaining lifetime hull maintenance costs for both types of coatings are given. The remaining lifetime maintenance cost differentials between nontoxic hard epoxy coatings and copper-based paints are also given. For example, for a new boat with 30 years of service remaining, lifetime hull maintenance costs for nontoxic hard epoxy coatings would be $1,726 over that of copper-based paints. For a boat aged 2.5 years, lifetime hull maintenance costs for nontoxic hard epoxy coatings would be $6,251 over that of copper-based paints. Finally, for a boat aged 15 years, lifetime hull maintenance costs for nontoxic hard epoxy coatings would be $2,303 over that of copper-based paints.

Table 27.2. Lifetime Hull Maintenance Cost Difference between Nontoxic Hard Epoxy and Copper: Worst Case Scenario for Nontoxic Hard Epoxy Expenditures.

Age of Boat	Years of Service Remaining	Lifetime Hull Maintenance Cost for Service Remaining: Copper	Lifetime Hull Maintenance Cost for Service Remaining: Nontoxic Hard Epoxy	Cost of Remaining Life Hull Maintenance (Differential, Nontoxic Hard Epoxy-Copper)
New	30	$11,922	$13,648	$1,726
2.5 Years	27.5	$12,060	$18,312	$6,251
15 Years (hull currently needs stripping)	15	$13,580	$15,884	$2,303

(Standardized boat; 40-foot length, 11-foot width)

It must be emphasized that the cost differentials described in Table 27.2 are associated with worst-case assumptions in terms of transitioning from copper-based paints to nontoxic hard epoxy coatings. In other words, the nontoxic hard epoxy paint duration was assumed to be on the low end of the range, and the price of paint application was assumed to be at the high end of the range.

If different parameters are assumed, then the results shown in Table 27.2 are significantly different. For example, if more optimistic assumptions are made about the price and duration of nontoxic hard epoxy coatings, then it becomes less expensive to apply nontoxic hard epoxy paint to a new boat, or to a boat that is currently in need of stripping. Table 27.3 demonstrates the costs associated with hull maintenance for different aged boats, for both types of coatings for best-case assumptions regarding nontoxic hard epoxy coatings. Under these assumptions, for a new boat with 30 years of service remaining, lifetime hull maintenance costs for nontoxic hard epoxy coatings would be $1,354 less than that of copper-based paints. For a boat aged 2.5 years, lifetime hull maintenance costs for nontoxic hard epoxy coatings would be $3,171 over that of copper-based paints. Finally, for a boat aged 15 years, lifetime hull maintenance costs for nontoxic hard epoxy coatings would be $26 less than that of copper-based paints.

Table 27.3. Lifetime Hull Maintenance Cost Difference between Nontoxic Hard Epoxy and Copper: Best Case Scenario for Nontoxic Hard Epoxy Expenditures.

Age of Boat	Years of Service Remaining	Lifetime Hull Maintenance Cost for Service Remaining: Copper	Lifetime Hull Maintenance Cost for Service Remaining: Nontoxic Hard Epoxy	Cost of Remaining Life Hull Maintenance (Differential, Nontoxic Hard Epoxy-Copper)
New	30	$11,922	$10,568	-$1,354
2.5 Years	27.5	$12,060	$15,231	$3,171
15 Years (hull currently needs stripping)	15	$13,580	$13,554	-$26

(Standardized boat; 40 foot length, 11 foot width)

As stated earlier, the parameters associated with the costs of nontoxic hard epoxy paint application are not precisely known. In terms of identifying the costs to boat owners of TMDL implementation, the conservative approach would be to assume the cost estimates presented in Table 27.2. However, it must be kept in mind that the variables associated with nontoxic alternatives are most likely affected by several factors. These include greater boater demand for nontoxic alternatives, and improving paint technology and resulting increase in number of available alternatives.

Report Findings on Incentives to Convert to Nontoxic Coatings

In conformance with a legislative mandate (CWC section 13366), the Carson report identified several important factors that create incentives for boat owners to convert from copper-based antifouling paints to nontoxic alternative coatings. In order to identify the incentives, a random survey of 200 San Diego Bay boat owners was conducted in 2002. The two most significant incentives cited in the Carson report were greater longevity of nontoxic coatings and a law requiring the phase-out of copper-based antifouling paint and the use of nontoxic coatings. Seven factors were rated extremely important or very important by boat owners in making a decision to convert to nontoxic coatings:

- The greater longevity of nontoxic paint (77 percent)
- A law requiring nontoxic coatings (76 percent)
- That San Diego Bay would be cleaner with nontoxic paint (71 percent)
- Marina or mooring requires nontoxic paint (62 percent)
- Hull must be cleaned more often with nontoxic paint (57 percent)
- Boat would be easier to resell with nontoxic paint (45 percent)
- Cost to remove old copper paint (39 percent)

Boat owners in the survey were willing to pay about $500 more to apply a nontoxic coating. The survey found that 63 percent of the participating boat owners knew that there was a copper pollution problem in San Diego Bay. However most of those boat owners were not aware that their boats were the cause of the copper problem. Of those surveyed, 80 percent were not familiar with any specific nontoxic hull coating. In summary, the survey demonstrated a significant need for boater education to highlight the considerations behind the need to replace traditional copper-based antifouling paints with nontoxic alternatives.

Report Findings on Policy Instruments

The Carson report recommended two important policy instruments that policy makers may wish to consider in resolving the copper pollution problem in San Diego Bay while still maintaining the economic viability of boating:

1. Announce a future ban on the use of copper-based antifouling paints and set a specific date by which copper-based antifouling paints will no longer be allowed in San Diego Bay; and

2. Require that all new boats be coated with nontoxic coatings and that existing boats convert to nontoxic alternatives when routine stripping is required.

The Regional Board recognizes that such policies could be instrumental in decreasing copper loading into SIYB. However, the identified dischargers, regardless of method, must meet the copper reductions identified in this report. A thorough discussion of the responsibilities of the dischargers is discussed in the Implementation Plan of this document.

28. SIYB TMDL Implementation Costs

Based on the policy recommendations of the Carson report, the Regional Board has determined that the most reasonably foreseeable method to attain compliance with the copper reductions specified for SIYB is a phased conversion from copper-based antifouling paints to nontoxic or less toxic alternatives over a 15-year period (following a 2-year orientation period). Therefore the following cost analysis focuses on such an effort. In accordance with the Carson report, the transition to nontoxic or less toxic alternatives may be accomplished by requiring all new boats to be coated with nontoxic or less toxic coatings and requiring existing boats to convert at the time when routine hull stripping is required.

Boater education and encouragement of the use of nontoxic and less toxic alternative coatings will help to ensure success of TMDL implementation. In the Carson report, it was found that few boaters in San Diego Bay were aware of the water quality problems caused by copper-based paints. However, there was a willingness to convert to nontoxic coatings if there was a suitable economic incentive, or a future ban was put in place.

According to the Carson report, two types of educational programs are necessary for a successful, sustainable, and smooth phase-in of nontoxic antifouling coatings:

- A 2-year educational effort for boat owners and boating industries on the copper pollution problem to increase awareness that (1) copper is a significant problem in San Diego Bay; (2) copper-based antifouling paints are a significant source of the problem; and (3) there are cost effective alternatives to copper-based antifouling paints when costs are considered over the life of the boats;

- A 2-year commercial demonstration for boat repair yards and underwater hull cleaning companies to acquire special equipment and develop expertise needed for applying and maintaining nontoxic boat bottom coatings.

It is assumed that marina owners/operators and the Port will incur the costs of these educational efforts. The marina owners/operators and the Port may choose to apply for grants to help fund such efforts. Estimates of the costs for this transition in SIYB for these agencies, as well as all identified dischargers of copper are shown below. Unless otherwise stated, the cost assumptions for TMDL implementation in SIYB are based on the Carson report.

Implementation Costs to Persons Owning Boats Moored in SIYB

The costs associated with a transition to nontoxic and less toxic coatings are variable based on factors such as: the age of each individual boat, initial application costs, repainting frequency, hull cleaning frequency, and hull stripping frequency.

Implementation of the requirements associated with this TMDL is assumed to occur by a transition to non-copper based antifouling coatings. The costs associated with such a transition are highly variable, as discussed earlier. Despite this variability, costs can be conservatively estimated and are represented in Table 27.2. Table 27.2 describes the costs associated with different-aged boats, and these costs are directly applicable to individual boat owners. If more optimistic assumptions are made regarding expenditures associated with nontoxic hard epoxy coatings, then cost comparisons to copper-based paints are more closely displayed in Table 27.3.

According to the Carson report, this transition could take place with minimal economic impact (~ $1.5 million) to the boating community in San Diego Bay over 15 years.

In addition, companion strategies for controlling fouling growth that can be used with nontoxic coatings include: using the vessel more often; using it at high speed; storing it on land or hoisting it above the water at the slip; surrounding it with a plastic liner and adding 10-15 percent fresh water to reduce salinity. Slip liners are available from a variety of manufacturers and cost $940 for a 25-foot vessel (manufacturer Bottom Liner) or $815 for a 28-foot vessel (manufacturer Armored Hull) (Johnson and Miller, 2002b).

Implementation Costs to Underwater Hull Cleaners

Since compliance with the required reduction in copper emissions is assumed to occur by a transition to non-copper based antifouling coatings, the implementation costs on the hull cleaning industry should be greatest in the early stages of conversion. Since nontoxic hard epoxy coatings are currently not widely used, there will be initial added costs because of the need to purchase new equipment, as well as the need for education and/or training to ensure the use of proper techniques. However, the investments required for a hull industry educational program should be offset by the increase in business from the application of these coatings. Specifically, the economic study (Carson *et al.*, 2002) found that hulls with nontoxic hard epoxy coatings require cleaning about 22 times per year, whereas hulls with copper-based paints require cleaning about 14 times per year. This reflects an approximate 57 percent increase in business for the hull cleaning industry.

Implementation Costs to Marina Owners/Operators

As a result of TMDL implementation, it will be necessary for marina operators located in SIYB to administer programs to encourage the phase-out of copper-based paints and introduction of nontoxic alternatives. As stated earlier, a 2-year educational program and commercial demonstration should help facilitate a smooth transition to nontoxic alternatives. Work in these areas has been ongoing by the University of California Sea Grant Extension Program (Sea Grant), a program based on a partnership between the nation's universities and National Oceanic and Atmospheric Administration (NOAA) with the purpose of providing science-based information regarding coastal resources. Specifically, Sea Grant has been involved with extensive public outreach and education pertaining to copper pollution in the San Diego area and demonstrations involving the use of nontoxic and less toxic coatings and strategies. Sea Grant has been extensively involved with these issues since 2000 and to date has spent approximately $450,000-$500,000 for these efforts (Johnson, 2003). Continuation and initiation of these types of programs in response to TMDL implementation shall be the responsibility of both the marina owners/operators and the Port District. The marina owners/operators and yacht clubs may chose to apply for grants to help fund these efforts.

In addition to imposing new programs, subsequent enforcement and reporting to the Regional Board will incur additional costs.

Implementation Costs to the San Diego Unified Port District

As with the marina owners and operators, the Port will be jointly responsible for implementation of a 2-year educational program/commercial demonstration. Costs for these programs are not precisely known but are probably comparable to what has been spent by Sea Grant, or approximately $450,000-$500,000 over a 3-year period. The Port as with the marina owners/operators and yacht clubs, may chose to apply for grants to help fund these efforts.

In addition, TMDL implementation requires monitoring to assess the concentration of dissolved copper. That the Port will play a major role in coordinating and completing this effort is anticipated.

In July 2003, the Regional Board issued a directive to all harbor authorities in the San Diego Region pursuant to section 13225 of the CWC. All harbor authorities are required to monitor and report the ambient water quality in Dana Point Harbor, Del Mar Boat Basin at the Marine Corps Base Camp Pendleton, Oceanside Harbor, Mission Bay, and San Diego Bay. Measurements of dissolved copper, amongst other pollutants, are required. Since compliance with this section 13225 directive is expected to satisfy the monitoring and reporting requirements of this TMDL, it follows that implementation of these requirements through TMDL adoption will add little to no further economic burden to the Port.

TMDL implementation could also result in potential cost savings to the Port in terms of costs associated with routine dredging. Harbors need regular dredging to maintain water depth. Sediment disposal costs are significantly higher if the material is classified as toxic or hazardous. For example, the cost to dredge/dispose of sediment on the beach or in the ocean is roughly $5-$10/cubic yard (McCoy and Johnson, 1995). In contrast, the cost to dredge and dispose of hazardous waste is roughly $40-$60/cubic yard (McCoy and Johnson, 1995). Since TMDL implementation will ultimately decrease the copper loading into SIYB, this will result in a decreased amount of copper reaching the sediments. The sediments, which are currently not classified as hazardous material, will continue to be free of added costs associated with disposal.

Implementation Costs to Boatyards

As with the hull cleaning industry described above, implementation costs will likely be greatest, although relatively minor, to the boatyard industry in the early stages of conversion. Since nontoxic alternatives are currently not widely used, there will probably be greater costs associated with the need for personnel training to ensure proper paint application. In terms of costs for the purchase of new equipment, TMDL implementation will not result in added economic burden, since application equipment for nontoxic coatings is the same as that used for copper-based paints (Roberts, 2003). Boats painted with alternative antifouling paints may not need to be painted as frequently as with copper antifouling paints, depending on the type of paint used. Overall, the boatyards should incur minor expenses as a result of transitioning to nontoxic alternative coatings.

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IX. APPENDICES

Appendix 1: Source Analysis Assumptions

The calculations to determine the loading from each significant source of copper are detailed in Appendix 2. The assumptions used in these calculations are provided below. Assumptions involving the calculation of the loading capacity of SIYB are documented in Appendix 3.

1. The San Diego Unified Port District's (Port) Harbor Police conduct an annual pleasure craft survey that documents the number of slips or buoys and their confirmed occupancy in San Diego Bay marinas. In 1999, San Diego Bay had approximately 9,001 slips or buoys, with confirmed occupancy of 7,295 boats. Furthermore, there were 2,363 slips at SIYB, with confirmed occupancy of 2,242 boats. The number of available slips in SIYB was used in the passive leaching and hull cleaning calculations of dissolved copper loading because it represents the maximum possible number of moored vessels.

2. The number of recreational vessels in SIYB is always constant.

3. All recreational vessels in SIYB are painted with hard, copper-based antifouling paints. Half (50 percent) of the vessels in SIYB are painted with epoxy copper-based antifouling paints and half are painted with copper-based antifouling vinyl paints. This assumption was based on a survey conducted by Sea Grant in the San Diego Region on boatyards and their usage of the most common types of antifouling paints for recreational boats (Johnson and Miller, 2002).

4. The majority of recreational vessels throughout San Diego Bay are sailboats between 30 to 40 feet in length (Conway and Locke, 1994). According to the Port Captain of Southwestern Yacht Club, of the boats moored in their marina approximately 75 percent are sailboats and 25 percent are powerboats (Wachtler, 2000). The average size of recreational vessels in the SIYB is 40 feet in length (12.2 meters), with an average beam width of 11 feet (3.4 meters) (Wachtler, 2000; Miller, 2000).

5. Hull surface area was estimated using the following equation: Hull Surface Area = Boat Length*Beam*0.85 (Interlux, 1999).

6. Recreational vessels in San Diego Bay are painted on average every two years (Conway and Locke, 1994).

7. The behavior of copper-based antifouling paint on fiberglass panels used in the study "Copper Emissions from Antifouling Paint on Recreational Vessels" (Schiff *et al.*, 2003) is sufficiently similar to the behavior of copper-based antifouling paint on pleasure craft.

8. Physical seawater parameters such as pH, temperature, and salinity are negligible in terms of affecting the behavior of copper-based antifouling paint on either fiberglass panels or boat hulls.

9. In this analysis, the passive leaching rate for recreational vessels was calculated to be 6.5 µg/cm^2/day of copper. See explanation in Appendix 2.

10. Half (50 percent) of the underwater hull cleaners use Management Practices (MPs) to perform cleanings.

11. All of the vessels in the SIYB are regularly maintained. Each recreational vessel in the SIYB undergoes underwater hull cleaning 14 times a year (Carson *et al*., 2002).

12. In this analysis, the underwater hull cleaning copper emissions rate for recreational vessels was calculated to be 8.5 µg/cm^2/event. See explanation in Appendix 2.

13. It was conservatively assumed that all storms result in some runoff that is expressed as an annual average (Pj equal to one) (See Section C of Appendix 2).

14. In order to convert from total copper to dissolved copper in freshwater, it was assumed that hardness was equal to 100 mg/L. Ninety six percent of the total copper in freshwater at a hardness of 100 mg/L is dissolved copper, based on the USEPA's default conversion factor (USEPA, 1996; USEPA, 2000) was also assumed.

15. Eighty-three percent of the total copper in saltwater is dissolved copper, based on the USEPA's default conversion factor (USEPA, 1996; USEPA, 2000).

16. Direct atmospheric deposition rates determined for Santa Monica Bay, Santa Monica, CA and its watershed are comparable to rates for SIYB.

17. The surface area of SIYB was based on estimates derived at mean lower low water (MLLW) (Moore, 2000). This estimate may under-represent the average surface area at SIYB over a yearly cycle.

18. In this analysis, it was assumed that sediment in SIYB does not act as a net source of dissolved copper.

19. There were no other significant sources of dissolved copper to the SIYB other than those identified in the source analysis.

Appendix 2: Source Analysis Calculations

a) Passive Leaching Calculations (Section 4, Passive Leaching)

Passive leaching rates from copper antifouling paints are dependent on a number of factors, including the type of paint, copper content, age of the paint, time since last hull cleaning, and frequency of painting. Leaching rates also vary with environmental conditions such as pH, temperature and existing slime layer.

Passive Leaching Rate Determination

The passive leaching rates from two separate studies were used to determine loading of dissolved copper into SIYB. One study was conducted by the US Navy and quantified rates of dissolved copper *in situ* from seven recreational vessels in San Diego Bay (Valkirs *et al.*, 2003). The other study was conducted by the Southern California Coastal Waters Research Project (SCCWRP) and looked at leaching rates of dissolved copper from fiberglass panels painted with both epoxy and hard vinyl paints (Schiff *et al.*, 2003). In the SCCWRP study, the rate of passive leaching was measured several times over a one-month time period, beginning one day after hull cleaning. Over the course of the month, the passive leaching rate was defined by integrating the area under the curve generated from all the data points. For epoxy paints, the passive leaching rate was reported as 4.3 $\mu g/cm^2/day$. For vinyl paints, the passive leaching rate was reported as 3.7 $\mu g/cm^2/day$. In contrast, the US Navy study looked at a "snapshot" of passive leaching rates for epoxy paints. An average leaching rate was estimated by averaging the instantaneous rates measured on seven different boats. This value was reported as 8.2 $\mu g/cm^2/day$. In the US Navy study, time since hull cleaning was not known.

In order to estimate loading of dissolved copper into SIYB, a passive leaching rate must first be established. After consultation with the principal authors of both studies, it was decided to use the results of both studies (Schiff, 2003a and Valkirs, 2003a). Combining study results assumes, however, that the behavior of epoxy paints is similar on both the fiberglass panels and the boat hulls. This also assumes that the effects of physical parameters in the surrounding seawater such as pH, temperature, and salinity, have negligible effects on the paint behavior since both studies were conducted under varying environmental conditions. The methodology for determining a passive leaching rate is described below.

Passive Leaching Rate for Epoxy Paints

In this analysis, a leaching rate for epoxy paints was estimated by taking the average of the data points from both the SCCWRP and Navy studies. Data point values for leaching rates were obtained from the figures provided in the publications. The average leaching rate for epoxy paints was estimated to be 7.1 $\mu g/cm^2/day$.

Passive Leaching Rate for Hard Vinyl Paints

A leaching rate for hard vinyl paints was estimated by taking the average of the data points for the SCCWRP study, only. This is because the US Navy study did not look at the effects of hard vinyl paints. The average leaching rate for hard vinyl paints was determined to be 5.9 $\mu g/cm^2/day$. Note that this number differs from what is reported by the authors, which is

3.7 μg/cm^2/day. That is because the rate reported by the authors was determined by integrating the area under the curve for the one-month experiments, whereas in this technical report the rate is determined by averaging the values of the individual data points. This was done to be consistent with the methodology used for determination of a leaching rate for epoxy paints.

Overall Leaching Rate for Copper-Based Paints

This analysis assumed that 50 percent of the boats in SIYB are painted with epoxy paints and the other 50 percent painted with hard vinyl paints. For this reason, the average leaching rates from both paints is needed to determine an overall passive leaching rate of dissolved copper. The rate is then used to determine overall loading of dissolved copper into SIYB from passive leaching.

Average passive leaching rate = (7.1 μg/cm^2/day + 5.9 μg/cm^2/day)/2
= 6.5 μg/cm^2/day

Determination of Source Loading Using Leaching Rate

In San Diego Bay, the majority of recreational vessels are sailboats ranging in length from 30 to 40 feet (9.1 to 12.2 meters) (Wachtler, 2000; Conway and Locke, 1994). In SIYB, the average size recreational vessel is 40 feet in length (12.2 meters), with a beam width of 11 feet (3.4 meters) (Miller, 2000; Conway and Locke, 1994; Wachtler, 2000). The average wetted hull surface area for vessels at SIYB was calculated according to the following equation (Interlux, 1999):

Wetted hull surface area = (Boat length)*(Beam)*(0.85).

The term "beam" refers to the boat width. Once the wetted hull surface area was determined, passive leaching over time per vessel was then calculated.

Dissolved copper loading from passive leaching for all of the recreational vessels in the SIYB was calculated based on the number of available slips in the marina. This number was obtained from the Port's Harbor Police annual pleasure craft survey, which documents the number of vessel slips and their confirmed occupancy throughout San Diego Bay (Harbor Police, 1999). In 1999, there were 2,363 slips or buoys at SIYB, with a confirmed occupancy of 2,242 boats. In order to be conservative, the total number of slips was used to represent the number of vessels in SIYB. Copper loading from passive leaching was calculated as follows:

Annual copper load (kg/year) = P*S* N_v, and S = L*B*0.85

Where:

P = Passive leaching rate
N_v = Number of vessels
S = Wetted hull surface area = Overall length*Beam*0.85
L = Average boat length
B = Average beam width

Given:

$P = 6.5$ µg/cm^2/day
N_v =2,363 (maximum number of vessels)
L = 12.2 meters (m)
B = 3.4 m

Wetted hull surface area = L*B*(0.85)
Wetted hull surface area = (12.2 m)*(3.4 m)*(0.85) = 35.3 square meters (m^2)
Annual load = (6.5 µg/cm^2/day)*(35 m^2)*(2,363 vessels)*(10,000 cm^2/m^2)*(kg Cu/10^9 µg)(365 days/yr.)
= 1,962 kg/year of copper.

Copper load from passive leaching to SIYB ≈ 2,000 kg/year of copper.

b) Underwater Hull Cleaning Calculations (Section 4, Underwater Hull Cleaning)
In order to determine the load from underwater hull cleaning, it was assumed that approximately half of the vessels in SIYB are painted with epoxy paints and half with vinyl paints, and that MPs are used to clean hulls on approximately half of the vessels. For epoxy paints, cleaning without MPs doubled the dissolved copper flux, from 8.6 µg/cm^2/event to 17.4 µg/cm^2/event (Schiff *et al*., 2003). The response from hard vinyl paints remained similar whether or not MPs were used (3.8 versus 4.2 µg/cm^2/event) (Schiff *et al*., 2003). Using these assumptions, the rates for the epoxy and vinyl paints were averaged to arrive at an emissions rate for underwater hull cleaning at SIYB:

Determination of Hull Cleaning Rate

Average dissolved copper emissions rate from epoxy paints	= (8.6 µg/cm^2/event + 17.4 µg/cm^2/event)/2 = 13 µg/cm^2/event
Average dissolved copper emissions rate from vinyl paints	= (3.8 µg/cm^2/event + 4.2 µg/cm^2/event)/2 = 4 µg/cm^2/event
Average dissolved copper emissions rate (both paint types)	= (13 µg/cm^2/event + 4 µg/cm^2/event)/2 = 8.5 µg/cm^2/event

Determination of Source Loading Using Hull Cleaning Rate
Annual copper load (kg/year) = P*S* N_v, and S = L*B*0.85

Where:

P = Underwater hull cleaning rate
N_v = Number of vessels
S = Wetted hull surface area = Overall length*Beam*0.85
L = Average boat length

B = Average beam width
Cu = Copper

Given:
$P = 8.5\ \mu g/cm^2/event$
$N_v = 2,363$ (maximum number of vessels)
L = 12.2 m
B = 3.4 m
$N_h = 14$ events/year

Wetted hull surface area = L*B*(0.85)
Wetted hull surface area = (12.2 m)*(3.4 m)*(0.85) = 35.3 m^2

Annual load = (8.5 $\mu g/cm^2/day$)*(35 m^2)*(2,363 vessels)*(10,000 cm^2/m^2)*(kg Cu/10^9 μg)*(142 events/year)
= 98.4 kg/year

Copper load from underwater hull cleaning to SIYB ≈ 100 kg/year.

c) Urban Runoff Calculations (Section 4, Urban Runoff)

Copper loading from urban runoff is dependent on several factors including perviousness (represented by a runoff coefficient), flow-weighted mean pollutant concentration (also known as the Event Mean Concentration, or EMC), and area under consideration. Both the runoff coefficient and EMC are functions of land-use types.

The Simple Method was used to calculate wet weather storm drain runoff to SIYB (Schueler, 1987). The equation used to determine dissolved copper loading follows (Schueler, 1987):

Pollutant Loading = P*Pj*Rv*C*A

Where:
P = Average annual rainfall
Pj = Unitless correction factor to account for storms with no rainfall
Rv = Runoff coefficient (dimensionless)
C = Flow-weighted mean pollutant concentration = EMC
A = Area under consideration

Statistics for the San Diego International Airport show an average annual rainfall of 26.5 cm from 1927 through 1998 (City of San Diego, 2000a). Conservatively, it was assumed that all storms result in some runoff that is expressed as an annual average, i.e. Pj is equal to one. These two values (P and Pj) are the same regardless of land-use type.

Land-use in the watershed draining to SIYB is comprised almost entirely of single-family residential land-use. This was determined by studying a land-use distribution of the watershed drainage area (City of San Diego, 2003). Land-use composition is roughly 95 percent single family residential, with the remaining types consisting of commercial, education, transportation, and others. The runoff coefficient corresponding to residential land-use is 0.55, the EMC for total copper is 34 µg/L, and the area associated with this land-use type (in the SIYB watershed) is 3.04 km^2.

Since the EMC is given in terms of total copper, this value must be converted to dissolved copper in order to calculate the contribution of dissolved copper from urban runoff into SIYB. USEPA (2000b, 1996) provides an equation for the calculation of dissolved copper from total copper in both freshwater or saltwater:

Dissolved copper = Total copper * Conversion factor.

The conversion factor for freshwater with an average hardness of 100 mg/L is 0.96. The average five-year EMC for residential land use in San Diego was determined to be 34 µg/L for total copper, which converts to 32.6 µg/L for dissolved copper, after applying the conversion factor of 0.96 (City of San Diego, 2000a).

Given:

P = 26.5 cm/year
Pj = 1.0
Rv = 0.55
C = EMC = 32.6 µg/L of dissolved copper
A = 3.04 km^2 = Area of SIYB watershed

Pollutant Loading = P*Pj*Rv*C*A
Pollutant Loading = (26.5 cm/year)*(1.0)*(0.55)*(32.6 µg Cu/L)*(3.04 km^2)*(kg Cu/10^9 µg)*(10^{10} cm^2/km^2)*(L/10^3 cm^3)
Pollutant Loading = 14.44 kg Cu/year

Similar calculations were performed for all other types of land-uses comprising the watershed drainage to SIYB. Each land-use type had a unique value for Rv, C, and A, resulting in various pollutant loadings. The pollutant loadings from each land-use type are shown below.

Table A2.1. Pollutant Loading into SIYB from Various Land-Uses.

Land-Use Type	**Rv**	**C (µg Cu/L)**	**A (km^2)**	**Pollutant Loading (kg Cu/yr)**
Single Family Residential	0.55	32.6	3.04	14.44
Commercial and Office	0.85	25.9	0.01	0.06
Education	0.85	25.9	0.03	0.15
Transportation	0.85	26.0	0.01	0.06
Institutions	0.85	25.9	0.02	0.12
Commercial Recreation	0.85	25.9	0.03	0.16
Undeveloped	0.55	27.84	0.01	0.05
Total			3.15	15.04

Total wet weather loading from all land-uses comprising watershed drainage to SIYB was calculated to be 15.0 kg/year of copper. Dry weather loading was conservatively estimated to be equal to wet weather loading. Therefore, the combined load from wet and dry weather flows (urban runoff) is approximately 30 kg/year of copper.

Copper load from urban runoff to SIYB ≈ 30 kg/year.

d) Background Calculations (Section 4, Background)

See Appendix 3: Linkage Analysis and Calculation of Background Loading for an analysis of loading from ambient seawater ("background") into SIYB.

e) Atmospheric Deposition Calculations (Section 4, Direct Atmospheric Deposition)

In a southern California study, the atmospheric deposition of copper was investigated for the Santa Monica Bay and the Santa Monica Bay watershed (Stolzenbach *et al.,* 2001). Contaminant loading from atmospheric deposition was determined through a combination of direct and indirect methods combining data collection, analysis and modeling. The results of this study were used to estimate direct atmospheric copper loading to SIYB. Direct atmospheric deposition results from wet and dry deposition directly to the surface of the waterbody. Indirect atmospheric deposition occurs when dissolved copper enters the watershed that drains to SIYB. Indirect deposition is a component of urban runoff to SIYB, and is accounted for in the urban runoff source analysis. This analysis addresses only direct atmospheric deposition.

Rainfall statistics from the San Diego area were used to estimate the amount of rainfall and the number of wet and dry days for SIYB. Statistics for the San Diego International Airport show an average annual rainfall of 26.5 cm from 1927 through 1998 (City of San Diego, 2000a). In addition, from 1948 to 1986 there was an average rain event duration of 9.24 hours, an average event depth of 0.97 cm, and 18.33 number of events per year (City of San Diego, 2000a). After subtracting out the number of rain days, it was determined that there are approximately 358 dry weather days per year:

Number of dry weather days = 365 days - Number of rain days

= [365 days – (9.24 hours)]*(18.33 events/year)*(day/24 hours)
= 358 days/year

The surface area of SIYB at MLLW was derived by the Port using bathymetry, and was determined to be 8,054,000 square feet (ft^2) (Moore, 2000).

Direct atmospheric deposition to SIYB during wet and dry weather was calculated separately below.

Wet weather deposition:
In the Santa Monica Bay study, the rain weighted mean copper concentration was determined to be 2.16 µg/L (Stolzenbach *et al.,* 2001). This value was converted to a dissolved copper concentration of 2.07 µg/L using a conversion factor of 0.96 for freshwater, assuming an average hardness of 100 mg/L (USEPA, 2000b; USEPA, 1996):

Dissolved copper = Total copper * Conversion factor
Dissolved copper = 2.07 µg/L

Wet weather atmospheric deposition was calculated using the following equation:

Aw = P* Cr*A

Where:
Aw = Wet weather atmospheric deposition
P = Average annual rainfall
Cr = Rain weighted mean copper concentration
A = Area under consideration

$$Aw = (2.07\ \mu g\ Cu/L)*(26.5\ cm/year)*(8{,}054{,}000\ ft^2)*(1\ ft/30.48\ cm)*(28.32\ L/ft^3)*(kg/10^9\ \mu g)$$

Aw = 0.410 kg Cu/year

Dry weather deposition:
In the Santa Monica Bay study, dry deposition flux of copper was estimated to be approximately 11.6 $\mu g/m^2$/day (Stolzenbach *et al.,* 2001). This rate was converted from total to dissolved copper using a conversion factor of 0.96 for freshwater, assuming an average hardness of 100 mg/L (USEPA 2000b, USEPA 1996):

Dissolved copper = Total copper * Conversion factor.

Dry weather loading was calculated using the following equation:

Ad = Dr*(0.96)*Nd*A

Where:

Ad = Dry weather loading
Dr = Dry deposition flux rate
0.96 = Conversion factor
Nd = Number of dry weather days
A = Area under consideration

Ad = (11.6 μg Cu/m^2/day)*(0.96)*(8,054,000 ft^2)*(m^2/10.76 ft^2)*(358 days/year)*(kg/10^9 μg)

Ad = 2.98 kg Cu/year

Direct atmospheric deposition:
Direct atmospheric deposition = Wet weather deposition + Dry weather deposition

Direct atmospheric deposition = 0.410 kg Cu/year + 2.98 kg Cu/year = 3.39 kg Cu/yr.

Copper load from direct air deposition to SIYB ≈ 3 kg/year.

f) Copper Loading Summary (Section 4, Summary of Loading Estimates)
Total Load = Load [(Passive leaching) + (Hull cleaning) + (Background) + (Urban runoff) + (Direct atmospheric deposition) + (Sediment)]

Total Load = (2000 + 100 + 30 + 30 + 3 + 0) kg Cu/year = 2,163 kg Cu/year

Total Load into SIYB ≈ 2,163 kg Cu/year

Appendix 3: Linkage Analysis and Calculation of Background Loading

The linkage analysis describes the relationship between the numeric target and the attainment of water quality standards by defining the waterbody's total assimilative capacity, or loading capacity, for the pollutant. The loading capacity represents the maximum amount of pollutant loading the waterbody can support and still attain water quality standards. This number, when adjusted by a margin of safety, defines the TMDL for a particular waterbody and pollutant.

A "box model" based on mass-balance principles was used to calculate the loading capacity of SIYB. This theoretical model, which was tailored to SIYB, describes copper fate and transport in and out of the Basin. This model was developed by Space and Naval Warfare Systems Command (SPAWAR) for use by the Regional Board (Chadwick, 2000).

Copper mass balance in SIYB was derived using general mass balance principles. In order to do so, a control volume must be defined. In this case, the control volume was defined as the volume of water in the entire Basin, where the only open boundary for tidal flushing occurs at the interface between the Basin and the rest of San Diego Bay, herein referred to as the "Basin entrance." This control volume was chosen for two reasons: (1) the entire Basin is listed as impaired on the State's Section 303(d) List, and (2) the geometry of the Basin as a whole is known, which results in increased confidence in the analysis.

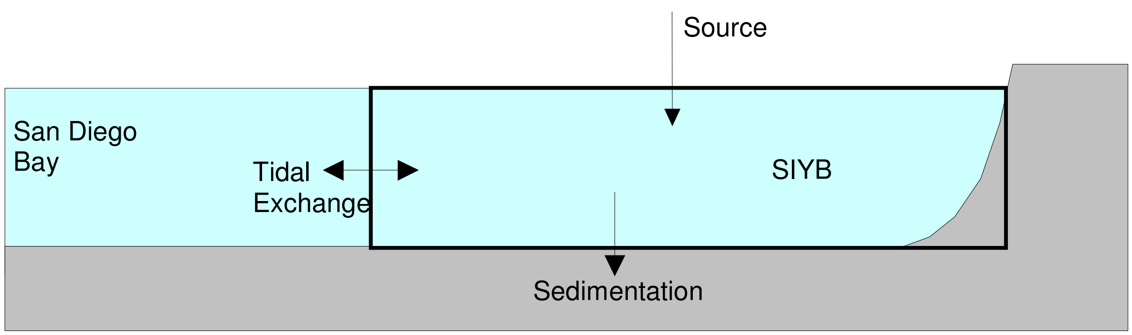


Figure A3.1. Schematic Profile of the Control Volume.

Movement of a constituent in and out of the defined control volume is described by conservation of mass. In conceptual form, this can be written as:

$$(a)\quad \begin{bmatrix} \textit{Rate of mass increase} \\ \textit{in control volume} \end{bmatrix} = \begin{bmatrix} \textit{Rate of mass entering} \\ \textit{control volume} \end{bmatrix} - \begin{bmatrix} \textit{Rate of mass leaving} \\ \textit{control volume} \end{bmatrix}$$

For this analysis, total copper (as opposed to dissolved copper) was analyzed as the constituent. By using total copper, this ensured that partitioning, or copper distribution among various chemical and biological forms, did not need to be accounted for in the analysis since total copper includes all forms. By not considering partitioning in the analysis, the mass generated and lost within the control volume is zero.

Although the analysis was performed for total copper, the loading capacity must be expressed in terms of dissolved copper, since the numeric target for this TMDL is expressed as dissolved copper. To account for this, the load reduction required to meet the numeric target was first calculated in terms of total copper, and then converted into a value for dissolved copper using a conversion factor.

General Equation for Conservation of Mass (Mass Balance)

There are two basic transport processes across the boundaries of the control volume:
(1) advection, or transport of a constituent resulting from the flow of water in which the constituent is dissolved or suspended; and (2) dispersion, or transport due to turbulence, or mixing in the water. Dispersion is often driven by concentration gradients. For example, tidal flow reversals as well as secondary currents driven by salinity gradients tend to increase dispersion (Metcalf and Eddy, 1991).

Advection and dispersion take place in three dimensions; however, a one-dimensional simplification was used for this analysis because SIYB is much longer than it is wide or deep. This is a useful simplification that is often made in characterizing enclosed embayments (Metcalf and Eddy, 1991, Fischer *et al.*, 1979). Thus, constituent transport is governed by tidal flushing, or movement of water across the cross-sectional area of the Basin entrance.

Combining the effects of advection and dispersion, and also accounting for sources and sinks of the constituent, results in the general conservation of mass equation. This serves as the basis for practically all water quality modeling (Metcalf and Eddy, 1991):

$$(b) \quad \frac{\partial C}{\partial t} = \underbrace{-U\frac{\partial C}{\partial x}}_{\text{Advection term}} + \underbrace{\frac{\partial}{\partial x}\left[K\frac{\partial C}{\partial x}\right]}_{\text{Dispersion term}} + \sum sources + \sum sinks$$

where C = the average concentration of the constituent within the control volume. The units are expressed as (mass/volume).
U = water velocity in the x- direction. (length/time).
K = dispersion coefficient. (length^2/time).

For purposes of analyzing an enclosed embayment, the time derivative term describes the change per tidal cycle, and K expresses the result of all the mixing processes that occur within the tidal cycle. Source terms include external inputs into the control volume, including various non-point sources. The effects of these sources are additive, and the rates of input can simply be summed in the conservation of mass equation. A discussion of source terms specific to SIYB is contained in the text, Section 4, Summary of Loading Estimates. The sink terms can likewise be summed in the equation. The dominant sink is the loss of copper to sediment, as discussed further later.

Conservation of Mass to Describe "Salt Balance"

The unique dispersion coefficient K for the SIYB system can be calculated by analyzing the "salt balance" within the Basin. This is done by modifying the conservation of mass equation to describe the movement of salt across the boundary of the control volume, or the Basin entrance. Assuming tidally averaged conditions, the salt balance for an evaporative Basin with a single entrance can be described as Equation 3 (Chadwick, 2002).

(c) $u_e A_c = eA_s$

where u_e = average advective velocity, (length/time)
A_c = cross sectional area of Basin entrance, (length^2)
e = rate of evaporation within the Basin, (length/time)
A_s = surface area of the Basin, (length^2).

This equation states that loss of water due to evaporation within the Basin must be balanced by the average advective flow through the entrance of the Basin. This is depicted in Figure A3.2.

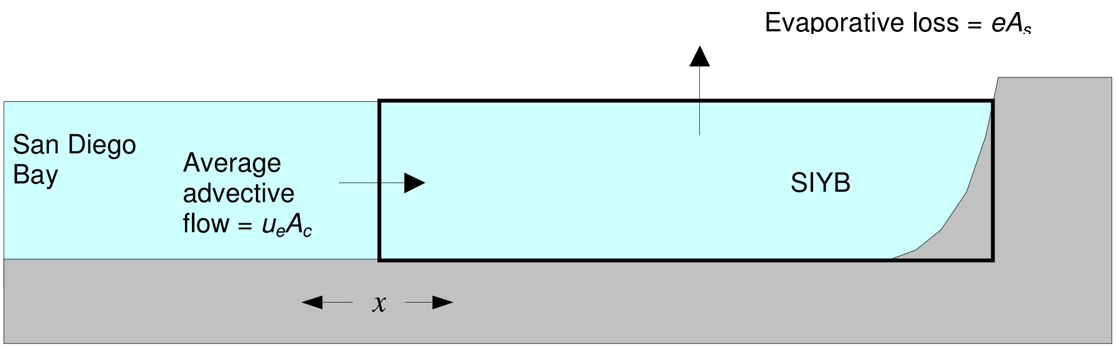


Figure A3.2. Salt Balance in SIYB.

Note that in this specific example, u_e replaces U in Equation *(b)* as the average cross-sectional velocity. Rearranging Equation *(c)* and solving for u_e,

(d) $$u_e = \frac{eA_s}{A_c}$$

Next, the conservation of mass equation is used to describe the salt balance. Since salt is the constituent under analysis, the variable C in Equation *(b)* now represents the concentration of salt within the Basin, denoted by the variable S. Assuming that the concentration of salt does not change over time, or steady state conditions:

(e) $$\frac{\partial S}{\partial t} = 0$$

The assumption of steady state conditions is useful in describing changes over long-term time frames, as opposed to describing transient effects caused by storms. This assumption is appropriate in this analysis because of the relatively low level of rainfall occurring in the watershed (Largier *et al*., 1997). After taking steady state conditions under consideration, Equation *(b)* becomes:

(f) $$u_e \frac{dS}{dx} = \frac{d}{dx}\left[K \frac{dS}{dx}\right] + \sum sources + \sum sinks$$

Assuming that there are no sources of salt except for the seawater entering the Basin entrance causes the source term to become zero. Also, at equilibrium, there is no sink and the Basin becomes hypersaline (Largier *et al.*, 1997):

(g) $$u_e \frac{dS}{dx} = \frac{d}{dx}\left[K \frac{dS}{dx}\right]$$

Multiplying both sides of the equation by the cross-sectional area A_c,

(h) $$u_e A_c \frac{dS}{dx} = \frac{d}{dx}\left[K A_c \frac{dS}{dx}\right]$$

Integrating both sides of the equation with respect to *dx*, the equation describing the long-term salt balance between evaporative advection (u_e), and tidal dispersion (K) is

(i) $$u_e A_c S_1 = K A_c \frac{dS}{dx} \cong K A_c \frac{(S_2 - S_1)}{\Delta x}$$

where S_1 and S_2 = data describing the salinity gradient in SIYB. Salinity is measured in practical salinity units (psu).
Δx = a "typical" mixing length corresponding to the salinity gradient in SIYB.

S_1 and S_2 were obtained from salinity data in San Diego Bay in late summer when evaporation is dominant and the bay is near steady state. Figure A3.3 depicts the salt balance in SIYB.

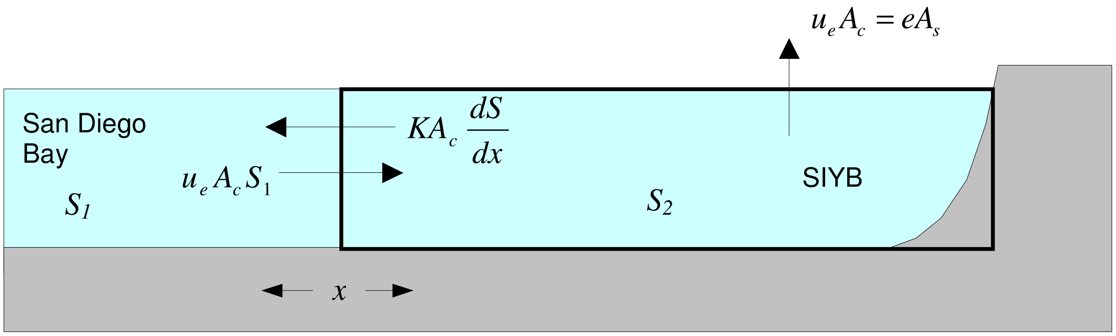
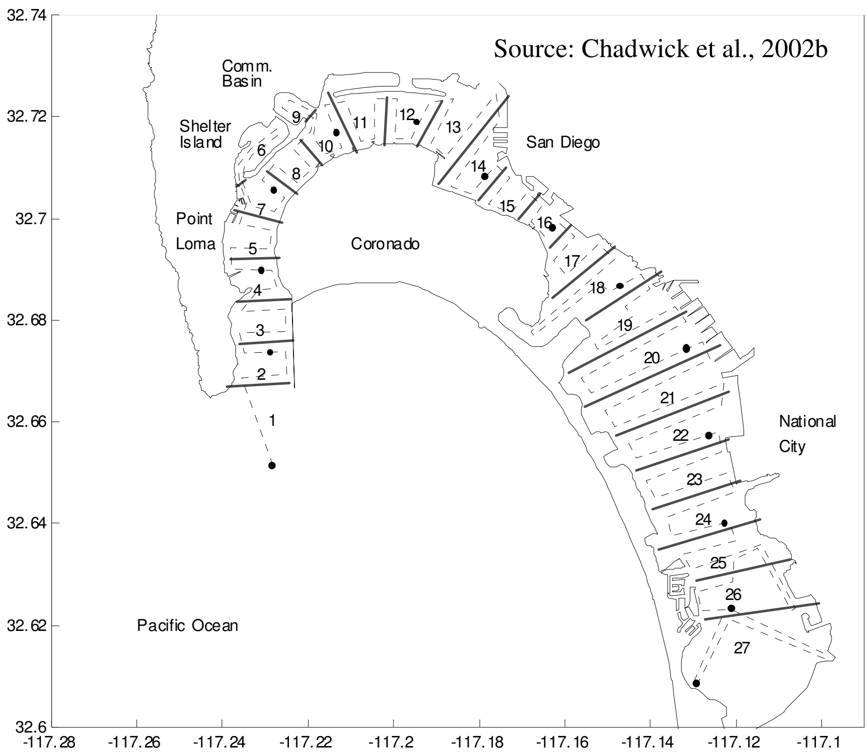


Figure A3.3. Salt Balance for K Determination.

Salinity Measurements and K Determination

Salinity measurements for S_1 and S_2 were made by SPAWAR in a series of surveys from August 2000 through September 2001 to provide distribution data for salinity and copper in San Diego Bay (Chadwick *et al.*, 2002b). Sampling occurred across several portions of San Diego Bay in the form of "boat transects." For this study, San Diego Bay was split into 27 distinct regions, or boxes shown in Figure A3.4. SIYB was included in this survey, and is identified as Box 6.



Sampling boxes = solid lines with numbers,

Survey transect = dashed line,

Vertical profile locations = solid circles.

Figure A3.4. Map of San Diego Bay Showing Sampling Boxes.

For each survey, each transect layout was developed to include two transverse legs within each of the 27 regions. During the transect, continuous measurements and composite samples were collected for salinity and copper, as well as several other parameters including temperature, depth, pH, and dissolved oxygen. The details of these surveys and a discussion of the findings will be available in the near future (Chadwick *et al.*, 2002b).

Data from the boat survey in September 2001 was used as input parameters for the box model. Specifically, salinity data from Box 7 was used to describe S_1, and salinity data from Box 6 was used to describe S_2. In addition, a "typical" mixing length (Δx) was estimated to represent the length of the salinity gradient. This value corresponds to an estimated distance between the endpoints for S_1 and S_2. This mixing length (Δx) corresponds to an average mixing length, which follows the natural contours of the shape of the Basin and surrounding area. In other words, this is not a straight-line distance. A rough schematic of the length of the salinity gradient (Δx) is provided in Figure A3.5.

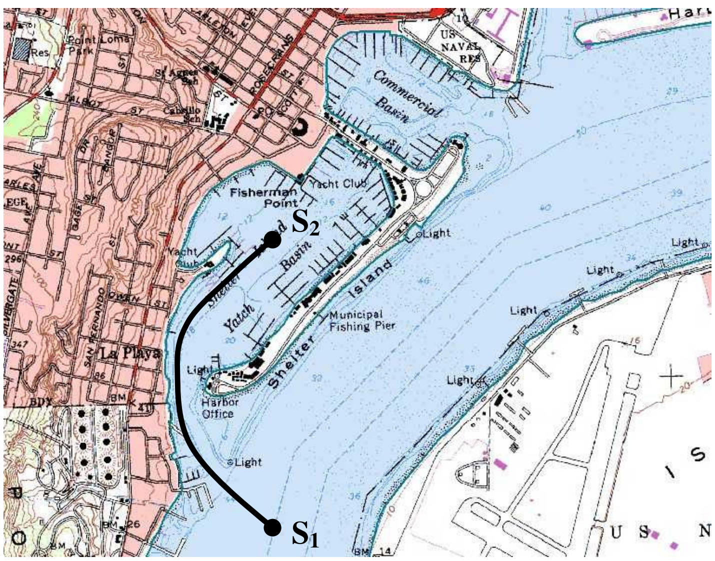


Figure A3.5. Salinity Gradient for SIYB.

Once (Δx) is estimated, the dispersion coefficient for this system can be approximated. Solving Equation *(i)* for K,

$$(j) \quad K \cong \frac{u_e S_1 \Delta x}{S_2 - S_1}$$

Combining Equations *(d)* and *(j)*,

$$(k) \quad K \cong \frac{e A_s S_1 \Delta x}{A_c (S_2 - S_1)}$$

Conservation of Mass to Describe Copper Fate and Transport

Now that the dispersion term *K* has been calculated for this particular system, the conservation of mass equation can be solved for total copper. Equation *(i)* is re-written to reflect the analysis of copper, denoted by the variable *C*. The source and sink terms are once again present since the analysis is for copper and not salt.

$$(l) \quad u_e A_c C_1 = K A_c \frac{dC}{dx} + \sum sources + \sum sinks$$

The additive effects of both sources and sinks can be incorporated into the equation by assigning one variable for each parameter. Copper loading to the Basin is represented by R_S. This describes the additive rates from all point and nonpoint sources discussed in the text, Section 4.7. Sources include contributions from boat hull cleaning, passive leaching, urban runoff, and others. The sink term is represented by R_L, or loss rate of copper from the Basin. Equation *(l)* now becomes:

$$(m) \quad u_e A_c C_1 = K A_c \frac{dC}{dx} + R_L - R_S$$

In addition to tidal flushing, movement of copper out of the Basin is dominated by loss to sediment (Chadwick, 2002). The loss to sediment is a first- order reaction with respect to the concentration of copper in the water column was assumed. This means that the loss rate of copper is directly proportional to the concentration of copper in the water column. This loss rate of copper is represented by:

$$(n) \quad R_L = k_L V_2 C_2$$

where k_L = rate constant describing total copper loss to sediment in SIYB. This is expressed as (percent/time).
V_2 = volume of the Basin (control volume)
C_2 = the average concentration of copper within the Basin, (mass/volume).

The mass balance for total copper is depicted in Figure A3.6. Note that the sign convention for the source and sink terms corresponds with the direction of copper movement specified by the arrows.

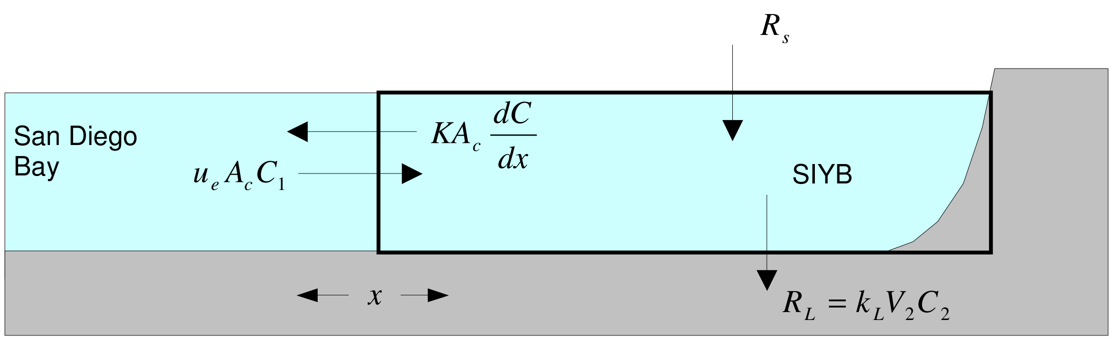


Figure A3.6. Mass Balance for Total Copper in SIYB.

Results for calculating dissolved copper concentrations using the approximation described by Equation *(n)* have been in close agreement with copper concentrations measured throughout San Diego Bay in a study conducted by SPAWAR. The range of values that were calculated for the rate constant k_L was four to seven percent/day for San Diego Bay (Chadwick *et al*., 2002b). However, a rate constant k_L was not calculated specifically for SIYB in the study.

Combining Equations *(m)* and *(n)*, the modified conservation of mass equation describes SIYB specifically. The final version becomes:

$$(o) \quad u_e A_c C_1 = KA_c \frac{(C_2 - C_1)}{\Delta x} + k_L V_2 C_2 - R_S$$

The maximum rate of copper loading into the Basin can now be determined by solving Equation *(o)* for R_S. Thus the maximum rate of copper loading, or loading capacity, is:

$$(p) \quad R_S = C_2\left(\frac{KA_c}{\Delta x} + k_L V_2\right) - A_c C_1\left(u_e + \frac{K}{\Delta x}\right)$$

Finally, Equation *(p)* is combined with Equation *(d)* to yield an expression for R_S where all the input variables can be supplied. Each variable, and the corresponding unit expressions, is described below.

$$(q) \quad R_S = C_2\left(\frac{KA_c}{\Delta x} + k_L V_2\right) - A_c C_1\left(\frac{eA_s}{A_c} + \frac{K}{\Delta x}\right)$$

where C_1 = average background concentration of copper (measured in the area of San Diego Bay adjacent to SIYB, expressed as total copper), (mass/volume).

C_2 = average target concentration for copper in the Basin (expressed as total copper), (mass/volume)
K = dispersion coefficient calculated from salinity measurements and mixing length approximation ($length^2$/time)
A_c = cross-sectional area of entrance to Basin ($length^2$)
A_s = surface area of Basin ($length^2$)
Δx = average mixing length between SIYB and adjacent area (length)
V_2 = volume of Basin (volume)
e = evaporation rate (length/time)
R_S = rate of all point and nonpoint sources of copper to Basin, expressed as total copper (mass/time).

Measured values and other calculated parameters can be substituted into Equation *(q)*. The model solves this mass balance equation for R_S, or the value describing the loading rate that results in a target value of C_2. In other words, when C_2 is set equal to the numeric target for copper, the model calculates the maximum loading rate R_S that the Basin can receive and still achieve the numeric target. Rs is calculated by way of an iterative process, as described below. The numeric target was set at a level to ensure attainment of water quality standards. Determination of C_2 is further discussed under the description of output variables below.

Input Variables for Box Model

Input variables are entered into the model by the user and affect the determination of each output variable, which are discussed in the next section. As discussed above, the loading capacity, R_S, was determined from Equation *(q)* using the model. Since the target copper concentration within the Basin, C_2, is an output variable that depends on the loading capacity, R_S, the value for R_S can be determined by iteration. Various values for R_S were input into the model until the maximum allowable loading rate was found that did not exceed the numeric target for copper in the Basin. The means of determining the value of each input variable necessary for the analysis is discussed below.

S_1, S_2 -- Salinity data was obtained from a SPAWAR sampling survey in September 2001. Data from the composite sampling of sampling Box 6 (SIYB) and sampling Box 7 (Bay adjoining SIYB) was used in the box model analysis (Figure A3.4). These values were 33.62 practical salinity units (psu) and 33.46 psu, respectively.

C_1 -- This represents the concentration of total copper in ambient seawater, or background concentration levels outside the control volume. Background copper concentrations in San Diego Bay were also measured by composite sampling by SPAWAR on two occasions, August 2000 and September 2001. Composite measurements for total copper were 0.69 µg/L and 0.39 µg/L, respectively, for sampling Box 7 (Bay adjoining SIYB). For the input variable C_1, the average of the two values, 0.5 µg/L, was used.

A_c -- This represents the cross-sectional area of the control volume at the boundary (Basin entrance), which is tidally dependent. This area was determined by using nautical charts to estimate cross-sectional width and average depth at mean lower low water. Multiplying the two results in a cross-sectional area of roughly 1,000 square meters (m^2).

A_s -- This represents the surface area of the control volume, which is tidally dependent. Using bathymetry, a value measured at mean lower low water provided by the Port District was used (Moore, 2000). This area was determined to be roughly 740,000 m^2.

e -- This represents the evaporation rate within the control volume, which was stated to be about 0.43 centimeter/day (cm/day) for San Diego Bay (Chadwick *et al.*, 2002b).

Δx – This represents a "typical" mixing length, or approximate length of the salinity gradient. This value corresponds to an estimated distance between the endpoints for S_1 and S_2, which was 2,000 meters (s). A rough schematic of the length of the salinity gradient (Δx) is provided in Figure A3.5.

V_2 -- This represents the control volume, which is tidally-dependent. This volume was provided by the Port, and was measured using bathymetry at mean lower low water to be approximately 31,000,000 cube meters (m^3) (Moore, 2000).

k_L -- This represents the rate constant describing the total copper loss to sediment, which is the dominating sink mechanism. A Bay-wide study found this rate to be about four to seven percent/day, depending on the area measured. A value of seven percent/day was chosen for the input parameter, since loading of copper into SIYB is probably high compared to most areas in the Bay due to elevated concentrations in the water column. That the drive towards equilibrium would cause this rate to likewise be high was assumed.

R_S -- This represents the maximum allowable copper input rate, or loading capacity, into SIYB. This input rate was determined by iteration to yield the maximum possible value without exceeding the numeric target, expressed as C_2 under "output variables" (see below). This value is expressed in kilograms/day (kg/day).

Output Variables from Box Model

The box model generates output variables based in part on input variables entered into the model by the user.

K -- This represents the dispersion coefficient, specifically describing mixing characteristics of SIYB, described by Equation *(k)*. For SIYB, this was found to be 15.3 square meters/second (m^2/sec).

u_e -- This represents the average evaporative advective velocity, given in Equation *(d)*. This was found to be 3.68 x 10^{-5} meters/second (m/s).

dS/dx -- This represents the salinity gradient, or difference in salinity measurements over an approximate measured distance. This is expressed as:

(r) $\frac{S_2 - S_1}{\Delta x}$ This was found to be 8.04 x10^{-5} psu/m.

C_2 -- This represents the "target" concentration of total copper within SIYB. "Target" concentration means the concentration equal to the numeric target established in this TMDL. By definition, the attainment of the numeric target will result in the attainment of water quality standards in the Basin. The value for C_2 was determined by expressing the numeric target for dissolved copper as total copper for use in the box model. The chronic water quality objective for dissolved copper is 3.1 µg/L. Since this concentration is a maximum level that cannot be exceeded, it must be adjusted to represent an average concentration. This is because the model relies on average values for most measured parameters. The average concentration was calculated using the ratio of average to maximum dissolved copper concentrations measured during a sampling survey by the Regional Board (Appendix 6). As shown below, the average concentration of dissolved copper measured by the Regional Board in SIYB was 5.45 µg/L, and the maximum concentration measured was 8 µg/L. Therefore the target average concentration for dissolved copper inside the Basin was determined by this ratio:

(s) $$\left[\frac{5.45\,\mu\text{g/L}}{8\,\mu\text{g/L}}\right]_{measured} = \left[\frac{\textit{average concentration, dissolved copper}}{3.1\,\mu\text{g/L}}\right]_{target}$$

Solving for Equation *(s)*, the average target concentration of dissolved copper in the Basin was found to be 2.11 µg/L. Finally, this number was adjusted to represent a value for total copper to be used in the box model. This was done by assuming that the ratio of dissolved copper to total copper in seawater is 0.83 (USEPA 2000). Therefore the target concentration of total copper, C_2, was determined to be 2.54 µg/L. This value was used to determine the Basin's maximum loading capacity, Rs, through the process of iteration. Various values for Rs were input into the model, until the maximum value was found that did not cause C_2 to exceed 2.54 µg/L. The value for R_S represents the maximum loading rate of copper that the Basin can receive and still attain the numeric target.

R_L -- This represents the rate of copper loading to sediment, given in Equation *(n)*. This is the same as the rate of copper loss from the water column in SIYB to the sediment. This was found to be 0.55 kg/day.

Assumptions and Limitations of Box Model

1. The model provides only an estimate of average concentration for the entire Basin. Some areas of the Basin, particularly the back portions where copper loading is high and flushing rates are low, are more impacted with copper than areas close to the entrance to San Diego Bay. This was verified by sampling by the Regional Board in 2000 and 2001 (Appendix 6). This shortcoming of the box model could be improved by dissecting the Basin into components and analyzing them individually. However, this would require knowledge of the geometry of the individual segments, as opposed to the geometry of the Basin as a whole. This is not readily available information at this time.

2. The model assumes tidally averaged conditions. The model does not resolve fluctuations that occur over tides, but rather averages them out.

3. The model assumes steady state conditions. The model does not resolve changes associated with transient sources, loss and mixing fluctuations on time scales shorter than the time to establish steady state.

4. The model does not represent the actual individual processes that lead to loss of copper from the water column such as complexation, sorption, and settling. Rather, settling, or loss to sediment, is treated as the dominant mechanism and assumed to behave as a first-order reaction. This means that loss to sediment is directly proportional to the concentration of copper in the surrounding water column.

5. The calibration of the dispersion coefficient depends on an adequate salinity gradient, (i.e. measurable difference), assumption of a steady-state salt balance, and knowledge of the evaporation rate.

6. A Bay-wide study found the rate constant k_L rate to be about four to seven percent/day, depending on the area measured. A value for the rate constant k_L is not specifically known for SIYB. The value for k_L was assumed to be seven percent/day for reasons discussed earlier.

7. The model assumes a constant background concentration, C_1. In reality, the background concentration may fluctuate because of general variations in San Diego Bay. Also, San Diego Bay is treated as "background" when in reality, levels of copper in the Bay are probably elevated over true ambient seawater conditions due to numerous point and nonpoint source discharges.

8. The values for A_c and Δx were roughly estimated from nautical charts.

9. The values of salinity and copper concentrations used in the analysis were based on limited sampling.

Results from Analysis Using Box Model

Using the input parameters described above, the model results are as follows:

R_S = loading capacity = 1.87 kg/day total copper
= 683 kg/year total copper
= 567 kg/year dissolved copper (using a ratio of dissolved copper/total copper of 0.83 in seawater)

The loading capacity defines the TMDL for SIYB. The margin of safety (MOS) calculation is provided in Appendix 4.

Calculation of Background Loading Using Box Model

In addition to using the box model to calculate the loading capacity for SIYB, the model was also used to calculate a loading rate of copper into the Basin from ambient seawater. This information is included in Tables 4.2 and 7.1 of the text. Copper loading from ambient seawater is expressed as "background" loading.

Because the box model is specific to SIYB (i.e., uses information such as geometry and unique dispersion coefficient), various parameters can be calculated if all others are known. For purposes of calculating background loading, the input value for R_S was set at zero. In other words, analysis of copper movement was performed as if all input sources such as hull cleaning, passive leaching, urban runoff and atmospheric deposition were nonexistent.

At steady state, net copper loading into SIYB from ambient seawater is assumed to be deposited in the sediment at the rate described by R_L. This is because at steady state, the net background copper loading is equal to the loss of copper to the sediment. Therefore all excess copper loading from ambient seawater (which has not been flushed back to San Diego Bay) must be deposited into a sink.

Using the same input parameters described previously, the model results are as follows:

R_L = loading from ambient seawater (background) = 0.09 kg/day total copper
= 33 kg/year total copper
= 27 kg/year dissolved copper (using a ratio of dissolved copper/total copper of 0.83)

Copper loading from ambient seawater (background) ≈ 30 kg/year.

Additional Capabilities of Box Model

In addition to the output variables previously described, the box model supplied by SPAWAR also has the capability to calculate two additional parameters, the flushing rate of copper to San Diego Bay, and the average residence time of water within SIYB. These two parameters were not used by the Regional Board for analysis of the loading capacity.

F -- This represents the flushing rate of total copper to San Diego Bay, i.e. the rate of copper loss from SIYB to San Diego Bay. Since tidal flushing and loading to sediment are almost entirely responsible for movement of copper out of the control volume, the rate of copper loss from SIYB to San Diego Bay is described by Equation *(t)*. This was found to be 1.32 kg/day.

(t) $$F = R_S - R_L$$

T_{res} -- This represents the average residence time of water in SIYB. This was found to be 4.7 days.

Determination of SIYB Loading Capacity Using Copper Box Model

Model based on advection dispersion equation

Various values for R_S were input into the model. From iteration, a value was reached describing the maximum loading (loading capacity) that SIYB can receive and still attain the numeric target (C_2).

	$U_eA_cC_1 = KA_c(dC/dx) + k_LV_2C_2 - R_S$
Assumes:	tidally averaged steady state first order loss to sediment

Inputs:	S_1: background salinity	S_1=	33.46	psu
	S_2: box salinity	S_2=	33.62	psu
	C_1: background concentration	C_1=	0.5	µg/L
	A_c: cross sectional area at boundary	A_c=	1,000	m^2
	A_s: surface area of box	A_s=	740,000	m^2
	e: evaporation rate	e=	0.43	cm/d
	dx: gradient length scale	dx=	2000	m
	V_2: box volume	V_2=	3,100,000	m^3
	k_L: loss rate coefficient	k_L=	7	%/d
	R_S: loading capacity (target loading)	**R_S=**	**1.87**	**kg/d**

Outputs:	K: dispersion coefficient	K=	15.3	m^2/s	
	dS/dx: salinity gradient	dS/dx=	8.04E-05	psu/m	
	U_e: evaporative advective velocity	U_e=	3.68E-05	m/s	
	T_{res}: residence time	T_{res}=	4.7	d	
	C_2: box concentration	C_2=	2.54	µg/L	Numeric target C_2 = 2.54 µg/L (expressed as average total copper)
	F: flushing rate to bay	F=	1.32	kg/d	
	R_L: sediment loading	R_L =	0.55	kg/d	

Determination of Background Copper Loading for SIYB Using Copper

Model based on advection dispersion equation

$$U_eA_cC_1 = KA_c(dC/dx) + k_LV_2C_2 - R_S$$

Assumes:	tidally averaged steady state first order loss to sediment

Inputs:	S_1: background salinity	S_1=	33.46	psu
	S_2: box salinity	S_2=	33.62	psu
	C_1: background concentration	C_1=	0.5	µg/L
	A_c: cross sectional area at boundary	A_c=	1,000	m^2
	A_s: surface area of box	A_s=	740,000	m^2
	e: evaporation rate	e=	0.43	cm/d
	dx: gradient length scale	dx=	2,000	m
	V_2: box volume	V_2=	3,100,000	m^3
	k_L: loss rate coefficient	k_L=	7	%/d
	R_S: external loading	R_S=	0	kg/d

Outputs:	K: dispersion coefficient	K=	15.3	m^2/s
	dS/dx: salinity gradient	dS/dx=	8.04E-05	psu/m
	U_e: evaporative advective velocity	U_e=	3.68E-05	m/s
	T_{res}: residence time	T_{res}=	4.7	d
	C_2: box concentration	C_2=	0.41	µg/L
	F: flushing rate to bay	F=	-0.09	kg/d
	R_L: sediment loading	**R_L =**	**0.09**	**kg/d**

To determine loading from ambient seawater, i.e., "background," the value for R_S was set to zero (this assumes there are no external sources of copper). Then, at steady state, the net background copper loading is equal to the loss of copper to the sediment, R_L. The resulting R_L value was used as "background" in the TMDL analysis and resulting load allocations.

Appendix 4: Margin of Safety Calculations

Ten percent of the loading capacity was reserved as the MOS. The loading capacity (TMDL) was determined using a "box model" based on mass balance principles (Appendix 3). The loading capacity (TMDL) was expressed in terms of dissolved copper. The calculations below demonstrate how the MOS was determined.

MOS = 0.10*(Loading Capacity)
MOS = 0.10*(567 kg/year of copper)
MOS = 57 kg/year of copper

Appendix 5: Allocations

The TMDL is equal to 567 kg/year of copper, as determined in Appendix 3.

Reductions in discharges will not be required from urban runoff, sediment, background, and direct atmospheric deposition. Compared to emissions from antifouling paints, contributions of dissolved copper from these sources are relatively insignificant. All of the required load reductions come from passive leaching and hull cleaning and were assigned as follows.

TMDL = Wasteload Allocations + Load Allocations + MOS

TMDL = Ap + Ah + Au + As + Ab + Aa + MOS
567 kg Cu/year = (Ap + Ah + 30 + 0 + 30 + 3) kg Cu/year + 57 kg Cu/year

Given:
Ap = Allocation for passive leaching
Ah = Allocation for hull cleaning
Au = Allocation for urban runoff
As = Allocation for sediment = Load from sediment
Ab = Allocation for background = Load from background
Aa = Allocation for direct atmospheric deposition = Load from direct atmospheric deposition

The only two unknown variables are for hull cleaning and for passive leaching. The calculation of these allocations is contained below.

Hull Cleaning Allocation

There are two main mechanisms identified in this analysis to achieve reductions in dissolved copper discharges from underwater hull cleaning. The first mechanism involves increasing the use of Management Practices (MPs) by hull cleaners. Approximately half of the underwater hull cleaners at SIYB were assumed to be currently using MPs (Appendix 1). Assuming an increase to 100 percent usage of MPs for hull cleaning results in an approximate 28 percent reduction in copper emissions, as shown in the calculations below.

The second way to achieve reductions in dissolved copper discharges from hull cleaning is to switch to nontoxic and less toxic antifouling paints. This scenario will likely result from the need to meet reductions from passive leaching. Therefore, assuming that both of these measures are implemented, then the reductions achieved from underwater hull cleaning will actually be much greater than the required reduction of 28 percent discussed in this technical report.

Current estimations of 50 percent MP usage result in a copper discharge rate of P = 8.5 $\mu g/cm^2$/event (See Appendix 2b for these calculations). Increasing the usage of MPs from 50 percent to 100 percent results in a lowered copper discharge rate of P = 6.2 $\mu g/cm^2$/event. This results in a loading of approximately 72 kg/year of copper, which is used as the assigned allocation for hull cleaning, Ah. This amounts to a 28 percent reduction in current loading.

Average dissolved copper emissions rate	= (13 µg Cu/cm^2/event + 4 µg Cu/cm^2/event)/2
(both paint types, 50 percent MPs)	= 8.5 µg Cu/cm^2/event
Load from hull cleaning	
(both paint types, 50 percent MPs)	= 98.4 kg/year

Average dissolved copper emissions rate	= (8.6 µg Cu/cm^2/event + 3.8 µg Cu/cm^2/event)/2
(both paint types, 100 percent MPs)	= 6.2 µg Cu/cm^2/event
Allocation for hull cleaning	= 72 kg/year
(both paint types, 100 percent MPs)	

Hull cleaning reduction = (100 percent)*[(100-72)/(100)] kg Cu/year = 28 percent

<u>Passive Leaching Allocation</u>
The remainder of the TMDL allocation is allotted to passive leaching. Returning to the TMDL equation,

TMDL = Wasteload Allocations + Load Allocations + MOS
TMDL = Ap + Ah + Au + As + Ab + Aa + MOS

The only unknown in the calculation above is the allocation for passive leaching, Ap.

567 kg Cu/year = Ap + 72 + 30 + 0 + 30 + 3) kg Cu/year + MOS
Ap = 375 kg Cu/year

Passive leaching will be required to make significant reductions from current estimated loading necessary to reach the TMDL.

Passive leaching reduction = (100 percent)*[(2,000 –375)/(2,000)] kg Cu/year = 81 percent

<u>Summary of Allocations</u>
TMDL = 567 kg Cu/year
Ap = Allocation for passive leaching = 375 kg Cu/year
Ah = Allocation for hull cleaning = 72 kg Cu/year
Au = Allocation for urban runoff = 30 kg Cu/year
As = Allocation for sediment = Load from sediment = 0 kg Cu/year
Ab = Allocation for background = Load from background = 30 kg Cu/year
Aa = Allocation for direct atmospheric deposition = Load from direct atmospheric deposition = 3 kg Cu/year

Appendix 6: Sampling Survey

The Regional Board conducted a Sampling Survey in 2000 to assist in TMDL development by confirming concentration levels for dissolved copper at the Shelter Island Yacht Basin. These measurements were not used to quantify ambient background concentration described in Appendix 3.

Sample station locations were chosen to characterize levels throughout the Basin and to verify the existence of a copper gradient. A total of seven stations were sampled for concentrations on two separate occasions in April and June 2000 using a grab technique. Samples were analyzed using a low detection method of analysis. Results from both sampling days were averaged and are presented in Table A6.1. Station locations are represented by dots on the map in Figure A6.1. The relative size of the “dots” correlate with the concentration of dissolved copper at the sample station. Figure A6.2 presents the change in dissolved copper concentration as a function of distance into the Yacht Basin.

Table A6.1. Results of Sampling Survey for the SIYB.

Station	Average dissolved [Cu] (µg Cu/L)	Latitude (North)	Longitude (West)	Distance from Station G (meters)
A	8.0	32.71797	117.22569	2,007
B	7.7	32.71386	117.22831	1,510
C	5.0	32.71550	117.22989	1,549
D	5.9	32.71683	117.23203	1,607
E	3.5	32.71217	117.23297	1,080
F	2.6	32.70858	117.23514	635
G	1.5	32.70386	117.23131	0

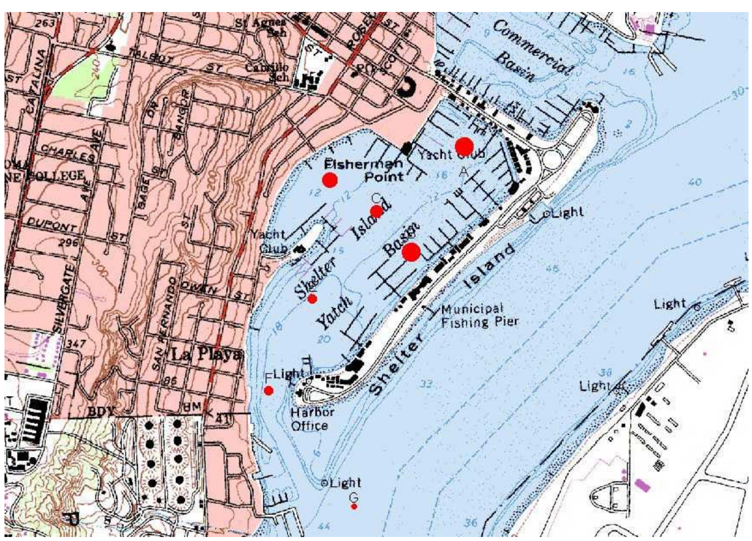


Figure A6.1. Map of the Shelter Island Yacht Basin Sampling Locations.

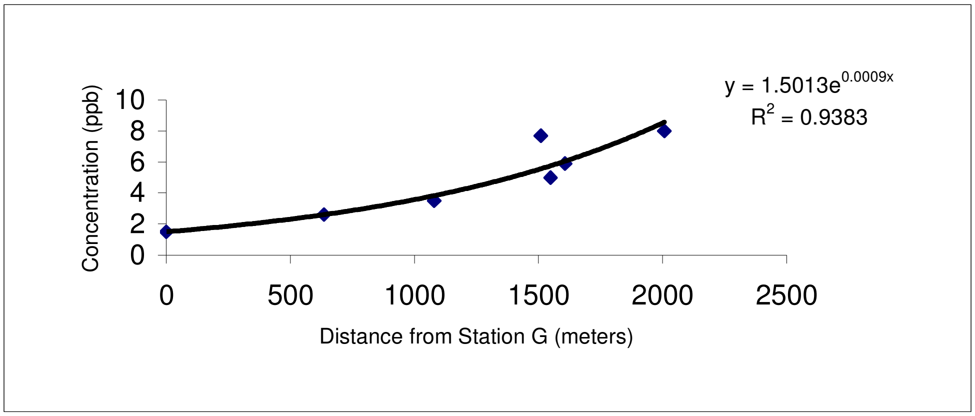


Figure A6.2. Dissolved Copper Concentration versus Distance into the Yacht Basin.

Appendix 7: Peer Review Comments and Responses to Comments

The scientific basis of the SIYB TMDL for dissolved copper underwent external scientific peer review, as required under Health and Safety Code section 57004. Professor Kenneth W. Bruland with the Ocean Sciences Department at University of California, Santa Cruz, reviewed the draft technical TMDL report, dated January 31, 2003.

As a result of peer review comments, modifications were made and incorporated into the technical TMDL analysis. These changes were made primarily to the source analysis discussion on sediment (Section 4, Sediment) and to the critical conditions (Section 8, Critical Conditions). While these modifications are believed to strengthen the technical analysis, they did not result in changes to the source loading estimates, calculation of the TMDL, or determination of the allocations.

Peer Review Comments

The SIYB TMDL for dissolved copper underwent external scientific peer review, as required under Health and Safety Code section 57004. Professor Kenneth W. Bruland, with the Ocean Sciences Department at University of California, Santa Cruz, reviewed the draft technical TMDL report, dated January 31, 2003. Dr. Bruland's comments are contained below in their entirety as provided to the Regional Board on March 14, 2003:

> I have carefully read the technical report for "Total maximum daily load for dissolved copper in the Shelter Island yacht basin." Much of the report is reasonable and appropriate. However, the rationale used to determine a zero mass loading rate associated with sediments is seriously flawed and, as a result, the whole report is flawed and is not reasonable in terms of its water quality objectives. In addition, it is difficult to defend reducing the copper loading from boat paint by 90 percent without data on Water Effect Ratios (WER's) and/or determination and evaluation of free [Cu^{2+}].
>
> It appears that based upon personal communication with Chadwick (2002), the authors of the technical report concluded that sediments are a sink for Cu and the source from sediments is, and will continue to be, zero. The rationale for this is apparently that studies using benthic flux chambers showed that, on average, the net loss of copper from the water column to the sediment is approximately four-seven percent per day throughout the Bay.
>
> There are two processes in which sediments can be a source for dissolved Cu in the overlying water column. First is a simple diffusive flux of pore waters out of the sediments that can be assessed with benthic flux chambers. The second process involves resuspension of sediments by turbulence (due to winds, tidal currents, boat propellers, etc.) and desorption of Cu from the particles to the water. Both processes are dynamic with exchanges in both directions (that undoubtedly vary temporally and spatially). The diffusive fluxes are both into and out of the sediments and adsorption and desorption reactions occur both ways between Cu dissolved in the water and adsorbed on the resuspended sediments.

Studies in the South San Francisco Bay, a system somewhat analogous to San Diego Bay, provide some insight into how important these processes are. Over the last three decades the sewage treatment plants have done a remarkable job of lowering the discharge rate of dissolved Cu into the Bay. However, contaminated sediments remain in the Bay and continue to be a significant source. These contaminated sediments, that once served as a sink for copper when the sources to the Bay were high, now can serve as a source of copper to the dissolved phase when the external loadings have been decreased. Recent estimates of Cu loadings to the South San Francisco Bay found in Gee and Bruland (Geochimica et Cosmochimica Acta, vol. 66, pp. 3063-3083, 2002) include external fluxes from the atmosphere (3,700 kg/year), tributaries (5,000 kg/year) and combined point sources (16,800 kg/year). The diffusive benthic flux is estimated at 860 kg/year. The adsorption and desorption exchange rates between Cu associated with resuspended sediments and dissolved Cu in the water column are estimated to be 20,000 to 44,000 kg/year. Thus, the resuspended sediments are not inert, but are dynamically exchanging Cu with the water column. This sorption exchange rate is far greater than the diffusive benthic flux and is roughly equivalent to the external loadings. What this means is that if the external loading is decreased markedly, there will still continue to be exchange with the historically contaminated sediments as they are resuspended in the water column and that what was a net sink during a period of high loading can become a long-term net source during a period of low loading. It acts to buffer the dissolved Cu concentration and modulate the response to changes in external loading.

What this means to this report dealing with the Shelter Island yacht basin is that Table i and ii are seriously flawed. The sediment source is not zero. The net source today in a time of high Cu loading may be zero, however there is likely to be a high level of exchange between Cu associated with resuspended contaminated sediments and the dissolved Cu in the water. If the South San Francisco Bay study is relevant, this exchange may be on the order of 5,000 kg/year being adsorbed to the particles and 5,000 kg/year being desorbed from the particles – note that in this case the net source or sink would be zero. If however, the external loading of Cu in the SIYB is decreased by 90 percent, then the adsorption term would be decreased, but the desorption term from the historically contaminated sediments would still be high and the resuspension of these sediments would become a net source of easily a few thousand kg/year. The sediments will act as a buffer to slow down the response of the dissolved Cu in the SIYB to lowering the external sources.

Another factor of concern in this report is the lack of any Cu speciation data or WER studies. The report acknowledges that the toxicity of copper is related to the free [Cu^{2+}] or [Cu′], and not the total dissolved Cu concentration ([Cu′] is the sum of the kinetically labile inorganic forms of Cu). Copper bound or chelated with organic ligands is not toxic. Without any data on the extent of organic chelation of dissolved Cu and the levels of free [Cu^{2+}], it is difficult to ascertain whether these extreme steps are necessary. An approach that many estuarine systems are using involves the use of a Water Effects Ratio or WER as a method to evaluate a reasonable numeric target concentration from the water quality criteria. For example, a WER of 2.2 combined with the water quality criteria of 3.1 μg Cu/L would yield a numeric target of 6.8 μg Cu/L. This might be a more reasonable numeric target for the Shelter Island Yacht Harbor, particularly since the only way to reduce the Cu sources from passive leaching and in-water hull cleaning by 90 percent would be to ban all the boats from the yacht harbor. A cost effective and reasonable alternative would be to carry out studies to assess the WER for this basin and complement this with some Cu speciation studies to determine the concentration of Cu-binding ligands and the free [Cu^{2+}]. With this knowledge you would be in a position to arrive at a reasonable and justifiable numeric target concentration of dissolved Cu.

The Regional Board presented a number of specific questions regarding scientific issues to the peer reviewer. The questions and the peer reviewer's comments follow:

<u>Scientific issues that require peer review:</u>

1. *[Regional Board question] Is the fate and transport of dissolved Cu, including physical and chemical processes, and biological uptake and assimilation adequately and correctly addressed?* [Peer Review comment] I would argue that they are not adequately addressed. Phytoplankton and bivalve larvae are the most sensitive organisms to copper toxicity and the copper toxicity is most closely related to the concentration of [Cu^{2+}], rather than dissolved Cu. This report, however, does not address these issues. It is missing WER studies and missing any copper speciation studies or measurements of [Cu^{2+}]. Data that is critical to arrive at rational and justifiable action.

2. *[Regional Board question] Are the sources of dissolved copper in the watershed adequately and correctly addressed?* [Peer Review comment] I am not convinced that they have adequately addressed the issue of the first street runoff of the year when the copper accumulated from the wear of vehicle brake pads, etc., is washed off into the storm runoff drains and into the basin. This first "rinse" and runoff can be the major input for the year.

3. *[Regional Board question] Are the calculations used to determine dissolved Cu mass loading associated with the sources reasonable and accurate?* [Peer Review comment] Reasonable assumptions were used for most of the sources. Unreasonable assumptions were used with respect to the sediments being a source. Desorption of Cu from resuspended historically contaminated sediments is ignored. Accuracy of any of the source estimates is difficult to assess. Various assumptions were required to come to these estimates. Although the estimates are presented with 4 significant figures (I am shocked that 4 significant figures are used in Table i and ii), none of the estimates are known better than a factor of 2, at best!

4. *[Regional Board question] Is the rationale used to determine a zero mass loading rate associated with sediment reasonable?* [Peer Review comment] No. This is based upon a lack of understanding of the processes involved.

5. *[Regional Board question] Based on the physical and hydrological characteristics of Shelter Island Yacht Basin, is the estimated loading capacity reasonable?* [Peer Review comment] No, because they neglect the sediment sources.

6. *[Regional Board question] Have the correct data gaps been identified in the analysis, particularly in the Source Analysis and in the Linkage Analysis sections?* [Peer Review comment] In most cases – yes. In other cases already discussed – no.

7. *[Regional Board question] Is the margin of safety incorporated into the TMDL of a reasonable magnitude to account for uncertainty?* [Peer Review comment] I think it was unreasonable. It was not based upon the relevant science issues – measurements of WER's and free [Cu^{2+}].

8. *[Regional Board question] Are data used in the report reliable and appropriate, and is the treatment of the data defensible?* [Peer Review comment] The data used appeared reliable and appropriate. Some critical data is missing. I think the sediment source data was misinterpreted and the interpretation of the sediments as being a zero source term is not defensible.

Responses to Peer Review Comments
A summary of Dr. Bruland's comments and the Regional Board's responses to his comments are contained below:

1. Comment on Sediment
<u>Summary of Peer Review Comment</u>
Sediment is not a zero source of copper to SIYB. Although sediment may currently act as a net *sink* for copper in the water column, it has the potential to act as a net *source* in the future. During a period of low external loading, sediment that once acted as a net sink for copper can become a long-term net source through exchange with historically contaminated sediments that are resuspended in the water column. As copper in sediments is resuspended, it may act as a buffer to slow down the reductions in copper concentrations in the water column that would be expected from decreased loading of other sources to SIYB.

In the Implementation Plan of this report, the Regional Board recognizes that the contribution of sediment to copper concentrations in the water column should be reassessed in the future to determine if sediment acts as a more significant source, as primary sources, such as copper-based antifouling paints, have been decreased. . Further studies are probably necessary to better understand this phenomenon. If studies demonstrate that sediment is, or could become a significant source once primary sources are decreased, then the TMDL and allocations could be amended at a later date. An allocation for sediment loading could be assigned to the dischargers responsible for the sediment contamination.

2. Comment on Water Effects Ratio (WER)
<u>Summary of Peer Review Comment</u>
An evaluation of the Water Effect Ratio (WER) and/or the free copper ion at SIYB should be conducted to determine a reasonable numeric target concentration.

<u>Regional Board Response</u>
Numeric targets in the TMDL are set equal to numeric water quality criteria (WQC) for dissolved copper as contained in the California Toxics Rule (CTR). The CTR's numeric criteria

serve as legally applicable water quality standards in the State of California for inland surface waters, enclosed bays and estuaries for all purposes and programs under the Clean Water Act (CWA). Criteria are derived based on a rigorous set of guidelines to provide both short-term and long-term protection to aquatic life. In the absence of site-specific objectives, the CTR's water quality criteria represent the most appropriate water quality objectives and therefore numeric targets for dissolved copper at SIYB.

The Regional Board recognizes that there are situations where site-specific conditions affect the toxicity of a pollutant, which results in a criterion that is over- or under-protective. WQC are primarily based on studies conducted using laboratory water in which organisms are exposed to one pollutant. Site-specific objectives (SSOs) adjust water quality objectives to account for differences in toxicity among sites based on site-specific information and scientific studies. SSOs must protect the beneficial uses of a waterbody and be developed in accordance with federal and State laws and regulations based on sound scientific rationale.

There are a number of the USEPA approved procedures that can be used to establish site-specific objectives, including the water effect ratio (WER) procedure. The WER procedure adjusts WQC to account for a site's water chemistry based on the ratio of the toxicity of a chemical in site water to the chemical's toxicity in laboratory water. This procedure is commonly used to determine whether chemical or physical conditions of a waterbody will cause a pollutant to be less bioavailable and therefore less toxic.

The toxicity of copper to aquatic life is influenced by the species and complexes that copper forms in seawater. Copper toxicity is most closely related to the concentration of free ions and weak inorganic complexes, as compared to the total or dissolved copper concentration. WQC have been developed and approved by the USEPA for the dissolved copper concentration, but not yet for the free ion concentration.

The Regional Board agrees that investigating the relevance of SSOs for copper at SIYB may be appropriate. At a public hearing on June 10, 2004, marina owners and operators residing in SIYB requested that the Regional Board include a Basin Plan issue on developing SSOs as part of the Triennial Review of the Basin Plan. This group announced that they had initiated scientific studies necessary for development of site-specific objectives for dissolved copper in SIYB. As a result, the Regional Board prepared a Triennial Review issue titled "Water Quality Objectives for Copper at Shelter Island Yacht Basin." This issue was assigned a technical ranking and score relative to other Triennial Review issues. This issue was ranked 31st on the prioritized issue list. The Triennial Review was completed on September 8, 2004. As the 31st ranked issue, it is not slated to receive basin planning resources for investigation over the next three years. However, developing a site specific objective for copper in SIYB waters may be feasible over the 17-year compliance period. Therefore, the draft Basin Plan amendment has been revised to include provisions for recalculating the TMDL, allocations, and reductions in the event that the water quality objective for copper in SIYB is changed.

Since it could take years for SSOs to be adopted into the Basin Plan, the appropriate strategy is for the Regional Board to proceed with adoption of the TMDL at this time mandating copper load reductions. When site-specific copper water quality objectives are developed for SIYB, this

TMDL will be modified accordingly. The Regional Board will not delay adoption of this TMDL mandating copper load reductions on the premise that a site-specific copper water quality objective must first be developed. Studies by interested parties supporting the development and adoption of SSOs may occur concurrently with actions by dischargers to meet compliance with this TMDL. Development of site-specific objectives is discussed in more detail in the State's *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed bays, and Estuaries of California* (State Board, 2000).

3. Comment on Ways to Reduce Copper Loading to SIYB

Summary of Peer Review Comment

The only way to significantly reduce copper loading from passive leaching and underwater hull cleaning would be to ban all the boats from the yacht harbor.

Regional Board Response

The Regional Board believes that there are alternative ways to meet load allocations from passive leaching and underwater hull cleaning that do not rely on banning boats from the Yacht Basin. Implementation of MPs to address passive leaching and hull cleaning will reduce copper loading from antifouling paints. MPs include switching to nontoxic or less toxic antifouling paint that does not contain copper, the use of slip-liners filled with freshwater to contain a vessel hull when it is not in use, the use of nonabrasive techniques when cleaning copper paints on vessel hulls underwater, and storage of boats out of the water when not in use. The most effective means to meet reductions involves switching to nontoxic and less toxic antifouling paints on vessel hulls. Copper antifouling paints are registered as pesticides through the regulatory authority of the California Department of Pesticide Regulation (DPR). The Regional Board is working with the DPR through a Memorandum of Understanding (MOU) to help resolve water quality problems caused by copper-based antifouling paints. The DPR has the authority to impose restrictions on, or cancel the registration of, pesticides in California. The Implementation Plan of this report includes a discussion on the coordination between the Regional Board and the DPR on this issue.

4. Comment on Urban Runoff

Summary of Peer Review Comment

Urban runoff can be a major input of copper through the "first flush" effect of a storm, and should be adequately addressed as a source in the source analysis. Copper accumulates through numerous sources in the urban environment including the wear of vehicle brake pads. This accumulation is washed off into the storm drains during storm events, particularly during the "first flush" of the year.

Regional Board Response

Urban runoff can be a significant source of heavy metals to a watershed. The contribution of urban runoff as a source of copper to SIYB was determined in the TMDL analysis to account for less than one percent of total loading. Urban runoff was found to be an insignificant source of copper, probably due in large part to the small size of the subwatershed that drains to SIYB. In a receiving waterbody with a larger watershed drainage area, or one with fewer sources that contribute such high loads of copper (as in the case of recreational vessels at SIYB), the proportional contribution of copper loading coming from urban runoff could be expected to be much greater.

In order to calculate the dissolved copper contribution from urban runoff to SIYB during wet weather, information was compiled from the San Diego County MS4 Copermittees' annual Wet Weather Monitoring Reports (City of San Diego, 2000a). Data was compiled and averaged from five years of monitoring data collected during storm events from 1994/95 to 1998/99. During storm events, direct measurements of pollutant concentrations in flow-weighted composite samples were collected using automatic samplers from three residential land use monitoring stations in the county of San Diego. Each station was sampled annually during three storm events, which included the first two storm events of the wet weather season, as defined by the USEPA's storm event criteria [40 CFR 122.21(g) (7)]. Automatic samplers were used to collect flow-weighted samples over the storm's entire hydrograph. Thus, the copper load from urban runoff during wet weather to SIYB was estimated based on direct sampling of three storm events over five years.

Data was not available in San Diego County to estimate copper loading to SIYB from urban runoff during dry weather. Dry weather loading of copper was assumed to be equal to wet weather loading of copper to SIYB. However, this is a source of uncertainty that should be reassessed in the future as more data becomes available. More information on urban runoff is provided in the source analysis (Section 4, Urban Runoff). Source estimate calculations are shown in Appendix 2.

5. Comment on Significant Figures

Summary of Peer Review Comment

Although the source analysis estimates are presented with four significant figures, none of the estimates are known better than a factor of two.

Regional Board Response

The Regional Board agrees with the peer review comment about significant figures, and the tables were adjusted accordingly.

6. Comment on Loading Capacity

Summary of Peer Review Comment

The estimated loading capacity is not reasonable because sediment was neglected as a source.

Regional Board Response

Sediment was appropriately addressed as a potential source of copper to SIYB at this time, and the tendency of sediment to act as a sink for copper was incorporated into the calculation of the loading capacity.

The loading capacity for copper at SIYB is the maximum amount of dissolved copper that can enter the Basin and remain in the water column without exceeding the numeric target. The loading capacity is a function of the different hydrodynamic processes, such as circulation, tidal flushing, and sediment flux, that affect the environmental fate and transport of dissolved copper. The loading capacity was determined through the use of a "box model" based on general mass-balance principles. The determination of the loading capacity was dependent on input parameters, including the numeric target, natural background copper concentration, salinity measurements to quantify local dispersion, and sediment flux. The net flux of copper from the sediment to the water column was incorporated into the model to estimate the loading capacity. Greater discussion of the model is presented in the source analysis and in Appendix 3.

7. Comment on Margin of Safety

Summary of Peer Review Comment

The margin of safety incorporated into the TMDL to account for uncertainty was unreasonable since it was not based upon measurements of the WER and free copper ion.

Regional Board Response

A ten percent explicit Margin of Safety (MOS) was incorporated into the TMDL to account for uncertainty in the source analysis and analysis of the loading capacity. In addition, an implicit MOS was incorporated into the TMDL through conservative assumptions made in the source analysis. The MOS was not based on data on the WER and free copper ion concentration since this information was not available.

Appendix 8: Public Participation

Public participation is an important component of TMDL development and effective implementation. Public participation has been provided for through two public workshops, numerous stakeholder group meetings and communications, and public presentations and participation at relevant conferences. In addition, staff contact information has been provided on the Regional Board's web site, along with periodically updated drafts of TMDL documents throughout the development process. Public participation will also be provided for through the Regional Board's Basin Plan amendment process, which includes a public workshop (bringing the total number of workshops to three) and formal public comment period. A chronology of public participation and major milestones is provided below:

Date	Event
05/00 - Ongoing	Web Site – Information including drafts of the technical report and contact information were made available on the Regional Board's web site.
05/17/00	Public Workshop – The Regional Board conducted a public workshop about the TMDL project.
06/28/00	Stakeholder Meeting – The Regional Board met with representatives from the San Diego Unified Port District (Port) about the TMDL project.
09/05/00	Marine Recreation Committee – The Regional Board attended and provided an update on the project at a stakeholder meeting of the San Diego Port Tenants Association.
09/06/00	Stakeholder Meeting – The Regional Board met with representatives from the Port about the TMDL.
09/21/00- 09/22/00	Alternative Antifouling Strategies for Recreation Boats: A Working Conference – The Regional Board participated in a conference on alternative antifouling strategies, and made a presentation on the TMDL project. Attendees included representatives from the boating and antifouling industries, boat owners, and environmental agencies and universities.
11/09/00	Stakeholder Meeting – The Regional Board met with representatives from the DPR about the TMDL project.
12/01/00	Stakeholder Meeting – The Regional Board met with representatives from the San Diego Port Tenants Association about the TMDL project.
12/11/00	Stakeholder Meeting – The Regional Board met with representatives from the Port about the TMDL project.

01/09/01	Stakeholder Meeting – The Regional Board met with representatives from the San Diego Port Tenants Association about the TMDL project.
03/01/01	Project Advisory Committee – The Regional Board served on a joint advisory committee for two projects related to recreational boating and water quality. The projects were the "Demonstration of Nontoxic Boat Bottom Paints in San Diego Bay" conducted by University of California Sea Grant Extension Program (Sea Grant), and "Assessing Effectiveness of Various Management Practices for Underwater Hull Cleaning" conducted by SCCWRP. These projects were funded in part by CWA section 319(h) grants.
03/23/01	Quarterly Commissioner's Pesticide Meeting – The Regional Board presented an update on the TMDL project at the San Diego County Department of Agriculture, Weights and Measures.
04/17/02	San Diego Advisory Committee for Antifouling Paints – The Regional Board served on the San Diego Advisory Committee for Superior Antifouling Paints. The purpose of the committee was to advise in the preparation of an economics report on the cost associated with transitioning to nontoxic antifouling paints in San Diego Bay. The formation of this committee was mandate through Senate Bill 315 (Alpert). Members of the committee included representatives from the Regional Board, DPR, Sea Grant, Port Tenants Association, Port, Environmental Health Coalition, US Navy, a marina, a boater, and a boatyard. (First of three meetings)
06/14/02	San Diego Advisory Committee for Antifouling Paints – The Regional Board participated in the advisory committee. (Second of three meetings)
07/21/02-07/26/02	11th International Congress on Marine Corrosion and Biofouling-The Regional Board participated in an international conference on marine biofouling, and made a presentation on the TMDL project.
09/19/02	San Diego Advisory Committee for Antifouling Paints – The Regional Board participated in the advisory committee. (Third of three meetings)
10/02/02	Stakeholder Meeting – The Regional Board met with representatives from the San Diego Advisory Committee for Antifouling Paints.
03/19/03	Public Workshop and CEQA Scoping Meeting
07/31/03	Stakeholder Meeting – The Regional Board met with the DPR, USEPA, CAC, and State Board to discuss the TMDL project.

09/6/03	Copper Summit – The Regional Board participated in a meeting coordinated by the DPR and the State Bard to discuss copper pollution throughout California and the SIYB TMDL for dissolved copper. Attendees included the California Coastal Commission (CCC), State Board and various California Regional Water Quality Control Boards, the DPR, USEPA, and Sea Grant
10/20/03	Stakeholder Meeting – The Regional Board met with the Port to discuss the TMDL project.
10/21/03	Stakeholder Meeting – The Regional Board met with marina operators to discuss the TMDL project.
10/21/03	Stakeholder Meeting – The Regional Board met with underwater hull cleaners and boat owners to discuss the TMDL project.
10/23/03	Stakeholder Meeting – The Regional Board met with members of the environmental community to discuss the TMDL project. Attendees included representatives from the Environmental Health Coalition, San Diego Bay Keeper, Surfrider and the Audubon Society.
10/24/03	Draft TMDL Technical Report and Implementation Plan released for formal public review and comment period.
11/17/03	Public Workshop
12/10/03	Public Hearing
9/07/04	Stakeholder Meeting – The Regional Board met with representatives of boat and paint manufacturers' organizations, along with representatives of marina operators at SIYB to discuss the Implementation Plan.
10/14/04	Revised Draft TMDL Technical Report and Implementation Plan released for formal public review and comment period.
12/03/05	Stakeholder Meeting - The Regional Board met with representatives from paint manufacturing companies to discuss the TMDL project.
01/19/05	Stakeholder Meeting – The Regional Board met with representatives from marinas/yacht clubs in SIYB to discuss development of site-specific objectives for dissolved copper in SIYB.
[02/09/05]	Regional Board Deliberates

Appendix 9: Nontoxic Antifouling Strategies Sampler[37]

Although nontoxic coatings will not slow fouling growth, they can be effective when used in a strategic combination with other methods. Nontoxic antifouling strategies may combine nontoxic coatings with slip liners, boat lifts, mechanical hull cleaning and/or frequent use. The following table describes several alternatives, their benefits and challenges. Information is compiled from manufacturer's data and experience of San Diego area boat repair yards and underwater hull cleaners. These products are relatively new, experience with them is limited and independent evaluation of long-term costs, benefits and performance is needed. The table is intended for educational purposes and does not constitute an endorsement or recommendation of any product. Investigate products carefully! Ask local boat repair yards and hull cleaning services about which nontoxic coatings have performed well in that area. Ask manufacturers for copies of independent tests of their products and references to others who have purchased them.

Antifouling Strategy Product Examples [2]	Manufacturers' Comments on Benefits [1]	Manufacturers' Comments on Challenges [1]
Silicone Coatings Interlux Veridian* (\$405/gallon covers 200 square feet (ft^2)) Protect Associates Water Shield (formerly Miracle Cover)* (\$29/gallon covers 150 ft^2) Kiss-Cote MegaGuard* (\$175/4 oz. covers 4000 ft^2) CSL Silicones Si-Cote 579* (\$72/gallon covers 50 ft^2) Eccotech Wearlon* (\$224/gallon covers 300 ft^2)	✓ Maintenance: Fouling easily removed if cleaned regularly/can be self-cleaning if vessel is used regularly ✓ Performance Capabilities: Can be used in variety of environments ✓ Slick Surface: Decreases drag and fuel consumption, improves speed, reduces engine load ✓ Creates slippery surface difficult for marine organisms to grow on ✓ Durability: Some products can last several years	o Hull preparations vary for each coating o Boatyard needs dedicated application area and equipment[5] o Safety Consideration: Boat bottom may become slippery o Must use craft often to decrease fouling o Coating is easily nicked or abraded o Requires regular cleaning to retain performance benefits: Frequency dependent on water temperature and boat use
Siloxane Coatings Adsil AD-100 (\$240/3 pints covers 200 ft^2) NewCoat Technology Sea-Speed (\$350/gallon covers 144 ft^2)	✓ Hard, smooth, slippery surface to which organisms have difficulty attaching ✓ Drag reduction decreases fuel consumption ✓ Can be applied to all surfaces including aluminum	o Clean and sand surface before application o New products; contact manufacturers about cleaning schedule
Epoxy Coatings Sound Specialty Coatings Corporation AquaPlyM* (\$280/2 gallons covers 450 ft^2)	✓ Maintenance: Early stages of marine growth can be removed with high pressure washing or scrubbing ✓ Provides fast, hard, and slippery surface for vessel ✓ Durability: Manufacturer reports some boats have had coating for ten years	o Remove old coating before application o Bottom cleaning may be needed twice monthly in warmer waters[3]

37 Johnson, Leigh T. and Jamie A. Miller. 2002. Nontoxic Antifouling Strategies Sampler. In: What You Need to Know about Nontoxic Antifouling Strategies for Boats. California Sea Grant College Program Technical Report T-049: 6-7. This information is taken primarily from manufacturer's reports.

Ceramic-Epoxy Coatings Freecom, Inc. CeRam-Kote 54* ($150/gallon covers 128 ft^2)	✓ Maintenance: Early stages of marine growth can be removed with high pressure washing or scrubbing ✓ Protection: Against corrosion, abrasion, blisters ✓ Durability: Manufacturer reports some boats have had coating for six years	o Remove old copper paint, clean and sand hull o Spray on for best results o Requires regular cleaning depending on boat use to maintain performance benefits; bottom cleaning may be needed twice monthly in warmer waters[3]
Fiber-Epoxy Coatings Sealcoat ($50/gallon epoxy and $15/pound fibers)	✓ Maintenance: Organisms that attach should fall off eventually due to their weight ✓ Movement of fibers expected to help prevent attachment of organisms ✓ Protection: Against corrosion and condensation	o Fibers can be damaged from rough scraping or close contact with chemicals o Remove old paint and apply barrier coat o Bottom cleaning may be needed twice monthly in warmer waters[3]
Polymer Coatings Performance Marine Corporation Marine Skin ($199.95/gallon covers 200-300 ft^2)	✓ Slick Surface: Reduces drag, cuts fuel costs, increases speed ✓ Creates slippery surface difficult for marine organisms to grow on ✓ Designed to replace standard antifouling paints	o Recommended as a seasonal coating o Bottom cleaning may be needed twice monthly in warmer waters[3]

Water-Based Urethane Interpolymer Dispersion American Marine Coatings Sea-Slide ($169.95/gallon covers 700-900 ft^2)	✓ Drag-reducing overcoating (can also be used as primary coating): Reduces friction between boat hulls and surrounding water	o Once cured, the coating should not be scrubbed or sanded
Bottom Wax Boat Armor EasyOn Bottom Coating ($20.70/15 oz treats 24 foot vessel) Aurora High Performance Bottom Wax ($29.99/15 oz treats 24 foot vessel)	✓ Barrier coat that applies with a soft cloth or damp sponge over existing bottom paint or new surfaces ✓ Slick surface: Reduces hull drag, increasing speed and reducing fuel consumption	o Seasonal coating (4-6 months) o Must be cleaned often to reduce fouling growth; bottom cleaning may be needed twice monthly in warmer waters[3]
Slip Liners Bottom Liner ($940 for 25 foot vessel) Armored Hull ($815 for 28 foot vessel)	✓ Eliminates need for antifouling paint and underwater hull cleaning (if boat is always returned to liner[5])	o Add 10-15 percent freshwater into slip enclosure to reduce fouling (check local regulations[5]) o Outside of liner will foul o Lines that suspend it may stretch and sag[4]
Boat Lifts (Prices depend on dock, water depth, boat model and size) AirBerth, Galva-Lift, HydroHoist	✓ Eliminates need for antifouling paint and underwater hull cleaning (if boat is always returned to lift[5]) ✓ Wide range of models available to fit variety of boats and docks	o Some models can be expensive for boaters who go out daily o May not be allowed or feasible in some marinas[5]
Mechanical Cleaning (Contact vendors for prices) Diving Service: Hand or Power Tools	✓ Works together with bottom paint to remove fouling growth ✓ Allows growth to be removed in early stages before it becomes firmly established	o Recommended to clean at regular intervals appropriate to water temperature and frequency of use of boat

Scrubbing Stations: Boat Scrubber, Marina-Tec, (and others)	✓ Cleaning frequency and type of cleaning tool for divers depend on water temperature, type of paint, frequency and speed of boat use ✓ Water and metals can be contained in tank recovery systems at scrubbing stations	o Owner must schedule and pay for diving service to visit boat o Boat must be taken to scrubbing station

1 ***Independent evaluation of long-term performance on recreational boats is needed for all products***
2 ***Disclaimer:*** *These examples are provided for purposes of illustration and do not constitute an endorsement or recommendation.*
Prices listed were effective in June 2002. Ask your marine supply dealer or boat repair yard for current prices of each product of interest. (References for pricing are listed). Ask local boat repair yards and underwater hull cleaning services how each product has performed in your area. Ask manufacturers for product data and reports of independent testing.
3 ***San Diego area experience***
4 ***Author's observation***
5 ***Reviewer's comments***

Special Notes:
Check with individual product labels for special considerations. Alternative hull coatings require a clean, smooth surface for best adherence. This varies with the type of nontoxic coating, the condition of the existing antifouling and undercoatings, and the condition of the hull.

* Epoxy and silicone based coatings generally require that dissimilar antifouling coatings be removed and an epoxy undercoat be applied (Wilson 2002; Roberts 2002).

Appendix 10: Global and Regional Efforts to Address Copper-Based Antifouling Paints

This appendix describes the global and regional efforts that are ongoing to address water quality problems resulting from copper antifouling paints. It also describes current laws, restrictions and recommendations pertaining to the gradual phase-out of copper antifouling paints.

Extent of the Problem: Statewide, National and Global Focus

Copper-based antifouling paints are recognized as a problem of statewide, national and global concern due to the potential for pollution in areas of heavy boating. Copper has been identified as a problem on the CWA section 303(d) list of impaired waterbodies in areas of California that include San Diego Bay (SIYB), Newport Bay and Marina del Rey. As part of the Southern California Bight 1998 regional monitoring study, sediments from marinas throughout southern California had consistently elevated copper levels and demonstrated frequent toxicity. Other areas throughout California are expected to have elevated copper levels in marinas. However, more studies are needed to document the extent of the problem.

Copper has also been identified as a problem of concern in the nation and worldwide. According to the USEPA, copper is the most common pollutant found in U.S. marinas at toxic levels (USEPA, 1993). Elevated levels of copper have been documented in areas in Florida, Washington and Maryland (Johnson and Miller, 2002). In 1999, the State of Washington banned underwater hull cleaning of ablative copper-based antifouling paints due to environmental concerns (Washington State Department of Ecology, 1999b). Copper pollution associated with antifouling paints has also been identified as a problem in areas throughout Europe, including Sweden, Denmark, and the Netherlands (Johnson and Miller, 2002).

Other TMDLs in California

In order to address these impairments, a TMDL and implementation plan has been developed for SIYB in San Diego Bay. In addition, a technical TMDL was developed by the USEPA, and the California Regional Water Quality Control Board, Santa Ana Region, will develop an implementation plan for Newport Bay. In the technical TMDL for Newport Bay, copper coatings on boat hulls in marinas were identified as a significant source of the copper problem. A TMDL and implementation plan will be developed for Marina del Rey in the near future, and copper paints on boat hulls are expected to be a significant contributor to the copper problem.

Copper Summit

On September 16, 2003, a Copper Summit interagency meeting was held in Sacramento to discuss the extent of the problem statewide, and the availability and need for data concerning copper antifouling paints and water quality. The interagency meeting was coordinated through the Management Agency Agreement (MAA) coordinators at the State Board and the DPR. Attendees included representatives from the State Board, various California Regional Water Quality Control Boards, the DPR, CCC, San Francisco Bay Conservation and Development Commission, Santa Monica Bay Restoration Project and State Parks and Recreation. The meeting's participants concluded that while copper is recognized as a problem in many areas of high boating activity, more data is needed to characterize the extent of the problem in California.

Bans on the Use of Copper Paints
Copper-based antifouling paints have been restricted or banned on recreational vessels in Europe in Sweden, the Netherlands, and in Denmark (Johnson and Miller, 2002). Furthermore, the European Union has asked the International Maritime Organization to ban all antifouling paints that are known to be toxic (Johnson and Miller, 2004).

California's Nonpoint Source Program
Section 319 of the CWA established the Nonpoint Source Management Program to help address nonpoint source pollution at the State and local levels. In California, the CCC and the State Board developed the Plan for California's Nonpoint Source Pollution Control Program (Program Plan) to respond to nonpoint source pollution (State Board and CCC, 2000). The Program Plan describes categories of Management Measures (MM) that serve as goals for dealing with nonpoint source pollution, and presents a 15-year strategy for fully implementing the MMs. The primary goal of the program is to measurably improve water quality through the implementation of MPs. MMs are organized according to six categories, including a category on marinas and recreational boating. Actions described in the marinas and recreational boating MMs include minimizing the use of toxic bottom paints, prohibiting discharges of these substances to State waters, and increasing the availability and use of less toxic and nontoxic recreational antifouling paints. Other actions identified to achieve the MMs include the phase out of the use of toxic hull paints on State and local agency-owned vessels. Another action identified in the Program Plan includes the consideration of the development of legislation to prohibit the sale and use of toxic hull paints, as necessary after a thorough analysis of situation. Lastly, MM actions include public education, outreach, and training programs to prevent and control the discharge of pollutants into State waters.

The USEPA's Management Measures for Marinas and Recreational Boating
The USEPA has produced a technical guidance and reference document, *National Management Measures to Control Nonpoint Source Pollution from Marinas and Recreational Boating*, to assist in implementing nonpoint source pollution management programs, including TMDLs (USEPA 2001). The document identified specific practices that relate to marinas and recreational boating to minimize the release of paint into marinas, and are described below:

- Prevent in-water hull scraping or other abrasive techniques that release paint into the environment;
- Switch to long-lasting and low-toxicity or nontoxic antifouling paints; and
- Apply antifouling paints in ways that will help reduce the impact to the environment.

2002 Carson Report on Economic Incentives (SB 315)
California Senate Bill 315 (Alpert), chaptered in October 2001, created a state-mandated local program to develop a report on the economic incentives necessary to ensure that nontoxic alternatives to metal-based antifouling hull coatings are used for recreational vessels. Funds were authorized from the California Department of Boating and Waterways (DBW), and the report was developed by an economics professor at University of California, San Diego, Dr. Richard Carson, in conjunction with Sea Grant. The report, which was made avaliable to the

State legislature, focused on the economics associated with a transition to nontoxic antifouling paints in San Diego Bay. According to the report, every major paint company is studying biocide-free antifouling paints (Carson *et al*., 2002). Representatives from the Regional Board served on an advisory committee for the developemnt of this report, the San Diego Advisory Committee for Environmentally Superior Antifouling Paints (see below). Greater discussion of the Carson report is contained in the Economics Analysis.

San Diego Advisory Committee for Environmentally Superior Antifouling Paints
California Senate Bill 315 (Alpert), chaptered in October 2001, established the San Diego Advisory Committee for Environmentally Superior Antifouling Paints. The purpose of the committee was to make recommendations and advise in the preparation of a report that identified incentives necessary to ensure that nontoxic alternatives to metal-based antifouling hull coatings are used for recreational vessels. Members of the committee included representatives from the Regional Board, DPR, Sea Grant, Port Tenants Association, Port, Environmental Health Coalition, US Navy, DBW, a marina, an underwater hull cleaner, a boater, and a boatyard.

Alternative Antifouling Strategies for Recreational Boats: A Working Conference
A conference on alternative antifouling strategies, "Alternative Antifouling Strategies for Recreational Boats: A Working Conference", was held on September 21-22, 2000, and was sponsored by Sea Grant, San Diego Port Tenants Association and the Port. Attendees included representatives from the Regional Board, boating and antifouling industries, boat owners, policy makers, and environmental agencies and universities. Draft recommendations that came out of the conference included a need for a legislative hearing on copper pollution to help assess the extent of the problem and current knowledge (Johnson, 2000). Also identified were research needs, including an economic analysis, demonstration projects of alternative antifouling strategies, and basic research (Johnson, 2000).

Public Education Materials and Efforts
A number of public education and outreach efforts are ongoing in California to address copper pollution from antifouling paints. Sea Grant has been actively involved in educating the boating community in southern California about alternative antifouling strategies. For example, Sea Grant is conducting a demonstration project of nontoxic hull coatings on recreational vessels as part of a CWA 319(h) grant to promote the use of nontoxic antifouling paints for recreational vessels in San Diego Bay. They have also coordinated and participated in conferences related to copper pollution from antifouling paints such as "Alternative Antifouling Strategies for Recreation Boats: A Working Conference", and the "11th International Congress on Marine Corrosion and Biofouling." Sea Grant has developed numerous outreach materials and brochures, including:

- Making Dollars and Sense of Nontoxic Antifouling Strategies for Boats" (Johnson and Miller, 2003)
- What you Need to Know About Nontoxic Antifouling Strategies For Boats (Johnson and Miller, 2002)
- Transitioning to Non-Metal Antifouling Paints on Recreational Boats in San Diego Bay (Carson et al., 2002)

- Staying Afloat with Nontoxic Antifouling Strategies for Boats (Johnson and Miller, 2004)
- Clean Boating Tips (Johnson and Clifton, 1995)
- Clean Boating Guide (Johnson et al., 1995)

Other agencies and groups are also conducting additional outreach and educational efforts to address pollution from marinas and recreational boating. For example, the CCC has published the California Clean Marina Guidebook (2nd Draft) and coordinates the Boating Clean and Green Campaign and the California Clean Boating Network. The Boating Clean and Green Campaign and the California Clean Boating Network are examples of educational programs designed to promote environmentally sound boating practices to marine business and boaters in California. In addition, the Santa Monica Bay Restoration Project, a coalition of environmentalists, government, scientists, business and the public is working on a diver certification program to certify underwater hull cleaners in the use of MPs. The program, funded through a CWA 319(h) grant, is designed to educate divers about the use of MPs to reduce copper loading to the environment. Currently in southern California, the California Professional Divers Association is coordinating a voluntary diver certification program in the use of MPs for underwater hull cleaning. Education and outreach to the boating community and the public is extremely important to increase awareness about copper pollution in marine waters and ways to prevent it.

Appendix 11: Restrictions on Tributyltin (TBT) Antifouling Paints

Tributyltin (TBT) is an extremely toxic chemical that was a common component of antifouling paints used on recreational vessels prior to restrictions on its use that took place in 1988. TBT is very effective as a component of antifouling paint, more effective than copper-based antifouling paints and longer lasting. Its use on vessels increased in the 1970s and 1980s, replacing in popularity antifouling paints that relied solely on copper as the toxic agent. However, TBT is highly toxic to marine and freshwater aquatic organisms, and accumulates in water and sediment. TBT bioaccumulates in oysters and mussels, fish and in sea otters, and is especially toxic to bivalves (State Board, 1988). Over time, TBT naturally breaks down in the environment though biodegradation (unlike copper), adsorption onto sediment and bioconcentration.

In the 1980s, researchers began to recognize the environmental problems associated with TBT coatings. Elevated levels of TBT were found throughout the nation in California, Virginia, Maryland, Canada, and in areas of Europe. Monitoring in the late 1980's in California by the State Board and other agencies found that TBT concentrations in the water column were elevated one to two orders of magnitude over acceptable levels in areas of heavy boating activity (State Board, 1988).

In 1986, the State Board requested that the California Department of Food and Agriculture (CDFA) reevaluate the registration of pesticides containing TBT (State Board, 1988).[38] In March 1987, CDFA placed TBT under reevaluation. Concurrently, the California legislature enacted a bill (AB 637) that took effect in January 1, 1988 that made it illegal to sell or use TBT coatings, except on vessels 25 meters (82 feet) or greater or on aluminum vessels or parts. On January 2, 1988, CDFA adopted regulations that superseded AB 637 making TBT coatings restricted materials and imposed similar restrictions on its use. In June 1988, the federal Organotin Antifouling Paint Control Act went into effect that prohibited the use of TBT coatings on vessels less than 25 meters in length, and limited the release rates on larger vessels. Also in September 1988, the USEPA released final TBT regulations that contain the same restrictions as the federal act (State Board, 1988). In summary, restrictions on the use of TBT for recreational vessels in the United States were imposed through state regulations through CDFA, federal regulations through the USEPA, and state and federal legislation. Since these restrictions were imposed, levels of TBT have decreased in areas that were elevated, including San Diego Bay.

Restrictions have also been imposed on the use of TBT antifouling paints on vessels worldwide. For example, in 1982 France prohibited the use of TBT coatings on vessels less than 25 meters in length (State Board, 1988). Furthermore, in November 1999, the International Maritime Organization adopted a resolution that calls for a global ban on the application of tributyltin antifouling paints on all vessels (regardless of size) by January 1, 2003, and a complete prohibition on its use on vessels by January 1, 2008.

[38] At this time, CDFA regulated the registration of pesticides in California. Today, pesticides are regulated in California by DPR.