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685

From: Craig J. Wilson
To: Carmencita Sannebeck; Yates, Randal
Date: 1/26/2006 3:08:16 PM
Subject: Fwd: Delist Proposal: Monterey Harbor Lead

For the record and distribution to the Board. CJW

>>> Pete Osmolovsky Thursday, January 26, 2006 >>>
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In brief, we are proposing the delist based on:

- The primary source of lead loading to the harbor has been removed and remediated (i.e., onshore riprap slag removal and some harbor bottom sediment removal).

- Water quality objectives are currently being met in the water column;

- 4/30 (13%) sediment samples analyzed for total lead exceeded the (highside) NOAA-PEL numeric sediment quality guideline for lead, and a majority of sediment samples exceeded the (lowside) numeric guideline (NOAA-TEL); however, analytical evidence (SEM:AVS method) demonstrated that much of the total lead in sediment is sequestered in lead sulfide phases. When bioavailable lead is considered, it appears that virtually all of the sediment samples are below the NOAA-PEL (highside endpoint) and TEL (lowside endpoint) numeric sediment quality guidelines;

- 4/19 (21%) mussel tissue samples exceeded the median international standards (MIS) guideline of 2.0 mg/kg for lead in shellfish tissue. However, the MIS guideline appears to be overly conservative, and not appropriate as a mussel tissue lead criterion in Monterey Harbor. Ecological risk analysis, weight of evidence analysis, in conjunction with other evidence and literature review adequately demonstrated that avian and mammalian populations native to Monterey Harbor are not at risk from lead in the tissue of shellfish; and

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3) Supporting Appendix 1: *"Appendix 1_MFG_Monterey_Harbor_Lead_Final_5-20-05"* (water quality, sediment quality, mussel tissue data); and

4) Supporting Appendix 2: *"Appendix 2_ MHL_Risk_Literature"* (ecological risk assessment literature review)

Cheers,

Pete Osmolovsky
Central Coast Regional Water Quality Control Board

895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401

Phone: (805) 549-3699
Fax: (805) 788-3587
email: paosmolovsky@waterboards.ca.gov

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Region 3 – Regional Water Quality Control Board
Data Submissions and Corrections for the 2006 303(d) list

1) Describe the reason(s) the listing is inappropriate.

Staff evaluated potential delisting for Monterey Harbor lead using two complimentary policy tools: the two-tiered approach used by USEPA for Newport Harbor TMDL (June, 2002), and *The Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List* (State Water Board 2004). **Regional Board staff recommends delisting Monterey Harbor for lead based on the fact that:**

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2) Provide the data and information necessary to enable SWRCB to conduct a complete reassessment. **Please see below and/or attached. Four PDF files are attached (report and four appendices of data).**

a. Name of the person or organization providing the information;
Regional Water Quality Control Board, Region 3

b. Mailing address, phone number, and email address of a contact responsible for answering questions about the information submitted;
895 Aerovista Place, Ste. 101
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(805) 549-3699
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Staff person: Pete Osmolovsky

c. Bibliographic citations for all published information provided;
See attached documentation.

d. To the extent possible, all information should be submitted in electronic format (e.g., Microsoft [MS] Word, Access database, Excel spreadsheet, ASCII, or Adobe Acrobat files);
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Monterey Harbor
Calwater watershed no. 30950042

g. Geographic extent of the potential water quality limited segment;
Monterey County

h. Pollutant(s) of concern;
Lead

i. Applicable water quality objective or criterion;
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- **Basin Plan's narrative objective for settleable and suspended material**

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j. Comparison of results against applicable water quality objective or criterion;
See attached staff report "Final Delist Project Report_Monterey Harbor Lead" dated January 26, 2006.

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Determination is that beneficial uses are NOT being impacted.

l. Complete background information (metadata) for field data (i.e., when and where measurements were taken, number of samples, detection limits, etc.); and
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1) The name of the group;
NA

2) A description of any training in water quality assessment completed by members of the group.
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3. Make sure all numeric data submitted in support of new listings or changes to existing listings, can be evaluated to address the following:
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b. spatial representation;
c. temporal representation;
d. age(s) of the data;
e. effects of seasonality;
f. effects of any events that might influence data evaluation (e.g., storm events, flow conditions, laboratory data qualifiers, etc.);
g. the total number of samples;
h. the number of samples exceeding standards;
i. the source or reference for samples;
j. the potential sources of pollutants; and
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Attached information addresses the above criteria.

303 (d) Deadline:
1/31/06

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RECEIVED
JAN 2006
SWRCB
Executive Ofc.

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Justification for Delisting Monterey Harbor for Lead, Monterey County, California

January 26, 2006

Regional Water Quality Control Board
Central Coast Region
895 Aerovista Place, Suite 101, San Luis Obispo, CA 93401-7906

Staff Contact: Pete Osmolovsky
(805) 549-3699

1.0 PROJECT DEFINITION

Monterey Harbor is located in the southeastern portion of Monterey Bay, a National Marine Sanctuary. The Harbor is generally bounded by the shoreline on the south and east, the public pier on the north and the Coast Guard jetty on the west. A channel is maintained in the northwest portion of the harbor as an entrance to the marina and boat moorings in the area. A second public pier consisting mostly of retail development is located south of the main public pier.

In the 1980's, mussels in Monterey Harbor were found to have a significant lead content. Shoreline riprap slag with a high lead content was identified in the 1980's along a segment of Monterey Harbor shoreline. The source of the lead was from slag that had been placed along the southern shore of the harbor to stabilize railroad tracks that had run along the shore in that area. In the early 1990's, Southern Pacific Railroad (owner of original slag site and now part of Union Pacific Railroad, (UPRR)) conducted remedial actions of onshore slag removal and some harbor bottom sediment removal. The railroad submitted a report to the Water Board in 1993 detailing the removal and sediment sampling at about 15 locations in the harbor. In 1993, all samples were below National Oceanic and Atmospheric Administration (NOAA) PEL guidance values for lead (PELs are probable-effects level guides).

In 1996, State Mussel Watch (SMW) sampled four locations in the Harbor. In fall 2000, SMW reported all four locations had lead tissue levels above US Food & Drug Administration guidance levels of potential concern for human consumption. In 1998, the State Bay Protection program (BPTCP) sampled four locations in the harbor, finding all four with sediment lead levels below the NOAA-PEL. BPTCP also conducted toxicity tests at two locations, finding no toxicity at one location and possible mild toxicity at the second (where both metals and organic compounds had been detected). BPTCP did not list Monterey Harbor as a "toxic hot spot" needing further action.

Reviewing Water Board files, staff found UPRR was the responsible party for the site and, based on the 303(d) listing and the 1996 SMW data, issued a letter (August 2002) to UPRR requesting an investigation of the mussel tissue impairment. UPRR responded with a workplan that included a sediment sampling program and possible follow-up work depending on the sediment results.

On September 13, 2004, UPRR's consultant, MFG, Inc. (MFG) submitted a report titled "Monterey Harbor Lead in Sediment Study: Union Pacific Railroad" to the Water Board. The report summarized the results of the consultant's work to date. In addition to presenting their most recent findings (mussel tissue sampling and analysis), the report concluded with a proposal to conduct an additional phase of work (i.e., Phase 2 Report: Monterey Harbor Lead in Sediment Study) to be concluded by March 2005.

The current submittal – Phase 2 Report: Monterey Harbor Lead in Sediment Study – includes:

1) A review of the toxicological literature to obtain information regarding the most relevant species of concern for Monterey Harbor.
2) Additional environmental sampling including water column, sediments, and in situ mussel tissue lead bioaccumulation tests consistent with the original investigation work.
3) Risk assessments using the updated project database.

Based on the results of the current and past submittals of the sediment and mussel sampling, Water Board staff evaluated whether or not Monterey Harbor Lead Impairment project would lead to a proposed regulatory action to delist the waterbody from California's CWA section 303(d) list.

Water Board staff used two approaches to guide this determination. First, staff used a modified version of the two-tiered approach framework from the *TMDL for Toxic Pollutants in San Diego and Newport Bay, Califorina, Part H* (United States Environmental Protection Agency [USEPA], June 2002). Secondly, staff evaluated the submittals with respect to The State Board *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) list* (adopted September 2004) which provides guidance for interpreting data and information to establish a standardized approach for developing California's section 303(d) list, including California Listing Factors and Delisting Factors.

Based on the results of the above analyses, Board staff recommends that Monterey Harbor be removed from the 303(d) list for lead.

2.0 WATERSHED DESCRIPTION

Monterey Harbor was added to California's Clean Water Act (CWA) 303(d) list for lead in 1998, because levels of lead in the tissue of mussels (*Mytilus californianus*) exceeded Median International Standards (MIS) and were greater than Elevated Data Levels (EDLs) as reported by the State Mussel Watch Program. Also, the State Water Resources Control Board (State Water Board) determined that sediment lead levels were elevated and published their findings in the *Bay Protection and Toxics Cleanup Program, Monterey Lead Study* (published as part of the document *Chemical and Biological Measures of Sediment Quality in the Central Coast Region Final Report* [State Water Board, 1998]).

The California Regional Water Quality Control Board, Central Coast Region (Water Board) asked UPRR to conduct a sediment sampling study as a follow-up to the 1992 removal of a potential onshore source of lead to the Monterey Harbor, so that Water Board staff could determine if a lead total maximum daily load (TMDL) was needed for the Harbor.

The following brief timeline of events and previous sampling efforts establishes context for this report.

- Circa 1880 — The railroad builds a railroad spur line to service canneries in Monterey Bay Harbor.
- Circa 1905 — The railway bed is stabilized along the shoreline using foundry slag that contains high levels of lead.
- 1981-1983 — State Mussel Watch Program results indicate tissue lead concentrations exceed Monterey County Health Department advisory limits.
- 1988 — Water Board sampling identifies the extent of lead contaminated sediments documented in *Monterey Harbor Lead Study, September 1988*, by Wilder and Jagger.
- 1989 — Southern Pacific Transportation Company (SP) contracts International Technology Corporation (IT) to partially remove onshore slag.
- 1990 — SP (IT) delineates extent of slag-related material onshore.
- 1992 — SP removes the onshore lead impacted material and disposes of the material into a regulated landfill.
- 1993 — SP (Entrix) sampling indicates declining concentrations of lead in sediments in the Harbor.
- 1996 — State Mussel Watch Program results indicate tissue lead concentrations that exceed the State Mussel Watch Program's EDLs.
- 1998 — State Water Board conducts sampling under *Bay Protection and Toxics Cleanup Program, Monterey Lead Study,* published as part of the document *Chemical and Biological Measures of Sediment Quality in the Central Coast Region Final Report* (State Water Board, 1998).
- 1998 — Monterey Harbor is listed as an impaired water body under the provisions of Section 303(d) of the CWA.

2.1 Beneficial Uses

The *Water Quality Control Plan, Central Coast Basin – Region 3* (Basin Plan) identifies various beneficial uses for Monterey Harbor, as depicted in Table 1, below:

Table 1: Beneficial Uses for the Monterey Harbor

Designated Beneficial Uses of Monterey Harbor
Water Contact Recreation (anticipated use)
Non Contact Water Recreation
Industrial Service Supply
Marine Habitat
Navigation
Shellfish Harvesting
Commercial and Sport Fishing (anticipated use)
Rare, Threatened, or Endangered Species

These beneficial uses are listed because they are important as it relates to which water quality objectives to apply to Monterey Harbor.

2.2 Land Uses

The Harbor serves as a marina for pleasure and commercial craft. The Coast Guard jetty includes a boat maintenance facility. Urban parkland and commercial properties surround the harbor coastline.

2.3 Habitat and fisheries

Monterey Bay is a protected National Marine Sanctuary. Within the bay, Monterey Harbor is designated for a mixture of commercial (commercial fishing, navigable waters, industrial water supply, shellfishing) and recreational uses (contact and non-contact recreation, sport fishing).

3.0 WATER QUALITY OBJECTIVES

Lead Objectives

3.1 Water

According to the Central Coast Water Board's Basin Plan (Water Board 1994), there should not be any constituents present in water bodies at levels that compromise beneficial uses. Numeric objectives exist for water; however, no numeric objectives exist for either sediment or tissue. The Basin Plan contains both narrative (Table 2) and numeric (Table 3) water quality objectives for specific metals and beneficial uses. In this situation, the narrative objective is interpreted to mean that concentrations of lead, should not exist in a suspended or settleable form in the water column. Water quality objectives in the Basin Plan are expressed as concentrations of *total* metals in the water column.

In addition to the Basin Plan, the California Toxics Rule (CTR) provides water quality objectives expressed as *dissolved* metals concentrations. The CTR supersedes the Basin Plan when it is more stringent than the Basin Plan. Similarly, if the Basin Plan is more stringent than the CTR, Basin Plan numeric criterion is used. It is now State Water Board policy to use dissolved metals measurements to evaluate compliance with aquatic life water quality standards because dissolved metal more closely approximates the bioavailable fraction of the metal in the water column than does total recoverable metal. Therefore, based on this policy and the rationale that dissolved metals more closely approximate the bioavailable fraction of metal in the water column, all water column samples collected during this study were analyzed for dissolved metals and compared to the CTR water quality standards, as this approach is the most protective of aquatic life (Table 4). In the case of lead in marine environments, the CTR is the most conservative (8.1 mg/l chronic, 210 mg/l maximum) and thus was considered as the numeric target for possible lead impairment of Monterey Harbor waters.

Table 2: Basin Plan's Narrative Objective Description

Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain settleable material in concentrations that result in deposition of material that causes nuisance or adversely affects beneficial uses.

Table 3: Basin Plan's Numeric Water Quality Objectives for Metals in Marine Environments

Metal	Total Concentration (μg/l)
Cadmium	0.2
Chromium	50
Copper	10
Lead	**10**
Mercury	0.1
Nickel	2
Zinc	20

Table 4: California Toxics Rule Water Quality Standards for Metals in Marine Environments

Metal	Saltwater	
	Criterion Maximum Concentration, dissolved (µg/l)	Criterion Continuous Concentration, dissolved (µg/l)
Arsenic	69	36
Cadmium	42	9.3
Chromium (total)	1,100	50
Copper	4.8	3.1
Lead	**210**	**8.1**
Nickel	74	8.2
Selenium	290	71
Silver	1.9	NA
Zinc	90	81

3.2 Sediment

There are no existing sediment quality standards, however the NOAA SQuiRT (Screening Quick Reference Table) tables provide one set of guidance values that are commonly used to evaluate sediment concentrations. SQuiRT presents screening concentrations for inorganic and organic contaminants in various environmental media. These screening concentrations were derived initially using a database compiled from studies performed in both saltwater and freshwater in all different areas of North America and published in NOAA Technical Memorandum. The tables are intended for preliminary screening purposes only; they do not represent official NOAA policy and do not constitute criteria or clean-up levels. Users of SQuiRT values are strongly encouraged to review supporting documentation to determine appropriateness for their specific use. Their use in certain situations may not be appropriate.

3.3 Tissue

Most metals do not have a standard tissue objective established by any of the following agencies: USEPA; California Office of Environmental Health Hazard Assessment (OEHHA); United States Food and Drug Administration (USFDA); California Department of Health Services (DHS); or the United States Fish and Wildlife Service (USFWS). The few metals that do have standards include: arsenic, cadmium, copper and chromium. All other metals do not have approved standards for tissues.

Although there are no approved United States standards against which to compare all tissue values, there are values called median international standards (MIS). MIS is a literature value criterion developed from a United Nations Food and Agriculture Organization publication of a survey of health protection criteria used by member nations (Table 5). Though the standards do not apply within the United States, they provide an indication of what other nations consider to be an elevated concentration of trace elements in shellfish (State Mussel Watch Program, 2000). These MIS values will be used as literature values to evaluate the tissue data collected in this study.

Table 5: Median International Standards for Trace Elements

Element	Freshwater Fish (mg/kg)	Shellfish (mg/kg)	Range of Standards (mg/kg)	Number of Countries with Standards
Arsenic	1.5	1.4	0.1 – 5.0	11
Cadmium	0.3	1.0	0.05 – 2.0	10
Chromium	1.0	1.0	1.0	1
Copper	20.0	20.0	10 – 100	8
Lead	**2.0**	**2.0**	**0.5 – 10.0**	**19**
Mercury	0.5	0.5	0.1 – 1.0	28
Selenium	2.0	0.3	0.3 – 2.0	3
Zinc	45.0	70.0	40 – 100	6

4.0 DATA COLLECTED

4.1 Phase I Study

On September 15, 2004, MFG submitted a report titled "Monterey Harbor Lead in Sediment Study" to the Water Board describing the potential impacts of lead to the beneficial uses of Monterey Harbor (MFG, 2004). The objective of the September 15th report was to answer the following questions: (1) is lead present in Harbor sediments above threshold criteria? (2) If elevated lead concentrations are present in Harbor sediments or mussels, do they originate from the removed slag pile? (3) If elevated lead concentrations originating from the former slag pile are present, do they represent impairment to the beneficial uses of shellfish in the Harbor?

The September 15th report presented the following findings and conclusions:

Lead concentrations in mussel tissue samples taken from Monterey Harbor have been reduced significantly over the past decade as evidenced in the mussel tissue assessments carried out in 2003-2004. However, even though there has been a significant reduction in lead contamination, the data indicates that there remains a slight potential for beneficial use impairment.

There are several factors that should be considered in evaluating the potential for impairment to beneficial uses in Monterey Harbor:

- *Shellfish harvesting in Monterey Harbor for both humans and as a food source for wildlife is marginal due to the limited amount of suitable habitat.*

- *The lead contaminant study in Monterey Harbor by Flegal, et al. 1987 indicates that there is uncertainty regarding the bioavailability of lead in mussels (sediment bound lead in gut) to higher trophic levels.*

- *Chemical analyses included in this study, including STLC and SEM:AVS, indicate that the lead is tightly bound in the sediment in forms that are not readily bioavailable.*

- *Preliminary avian and mammalian risk assessments, using the assumption that all lead in the mussel tissues is bioavailable, suggest that the MIS is not the most appropriate standard for Monterey Harbor and that a mussel tissue lead criterion could be adjusted upward.*

Using the current criteria (TEL and MIS) there is minimal environmental risk to humans and wildlife in Monterey Harbor.

Portions of the environmental data collected as part of this project, preliminary risk calculations, and other factors listed above support consideration of updated numeric targets for lead in Monterey Harbor. Additional environmental data, literature reviews, and risk calculations are needed to propose updated numeric targets for Monterey Harbor.

4.2 Phase II Study

Phase II was designed to address the additional needs discussed above, so that a determination of whether lead is continuing to be a source of impairment to Monterey Harbor could be made. The study design used a multi-stepped approach to investigate the levels of lead in the sediments, water column, and mussel tissues, and the potential impact any remaining lead in the sediments may have on the beneficial uses of Monterey Harbor. The steps of the Phase II study may be summarized as follows:

- Step 1: Sediment core samples were collected from 15 sites within Monterey Harbor where Southern Pacific removed the slag material and where previous monitoring efforts have been focused (Figure 4-1). The cores (12") were sectioned into two aliquots (upper 2" and lower 2") and analyzed for total lead, in an effort to provide additional data to assess (a) whether temporal declines in sediment lead concentrations have continued, and (b) whether lead concentrations in Harbor sediment exceed Threshold Effects Levels (TELs).

- Step 2: The bioavailability of the lead was evaluated (e.g., the ratio of simultaneously extracted metals to acid volatile sulfides – SEM:AVS) to assess the potential risk posed to shellfish and other organisms. This evaluation could support a) delisting for lead, b) a site-specific cleanup target, and/or c) a TMDL endpoint for lead, if necessary.

- Step 3: Surface water was collected from 15 sites within Monterey Harbor to measure the total and dissolved fractions of lead in the water column (Figure 4-1).

- Step 4: Bioassessment monitoring of mussels (*Mytilus californianus)* was used to evaluate the potential for contamination of whole shellfish tissue originating from lead in the sediments. This monitoring used the protocols developed by the California State Mussel Watch Program, and was identical to the protocols that originally resulted in Monterey Harbor being listed for lead. The mussels were deployed at 10 sites during the winter months when the water conditions are their most turbulent and the chances of sediment-bound lead suspension are the greatest.

- Step 5: Small-scale ecological risk assessment using mussel tissues as a source of dietary lead to the most sensitive life stage of marine birds and protected mammals (sea otter and harbor seal).

5.0 DATA ANALYSIS

5.1 Numeric Targets

In evaluating the data collected in Phase II, preliminary planning for Monterey Harbor follows a pattern set by USEPA on the Newport Bay TMDL (June, 2002). This pattern included use of screening reference sediment guideline values developed by the US National Oceanic and Atmospheric Administration (NOAA-SQuiRT tables, Buchman 1999). These tables included two values, PELs and TELs, which are sediment guidance values extracted from the literature. They were: the level above which aquatic life effects are anticipated (**PEL**), and the level below which aquatic life are not anticipated to be affected (**TEL**).

The proposed numeric targets for the Monterey Harbor lead impairment would therefore be:

- **Tier One (no further action needed scenario)** :
    - ≤ 25% of (at least 8) sediment samples randomly spaced throughout the harbor exceed the NOAA-PEL for lead of 112.18 mg/kg (i.e., exceed high sediment quality guideline); **OR**

    - < 10% of (at least 12 randomly spaced – in time and spatial extent over a three year period) water column samples exceed the appropriate CTR objective for dissolved lead (Chronic = 8.1 ug/L, Maximum = 210 ug/L); **OR**

    - ≤ 25% of (at least 4) randomly placed (throughout the harbor) mussel samples exceed an appropriate tissue level for lead (e.g., MIS, 2.0 mg/kg wet weight).

- **Tier Two (no further action needed scenario) – At least two of the three bullets below must be met:**
  - ≤ 10% of (at least 8) sediment samples randomly spaced throughout the harbor exceed the NOAA-TEL for lead of 30.24 mg/kg (i.e., exceed low sediment quality guideline); **OR**
  - < 2 of (at least 12 randomly spaced – in time and spatial extent over a three year period) water column samples exceed the appropriate CTR objective for dissolved lead (Chronic = 8.1 ug/L, Maximum = 210 ug/L); **OR**
  - ≤ 10 % of (at least 4) randomly placed (throughout the harbor) mussel samples exceed an appropriate tissue level for lead (e.g MIS, 2.0 mg/kg wet weight).

5.2 USEPA Two Tiered approach

In Tier 1, data should be compared to selected targets and if any target is *exceeded in any one category*, then a TMDL is required. Exceedence of at least one (or more) categories in Tier One should be taken as demonstrable evidence of "*impairment* to aquatic life or *probable* adverse human health effects" (USEPA, 2002).

In Tier 2, if there is an exceedence *in at least two of the three categories,* a TMDL is required. Tier 2 should be used when there are not enough data in any one category to justify developing a TMDL, where data sets are incomplete, or where there is evidence of potential future impairment based on water quality conditions in adjacent segments. Exceedences of two out of three categories in Tier Two should be taken as demonstrable evidence of "*possible* effects to aquatic life or human health" (USEPA, 2002).

In recommending to delist, USEPA recommends using both Tiers.

5.2.1 Tier One

Sediment: 4/30 sediment samples (13%) analyzed for total lead (mg/kg – dry weight) exceeded the NOAA-PEL for lead of 112.18 mg/kg. The range of observed total lead concentrations was 21.2 to 754 mg/kg.

Water: None of the 30 (0/30) surface water samples collected during both the 2004 and 2005 sampling events exceeded the CTR water quality criteria for dissolved lead (Chronic = 8.1 μg/L, Maximum = 210 μg/L). The range of observed dissolved lead concentrations was non-detect to 2.8 μg/l.

Mussel Tissue: 4/19 mussel tissue samples (21%) from both the 2004 and 2005 sampling events exceeded the MIS guideline of 2.0 mg/kg in shellfish tissue. The range of observed mussel tissue lead concentrations was 0.9 to 3.0 mg/kg. In addition, there was a significant decrease between 2004 and 2005, in both the concentrations of tissue lead, and the number of exceedences of the MIS.

Conclusion: None of the three Tier One categories for impairment were exceeded. Delisting would be justified based simply on Tier One parameters. However, to conclude no further site action, both Tier One and Tier Two scenarios must be satisfied in accordance with the USEPA Newport Bay methodology (USEPA, 2002).

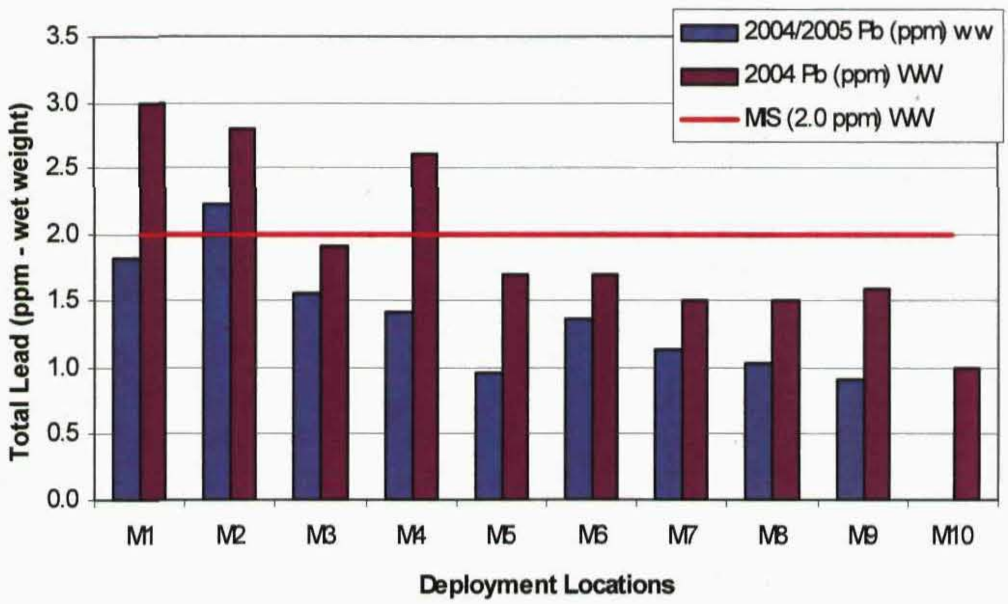
5.2.2 Tier Two

Sediment: 24/30 of sediment samples (80%) for total lead (mg/kg) from the 2004 and 2005 sampling events exceed the low sediment quality guideline (NOAA-TEL for lead of 30.2 mg/kg). There was a decrease in total lead concentrations, and exceedences of the TEL between the 2004 and 2005 sampling events.

Water: None of the surface water samples from either the 2004 or 2005 sampling events exceeded the appropriate CTR objective for dissolved lead (Chronic = 8.1 ug/L, Maximum = 210 ug/L).

Mussel Tissue: 4/19 tissue lead samples (21%) for both the 2004 and 2005 sampling events exceeded the MIS of 2.0 mg/kg – wet weight. The concentrations of tissue lead, and the number of exceedences of the MIS dropped significantly between 2004 and 2005. The 2005 sampling event found only 1/9 tissue samples (11%) exceeding the MIS (Figure 1).

Figure 1: Comparison of 2004 and 2004/2005 Mussel Tissue Lead Concentrations in Monterey Harbor (WW = wet weight)



5.2.3 Summary of Two Tiered Approach

None of the three Tier One categories for impairment are exceeded. Delisting would be justified based simply on Tier One categories. Two of the three Tier Two categories were exceeded. Most sediment samples exceeded the low sediment quality guideline (NOAA-TEL for lead of 30.2 mg/kg); whereas tissue lead samples only marginally exceed the tier two parameter for evidence of impairment [(>10% of randomly placed mussel samples exceed an appropriate tissue level for lead (e.g., MIS 2.0 mg/kg wet weight)].

Tier One suggested no demonstrable impairment, and that delisting is warranted - while Tier Two suggested evidence of possible effects to aquatic life or human health. However, other lines of evidence suggested that the MIS, and the TEL may not be appropriate sediment and tissue numeric criteria for Monterey Harbor, as discussed below in the Weight of Evidence Approach.

5.2.4 State Water Board Policy Guidance for Delisting

The Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (State Water Board 2004) establishes California's policy for implementing parts of the Clean Water Act (CWA) by describing the conditions that must be met before a water body can be either listed or de-listed from the State's 303(d) list. This document provides guidance for interpreting data and information to establish a standardized approach for developing California's section 303(d) list, including California Listing Factors and Delisting Factors.

This policy does allow for a "weight of evidence" approach, providing that "the weight of evidence indicates that a water quality standard is attained. If the weight of evidence indicates attainment, the water quality segment shall be removed from the section 303(d) list. If warranted, a listing may be maintained if the weight of evidence indicates a water quality standard is not attained."

Below is a discussion of the data from the numerous studies performed in the Harbor as they relate to the State's Listing/De-Listing Policy (State Water Board 2004).

Water: No surface water samples from the monitoring events exceeded the CTR water quality objective of 8.1 μg/l dissolved lead (Table 6). The ranges for dissolved lead in the 30 Monterey Harbor surface water samples between 2004 and 2005 were non-detect to 2.8 μg/l. These results meet the Delisting criteria set forth in the State Water Board 2004 policy, for numeric water quality objectives for toxicants in water.

Table 6: Results of Surface Water Lead Concentrations in Monterey Harbor

Sample ID	December 2004 Total Pb (µg/l)	December 2004 Dissolved Pb (µg/l)	December 2004 TSS (mg/l)	February 2005 Total Pb (µg/l)	February 2005 Dissolved Pb (µg/l)	February 2005 TSS (mg/l)
1	<1.0	<1.0	<6.0	5.4	1.7	<5
2	<1.0	1.05	6.0	5.9	2.1	<5
3a	2.29	<1.0	<6.0	10.0	2.1	40
3b	NS	NS	NS	10.6	2.8	10
4	2.51	<1.0	<6.0	8.1	2.2	6
5	1.65	<1.0	<6.0	5.0	1.6	<5
6	<1.0	<1.0	<6.0	4.1	1.2	<5
7a	<1.0	<1.0	6.0	3.8	1.5	<5
7b	<1.0	<1.0	<6.0	NS	NS	NS
8	<1.0	<1.0	<6.0	3.5	1.6	<5
9	<1.0	<1.0	<6.0	2.9	1.5	<5
10	<1.0	<1.0	<6.0	3.0	1.4	<5
11	<1.0	<1.0	<6.0	2.9	1.4	<5
12	<1.0	<1.0	<6.0	2.8	1.3	<5
13	<1.0	<1.0	<6.0	2.8	1.5	<5
14	<1.0	<1.0	<6.0	2.8	1.2	<5
15	<1.0	<1.0	<6.0	2.5	1.1	<5

NS= Not sampled

Sediment: 97 sediment samples (53 from the surface and 44 from depth (8-12")) were collected from Monterey Harbor between 1993 and 2004 (Entrix 1993, MFG 2003, MFG 2004).

The Policy allows Water Boards to select sediment quality guidelines that have been published in peer-reviewed literature or by state and federal agencies, with the caveat that "only those sediment guidelines that are predictive of sediment toxicity shall be used (i.e., those guidelines that have been shown in published studies) to be predictive of sediment toxicity in *50 percent or more of the samples analyzed*" (State Water Board, 2004).

The screening-level value that meets the aforementioned 50% requirement stated in the Policy is the NOAA-PEL for lead of 112.18 mg/kg. A minority of the Monterey Harbor sediment samples (10 out of 97) collected between 1993 and 2004 (Entrix 1993, MFG 2003, MFG, 2004) had total lead concentrations that exceeded the NOAA-PEL, with only 4 of them occurring in 2004/2005.

State Water Board Policy Conditions - The Policy uses a binomial distribution model to determine the number of exceedances that are allowed based on the number of samples collected. The Policy states:

> *Using the binomial distribution, waters shall be removed from the section 303(d) list if the number of measured exceedances supports rejection of the null hypothesis as presented in Table 4.1.*

The Policy's Table 4.1 indicates that for a sample size of n = 95 to 106, "delist if the number of exceedances equal or is less than 8." The exceedances are:

- Total number of samples exceeding the PEL = 10
- Total number of surface samples exceeding the PEL = 4. (Table 4.1 from the Policy allows for 4 exceedances based on the number of surface samples being 53).
- Total number of depth samples exceeding the PEL = 6. (Table 4.1 of the Policy allows for 3 exceedances based on the number of depth samples being 44).

Therefore, based simply on "total" lead concentrations in sediment, delisting could be warranted for the surface samples but not for sediments found at a depth >8" based on this factor. However, total lead is considered a poor indicator of the amount of bioavailable lead.

MFG used SEM:AVS analysis (USEPA Method 6020/7470) to determine the quantity of "available" lead in the sediment. Simultaneous extracted metal (SEM) minus (-) acid volatile sulfide (AVS) is a measure of sediment toxicity based on the amount of sulfide in the sediment that can bind with toxic heavy metals and make them unavailable to plants and animals.

The SEM/AVS molar rations are an indicator of the amount of metals present in the sediment pore-water. When SEM/AVS ratios are <1, the concentrations of metals in the sediment porewater are generally below toxic levels because of the low solubility of the metal sulfides.

SEM:AVS is a scientifically defensible methodology to determine the bioavailability of divalent metals. The SEM:AVS tests for Monterey Harbor sediment samples suggest that there exists sufficient volatile sulfide concentrations in most of the Harbor sediment to bind the lead as lead sulfide. Lead sulfide is not readily soluble in water. This lack of solubility was supported by the low concentrations of dissolved lead in the water column and non-detectable concentration of lead that could be leached using the weak acid extraction method of the STLC leachate test. Sulfide sequestration of lead reduces its bioavailability and, thus, results in normally toxic concentrations of lead becoming non-toxic to aquatic life.

The SEM:AVS test indicated that all (100%) available lead in the Monterey Harbor sediment is below the PEL guidance (and TEL guidance). The analysis indicated that the concentration of (theoretically) available lead ranges between 0 to 87.6 mg/kg. According to the SEM:AVS test, over 50% of samples indicated concentrations of available lead at zero, indicating the lead was largely sequestered in sediment and sulfide phases.

Mussel Tissue: There were an insufficient number of tissue lead samples (N=19) to evaluate potential for delisting using the State Water Board policy conditions using the binomial distribution (State Water Board 2004, table 4.1, N=28 to 129).

However, State Water Board policy (June 2004) allows a weight of evidence approach to support a delisting. When making a delisting decision based on a situation-specific weight of evidence, the Water Board must justify its recommendation by:

- *Providing any data or information including current conditions supporting the decision;*
- *Describing in fact sheets how the data or information affords a substantial basis in fact from which the decision can be reasonably inferred;*
- *Demonstrating that the weight of evidence of the data and information indicates that the water quality standard is attained; and*
- *Demonstrating that the approach used is scientifically defensible and reproducible.*

MFG proposed the following "weight of evidence" of water quality standard attainment and protection of the designated beneficial uses of Monterey Harbor. MFG performed a review of the most current literature pertaining to bioaccumulation of lead in marine organisms and found that:

- Inorganic lead is transformed into granules by marine mollusks and benthic invertebrates, thereby reducing the bioavailability of lead;
- Absorption of lead from the gut of mussels and crabs is inefficient;
- Lead does not biomagnify up the food chain but, rather, biopurifies;
- Increases in anthropogenic lead fluxes do not result in an increase in lead contaminated otters;
- Lead consumed with food by waterfowl becomes chelated by various ligands that render the lead into non-soluble or non-bioavailable forms; and

- Any soluble lead in the Monterey Harbor sediment has a high likelihood of being further sequestered by either granulation in invertebrates or chelated by ligands in waterfowl digestive tracts. This will result in the lead being rendered non-bioavailable and, therefore, most likely will not result in degradation of the beneficial uses of the harbor.

The literature indicated that, while lead can bioaccumulate in tissues, it does not biomagnify but rather "biopurifies" as it moves up the food chain. Thus, the "weight of evidence" suggested that lead is not currently a bioaccumulation hazard in Monterey Harbor.

In addition, MFG did a small-scale ecological risk assessment, which appears to adequately demonstrate that that avian and mammalian populations native to Monterey Harbor are not at risk from lead in the tissue of shellfish. This risk assessment used the working assumption that all lead in the mussel tissues is bioavailable and that the organisms would subsist on the exposed mussel tissues. This assumption provided a conservative (most protective) estimate of lead exposure. The risk assessments for Herring Gull, Southern Sea Otter, and Harbor Seal suggested that even using conservative assumptions (all lead bioavailable, MIS guideline of 2.0 mg/kg), there was no risk indicated to avian and mammalian species. The risk assessment also appeared to suggest that the MIS guideline was overly conservative, and not appropriate as a mussel tissue lead criterion in Monterey Harbor.

6.0 RATIONALE FOR DELISTING

Discussion-conclusions

Staff evaluated potential delisting for Monterey Harbor lead using two complimentary policy tools: the two-tiered approach used by USEPA for Newport Harbor TMDL (June, 2002), and *The Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (State Water Board 2004)*

With respect to the two-tiered framework USEPA used in Newport Harbor, Monterey Harbor is justified for delisting in accordance with Tier One parameters, but is potentially impaired in accordance with Tier Two standards (two of the three parameters are not met for delisting). Nominally, both Tier One and Tier Two parameters must be met to justify delisting.

However, UPRR provided evidence that much of the total lead in sediment is sequestered in lead sulfide phases, by using SEM:AVS analysis (EPA Method 6020/7470). When bioavailable lead is considered, using SEM:AVS results, it appears that virtually all of the sediment samples are below the PEL (highside endpoint) and TEL (lowside endpoint) numeric sediment quality guidelines.

In addition, none of the 30 surface water samples collected during both the 2004 and 2005 sampling events exceeded the CTR water quality criteria for dissolved lead

(Chronic = 8.1 μg/l, Maximum = 210 μg/l). The range of observed dissolved lead concentrations was non-detect to 2.8 μg/l.

4/19 tissue lead samples (21%) for both the 2004 and 2005 sampling events exceeded the MIS of 2.0 mg/kg – wet weight. The concentrations of tissue lead, and the number of exceedences of the MIS dropped significantly between 2004 and 2005. The 2005 sampling event found only 1/9 tissue samples (11%), which only nominally exceeds the Tier Two tissue lead parameter of 10% exceedences.

In addition, MFG did a small-scale ecological risk assessment, which adequately demonstrated that avian and mammalian populations native to Monterey Harbor are not at risk from lead in the tissue of shellfish. This risk assessment used the working assumption that all lead in the mussel tissues is bioavailable and that the organisms would subsist on the exposed mussel tissues. Furthermore, review of the most current literature pertaining to bioaccumulation of lead in marine organisms demonstrated that absorption of lead from the gut of mussels and crabs is inefficient; lead does not biomagnify up the food chain, but rather biopurifies; lead consumed by waterfowl becomes chelated by various ligands that render the lead into non-soluble or non-bioavailable forms.

In accordance with State Water Board policy (September 2004), UPRR has adequately demonstrated that delisting is merited using binomial statistical distribution guidelines, and a weight of evidence approach for site-specific conditions.

In summary, surface water sampling, SEM:AVS analysis, ecological risk analysis, weight of evidence analysis, in conjunction with other evidence and literature review provided by UPRR, staff recommends that Monterey Harbor be delisted from the 303(d) list for lead.

7.0 REFERENCES

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MFG
consulting
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February 17, 2005
MFG Project No. 030213

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From: Gary Wortham and Clayton Creager

***Subject:* Monterey Harbor Lead in Sediment Study Phase II**
Ecological Risk Assessment – Literature Review Update

The purpose of this memorandum is to provide the Regional Water Quality Control Board with an interim deliverable for the Monterey Harbor Lead Study. The work plan submitted by MFG and approved by RWQCB3 calls for staged review of project components as they become available. This interim deliverable includes a description of the results of the risk assessment information-gathering task. This task provides background information that will be used in the risk assessment and identifies the risk-assessment methodology to be used. This task **does not** provide any conclusions or recommendations since the study is still underway and a significant amount of data is still outstanding. Rather this memorandum provides a summary of the information gathered and reviewed to date.

The memorandum includes the following project components:

- Description of the information collection process;
- List of resident species;
- Summary of the information gathered and reviewed to date;
- Methodology that will be used for the risk assessment;
- Conceptual model of the risk assessment process; and
- Bibliography.

Each of these is described in greater detail in the following sections.

INFORMATION COLLECTION PROCESS

The process of collecting information that will be used in the Risk Assessment task of this project involved personal interviews, phone interviews, on-line database searches, and library literature searches. Phone interviews and library literature searches were the most common methods used to acquire the information. Contact information for prospective data sources was acquired through contacts made at conferences, recommendations from personnel at Tetra Tech, web searches, and referrals from contacts made during the information collection process.

Table 1 contains a list of local contacts made by Tetra Tech and their affiliation. This list includes members of the federal and local governments, academia, as well as private citizens and environmental groups who provided information on the natural history of Monterey Harbor as well as the effects of environmental lead in marine and freshwater food chains.

Table 1. Contact List for Monterey Harbor

Contact	Affiliation
Tina Fahy	National Marine Fisheries Service (NMFS), Southwest Regional Office
Scott Kathey	Monterey Bay National Marine Sanctuary
Diedre Hall	Monterey Bay National Marine Sanctuary
Gary Ichikawa	California Department of Fish & Game, Moss Landing, CA
Steve Scheiblauer	Monterey Harbormaster
Scott Prior	NOAA
Steve Lonhart	NOAA
Robert Gwiazda, PhD	UC Santa Cruz
David Hoffman	USGS
Milosh Radokovich	Monterey Bay Net
Jonathon Geller	California Department of Fish & Game, Moss Landing, CA

SPECIES RESIDENT IN MONTEREY HARBOR

Steve Lonhart (NOAA) provided a list of species resident in Monterey Harbor. This list is fairly comprehensive and includes a broad range of phyla comprising 74 different species; one-third of which (25) belong to the phylum chordata, which includes tunicates, fish, mammals, and birds. The sponges represent the smallest number of species (2) (Table 2).

Table 2. Resident Species in Monterey Harbor

Phylum	Scientific Name	Common Name
Annelida	*Ctenodrilus serratus*	Polychaete
	Dipolydora socialis	Polychaete
	Exogone lourei	Polychaete
	Ficopomatus enigmaticus	Tube worm
	Myxicola infundibulum	Polychaete
	Neoleprea japonica	Polychaete
	Platynereis bicanaliculata	Polychaete
	Polydora cornuta	Polychaete
	Polydora Limicola	Polychaete
	Polydora sp.	Polychaete
	Sphaerosyllis sp.	Polychaete
	Typosyllis sp.	Polychaete
	Naineris sp.	Polychaete
Arthropoda	**Balanus improvisus**	Barnacle
	Corophium insidiosum	Amphipod
	Ianiropsis tridens	Isopod
	Melita nitida	Amphipod
	Monocorophium acherusicum	Amphipod (tube-dwelling)
	Sphaeroma quoyanum	Isopod
	Caprella acanthogaster	Amphipod (skeleton shrimp)
	Caprella californica	Amphipod (skeleton shrimp)
	Pugettia producta	Northern kelp crab
	Pagarus spp.	Hermit crab

Chordata:		**Ascidia zara**	Tunicate
		Botrylloides violaceus	Tunicate
		Ciona intestinalis	Tunicate
		Ciona sp.	Tunicate
		Didemnids	Tunicate
		Styela clava	Tunicate
		Botryllus schlosseri	Tunicate
		Botrylloides sp.	Tunicate
		Diplosoma macdonaldi	Tunicate
	Fishes	*Gibbonsia montereyensis*	Kelp fish
		Apodichthys fucorum	Rockweed Gunnel
		Coryphopterus nicholsii	Blackeyed goby
		Embiotoca jacksoni	Black perch
		Embiotoca lateralis	Striped surf perch
	Mammals	*Enhydra lutris*	Sea otter
		Zalophus californianus	California sea lion
		Phoca vitulina	Harbor seal
		Mirounga angustirostris	Northern elephant seal
	Birds	*Gavia immer*	Common loon
		Pelecanus occidentalis	Brown pelican
		Phalacrocorax penicillatus	Brandt's cormorant
		Phalacrocorax auritus	Double-crested cormorant
		Phalacrocorax pelagicus	Pelagic cormorant
		Larus californicus	California gull
		Larus occidentalis	Western gull
Cnidaria		*Diadumene lineata*	Anemone
		Ectopleura crocea	Pink-hearted hydroid
		Metridium senile	Anemone
		Corynactis californica	Anemone
		Urticina lofotensis	Anemone

	Tubularia marina	Pink-mouth hydroid
Ectoprocta	*Bowerbankia gracilis*	Bryozoan
	Bugula neritina	Bryozoan
	Cryptosula pallasiana	Bryozoan
	Membraniphora sp.	Bryozoan
	Schizoporella unicornis	Bryozoan
	Watersipora subtorquata	Bryozoan
Mollusca	*Batillaria attramentaria*	Snail
	Gemma gemma	Gem clam
	Haliotis rufescens	Red Abalone
	Mercenaria mercenaria	Quahog clam
	Petricolaria pholadiformis	False Angel Wing clam
	Crepidula sp.	Snail
	Olivella biplicata	Purple dwarf olive snail
	Mopalia spp.	Chiton
Echinoidia	*Pisaster ochraceus*	Ochre starfish
	Pisaster brevispinus	Starfish
	Pisaster giganteus	Starfish
	Asterina miniata	Batstar
Porifera	*Hymeniacidon sp.*	Sponge
	Prosuberites sp.	Sponge

LITERATURE SUMMARY

Lead has been mined and smelted by humans for centuries, with the use of lead-based products increasing greatly since the Industrial Revolution. Consequently, lead today is ubiquitous in air, water, soil, and sediments, in both rural and urban environments in concentrations that far exceed background levels. Aquatic and terrestrial organisms are exposed to lead mainly via transport across gill membranes, food ingestion, and inhalation.

The form of a chemical in the environment has a marked effect on the extent to which it can be taken up into the tissues of organisms and interact with the tissues to cause various harmful biological effects in the organisms themselves and their consumers, including humans (Nelson and Donkin, 1985; Waldichuk, 1985).

Only bioavailable chemicals may be bioaccumulated by marine organisms. Bioavailability is the extent to which a chemical can be absorbed or adsorbed by a living organism by active (biological) or passive (physical and chemical) processes. A chemical is said to be bioavailable if it is in a form that can move through or bind to the surface coating (e.g., skin, gill epithelium, gut lining, cell membrane) of an organism (Newman and Jagoe, 1994).

The bioavailability and bioaccumulation of lead in marine sediments and organisms (including invertebrates, mammals, and birds) is discussed in greater detail in the following sections.

Bioavailability Of Lead In The Sediment

SEM/AVS – Simultaneously Extracted Metals/Acid Volatile Sulfide - Acid volatile sulfide (AVS) plays an important role in metal bioavailability in aquatic sediments. AVS binds with several cationic metals (copper, lead, cadmium, zinc, and nickel) on an equimolar basis, forming insoluble metal sulfides. These metal sulfides are very stable and render the metal biologically inert and unavailable to organism assimilation. Additionally, these metals are converted to their respective sulfides in order of increasing solubility, meaning that copper sulfide will form first, followed by lead sulfide and so on until all of the nickel is converted, or until AVS has been depleted.

SEM and AVS are generally represented as a ratio of SEM to AVS. If the ratio is less than one (i.e., AVS exceeds SEM), then it is expected that the metals are bound to sulfide and are not readily biologically available. If the ratio is greater than one (i.e., SEM exceeds AVS), then it is expected that there is a potential for some metal to be bioavailable and since the rate of metal-sulfide conversion is predictable, it is possible to predict those metal(s) which would be bioavailable and those that will not be bioavailable.

Preliminary analysis of 34 sediment samples that were collected from 15 sites within Monterey Harbor in December 2004 indicates that lead is present in measurable concentrations. However, SEM/AVS analysis demonstrates that there is sufficient sulfide in the sediments to sequester and render biologically unavailable all of the lead in 28 of the samples and most of the lead in the remaining six. Preliminary calculated lead concentrations in those six samples are all below the Probable Effects Level (PEL) of 112 mg/kg, with 5 being slightly to moderately above the Effects Range Low (ERL) of 46.7 mg/kg (Range: 29.2 – 111.7 mg/kg).

Bioavailability and Bioaccumulation of Lead by Marine Organisms

Aquatic Organisms - Lead accumulates outside cells, at least in invertebrates, in granules rich in carbonate (perhaps as a $PbCO_3$ precipitate) (Luoma 1986). Particulate lead may be taken up into epithelial cells of the gut and possibly other tissues such as gills and mantle, in marine mollusks (George et al., 1975, 1976, 1977; Fowler et al. 1981). Metal-rich granules, either formed inside cells or taken up across epithelial surfaces, are stored in various tissues, usually the kidney or hepatopancreas, and the metals in them have a limited bioavailability to the animals or their predators (Nott and Nicolaidou, 1994; Regoli and Orlando, 1994), thus, allowing for the possibility that this mode of accumulation without assimilation is responsible for the relatively low toxicity of inorganic lead to marine animals.

No studies were identified in the scientific literature demonstrating that lead tissue concentrations can be actively regulated by aquatic biota. However, lead will bind to metallothionein and also probably has a higher affinity for other metabolic ligands, as it is often associated with deposited inorganic granules with high concentrations of calcium (Rainbow, 1988). Hopkins and Nott (1979) demonstrated that the shore crab *Carcinus maenas* detoxifies lead in calciferous granules in the midgut gland. The detoxification and storage of lead in shellfish has been suggested for the zebra mussel *Dreissena polymorpha* (Kraak, et al 1994; Bleeker, et al. 1992), the blue mussel *Mytilus edulis* (Talbot et al. 1976; Schulz-Baldes, 1974), the Eastern oyster *Crassostrea virginica* (Schuster and Pringle, 1969; Pringle, et al. 1968; Zaroogian, et al. 1979) and the soft-shell clam *Mya arenaria* (Pringle, et al. 1968). Mussels *Mytilus edulis* accumulate 23.5 percent of the lead provided to them in lead-contaminated algae *Dunaliella marina* compared to 29 percent of the lead provided in solution in the ambient seawater (Shultz-Baldes, 1974). However, the feces of mussels is enriched nearly six-fold with lead compared to their algal food, suggesting that absorption of lead from the gut is inefficient (Amiard et al., 1986). It should be noted, that while dietary lead may be unavailable to some species, for others, dietary lead could be taken up; however, the very low efficiency of uptake (Vighi, 1981) ensures that it does not biomagnify.

The bioavailability of lead to Benthic animals is proportional to the lead/iron concentration ratio in weak acid extracts of the sediment, indicating that the lead that is adsorbed to iron oxide coatings on sediment particles is not bioavailable. In moderately hypoxic or anoxic sediments, most of the lead is precipitated as lead sulfide and is not bioavailable (Kersten and Főrstner, 1986; Bourgoin et al. 1991a,b; DeLaune et al. 1999). Oxidation of anoxic sediments caused by biological or physical resuspension does not increase the bioavailability of lead to Nereid polychaetes (Howell, 1985), suggesting that lead sulfide is oxidized very slowly in oxidized sediments.

Sea otters, *Enhydra lutris*, consume both Benthic invertebrates and kelp-bed fishes and, therefore, can be considered one of the top predators locally. Lead isotopic ratios in otter teeth from otters collected from the Aleutian Islands, Alaska indicate that concentrations of lead in the otters has not increased due to anthropogenic inputs of lead into the environment (Smith et al. 1990). The lack of an increase in concentrations of lead in otter tissues despite historic increases in the flux of industrial lead to the ocean indicates that lead is not being biomagnified through the marine food chain (Smith, et al, 1990).

Waterfowl - The literature is replete with examples of lead toxicity to waterfowl, particularly with respect to the ingestion of spent lead shot (Bellrose, 1959; Sanderson and Bellrose, 1986; Pain 1992) and lead fishing weights (Simpson, *et. al* 1979; Sears 1988). Additionally, studies in both the field and laboratory have demonstrated that the ingestion of lead-contaminated sediment containing between 4,520 and 6,990 µg/g lead can also poison waterfowl (Blus *et al*. 1991, 1999; Beyer *et al*. 1998, 2000; Heinz *et al* 1999; Hoffman *et al* 2000a, b; Sileo *et al*. 2001). These concentrations are more than two orders of magnitude greater than those found in the Monterey Harbor sediments.

Although the effects of diet are widely recognized, the exact mechanisms by which they occur have not been fully explained. Much of the protective effect of nutrient-rich diets appears to occur in the digestive system (Sanderson, 1992) and, when lead is ingested along with food, certain chemical groups in food components have a ligand effect; binding lead in a nonsoluble and non-bioavailable form in the intestine (Morton et al. 1985).

Additionally, lead does not bioaccumulate in fat or soft tissue. It is stored mostly in bone but it is not preferentially enriched in bone with respect to the lead concentration in the medium from which the lead is picked up. Thus, there is no enrichment, or increase in concentration, up the food chain, but in fact biopurification (Gwiazda, personal communication, January 28, 2005; Elias, et al. 1982). Biopurification, or depletion, of lead occurs in marine food chains relative to its biogeochemical analogue, calcium (Smith, et al. 1990). Lead is biodepleted relative to calcium during transfer from marine plants to primary consumers because of discrimination against lead in favor of calcium in the gut of the consumer. Lead is further depleted, or biopurified, during transfer from the primary consumers to carnivores. Thus, lead concentrations are actually reduced as one moves up the food chain.

In summary, these findings suggest the following:

- Lead in Monterey Harbor sediments is tightly bound as sulfides and, in most cases, biologically unavailable.
- Inorganic lead is transformed into insoluble granules by marine mollusks and benthic invertebrates, thereby reducing the bioavailability of the lead.
- Absorption of lead from the gut of mussels and crabs is inefficient.
- Lead does not biomagnify up the food chain but, rather, biopurifies.
- Increases in anthropogenic lead fluxes has not resulted in an increase in lead contaminated sea otters.
- Lead consumed with food by waterfowl becomes chelated by various ligands that render the lead into a nonsoluble or non-bioavailable form.
- Any soluble lead in the Monterey Harbor sediment has a high likelihood of being further sequestered by either granulation in invertebrates or chelated by ligands in waterfowl digestive tracts. This will result in the lead being rendered non-bioavailable and, therefore, most likely will not result in degradation of the beneficial uses of the harbor.

RISK ASSESSMENT METHODOLOGY

The purpose of this task is to provide a screening-level risk assessment for Monterey Harbor that can be used to assess whether lead concentrations currently found in the harbor sediments pose any risk to the beneficial uses of the harbor.

The methods that will be used for the Risk Assessment task of this study will conform to those described in EPA 600/R-93/187 "Wildlife Exposure Factors Handbook Volume I of II" as well as EPA/630/R-95/002B "Proposed Guidance for Ecological Risk Assessment" and Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments." As illustrated in the draft conceptual model below, the risk assessment will evaluate the pathways for ingestion and absorption for sources, exposure, and effects. Where possible, the indicator species used for the Risk Assessment will be those who are resident to Monterey Harbor. Otherwise, the closest surrogate species will be used.

Monterey Harbor Lead Study
Risk Assessment Conceptual Model

Pathways ranked in order of assumed risk:

Ingestion

Source
- 5 sites with levels above ERL
- AVS binds majority of lead
- Several species reside or feed in sediments

→

Exposure
- Biochemical ligands bind available lead in gut.
- Lead is granulated in invertebrate gut
- Inefficient lead absorption in intestinal tracts

→

Effects
- Toxicity of lead on resident species evaluated
- Reduced exposure to toxic levels of lead
- Lead depletion occurs as one moves up the food chain
- Higher level organisms not adversely affected by food borne lead

Absorption

Source
- Several species reside in the water column and are exposed to dissolved toxicants.
- Water column dissolved lead concentrations <1 ppb

→

Exposure
- Active lead is transported across gills and membranes

→

Effects
- Waterborne lead is below levels known to cause impairment to aquatic life.

Inhalation

Not considered to be a significant pathway for this study.

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May 20, 2005
MFG Project No. 030213

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Subject: Monterey Harbor Lead in Sediment Study, Phase II and Proposal to Delist Monterey Harbor for Lead

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Dear Ms. McCann:

1.0 INTRODUCTION

Union Pacific Railroad Company (UPRR) requested MFG, Inc., a Tetra Tech company, to assist the railroad in developing a sampling strategy and Work Plan, and to provide technical and regulatory support regarding potential lead impacts to Monterey Harbor. On behalf of UPRR, MFG is submitting this technical report that presents the following:

- Background information;
- Results of a multi-tiered study that included sediment, water, and tissue analyses for lead and a small-scale Ecological Risk Assessment based on these analyses;
- Comparison of the results to established criteria, literature guidelines, and beneficial uses of Monterey Harbor; and
- Findings supporting consideration of delisting Monterey Harbor for lead.

Each of these topics is discussed in greater detail in the following sections.

2.0 BACKGROUND

Monterey Harbor was added to California's Clean Water Act (CWA) 303(d) list for lead in 1998, because levels of lead in the tissue of mussels (*Mytilus californianus*) exceeded Median International Standards[1] (MIS) and were greater than Elevated Data Levels[2] (EDLs) as reported by the State Mussel Watch Program. Also sediment lead levels were elevated sediment lead levels as determined by the State Water Resources Control Board (SWRCB) and published in the *Bay Protection and Toxics Cleanup Program, Monterey Lead Study* (published as part of the document *Chemical and Biological Measures of Sediment Quality in the Central Coast Region Final Report* [SWRCB, 1998]).

UPRR was asked by the California Regional Water Quality Control Board, Central Coast Region, (RWQCB) to conduct a sediment sampling study as a follow-up to the 1992 removal of a potential onshore source of lead to the Monterey Harbor, so that the RWQCB staff could determine if a lead total maximum daily load (TMDL) were needed for the Harbor.

A brief timeline of events and previous sampling efforts will establish context for this report.

- Circa 1880 — The railroad builds a railroad spur line to service canneries in Monterey Bay harbor.
- Circa 1905 — The railway bed is stabilized along the shoreline using foundry slag that contains high levels of lead.
- 1981-1983 — State Mussel Watch Program results indicate tissue lead concentrations that exceed Monterey County Health Department advisory limits.
- 1988 — RWQCB sampling identifies the extent of lead contaminated sediments documented in *Monterey Harbor Lead Study, September 1988*, by Wilder and Jagger.
- 1989 — Southern Pacific Transportation Company (SP) contracts International Technology Corporation (IT) to partially remove onshore slag.

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[1] Median International Standards are values compiled by the State Water Resources Control Board as in-house guidance provided to the Regional Boards. They are based on criterion developed from a United Nations Food and Agriculture Organization publication of a survey of health protection criteria used by member nations (Nauen, 1983). They are guidance values only.

[2] Introduced by State Water Resources Control Board staff in 1983 as an internal comparative measure (SWRCB, 2003).

- 1990 SP (IT) delineates extent of slag-related material onshore.
- 1992 SP removes the onshore lead impacted material and disposes of the material into a regulated landfill.
- 1993 SP (Entrix) sampling indicates declining concentrations of lead in sediments in the Harbor.
- 1996 State Mussel Watch Program results indicate tissue lead concentrations that exceed the program's EDLs.
- 1998 SWRCB conducts sampling under *Bay Protection and Toxics Cleanup Program, Monterey Lead Study,* published as part of the document *Chemical and Biological Measures of Sediment Quality in the Central Coast Region Final Report* (SWRCB, 1998).
- 1998 Monterey Harbor listed as an impaired water body under the provisions of Section 303(d) of the CWA.

3.0 LEAD OBJECTIVES

3.1 Basin Plan Objectives

According to the RWQCB, Region 3's *Water Quality Control Plan* (Basin Plan) (RWQCB, 1994), there should not be any constituents present in water bodies at levels which compromise beneficial uses. Numeric objectives exist for water; however, no numeric objectives exist for either sediment or tissue. Existing Beneficial Uses for Monterey Harbor include: non-contact recreation, industrial service supply, navigation, marine habitat, shellfish harvesting, and habitat for rare and endangered species. Anticipated beneficial uses include contact recreation, and commercial and sport fishing.

Water

The Basin Plan contains both narrative (Table 3-1) and numeric (Table 3-2) water quality objectives for specific metals and beneficial uses. The narrative objective is interpreted to mean that concentrations of lead, in this situation, should not exist in a suspended or settleable form in the water column. Water quality objectives in the Basin Plan are expressed as concentrations of *total* metals in the water column. In addition to the Basin Plan, the California Toxics Rule[3] (CTR) provides water quality objectives expressed as *dissolved*

[3] Federal Register, May 18, 2000 (40 CFR Part 131: Vol. 65, No.97, Page 31682)

metals concentrations. The CTR supersedes the Basin Plan when it is more stringent than the Basin Plan[4]. Similarly, if the Basin Plan is more stringent than the CTR, Basin Plan numbers shall be used.

Table 3-1. Basin Plan's Narrative Objective Description

Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain settleable material in concentrations that result in deposition of material that causes nuisance or adversely affects beneficial uses.

Table 3-2. Basin Plan's Numeric Water Quality Objectives for Metals in Marine Environments

Metal	Total Concentration (µg/l)
Cadmium	0.2
Chromium	50
Copper	10
Lead	**10**
Mercury	0.1
Nickel	2
Zinc	20

3.2 California Toxics Rule

Water

Existing policy at the Federal level and at the SWRCB is to use dissolved metals measurements to evaluate compliance with aquatic life water quality standards, because dissolved metal more closely approximates the bioavailable fraction of the metal in the water column than does total recoverable metal[5]. Therefore, based on this policy and the rationale that dissolved metals more closely approximate the bioavailable fraction of metal in the water column, all water column samples collected during this study were analyzed for dissolved metals and compared to the CTR water quality standards, as this approach is considered the most protective measurement for aquatic life (Table 3-3).

[4] Federal Register, May 18, 2000, (40 CFR Part 131: Vol. 65, No.97, pp. 31687)
[5] Federal Register, May 18, 2000, (40 CFR Part 131: Vol. 65, No.97, pp 31690)

Table 3-3. California Toxics Rule[6] Water Quality Standards for Metals in Marine Environments

Metal	Saltwater	
	Criterion Maximum Concentration[7], dissolved (µg/l)	Criterion Continuous Concentration[8], dissolved (µg/l)
Arsenic	69	36
Cadmium	42	9.3
Chromium (total)	1,100	50
Copper	4.8	3.1
Lead	**210**	**8.1**
Nickel	74	8.2
Selenium	290	71
Silver	1.9[9]	NA
Zinc	90	81

3.3 Other Guidance (Sediment and Tissue)

Sediment

There are no existing sediment quality criteria, however the NOAA SQuiRT[10] tables provide one set of guidance values that are commonly used to evaluate sediment concentrations. SQuiRT presents screening concentrations for inorganic and organic contaminants in various environmental media. These screening concentrations were derived initially using a database compiled from studies performed in both saltwater and freshwater in all different areas of North America and published in NOAA Technical Memorandum NOS OMA 52. The tables are intended for preliminary screening purposes only; they do not represent official NOAA policy and do not constitute criteria or clean-up levels. Users of SQuiRT values are strongly encouraged to review supporting documentation to determine appropriateness for their specific use. Their use in certain situations may not be appropriate.

[6] Federal Register, May 18, 2000, (40 CFR Part 131: Vol. 65, No.97, pp 31712)
[7] An estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.
[8] An estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.
[9] Instantaneous maximum.
[10] NOAA SQuiRT values are "Screening Quick Reference Tables," October 1999. These tables can be downloaded from: http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html

Tissue

Most metals do not have a standard tissue objective established by any of the following agencies: United States Environmental Protection Agency (USEPA); California Office of Environmental Health Hazard Assessment (OEHHA); United States Food and Drug Administration (USFDA); California Department of Health Services (DHS); or the United States Fish and Wildlife Service (USFWS). The few metals that do have standards include: arsenic[11], cadmium[12], copper[13] and chromium[14]. All other metals do not have approved standards for tissues.

Although there are no approved United States standards against which to compare all tissue values, there are values called median international standards (MIS). MIS is a literature value criterion developed from a United Nations Food and Agriculture Organization publication of a survey of health protection criteria used by member nations (Table 3-4). Though the standards do not apply within the United States[15], they provide an indication of what other nations consider to be an elevated concentration of trace elements in shellfish (State Mussel Watch Program, 2000). These MIS values will be used as literature values to evaluate the tissue data collected in this study.

Table 3-4. Median International Standards for Trace Elements[16]

Element	Freshwater Fish (mg/kg)	Shellfish (mg/kg)	Range of Standards (mg/kg)	Number of Countries with Standards
Arsenic	1.5	1.4	0.1 - 5.0	11
Cadmium	0.3	1.0	0.05 - 2.0	10
Chromium	1.0	1.0	1.0	1
Copper	20.0	20.0	10 - 100	8
Lead	**2.0**	**2.0**	**0.5 - 10.0**	**19**
Mercury	0.5	0.5	0.1 - 1.0	28
Selenium	2.0	0.3	0.3 - 2.0	3
Zinc	45.0	70.0	40 - 100	6

[11] USEPA standard = 1.2 ppm (wet weight) for inorganic As and OEHHA objective = 1.0 ppm (wet weight) for total As. (From: RWQCB, 2003)
[12] USEPA standard = 4.0 ppm (wet weight) and OEHHA objective = 3.0 ppm (wet weight) (From: RWQCB, 2003).
[13] USFWS Biological Effects level = 15 ppm (wet weight) (From: RWQCB, 2003).
[14] USFDA cites a chromium "level of concern" for shellfish of 13 ppm (USFDA, 1993) (From: RWQCB, 2003).
[15] Project Report: Recommendation to Delist Morro Bay, San Luis Obispo County, California for Metals from the 303(d) List. State of California Central Coast Regional Water Quality Control Board. December 2003.
[16] Values in table are for the edible portion, ppm - wet weight), (Nauen, 1983).

4.0 EVALUATION OF EXISTING LEVELS OF LEAD IN MONTEREY HARBOR

4.1 Historical Assessment Studies

Previous sediment surveys indicate a significant decline in lead concentrations in Monterey Harbor between the 1988 RWQCB report and the 1993 sampling conducted by Entrix (1993) (Table 4-1).

However, the 1996 State Mussel Watch Program reported that Monterey Harbor mussel tissues had elevated lead concentrations (6.9 ppm), which suggests that there may be a continuing (or additional) source(s) of lead.

Table 4-1. Historical Lead Concentrations in Monterey Harbor Sediment

	Lead (mg/kg – dry weight)	
Sample ID*	**1988**	**1993**
MFG-1A	NS	90.1
MFG-1A (dup)	NS	NS
MFG-2	130	41
MFG-3	NS	32.6
MFG-4	NS	29.2
MFG-5	NS	NS
MFG-6A	46	33
MFG-6B (dup)	NS	80
MFG-7	78	58
MFG-8	13	5
MFG-9	97	39
MFG-10	76	40
MFG-11	140	96
MFG-12	49	50
MFG-13	100	60
MFG-14	5800	190
MFG-15	200	37

Historical lead concentrations from: Table 4, page 15 of the Entrix report (Entrix, 1993).

* Sample IDs are those used for 2003/2004 sample locations (MFG, 2004). Locations of 2003/2004 samples were approximately the same as in 1988 and 1993.
NS = Not Sampled

4.2 Background - Phase I

On September 13, 2004, MFG submitted a report to the RWQCB describing the potential impacts of lead to the beneficial uses of Monterey Harbor (MFG, 2004). The objective of the September 13th report was to answer the following questions: (1) is lead present in Harbor sediments above threshold criteria? (2) If elevated lead concentrations are present in Harbor sediments or mussels, do they originate from the removed slag pile? (3) If elevated lead concentrations originating from the former slag pile are present, do they represent impairment to the beneficial uses of shellfish in the Harbor?

The September 13th report presented the following findings and conclusions:

> *"Lead concentrations in mussel tissue samples taken from Monterey Harbor have been reduced significantly over the past decade as evidenced in the mussel tissue assessments carried out in 2003-2004. However, even though there has been a significant reduction in lead contamination, the data indicates that there remains a slight potential for beneficial use impairment.*
>
> *There are several factors that should be considered in evaluating the potential for impairment to beneficial uses in Monterey Harbor:*
>
> - *Shellfish harvesting in Monterey Harbor for both humans and as a food source for wildlife is marginal due to the limited amount of suitable habitat.*
> - *The lead contaminant study in Monterey Harbor by Flegal, et al. 1987 indicates that there is uncertainty regarding the bioavailability of lead in mussels (sediment bound lead in gut) to higher trophic levels.*
> - *Chemical analyses included in this study, including STLC and SEM:AVS, indicate that the lead is tightly bound in the sediment in forms that are not readily bioavailable.*
> - *Preliminary avian and mammalian risk assessments, using the assumption that all lead in the mussel tissues is bioavailable, suggest that the MIS is not the most appropriate standard for Monterey Harbor and that a mussel tissue lead criterion could be adjusted upward.*
>
> *Using the current criteria (TEL and MIS) there is minimal environmental risk to humans and wildlife in Monterey Harbor.*

Portions of the environmental data collected as part of this project, preliminary risk calculations, and other factors listed above support consideration of updated numeric targets for lead in Monterey Harbor. Additional environmental data, literature reviews, and risk calculations are needed to propose updated numeric targets for Monterey Harbor"

4.3 Background - Phase II

Phase II was designed to address the additional needs discussed above, so that a determination of whether lead is continuing to be a source of impairment to Monterey Harbor could be made. The study design used a multi-stepped approach to investigate the levels of lead in the sediments, water column, and mussel tissues, and the potential impact any remaining lead in the sediments may have on the beneficial uses of Monterey Harbor. The steps of the Phase II study may be summarized as follows:

- Step 1: Sediment core samples were collected from 15 sites within Monterey Harbor where Southern Pacific removed the slag material and where previous monitoring efforts have been focused (Figure 4-1). The cores (12") were sectioned into two aliquots (upper 2" and lower 2") and analyzed for total lead, in an effort to provide additional data to assess (a) whether temporal declines in sediment lead concentrations have continued, and (b) whether lead concentrations in Harbor sediment exceed Threshold Effects Levels[17] (TELs).

- Step 2: The bioavailability of the lead was evaluated (e.g., the ratio of simultaneously extracted metals to acid volatile sulfides - SEM:AVS) to assess the potential risk posed to shellfish and other organisms. This evaluation could support a) delisting for lead, b) a site-specific cleanup target, and/or c) a TMDL endpoint for lead, if necessary.

- Step 3: Surface water was collected from 15 sites within Monterey Harbor to measure the total and dissolved fractions of lead in the water column (Figure 4-1).

- Step 4: Bioassessment monitoring of mussels (*Mytilus californianus)* was used to evaluate the potential for contamination of whole shellfish tissue originating from lead in the sediments. This monitoring used the protocols developed by the California State Mussel Watch Program, and was identical to the protocols that originally resulted in Monterey Harbor

[17] Developed by the Florida Department of Environmental Protection (FDEP). The TEL is the concentration below which negative biological effects are unlikely.

being listed for lead. The mussels were deployed at 10 sites during the winter months[18] when the water conditions are their most turbulent and the chances of sediment-bound lead suspension are the greatest.

- Step 5: Small-scale ecological risk assessment using mussel tissues as a source of dietary lead to the most sensitive life stage of marine birds and protected mammals (sea otter and harbor seal).

Step 1 and Step 2 are discussed in more detail in Section 4.3.1. Step 3 is discussed in more detail in Section 4.3.2. Step 4 is discussed in more detail in Section 4.3.3. Step 5 is discussed in more detail in Section 5.0.

[18] December 2004 to February 2005.

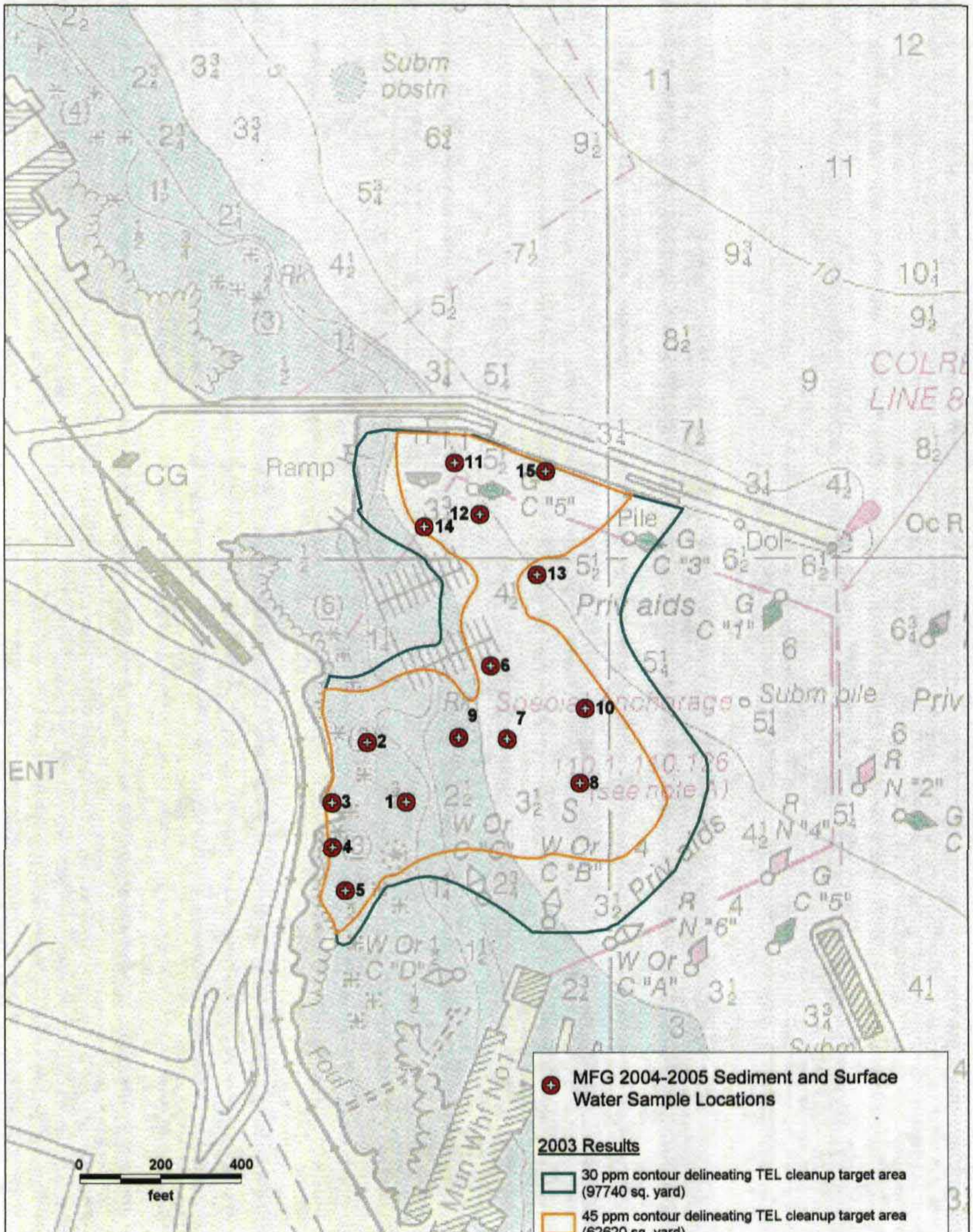


Figure 4-1. Locations of Sediment and Surface Water Sampling Sites in Monterey Harbor

Table 4-1. Latitude and Longitude of Sediment and Water Sampling Sites

Site ID	Latitude	Longitude	Water Depth (feet)
1	36.60667	-121.89343	8
2	36.60707	-121.89372	8
3	36.60665	-121.89402	3
4	36.60633	-121.89403	4
5	36.60597	-121.89388	4
6	36.60765	-121.89269	25
7a	36.60712	-121.89253	24
7b	36.60712	-121.89253	24
8	36.60682	-121.89192	28
9	36.60713	-121.89297	20
10	36.60730	-121.89185	30
11	36.60907	-121.89298	32
12	36.60872	-121.89275	33
13	36.60823	-121.89223	34
14	36.60862	-121.89318	27
15	36.60900	-121.89208	40

Photo 4-1. Diver Collecting Sediment in Monterey Harbor

4.3.1 *Summary of Sediment Data*

On December 20, 2004, MFG contracted California Department of Fish & Game divers to collect sediment samples from the sediment-water interface and at a depth of one foot from 15 locations in Monterey Harbor (Figure 4-1, Table 4-1, and Photo 4-1). The locations were centered on the sites that exhibited the highest concentrations of lead observed during the Phase I portion of the study. These samples were analyzed by North Creek Analytical (Bothell, WA) for the following sediment parameters:

- Total lead; and
- The ratio of Simultaneously Extracted Metals to Acid Volatile Sulfides (SEM:AVS).

A description of each of the sediment parameters is presented below.

Total Lead - Analysis of total lead concentrations in the sediment provides, on a dry-weight basis, a numerical value of the sum of all of the lead species (organic, inorganic, labile) present in a particular sediment sample. This method uses a strong acid digestion that liberates all the lead in whatever form. This analysis provides a "worst-case" scenario since it liberates and measures all lead that might be sequestered by various organic (total organic carbon or TOC) and inorganic (acid volatile sulfides or AVS) compounds.

SEM:AVS – Simultaneously Extracted Metals:Acid Volatile Sulfide - Acid volatile sulfide (AVS) plays an important role in metal bioavailability in aquatic sediments. AVS binds with several cationic metals (copper, lead, cadmium, zinc, and nickel) on an equimolar basis, forming insoluble metal sulfides. These metal sulfides are very stable and render the metal biologically inert and unavailable to organism digestion. Additionally, these metals are converted to their respective sulfides in order of increasing solubility, meaning that copper sulfide will form first, followed by lead sulfide and so on until all of the nickel is converted, or until AVS has been depleted. The lead extraction method used in the SEM:AVS is different than the previously described total lead analysis in that it is based on an acid drip methodology that is less aggressive than the baked acid extraction method used in the total lead analyses.

SEM and AVS are generally represented as a ratio of SEM to AVS (SEM:AVS). If the ratio is less than one (i.e., AVS exceeds SEM), then it is expected that the metals are bound to sulfide and are not readily biologically available. If the ratio is greater than one (i.e., SEM exceeds AVS), then it is expected that there is a potential for some metal to be bioavailable. Since the rate of metal-sulfide conversion is predictable, it is possible to predict those metal(s) that would be bioavailable and those that would not be bioavailable.

Relevant Sediment Quality Guidance

No sediment quality criteria have been established for California waters. However, regulators are frequently using sediment quality screening guidelines developed by NOAA as numeric endpoints for various assessments (Section 3.3). These commonly used NOAA screening guidelines for impairment of marine sediments are:

- **Threshold Effects Level (TEL)** represents the concentration below which adverse effects are expected to occur only rarely. The TEL is calculated as the geometric mean of the 15^{th} percentile concentration of the toxic effects data set and the median of the no effects data set.

- **Effects Range-Low (ERL)** is at the low end of a range of levels at which effects were observed in the studies compiled. The ERL represents the value at which toxicity may begin to be observed in sensitive species. The ERL is calculated as the lower 10^{th} percentile concentration of the available sediment toxicity data that have been screened for only those samples that were identified as toxic by original investigators.

- **Probable Effects Level (PEL)** is the level above which adverse effects are frequently expected. The PEL is calculated as the geometric mean of the 50^{th} percentile of impacted, toxic samples and the 85^{th} percentile of the non-impacted samples.

Table 4-2 provides a summary of the Phase II data. Values exceeding the Probable Effects Level (PEL=112 mg/Kg) are highlighted in yellow and bold italic print; those exceeding the Effects Range-Low (ERL=46.7 mg/Kg) are highlighted in blue and bold print; and those exceeding the Threshold Effects Level (TEL=30.2) are highlighted in green and italic print. As discussed in Section 3.3, the PEL, ERL and TEL values are screening level values published by NOAA and do not constitute criteria or clean-up levels.

Figures 4-2 through 4-7 illustrate the sediment lead concentrations for both measured and calculated samples from the Monterey Harbor December 2004 monitoring conducted by MFG. The charts are organized by method presenting both the surface and depth samples separately. The three sets of values include: Figures 4-2 and 4-3 - total lead sediment concentration using EPA Method 6020, which is the most intense acid extraction; Figures 4-4 and 4-5 - total lead using the Simultaneous Extracted Metals procedure, which is a less intense acid digestion; and Figures 4-6 and 4-7 - the calculated lead concentration believed to be bioavailable after accounting for the lead that is sequestered by the sulfides present in the sediment sample. Included on the charts are reference lines for the SQuiRT screening-level endpoints: PEL, ERL, and TEL.

One surface and three deep sediment samples contained concentrations of total lead in excess of the PEL guidance level of 112 mg/kg. Seventeen of the samples contained total lead concentrations that were greater than the ERL guidance level of 46.7 mg/kg (but less than the PEL). Seven of the samples had total lead concentrations in excess of the TEL guidance level of 30.2 mg/kg (but less than the ERL).

The percentage of samples containing available lead is sharply reduced when the SEM:AVS data are included (Table 4-2). As mentioned previously, AVS has the ability to form insoluble lead-sulfide complexes that render the lead non-bioavailable and, thus, not toxic to aquatic life. When AVS is included, the number of samples that had lead concentrations greater than the SQuiRT guidance dropped to five. The available lead concentrations of all five samples were below the PEL and slightly-to-moderately greater than the ERL. This indicates that the majority of the sediment-bound lead in Monterey Harbor is sequestered as lead sulfide complexes and less bioavailable than would be predicted if total lead concentration values were used alone.

Table 4-2.
Data Summary for Analyses Performed on Sediments Collected From Monterey Harbor (December 20, 2004)

1 Top 2-inches of a 12" core.
2 Bottom 2-inches of a 12" core.
3 SEM:AVS < 1.0 indicates an excess of AVS and non-bioavailability of sediment lead; SEM:AVS > 1.0 indicates an excess of bioavailable lead.
4 A "zero" value indicates that there is sufficient AVS to sequester all available lead and is a calculated rather than measured value.

Concentration greater than of one or more of the following screening criteria are indicated by:

- *Italic:* Threshold Effects Level (TEL = 30.2 mg/Kg)
- **Bold:** Effects Range-Low (ERL = 46.7 mg/Kg)
- ***Bold Italic***: Potential Effects Level (PEL = 112 mg/Kg)

Sample ID	Total Pb (mg/kg – dry weight) [EPA Method 6020]		SEM Pb (mg/kg – dry weight)		SEM:AVS[3] (Cu + Pb: AVS) [EPA Method 6020/7470]		Concentration of Available Pb (mg/kg) [Theoretical]	
	Surface [1]	Depth [2]	Surface [1]	Depth [2]	Surface [1]	Depth [2]	Surface [1]	Depth [2]
01	**78.3**	**61.8**	**54.1**	**49.4**	<1	<1	0[4]	0
02	***126***	***122***	**75.5**	**108**	<1	<1	0	0
03	**76.7**	**62.9**	**60.4**	**59.6**	>1	>1	**60.4**	**59.6**
04	**98.7**	**70.4**	**87.6**	**77.3**	>1	>1	**87.6**	**77.3**
05	23.5	21.2	*32.2*	14.6	<1	<1	0	0
06	**63.5**	**95.2**	*33.7*	**83.9**	<1	<1	0	0
07a	**92.4**	**70.9**	**52.8**	*44.6*	<1	<1	0	0
07b	**98.4**	**73.2**	**96.9**	**69.8**	<1	<1	0	0
08	28.5	**50.1**	23.6	**50.7**	<1	<1	0	0
09	**99.0**	***133***	**78.5**	***130***	<1	>1	0	**75.5**
10	*42.0*	*32.0*	*36.3*	*41.3*	<1	<1	0	0
11	*46.4*	*31.5*	*35.2*	26.7	<1	<1	0	0
12	25.3	*40.6*	*38.9*	*33.8*	<1	>1	0	29.2
13	*43.6*	**54.7**	*37.8*	*41.2*	<1	<1	0	0
14	*39.5*	**72.8**	*36.1*	**71.9**	<1	<1	0	0
15	**63.1**	***754***	**62.5**	***242***	<1	<1	0	0

Figure 4-2. Surface Total Lead Sediment Concentrations

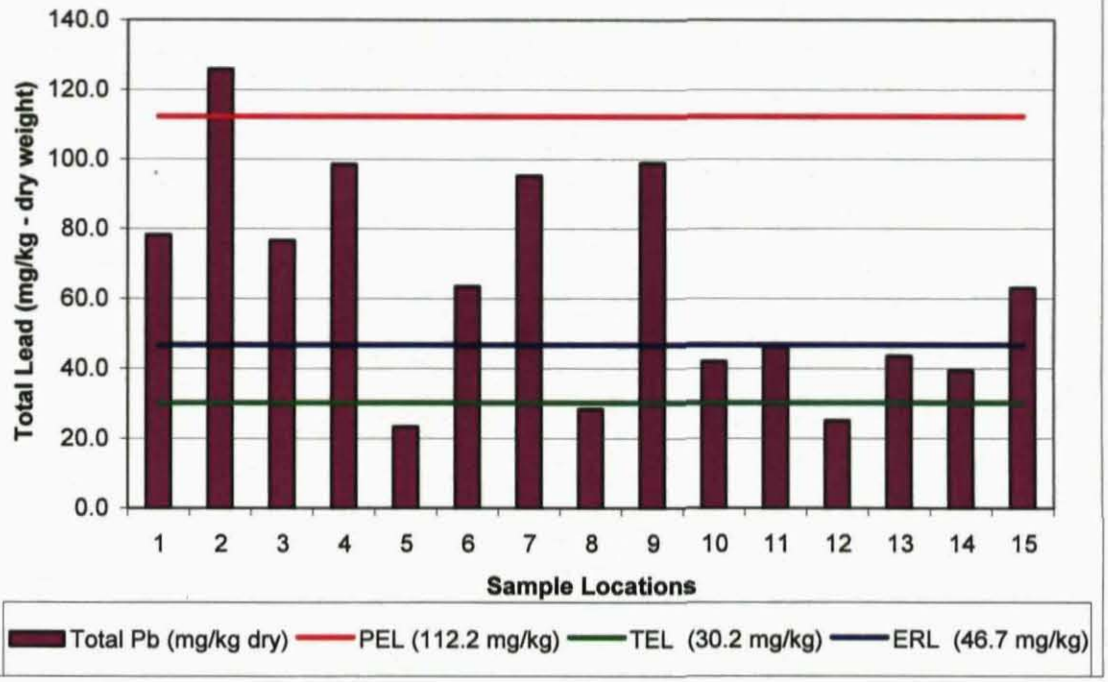


Figure 4-3. Depth Total Lead Sediment Concentrations

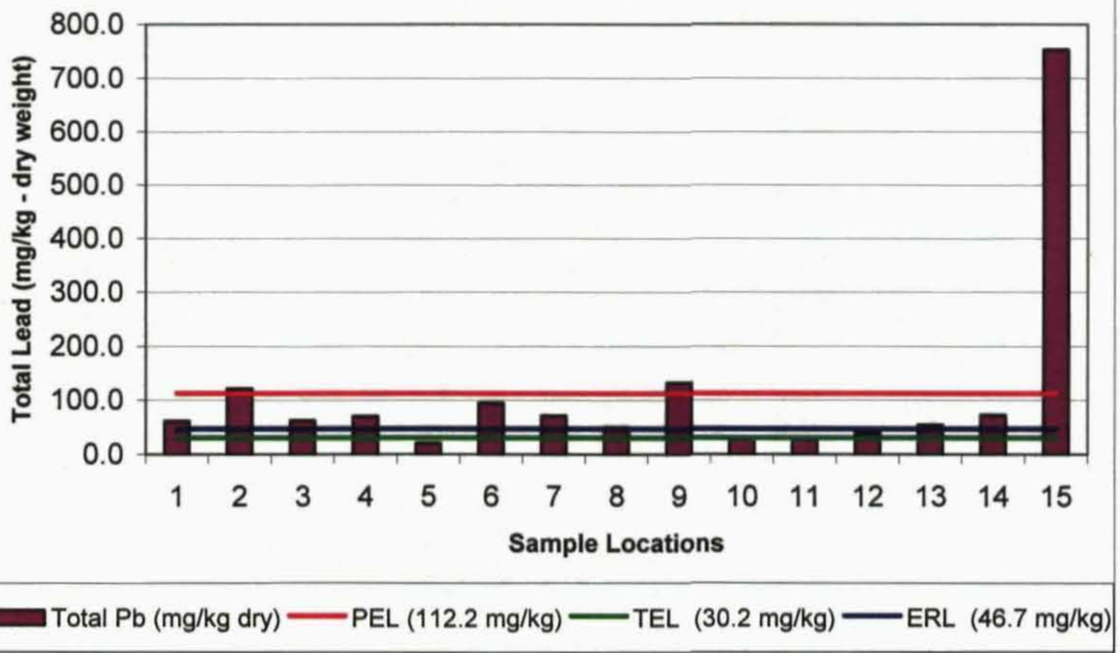


Figure 4-4. Surface SEM Lead Sediment Concentrations

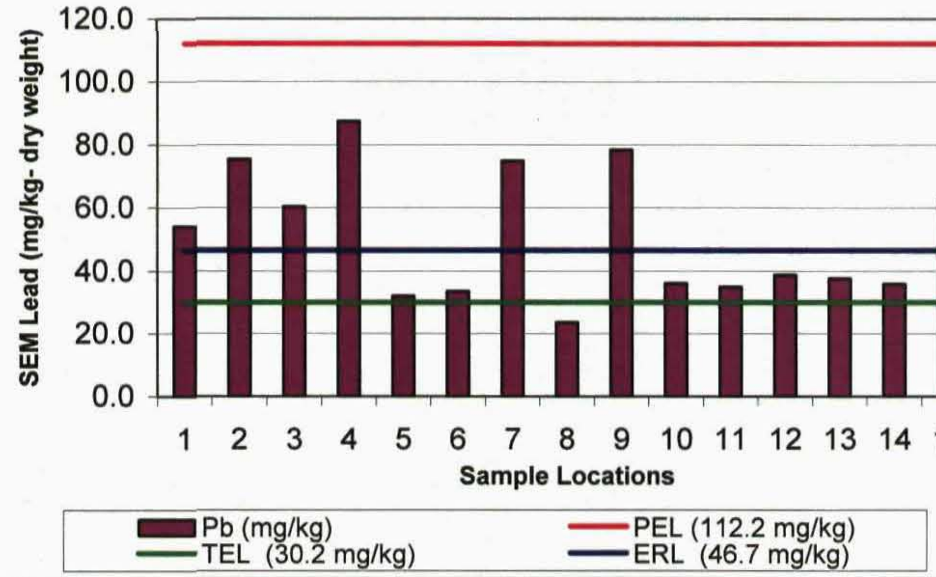


Figure 4-5. Deep SEM Lead Sediment Concentrations

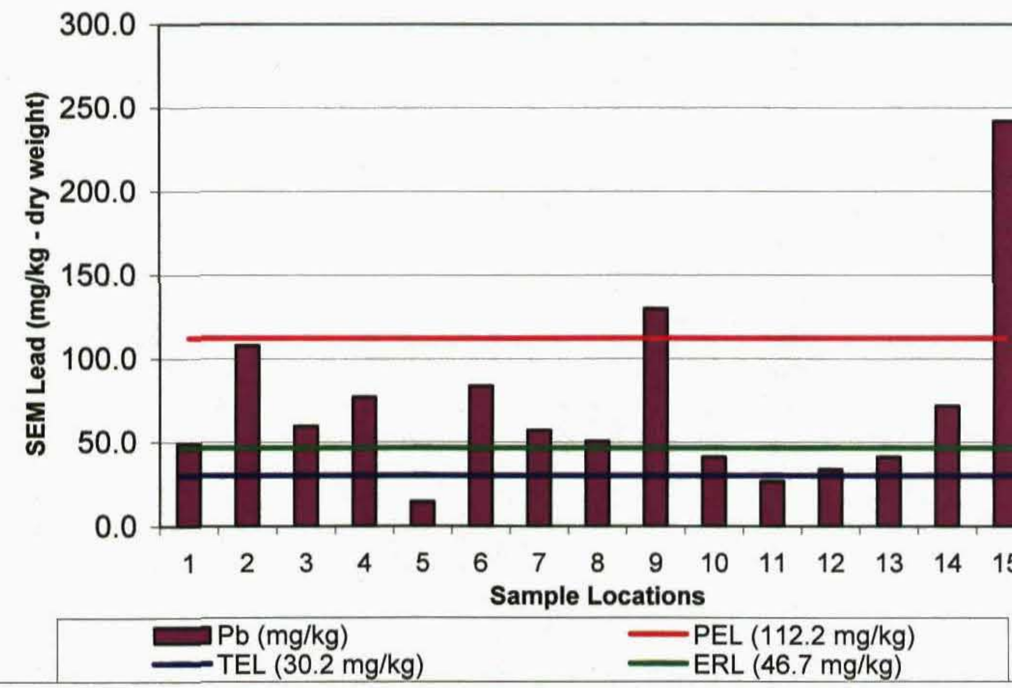


Figure 4-6. Surface AVS Adjusted Lead Concentrations

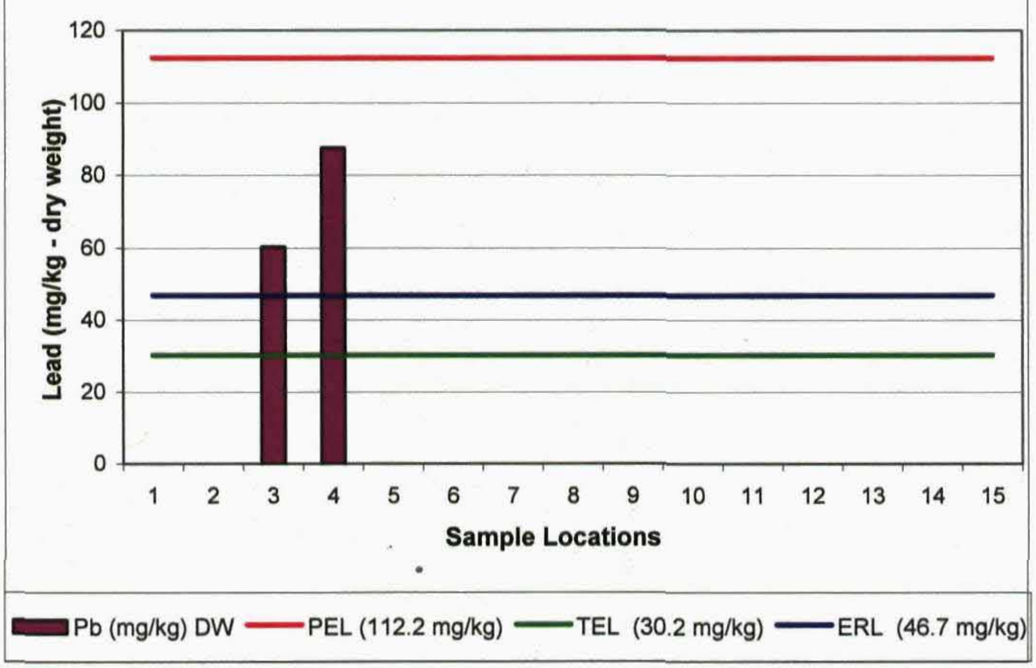
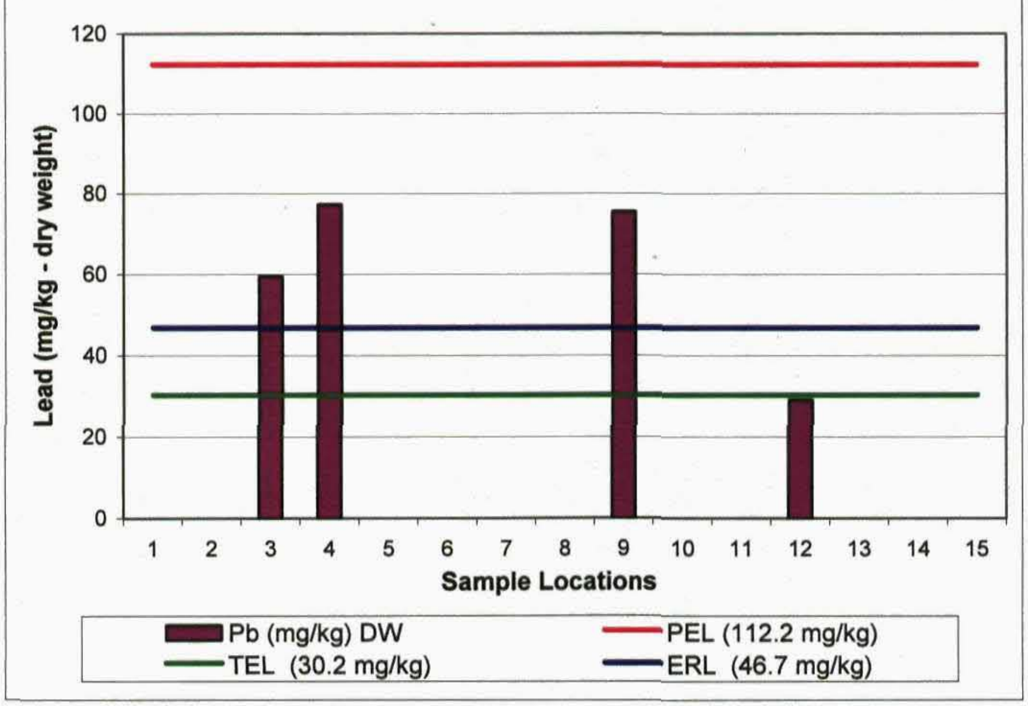


Figure 4-7. Deep AVS Adjusted Lead Concentrations



4.3.2 *Summary of Water Column Data*

Surface water samples were collected from 15 sites within Monterey Harbor on two occasions (December 20, 2004 and February 3, 2005). These samples were analyzed for total lead, dissolved lead and total suspended solids (TSS). The sampling sites were co-located with the 15 sediment collection sites (Figure 4-1 and Table 4-1).

The results of these surface water samples are summarized in Table 4-3. The laboratory reports for these samples are presented in Appendix A.

The results indicate that concentrations of *total* lead are quite variable, especially after large winter storms that generate significant urban runoff and sediment resuspension, as was observed during the February monitoring event (Table 4-3). Conversely, there is very little variability in the *dissolved* lead concentrations, which indicates that most of the lead measured in the water column, is bound to particulate matter.

Applicable water quality criteria for water column metals are based upon the *dissolved* fraction of the metal rather than the *total* fraction. The rationale for this approach is discussed in greater detail in Section 3.2, above. As such, the regulatory limit for water column lead is 8.1 µg/l, as dissolved metal. Water column lead concentrations in all samples were well below the 8.1 µg/l limit promulgated in the CTR (Table 4-3).

Table 4-3. Summary Results of Surface Water Lead Concentrations in Monterey Harbor

Sample ID	December 2004			February 2005		
	Total Pb (µg/l)	**Dissolved Pb (µg/l)**	**TSS (mg/l)**	**Total Pb (µg/l)**	**Dissolved Pb (µg/l)**	**TSS (mg/l)**
1	<1.0	<1.0	<6.0	5.4	1.7	<5
2	<1.0	1.05	6.0	5.9	2.1	<5
3a	2.29	<1.0	<6.0	10.0	2.1	40
3b	NS	NS	NS	10.6	2.8	10
4	2.51	<1.0	<6.0	8.1	2.2	6
5	1.65	<1.0	<6.0	5.0	1.6	<5
6	<1.0	<1.0	<6.0	4.1	1.2	<5
7a	<1.0	<1.0	6.0	3.8	1.5	<5
7b	<1.0	<1.0	<6.0	NS	NS	NS
8	<1.0	<1.0	<6.0	3.5	1.6	<5
9	<1.0	<1.0	<6.0	2.9	1.5	<5
10	<1.0	<1.0	<6.0	3.0	1.4	<5
11	<1.0	<1.0	<6.0	2.9	1.4	<5
12	<1.0	<1.0	<6.0	2.8	1.3	<5
13	<1.0	<1.0	<6.0	2.8	1.5	<5
14	<1.0	<1.0	<6.0	2.8	1.2	<5
15	<1.0	<1.0	<6.0	2.5	1.1	<5

NS= Not sampled

4.3.3 *Summary of Mussel Tissue Data*

MFG contracted with the California Department of Fish and Game (CDFG) Regional Office in Moss Landing, CA to deploy and retrieve the mussels in Monterey Harbor, because they were the agency that performed those functions for the State Mussel Watch Program (SMWP) and were familiar with the SWMP protocols. Mesh bags containing adult mussels were attached to existing structures within the Harbor (Photos 4-2a and 4-2b). The mussels were exposed to conditions within Monterey Harbor for approximately 85 days.

MFG, in consultation with the RWQCB and CDFG, selected ten mussel deployment sites (Table 4-4, Figure 4-8). Mussels (*Mytilus californianus*) were deployed and retrieved using SMWP protocols by the CDFG on November 11, 2004 and February 3, 2005, respectively.

Table 4-4. Coordinates of Deployed Mussels

Station	Latitude	Longitude	Deployment Date	Retrieval Date
M-1	36.60659	-121.89354	11/11/2004	2/3/2005
M-2	36.60722	-121.89368	11/11/2004	2/3/2005
M-3	36.60786	-121.89359	11/11/2004	2/3/2005
M-4	36.60818	-121.89371	11/11/2004	2/3/2005
M-5	36.60686	-121.89249	11/11/2004	2/3/2005
M-6	36.60782	-121.89277	11/11/2004	2/3/2005
M-7	36.60718	-121.89147	11/11/2004	2/3/2005
M-8	36.60771	-121.89125	11/11/2004	2/3/2005
M-9	36.60603	-121.89139	11/11/2004	2/3/2005
M-10	36.60773	-121.88873	11/11/2004	lost

Analysis of Mussel Tissues

The mussels were taken to the CDFG lab (Moss Landing, CA) immediately upon retrieval and homogenized. The mussels were not depurated prior to being homogenized. The homogenized tissue samples were then shipped to Columbia Analytical Services (Kelso, WA), where they were analyzed for total lead using EPA Method 200.8. The laboratory report for the mussel tissue analyses is provided in Appendix C.

Mussel Tissue Results and Discussion

Table 4-5 presents the mussel tissue results for the last two deployment events (2003/2004 and 2004/2005), as well as the tissue lead level guidance (Median International Standard [MIS]). Overall, mussel tissue lead concentrations were either below the MIS or slightly above it, with in-harbor tissue lead concentrations ranging from 1.0 to 3.0 during 2003/2004 and from 0.9 to 2.2 ppm for the most recent deployment period (Table 4-5). The mussel tissue lead concentrations at all stations in the most recent deployment period were less than the corresponding concentrations during the 2003/2004-deployment period (Figure 4-9).

a.

b.

Photos 4-2a, b. Bags containing deployed mussels

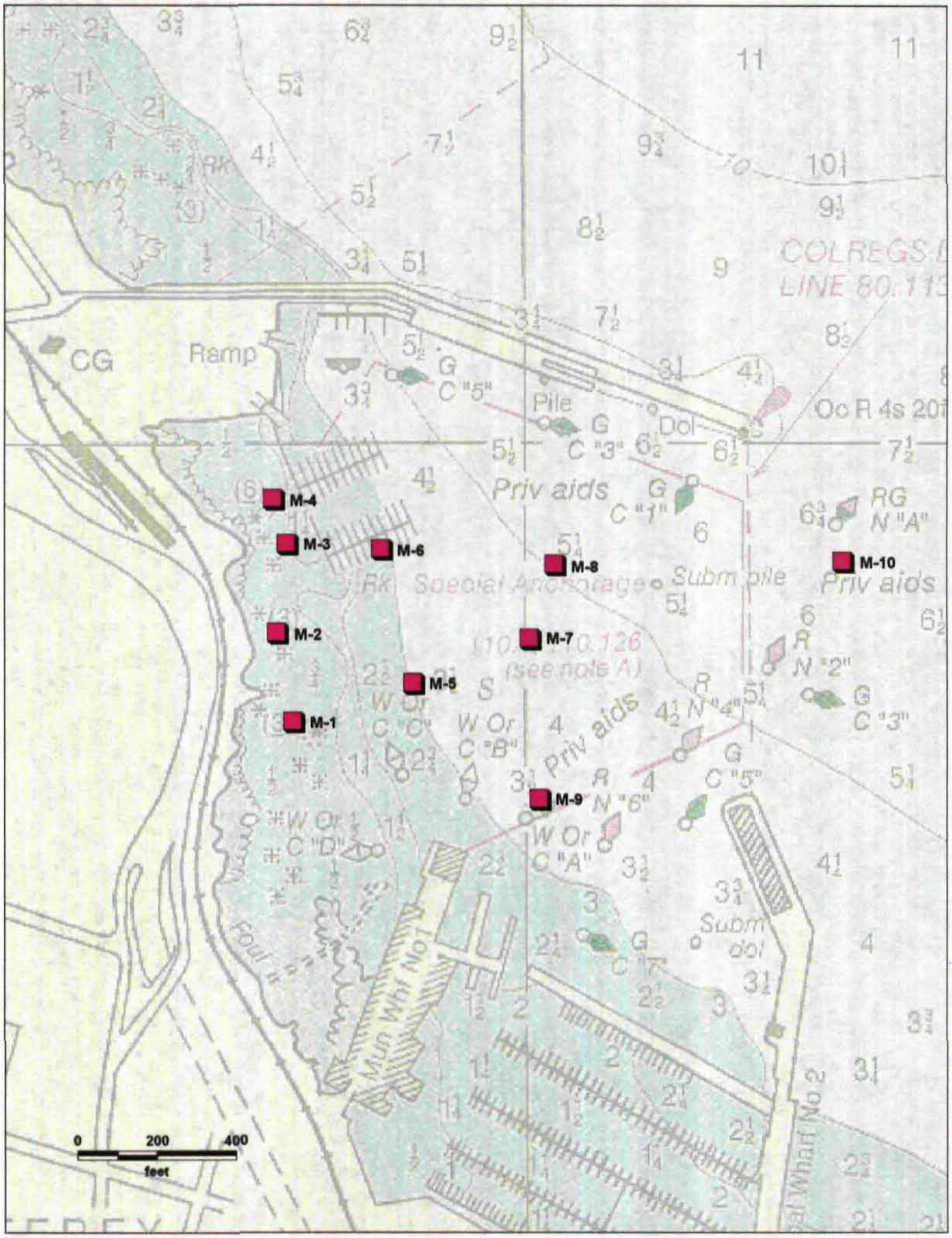


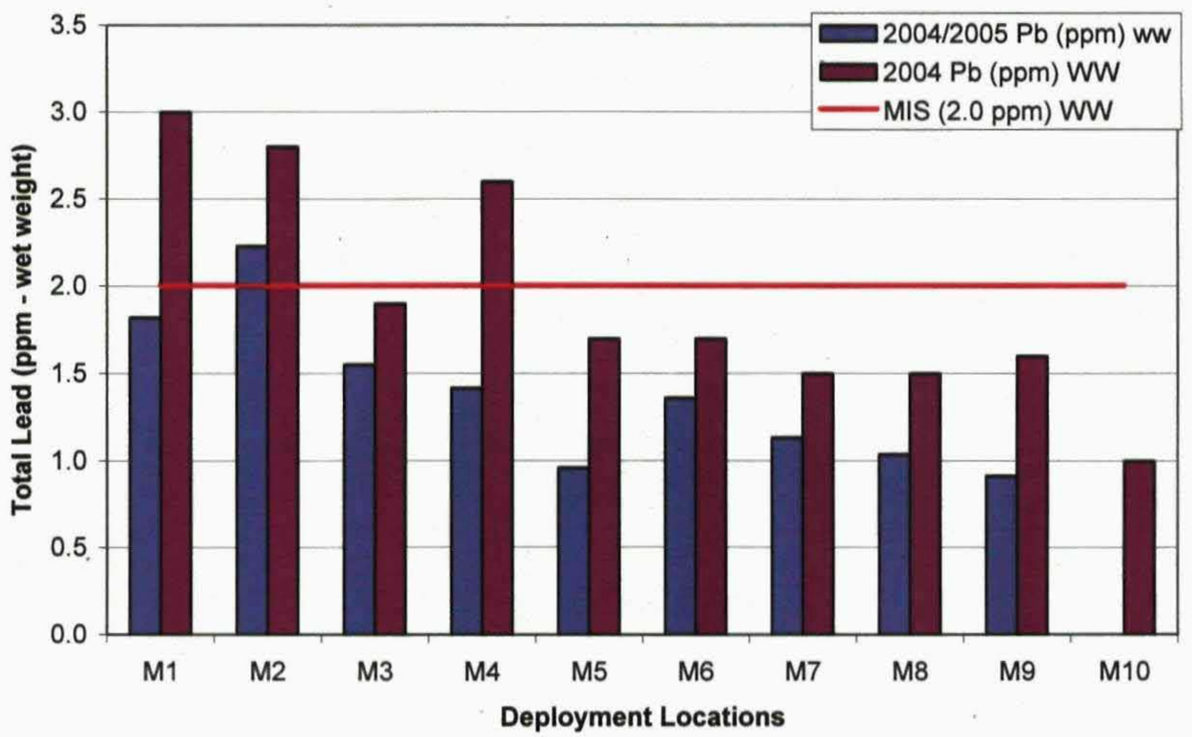
Figure 4-8. Location of Mussel Deployment Sites

Table 4-5.
Mussel Tissue Lead Concentrations (mg/kg - wet weight)

Station ID	2003/2004 Total Lead*	2004/2005 Total Lead	Median International Standard (MIS)
M1	3.0	1.8	2
M2	2.8	2.2	2
M3	1.9	1.6	2
M4	2.6	1.4	2
M5	1.7	1.0	2
M6	1.7	1.4	2
M7	1.5	1.1	2
M8	1.5	1.0	2
M9	1.6	0.9	2
M10	1.0	Lost	2

* Mean value (n=2)

Figure 4-9. Comparison of 2003/2004 and 2004/2005 Mussel Tissue Lead Concentrations in Monterey Harbor



The 1995-1997 SMWP report states that mussel tissue lead levels in Monterey Harbor ranged from 1.8 to 10.0 ppm (wet weight), with tissues collected from two of the four test sites having lead levels (6.8 and 10.0 ppm) that were significantly greater than the 2.0 ppm MIS.

The results from this study reveal that the 2003/2004 and 2004/2005 mussel tissue lead levels were much lower than those reported by the SMWP in its 1995-1997 report, with the highest observed mean tissue level (3.0 ppm) being only one-third to one-half of previously reported values for Monterey Harbor.

5.0 SMALL-SCALE ECOLOGICAL RISK ASSESSMENT

The small-scale risk assessment included the following two tasks:

- Perform a literature review to determine the species resident to Monterey Harbor and the effects of lead exposure and
- Calculate the risk posed to resident species if they consumed a diet based solely on mussels.

The following sections describe these two tasks in greater detail.

5.1 Literature Review

The process of collecting information and data that were used in the small-scale risk assessment involved personal interviews, phone interviews, on-line database searches, and library literature searches. Phone interviews and library literature searches were the most commonly used techniques.

5.1.1 Resident Species

The review revealed a list of species that is fairly comprehensive and includes a broad range of phyla comprising 74 different species; one-third of which (25) belong to the phylum chordata, which includes tunicates, fish, mammals, and birds. The sponges represent the smallest number of species (2) (Appendix D).

5.1.2 Effects of Lead Exposure

Aquatic and terrestrial organisms are exposed to lead mainly via transport across gill membranes, food ingestion, and inhalation.

The form of a chemical in the environment has a marked effect on the extent to which it can be taken up into the tissues of organisms and interact with the tissues to cause various harmful biological effects in the organisms themselves and their consumers, including humans (Nelson and Donkin, 1985; Waldichuk, 1985).

Only bioavailable chemicals may be bioaccumulated by marine organisms. Bioavailability is the extent to which a chemical can be absorbed or adsorbed by a living organism by active (biological) or passive (physical and chemical) processes. A chemical is said to be bioavailable if it is in a form that can move through or bind to the surface coating (e.g., skin, gill epithelium, gut lining, cell membrane) of an organism (Newman and Jagoe, 1994).

Bioavailability and Bioaccumulation of Lead by Marine Organisms

Aquatic Organisms - Lead accumulates outside cells, at least in invertebrates, in granules rich in carbonate (perhaps as a $PbCO_3$ precipitate) (Luoma 1986). Particulate lead may be taken up into epithelial cells of the gut and possibly other tissues such as gills and mantle, in marine mollusks (George et al., 1975, 1976, 1977; Fowler et al. 1981). Metal-rich granules, either formed inside cells or taken up across epithelial surfaces, are stored in various tissues, usually the kidney or hepatopancreas, and the metals in them have a limited bioavailability to the animals or their predators (Nott and Nicolaidou, 1994; Regoli and Orlando, 1994), thus, allowing for the possibility that this mode of accumulation without assimilation is responsible for the relatively low toxicity of inorganic lead to marine animals.

No studies were identified in the scientific literature demonstrating that lead tissue concentrations can be actively regulated by aquatic biota. However, lead will bind to metallothionein and also probably has a higher affinity for other metabolic ligands, as it is often associated with deposited inorganic granules with high concentrations of calcium (Rainbow, 1988). Hopkins and Nott (1979) demonstrated that the shore crab *Carcinus maenas* detoxifies lead in calciferous granules in the midgut gland. The detoxification and storage of lead in shellfish has been suggested for the zebra mussel *Dreissena polymorpha* (Kraak, et al 1994; Bleeker, et al. 1992), the blue mussel *Mytilus edulis* (Talbot et al. 1976; Schulz-Baldes, 1974), the Eastern oyster *Crassostrea virginica* (Schuster and Pringle, 1969; Pringle, et al. 1968; Zaroogian, et al. 1979) and the soft-shell clam *Mya arenaria* (Pringle, et al. 1968). Mussels *Mytilus edulis* accumulate 23.5 percent of the lead provided to them in lead-contaminated algae *Dunaliella marina* compared to 29 percent of the lead provided in solution in the ambient seawater (Shultz-Baldes, 1974). However, the feces of mussels is enriched nearly six-fold with lead compared to their algal food, suggesting that absorption of lead from the gut is inefficient (Amiard et al., 1986). It should be noted, that while dietary lead may be unavailable to some species, for others, dietary lead could be taken up; however, the very low efficiency of uptake (Vighi, 1981) ensures that it does not biomagnify.

The bioavailability of lead to Benthic animals is proportional to the lead/iron concentration ratio in weak acid extracts of the sediment, indicating that the lead that is adsorbed to iron oxide coatings on sediment particles is not bioavailable. In moderately hypoxic or anoxic sediments, most of the lead is precipitated as lead sulfide and is not bioavailable (Kersten and Főrstner, 1986; Bourgoin et al. 1991a,b; DeLaune et al. 1999). Oxidation of anoxic sediments caused by biological or physical resuspension does not increase the bioavailability of lead to Nereid polychaetes (Howell, 1985), suggesting that lead sulfide is oxidized very slowly in oxidized sediments.

Sea otters, *Enhydra lutris*, consume both Benthic invertebrates and kelp-bed fishes and, therefore, can be considered one of the top predators locally. Lead isotopic ratios in otter teeth from otters collected from the Aleutian Islands, Alaska indicate that concentrations of lead in the otters has not increased due to anthropogenic inputs of lead into the environment (Smith et al. 1990). The lack of an increase in concentrations of lead in otter tissues despite historic increases in the flux of industrial lead to the ocean indicates that lead is not being biomagnified through the marine food chain (Smith, et al, 1990).

Waterfowl - The literature is replete with examples of lead toxicity to waterfowl, particularly with respect to the ingestion of spent lead shot (Bellrose, 1959; Sanderson and Bellrose, 1986; Pain 1992) and lead fishing weights (Simpson, *et. al* 1979; Sears 1988). Additionally, studies in both the field and laboratory have demonstrated that the ingestion of lead-contaminated sediment containing between 4,520 and 6,990 µg/g lead can also poison waterfowl (Blus *et al.* 1991, 1999; Beyer *et al.* 1998, 2000; Heinz *et al* 1999; Hoffman *et al* 2000a, b; Sileo *et al.* 2001). These concentrations are more than two orders of magnitude greater than those found in the Monterey Harbor sediments.

Although the effects of diet are widely recognized, the exact mechanisms by which they occur have not been fully explained. Much of the protective effect of nutrient-rich diets appears to occur in the digestive system (Sanderson, 1992) and, when lead is ingested along with food, certain chemical groups in food components have a ligand effect; binding lead in a nonsoluble and non-bioavailable form in the intestine (Morton et al. 1985).

Additionally, lead does not bioaccumulate in fat or soft tissue. It is stored mostly in bone but it is not preferentially enriched in bone with respect to the lead concentration in the medium from which the lead is picked up. Thus, there is no enrichment, or increase in concentration, up the food chain, but in fact biopurification (Gwiazda, personal communication, January 28, 2005; Elias, et al. 1982). Biopurification, or depletion, of lead occurs in marine food chains relative to its biogeochemical analogue, calcium (Smith, et al. 1990). Lead is biodepleted relative to calcium during transfer from marine plants to primary consumers because of discrimination against lead in favor of calcium in the gut of the consumer. Lead is further depleted, or biopurified, during transfer from the primary consumers to carnivores. Thus, lead concentrations are actually reduced as one moves up the food chain.

5.2 Risk Assessment Calculations

MFG performed a small-scale ecological risk assessment to evaluate the amount of potential risk to which resident or surrogate avian and rare and endangered species would be subjected if they were to subsist on a diet of shellfish from the study area.

This risk assessment used the working assumption that all lead in the mussel tissues is bioavailable and that the organisms would subsist on the exposed mussel tissues. This assumption provides a conservative estimate of lead exposure, because all three organisms that were used as indicator species, (gull, sea otter, and harbor seal) are highly mobile and most likely do not rely upon food sources within Monterey Harbor as their sole source of nourishment.

This ecological risk assessment indicates that tissue lead concentrations observed during the 2003/2004 and 2004/2005 monitoring events are not negatively impacting the most sensitive life stage of aquatic birds or rare and endangered species in Monterey Harbor (Text Box 5-1).

AVIAN – Species: Herring Gull (*Larus argentus*)
Most sensitive life stage: Breeding females
Average body weight: 0.987 kg
Food ingestion rate: 0.21 kg/kg body weight/day
Maximum observed mussel lead concentration (wet weight): 3.0 mg/kg (2003/2004) and
2.2 mg/kg (2004/2005)
Daily lead exposure – (2003/2004): 3.0 mg/kg x 0.21 kg/kg BW/day x 0.987 kg BW = 0.62mg Pb/day
(2004/2005): 2.2 mg/kg x 0.21 kg/kg BW/day x 0.987 kg BW = 0.46 mg Pb/day

Daily lead exposure risk is:

- **0.62 mg Pb/day (2003/2004) and 0.46 mg Pb/day (2004/2005)**
- **One to four orders of magnitude lower than the No Observable Apparent Effect Levels (NOAEL) for avian reproduction, pathology, physiology, behavior, and most biochemical risk factors (EPA Eco-SSL, 2000). No risk indicated for avian species.**

MAMMALIAN – Species: Southern Sea Otter (*Enhydra lutris nereis*)
Average body weight: 20 kg
Food ingestion rate: 0.25 kg/kg body weight/day
Most sensitive surrogate: Rat (*Rattus norvegicus*)
Most sensitive endpoint: Enzymatic activity (NOAEL = 1 mg Pb/kg body weight/day)
Extrapolation to the Southern Sea Otter (weight = 20 kg): NOAEL = 16.0 mg Pb/day
Maximum observed mussel lead concentration (wet weight): 3.0 mg/kg (2003/2004) and
2.2 mg/kg (2004/2005)
Daily lead exposure – (2003/2004): 3.0 mg/kg x 0.25 kg/kg BW/day x 20 kg BW = 15 mg Pb/day
(2004/2005): 2.2 mg/kg x 0.25 kg/kg BW/day x 20 kg BW = 11 mg Pb/day

Daily lead exposure risk is:

- **15 mg Pb/day (2003/2004) and 11 mg Pb/day (2004/2005)**
- **< 16.0 mg Pb/day (NOAEL) – No risk indicated for sea otters**

MAMMALIAN – Species: Harbor Seal (*Phoca vitulina*)
Average body weight: 100 kg
Food ingestion rate: 0.06 kg/kg body weight/day
Most sensitive surrogate: Rat (*Rattus norvegicus*)
Most sensitive endpoint: Enzymatic activity (NOAEL = 1 mg Pb/kg body weight/day)
Extrapolation to the Harbor Seal (weight = 100 kg): NOAEL = 71.2 mg Pb/day
Maximum observed mussel lead concentration (wet weight): 3.0 mg/kg (2003/2004) and
2.2 mg/kg (2004/2005)
Daily lead exposure – (2003/2004): 3.0 mg/kg x 0.06 kg/kg BW/day x 100 kg BW = 18.0 mg Pb/day
(2004/2005): 2.2 mg/kg x 0.06 kg/kg BW/day x 100 kg BW = 13.2 mg Pb/day

Daily lead exposure risk is:

- **18.0 mg Pb/day (2003/2004) and 13.2 mg Pb (2004/2005)**
- **< 71.2 mg Pb/day (NOAEL) – No risk indicated for Harbor Seals**

Notes:

1. All calculations assume most sensitive life-stage or surrogate species.
2. Based on DTSC-approved Toxicity Reference Values.
3. Southern Sea Otter and Harbor Seal NOAELs extrapolation based on Rat NOAEL from DTSC Eco-Note 5 (2002) and Sample, B.E. and C. A. Arenal (1999).

Text Box 5-1. Calculations for a Limited Scale Risk Assessment in Monterey Harbor

6.0 CONCLUSIONS

Based on the findings of this and the previous study (MFG, 2004), total lead in sediment concentrations in Monterey Harbor remain elevated above SQuiRT guidelines; however, SEM:AVS tests suggest that there exist sufficient volatile sulfide concentrations in most of the Harbor sediment to bind the lead as lead sulfide. Lead sulfide is not readily soluble in water. This lack of solubility is supported by the low concentrations of dissolved lead in the water column and non-detectable concentration of lead that could be leached using the weak acid extraction method of the STLC leachate test[19]. Sulfide sequestration of lead reduces its bioavailability and, thus, results in normally toxic concentrations of lead becoming non-toxic to aquatic life. The relatively low levels of lead that accumulated in deployed mussels support this claim. Additionally, mussel tissue lead levels have decreased steadily since the original State Mussel Watch Program report and are now below, or very slightly greater than, MIS guidelines.

The small-scale risk assessment indicates that the most sensitive life stages of resident or surrogate bird and rare and endangered animals are not at risk by consuming the bivalve tissues.

These findings support the claim that the MIS guideline for lead is an inappropriate criterion to apply to mussel tissues in Monterey Harbor. The MIS guideline should not be treated as if it were a tissue standard.

The beneficial uses of Monterey Harbor do not currently appear to be impaired by lead. The following lines of evidence support this:

- Lead in the sediments is tightly bound as sulfides, and it is not readily soluble in either water or weak acid;
- Water quality objectives are currently being met in the water column;
- There appears to be no correlation between the concentration of metals in the sediment and the water above it;
- Deployed mussel tissue concentrations of lead are below or very slightly higher than the MIS guidelines;
- Inorganic lead is transformed into granules by marine mollusks and Benthic invertebrates, thereby reducing the bioavailability of lead;
- Absorption of lead from the gut of mussels and crabs is inefficient;
- Lead does not biomagnify up the food chain but, rather, biopurifies.

[19] *Monterey Harbor Lead in Sediment Study*, Table 1 (MFG, 2004).

- Increases in anthropogenic lead fluxes has not resulted in an increase in lead contaminated otters;

- Lead consumed with food by waterfowl becomes chelated by various ligands that render the lead into non-soluble or non-bioavailable forms;

- Any soluble lead in the Monterey Harbor sediment has a high likelihood of being further sequestered by either granulation in invertebrates or chelated by ligands in waterfowl digestive tracts. This will result in the lead being rendered non-bioavailable and, therefore, most likely will not result in degradation of the beneficial uses of the harbor.

- Small-scale risk assessment indicates that there is no ecological risk indicated for either marine birds, sea otters, or harbor seals; and

- There are no existing lead standards for sediment or bivalve tissues.

Based on these lines of evidence, MFG recommends that the RWQCB take the following actions:

- Issue UPRR a letter of case closure, and
- Delist Monterey Harbor from the 303(d) list for lead.

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Appendix A: Laboratory report – Sediment Data Reports

Appendix B: Laboratory reports – Water Column Data Reports

Appendix C: Laboratory report – Mussel Tissue Data Reports

Appendix D: Resident Species List

APPENDIX A

Sediment Data Reports

APPENDIX B

Water Column Data Reports

APPENDIX C

Mussel Tissue Data Reports

APPENDIX D

Resident Species List

Resident Species in Monterey Harbor

Phylum	Scientific Name	Common Name
Annelida	*Ctenodrilus serratus*	Polychaete
	Dipolydora socialis	Polychaete
	Exogone lourei	Polychaete
	Ficopomatus enigmaticus	Tube worm
	Myxicola infundibulum	Polychaete
	Neoleprea japonica	Polychaete
	Platynereis bicanaliculata	Polychaete
	Polydora cornuta	Polychaete
	Polydora Limicola	Polychaete
	Polydora sp.	Polychaete
	Sphaerosyllis sp.	Polychaete
	Typosyllis sp.	Polychaete
	Naineris sp.	Polychaete
Arthropoda	*Balanus improvisus*	Barnacle
	Corophium insidiosum	Amphipod
	Ianiropsis tridens	Isopod
	Melita nitida	Amphipod
	Monocorophium acherusicum	Amphipod (tube-dwelling)
	Sphaeroma quoyanum	Isopod
	Caprella acanthogaster	Amphipod (skeleton shrimp)
	Caprella californica	Amphipod (skeleton shrimp)
	Pugettia producta	Northern kelp crab
	Pagarus spp.	Hermit crab
Chordata:	*Ascidia zara*	Tunicate
	Botrylloides violaceus	Tunicate
	Ciona intestinalis	Tunicate
	Ciona sp.	Tunicate
	Didemnids	Tunicate
	Styela clava	Tunicate
	Botryllus schlosseri	Tunicate
	Botrylloides sp.	Tunicate
	Diplosoma macdonaldi	Tunicate
Fishes	*Gibbonsia montereyensis*	Kelp fish
	Apodichthys fucorum	Rockweed Gunnel
	Coryphopterus nicholsii	Blackeyed goby
	Embiotoca jacksoni	Black perch
	Embiotoca lateralis	Striped surf perch
Mammals	*Enhydra lutris*	Sea otter
	Zalophus californianus	California sea lion
	Phoca vitulina	Harbor seal
	Mirounga angustirostris	Northern elephant seal
Birds	*Gavia immer*	Common loon
	Pelecanus occidentalis	Brown pelican
	Phalacrocorax penicillatus	Brandt's cormorant
	Phalacrocorax auritus	Double-crested cormorant
	Phalacrocorax pelagicus	Pelagic cormorant
	Larus californicus	California gull
	Larus occidentalis	Western gull
Cnidaria	*Diadumene lineata*	Anemone
	Ectopleura crocea	Pink-hearted hydroid
	Metridium senile	Anemone
	Corynactis californica	Anemone
	Urticina lofotensis	Anemone
	Tubularia marina	Pink-mouth hydroid
Ectoprocta	*Bowerbankia gracilis*	Bryozoan
	Bugula neritina	Bryozoan
	Cryptosula pallasiana	Bryozoan
	Membraniphora sp.	Bryozoan
	Schizoporella unicornis	Bryozoan
	Watersipora subtorquata	Bryozoan

Resident Species in Monterey Harbor, Cont'd.

Phylum	Scientific Name	Common Name
Mollusca	*Batillaria attramentaria*	Snail
	Gemma gemma	Gem clam
	Haliotis rufescens	Red Abalone
	Mercenaria mercenaria	Quahog clam
	Petricolaria pholadiformis	False Angel Wing clam
	Crepidula sp.	Snail
	Olivella biplicata	Purple dwarf olive snail
	Mopalia spp.	Chiton
Echinoidia	*Pisaster ochraceus*	Ochre starfish
	Pisaster brevispinus	Starfish
	Pisaster giganteus	Starfish
	Asterina miniata	Batstar
Porifera	*Hymeniacidon sp.*	Sponge
	Prosuberites sp.	Sponge