Lower Newport Bay Copper/Metals Marina Study

Final Report

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Prepared for the City of Newport Beach
by
Orange County Coastkeeper

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Executive Summary

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

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

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

Water column

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

Sediment

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

Toxicity

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

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

Table of Contents

EXECUTIVE SUMMARY	**2**
Background	**6**
Sample Design	**7**
Methodology	**9**
Data Analysis Methods	**12**
Objective Exceedence Discussion	**14**
Statistical Analysis Discussion	**33**
Toxicity Testing	**45**
Conclusions	**46**
Appendix A Maps	**47**
Appendix B Toxicity Testing Report	**56**
Appendix C Copper Graphs	**57**
Appendix D Metals, TSS, Turbidity, Salinity, DOC Means	**65**
Appendix E Grain size, Pore Water Metals, Acid Volatile Sulfides	**71**

Background

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

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

An additional source of metals to Newport Bay is urban runoff which may enter the Bay via storm drains or surface runoff. Metal inputs to the Bay from stormwater inputs can be significant in winter. Over 200 stormdrains empty into Newport Bay and studies show high metal concentrations around storm drains in the Rhine Channel section of the bay (Bay 2003, OCCK 2004). Two marinas with storm drains in Lower Bay were sampled to investigate the impact of storm drain inputs into marinas to determine if stormdrains significantly affect metals concentrations in marinas.

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

Sampling Design

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

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

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

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

Methodology

Sampling Events and Sites

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

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

Sample Collection and Analyses

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

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

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

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

Toxicity Tests

Mussel Embryo Development Test

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

Sediment-Water Interface (SWI) Test

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

Whole Sediment Toxicity Test

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

Whole Sediment Toxicity Identification Evaluation

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

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

Pore Water Toxicity Tests

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

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

Data Analysis Methods

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

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

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

Table 2 Water Criteria

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

Table 3 Sediment Criteria

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

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

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

Results

Objective Exceedence Discussion

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

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

Water Column

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

Sediment

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

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

Newport Dunes marina Cd(100%) Cu (100%) Zn (77.8%), (<50% -As)
Newport Dunes Channel Cu (100%); (<50% -Cd, Zn)
De Anza marina; As (66.7) Cd (55.6%), Cu (100%) Zn (100%), (<50% -Hg)
De Anza inner channel Cu (100%), Zn (66.7%), (<50% -As, Cd)
Balboa Yacht Basin marina; As (88.99%), Cu (88.9%), Hg (100%) Zn (88.9%),
Balboa Yacht Basin Channel; Cu (100%), Hg (66.7%) Zn (100%), (<50% -As)
Bahia Corinthian marina; As (77.8%),Cd (88.9%),Cu (100%),Zn (100%),
(<50% -Hg)
Bahia Corinthian channel; Cu (100%),Hg (100%), (<50% -Hg)
Harbor marina; As(83.3%), Cd(83.3%), Cu(83.3%), Pb(66.7%), Zn, (83.3%)
(<50% -Hg)
Harbor marina channel; As(100%), Cd(66.7%), Cu(100%), Pb(66.7%),
Hg(100%), Zn, (100%),
Lido Village marina; As(100%), Cu(100%), Pb(66.7%), Hg(100%),Zn, (100%),
Lido village channel; As(66.7%), Cu(100%), Hg(100%), Zn, (66.7%), (<50% -Pb)
Lido Yacht Anchorage; As(100%), Cu(100%), Hg(100%),Zn, (100%),
(<50% -Cd, Pb)
Lido Yacht Anchorage channel; As(100%), Cu(100%), Hg(100%),Zn, (100%),
(<50% -Cd, Pb)
H&J Mooring; As(77.8%), Cu(100%), Hg(100%),Zn, (100%),
H&J Mooring channel; As(100%), Cu(100%), Hg(100%),Zn, (100%) (<50% -Cd).

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

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

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

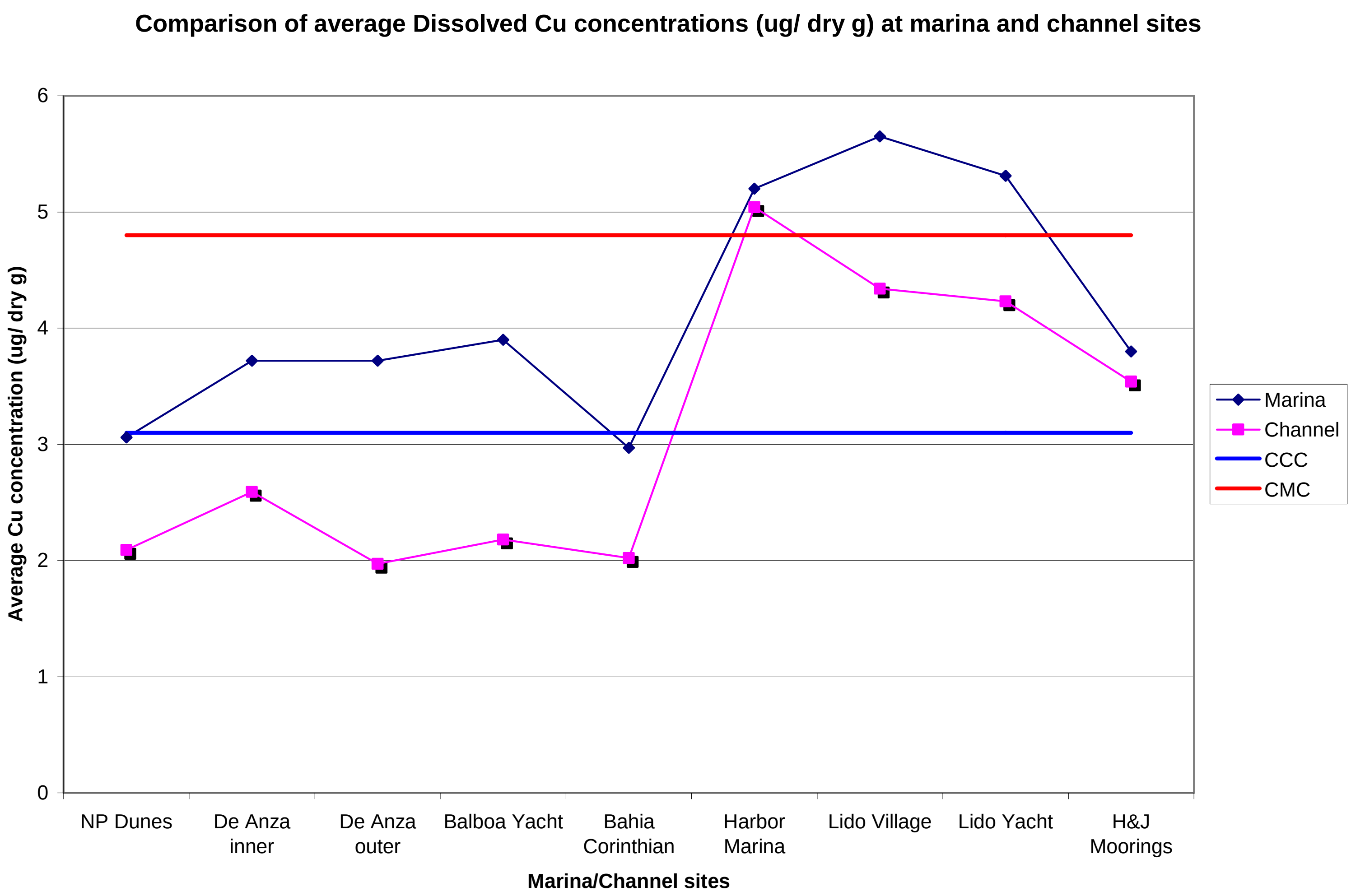
Sample Site	Newport Dunes Sediment (TEL)/(ERL)/(ERM)	Newport Dunes Dissolved [CCC/CMC]	Newport Dunes (Channel) Sediment (TEL/ERL/ERM)	Newport Dunes (Channel) Dissolved [CCC/CMC]	De Anza Marina Sediment [TEL/ERL/ERM]	De Anza Marina Dissolved [CCC/CMC]	De Anza Marina Channel (IN) Sediment [TEL/ERL/ERM]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

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

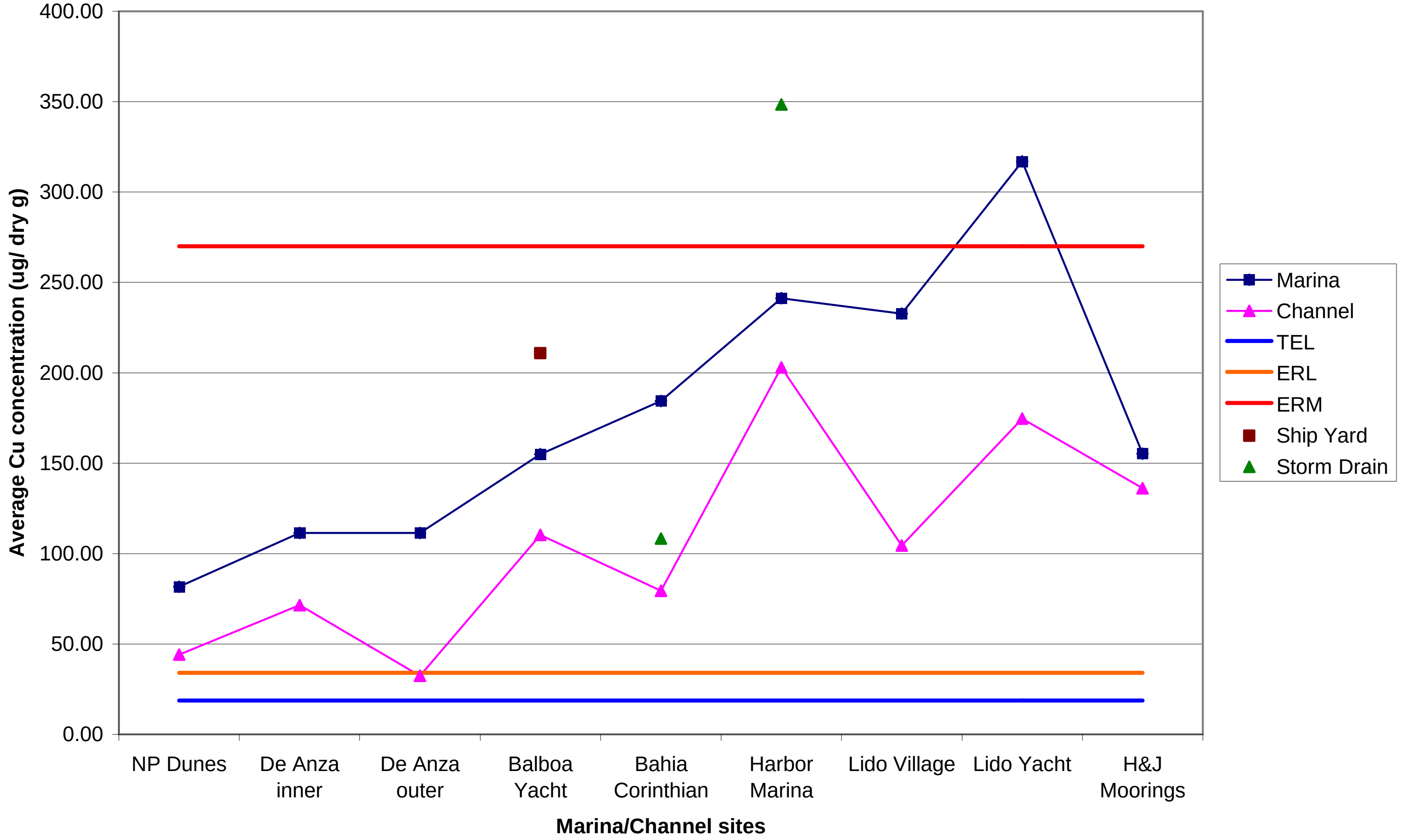
Sample Site	Bahia Corinthian (Channel) Sediment [TEL/ERL/ERM]	Bahia Corinthian (Channel) Dissolved [CCC/CMC]	Harbor Marina Sediment [TEL/ERL/ERM]	Harbor Marina Dissolved [CCC/CMC]	Harbor Marina (Channel) Sediment [TEL/ERL/ERM]	Harbor Marina (Channel) Dissolved [CCC/CMC]	Lido Village Sediment [TEL/ERL/ERM]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

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

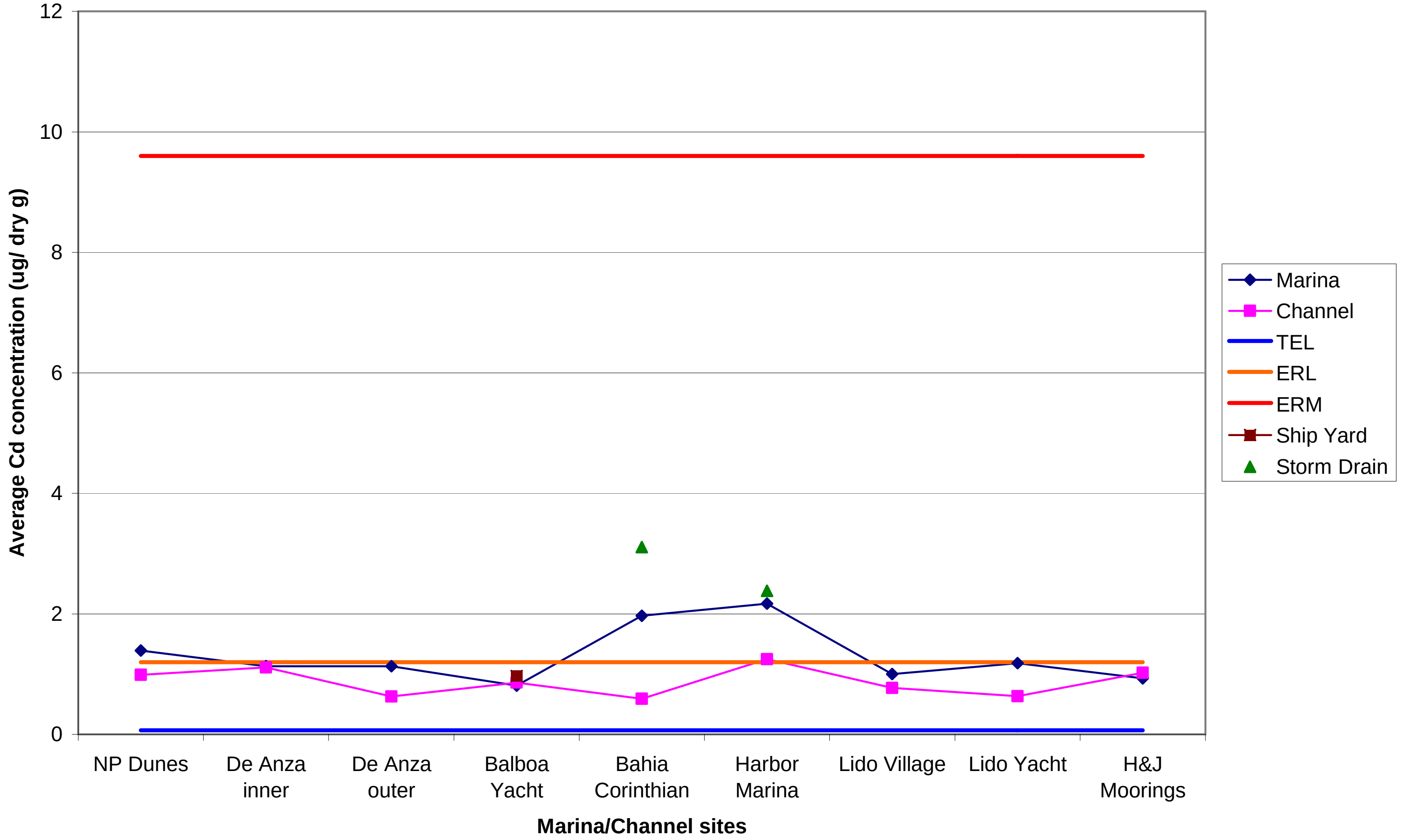
Graph set 1 Average Dissolved and Sediment Metals Concentrations

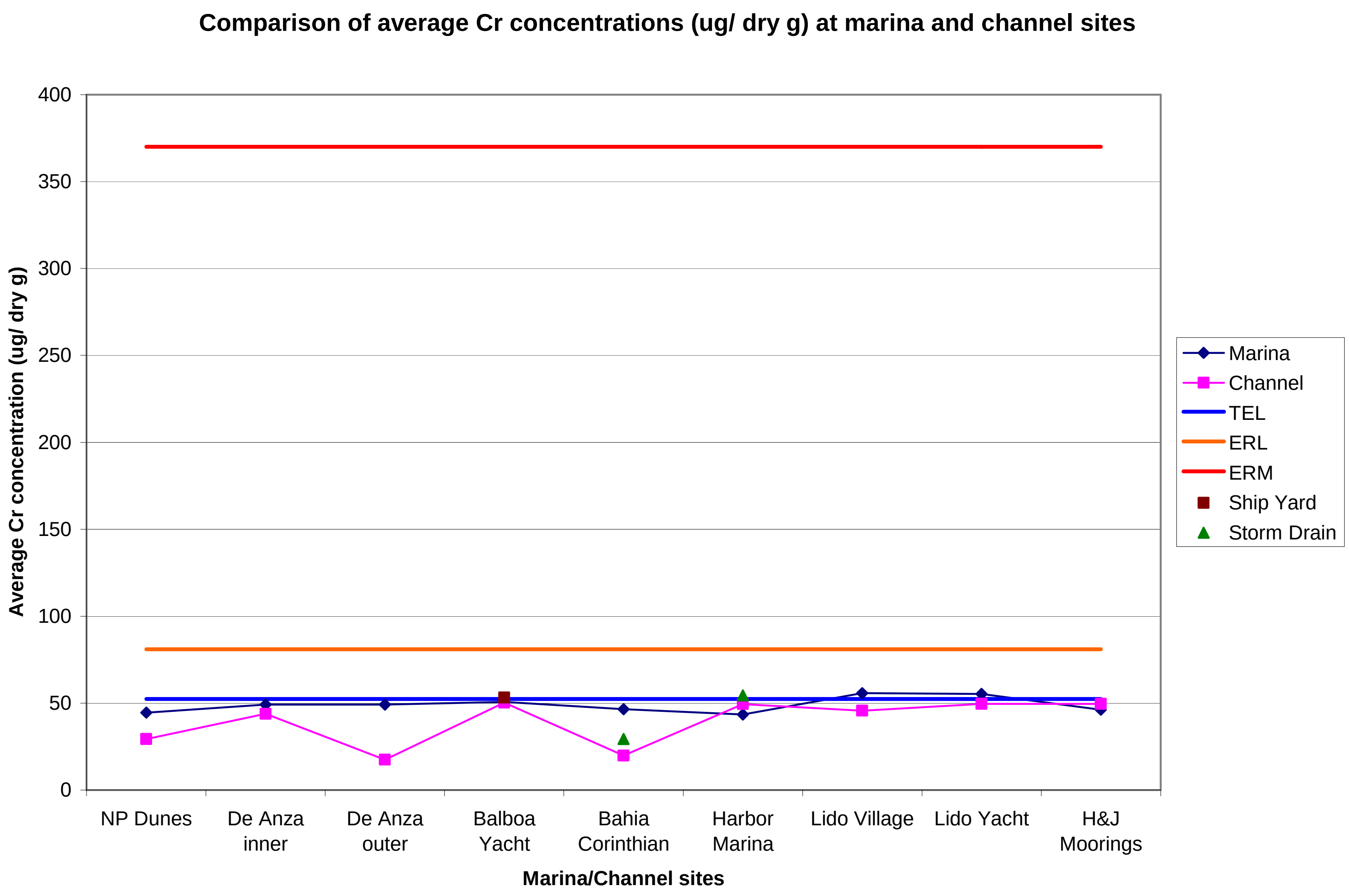


Comparison of average Cu concentrations (ug/ dry g) at marina and channel sites

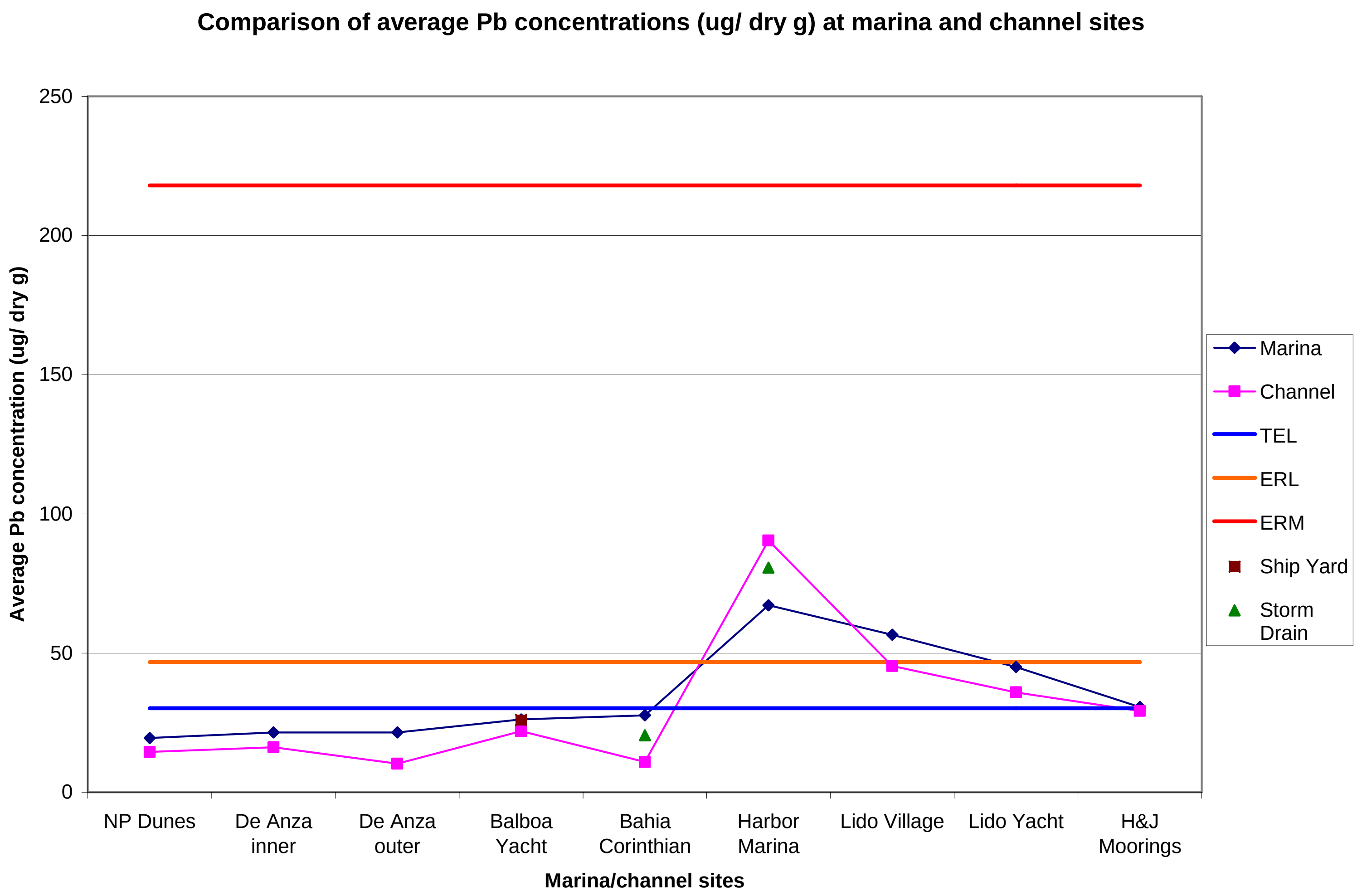


Comparison of average Cd concentrations (ug/ dry g) at marina and channel sites



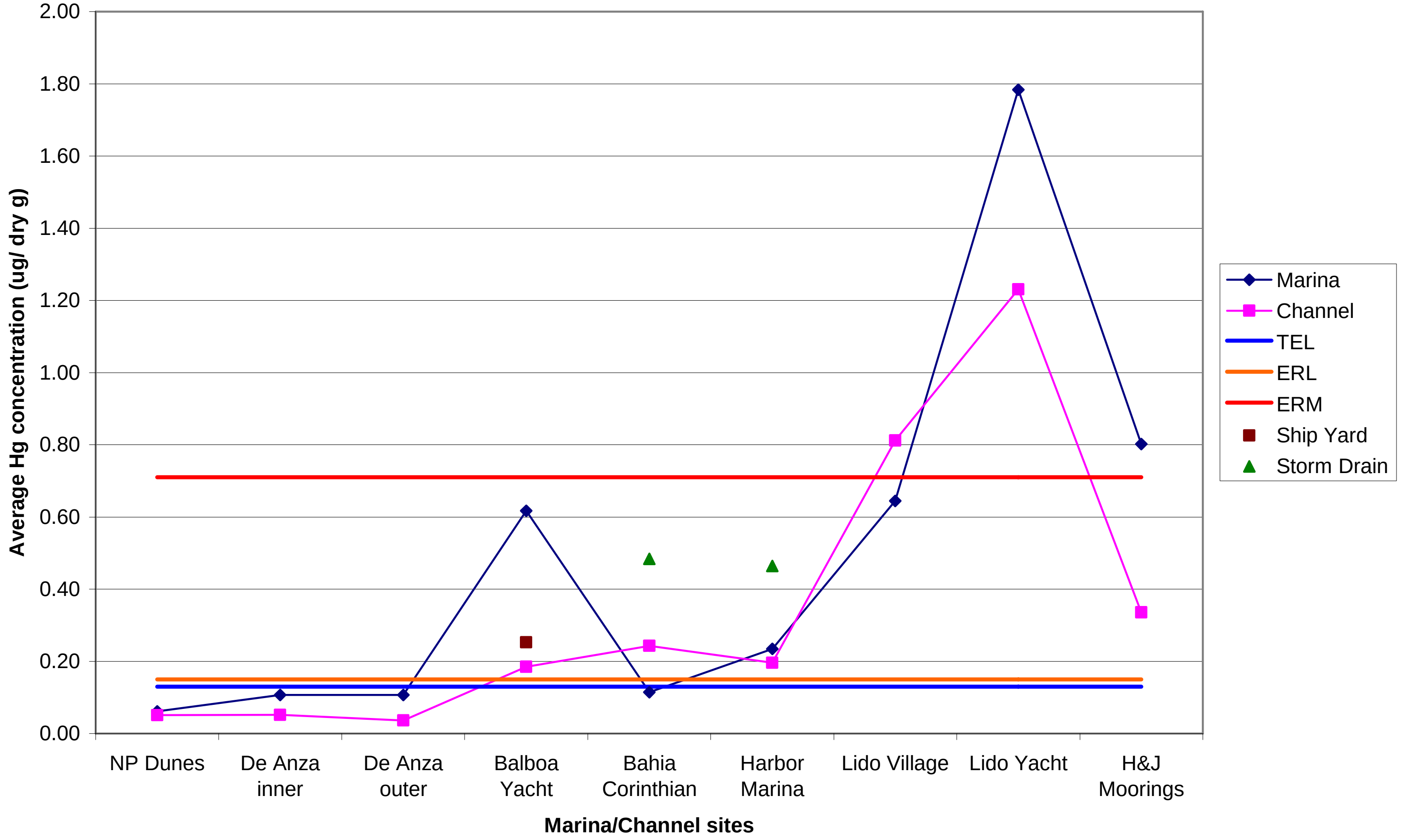


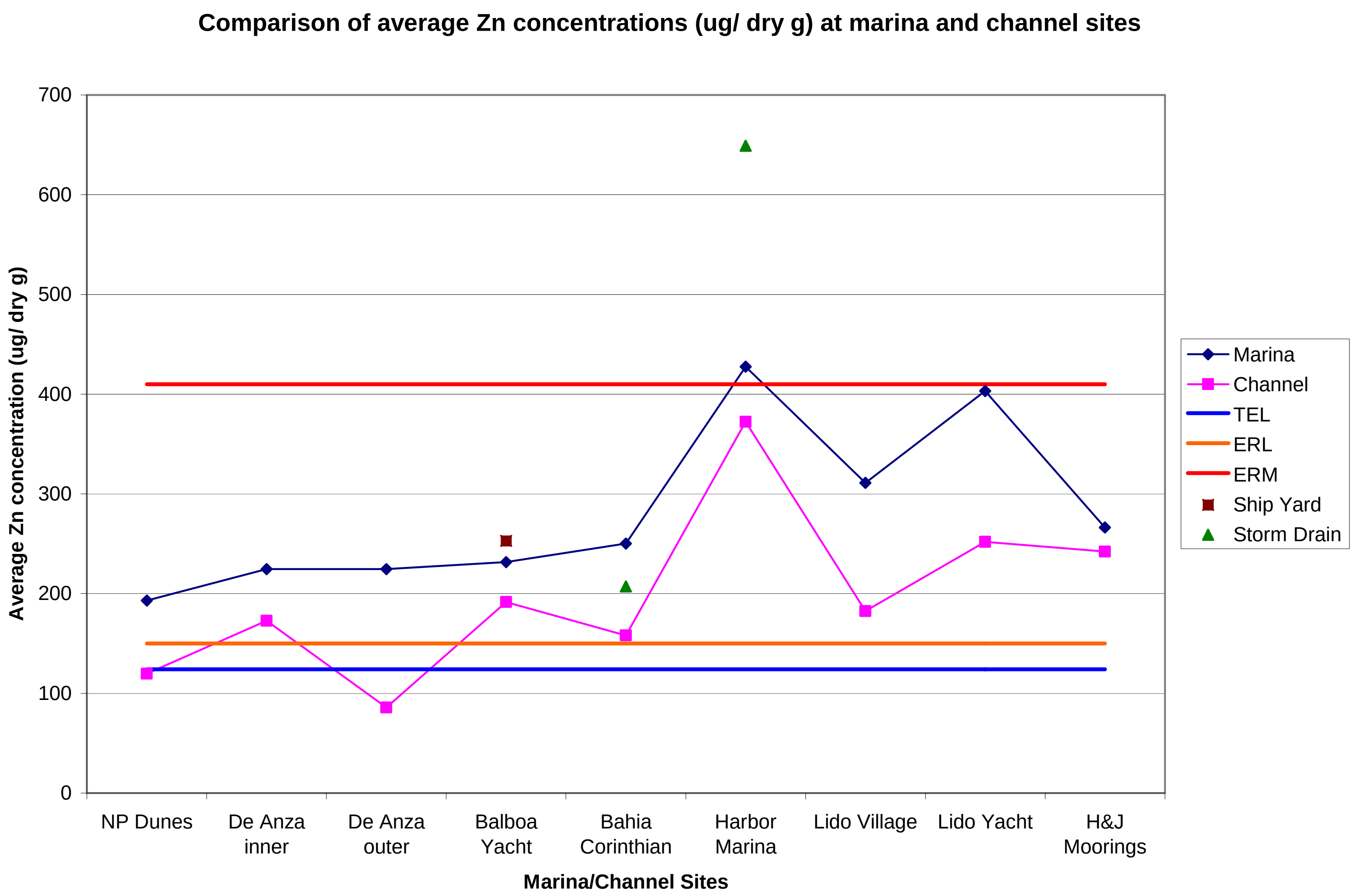
Comparison of average Cr concentrations (ug/ dry g) at marina and channel sites
Average Cr concentration (ug/ dry g)
400
350
300
250
200
150
100
50
0
NP Dunes
De Anza inner
De Anza outer
Balboa Yacht
Bahia Corinthian
Harbor Marina
Lido Village
Lido Yacht
H&J Moorings
Marina/Channel sites
Marina
Channel
TEL
ERL
ERM
Ship Yard
Storm Drain



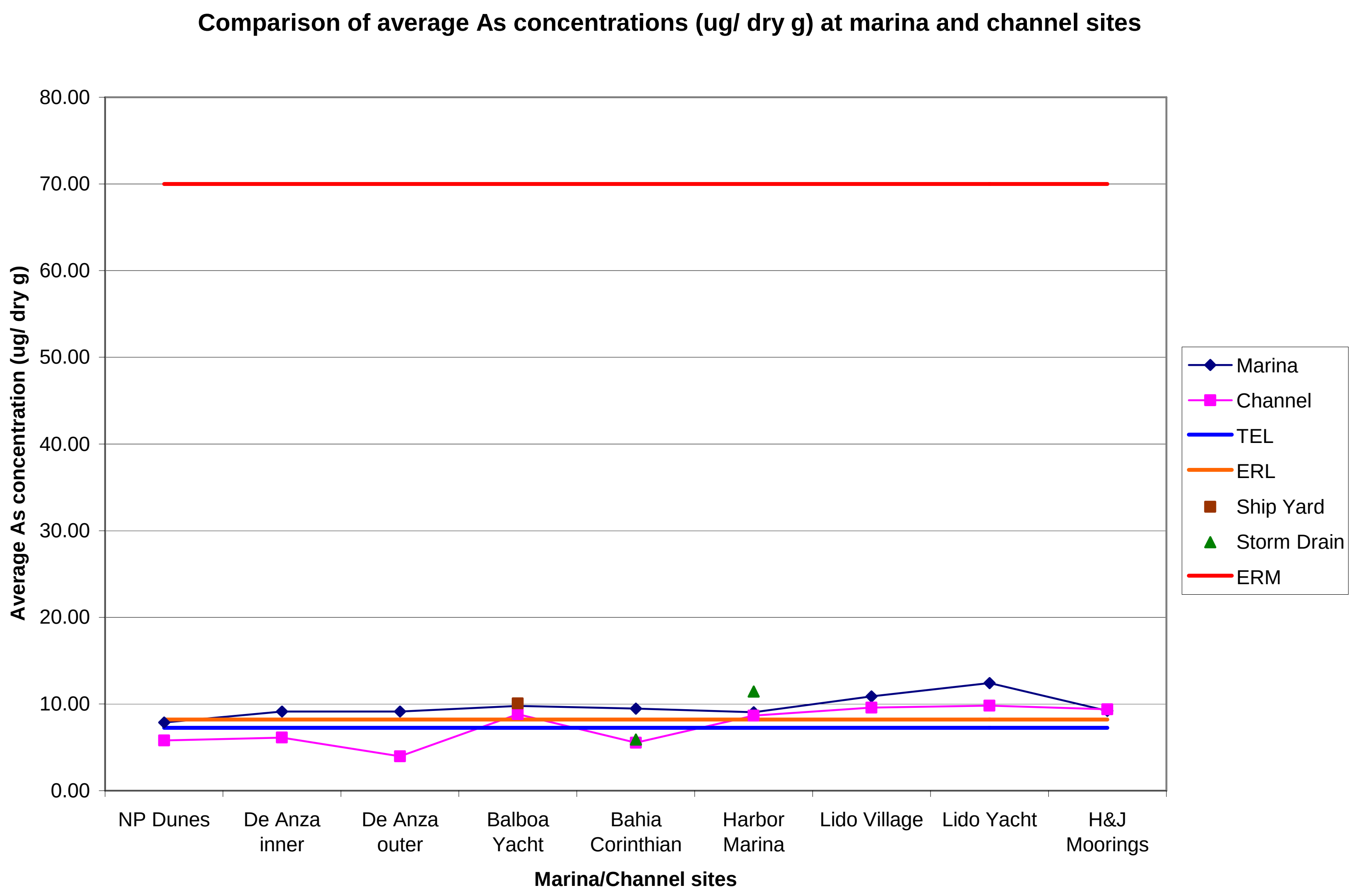
Comparison of average Pb concentrations (ug/ dry g) at marina and channel sites
Average Pb concentration (ug/ dry g)
250
200
150
100
50
0
NP Dunes
De Anza inner
De Anza outer
Balboa Yacht
Bahia Corinthian
Harbor Marina
Lido Village
Lido Yacht
H&J Moorings
Marina/channel sites
Marina
Channel
TEL
ERL
ERM
Ship Yard
Storm Drain

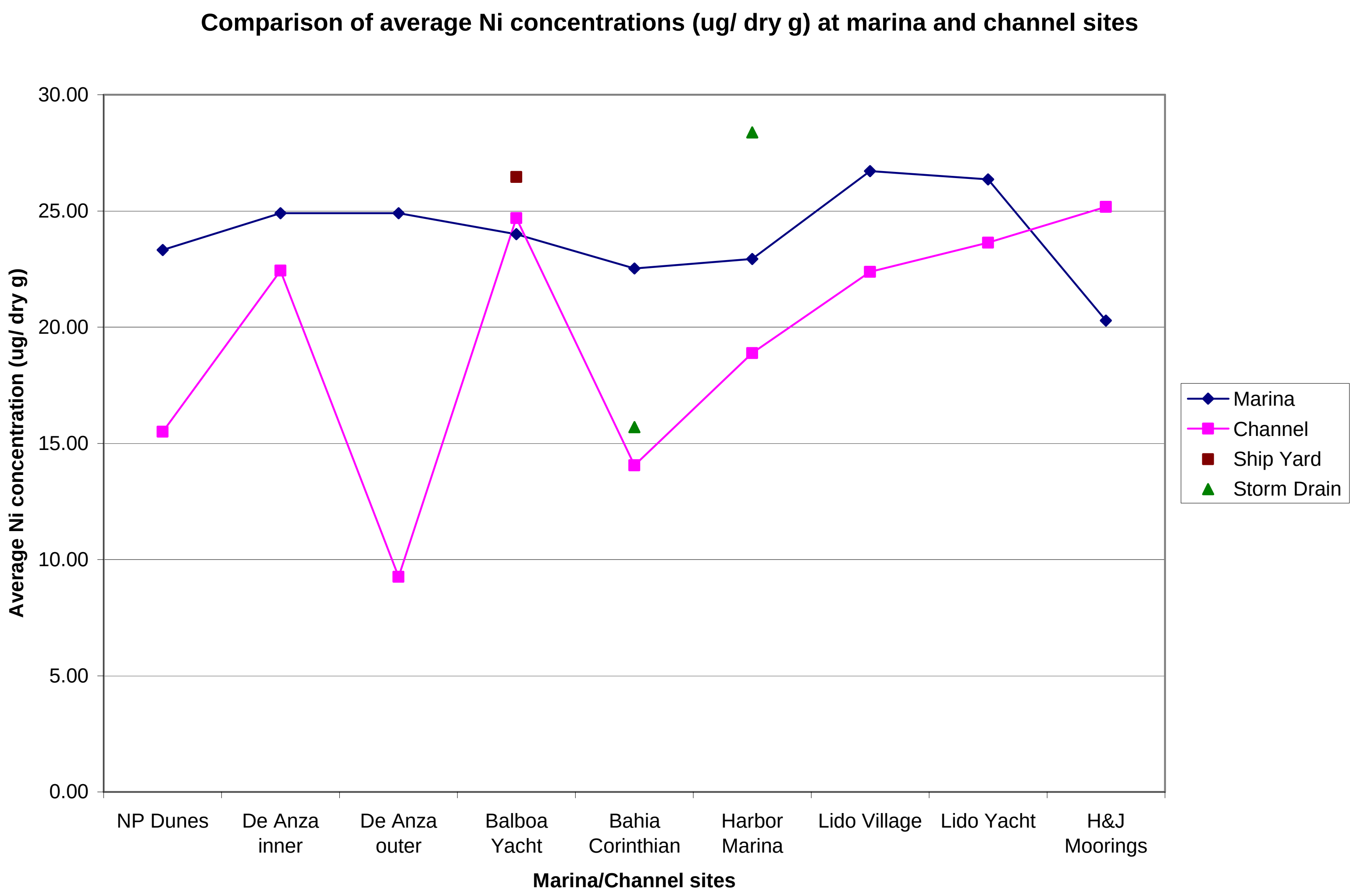
Comparison of average Hg concentrations (ug/ dry g) at marina and channel sites

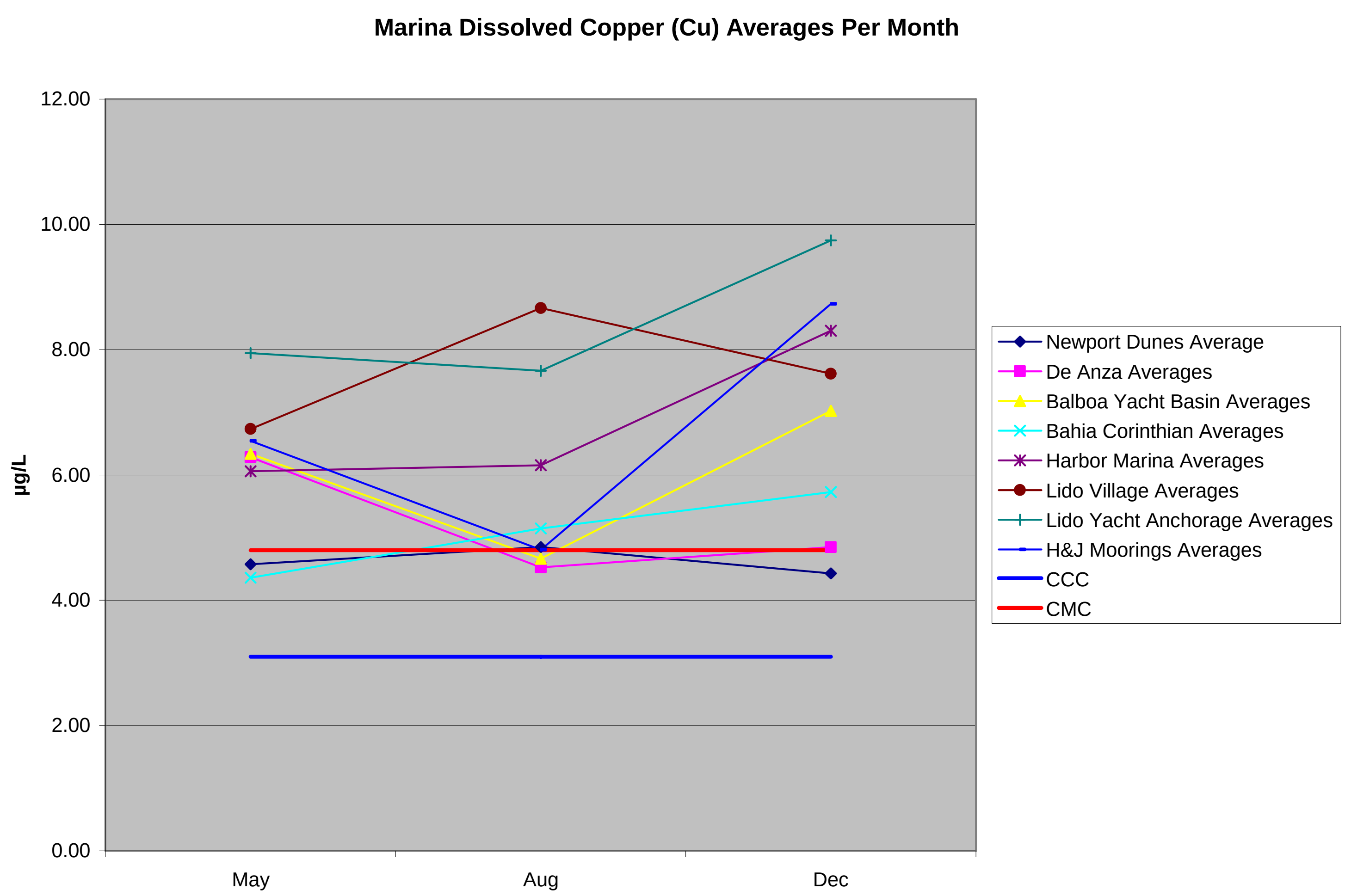


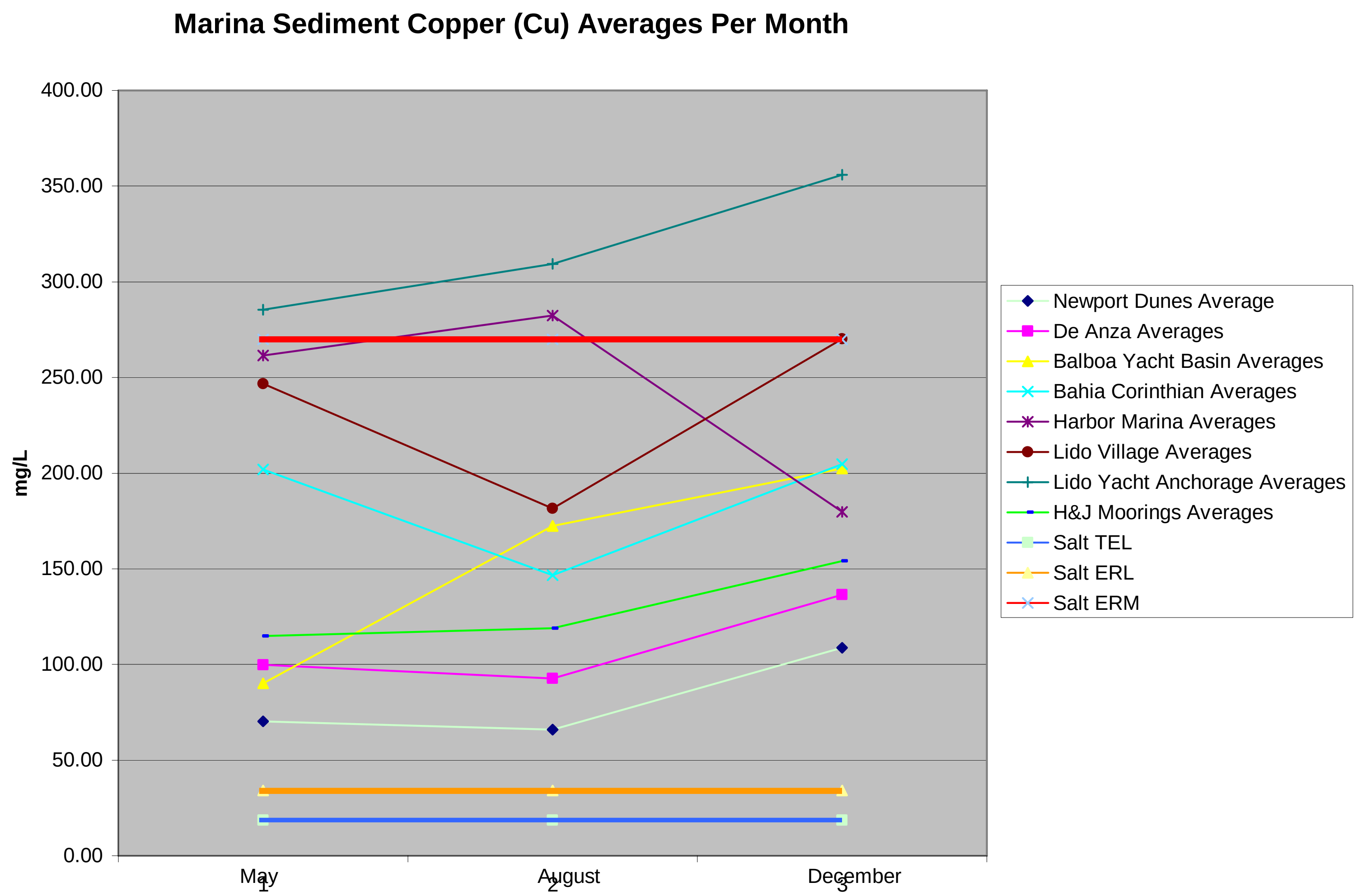


Comparison of average Zn concentrations (ug/ dry g) at marina and channel sites
700
600
500
400
300
200
100
0
Average Zn concentration (ug/ dry g)
NP Dunes
De Anza inner
De Anza outer
Balboa Yacht
Bahia Corinthian
Harbor Marina
Lido Village
Lido Yacht
H&J Moorings
Marina/Channel Sites
Marina
Channel
TEL
ERL
ERM
Ship Yard
Storm Drain

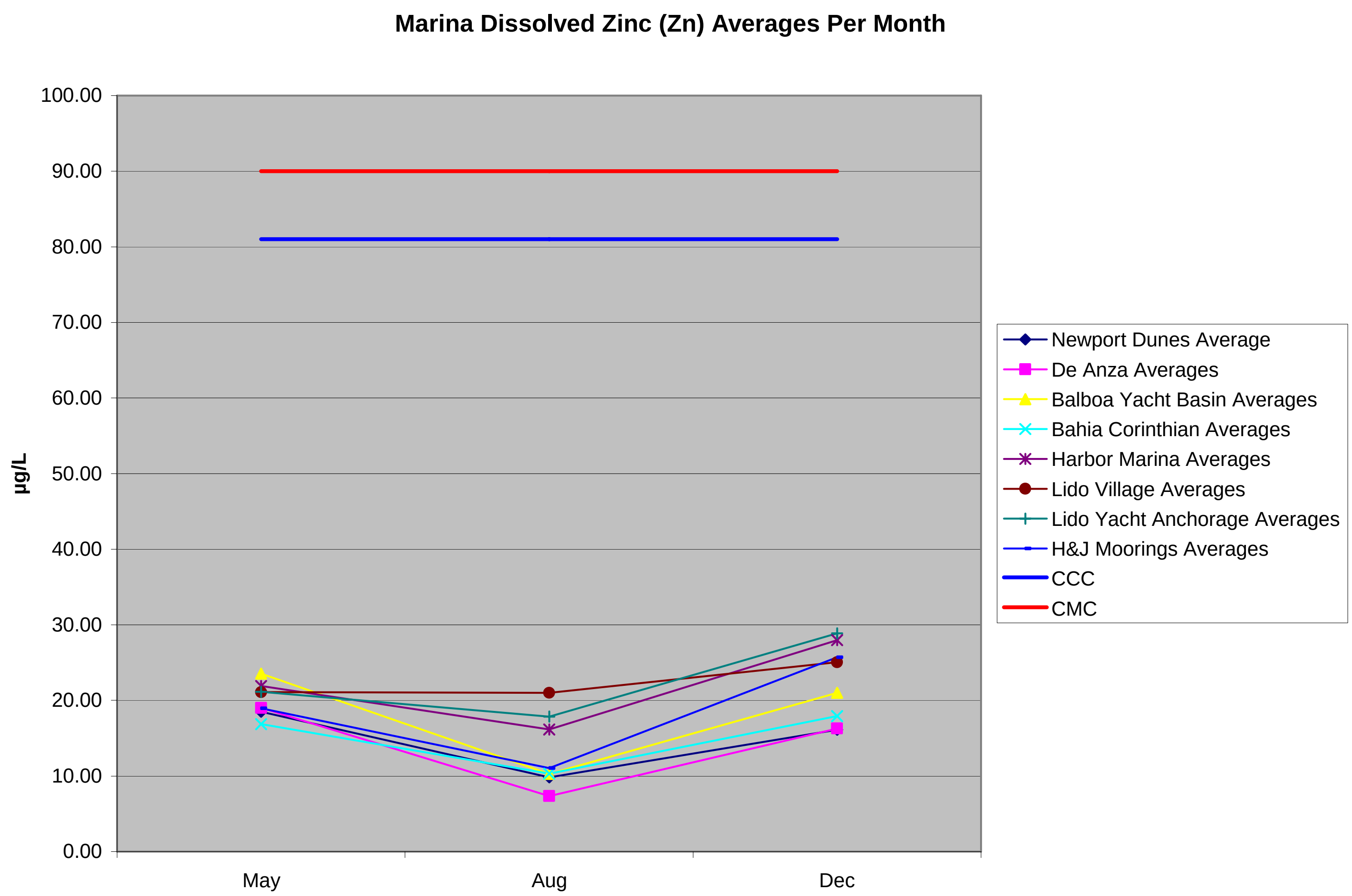

Comparison of average As concentrations (ug/ dry g) at marina and channel sites
Average As concentration (ug/ dry g)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
NP Dunes
De Anza inner
De Anza outer
Balboa Yacht
Bahia Corinthian
Harbor Marina
Lido Village
Lido Yacht
H&J Moorings
Marina/Channel sites
Marina
Channel
TEL
ERL
Ship Yard
Storm Drain
ERM

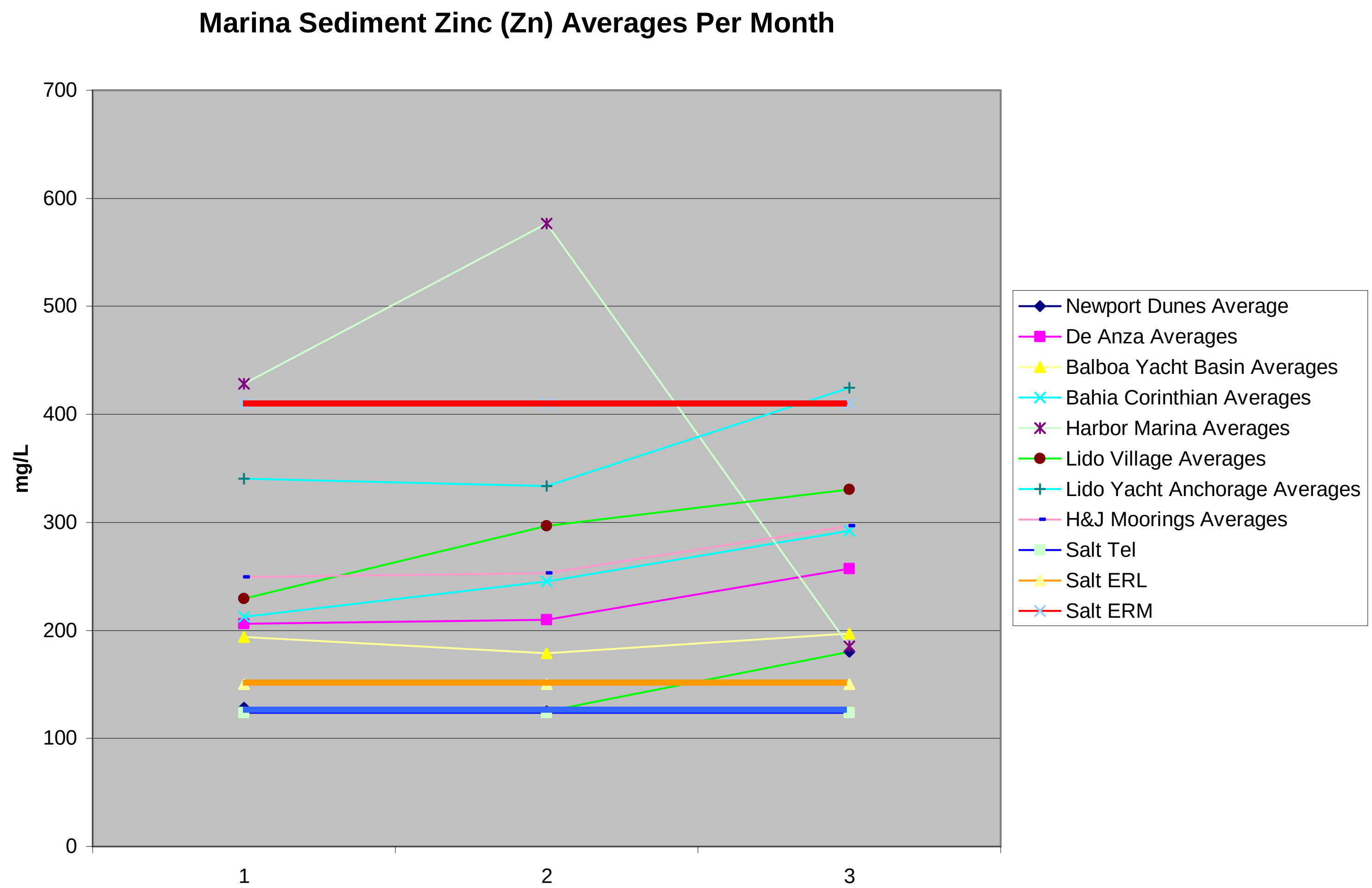

Comparison of average Ni concentrations (ug/ dry g) at marina and channel sites
Average Ni concentration (ug/ dry g)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
NP Dunes
De Anza inner
De Anza outer
Balboa Yacht
Bahia Corinthian
Harbor Marina
Lido Village
Lido Yacht
H&J Moorings
Marina/Channel sites
Marina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


Marina Dissolved Copper (Cu) Averages Per Month
12.00
10.00
8.00
6.00
4.00
2.00
0.00
µg/L
May
Aug
Dec
Newport Dunes Average
De Anza Averages
Balboa Yacht Basin Averages
Bahia Corinthian Averages
Harbor Marina Averages
Lido Village Averages
Lido Yacht Anchorage Averages
H&J Moorings Averages
CCC
CMC



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


Marina Dissolved Zinc (Zn) Averages Per Month
µg/L
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
May
Aug
Dec
Newport Dunes Average
De Anza Averages
Balboa Yacht Basin Averages
Bahia Corinthian Averages
Harbor Marina Averages
Lido Village Averages
Lido Yacht Anchorage Averages
H&J Moorings Averages
CCC
CMC



Marina Sediment Zinc (Zn) Averages Per Month
mg/L
700
600
500
400
300
200
100
0
1
2
3
Newport Dunes Average
De Anza Averages
Balboa Yacht Basin Averages
Bahia Corinthian Averages
Harbor Marina Averages
Lido Village Averages
Lido Yacht Anchorage Averages
H&J Moorings Averages
Salt Tel
Salt ERL
Salt ERM

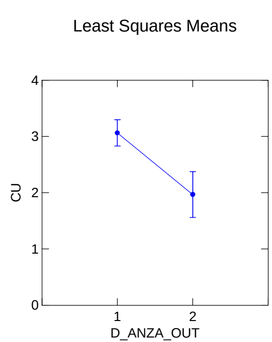
Statistical Analysis Discussion

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

Marinas vs. Adjacent Channel Sites

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

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



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

Marina vs. Marina

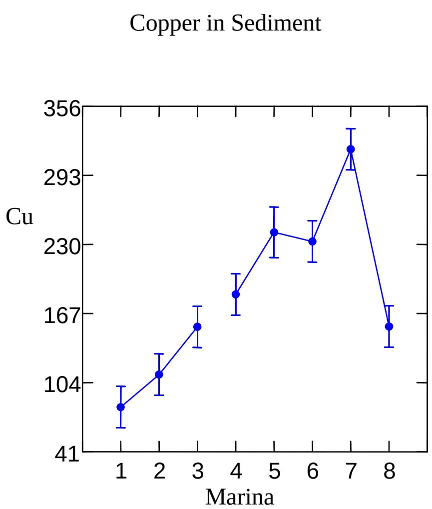
The dissolved and sediment metals (listed in table 2 and 3) in samples within each marina were compared to all the other marinas individually and there are very clear patterns. (Channel data comparison was not analyzed.) The findings for dissolved and sediment metals are discussed seperatly.

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

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

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

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



Stormdrains and shipyards

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

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

Table 4 Significant Differences Between Marina And Channel Sites

S= Marina sites metals concentration significantly were higher than channel sites metals concentration
N= no significant difference.

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

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

Table 5 Significant Differences- Marina vs. Marina

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

Dissolved Metals

Dissolved

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

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

Sediment Metals

Sediment

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

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

Wet vs. Dry Weather

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

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

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

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

Table 6 Significant differences in wet vs. dry weather

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

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

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

Toxicity Testing

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

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

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

Conclusions

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

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

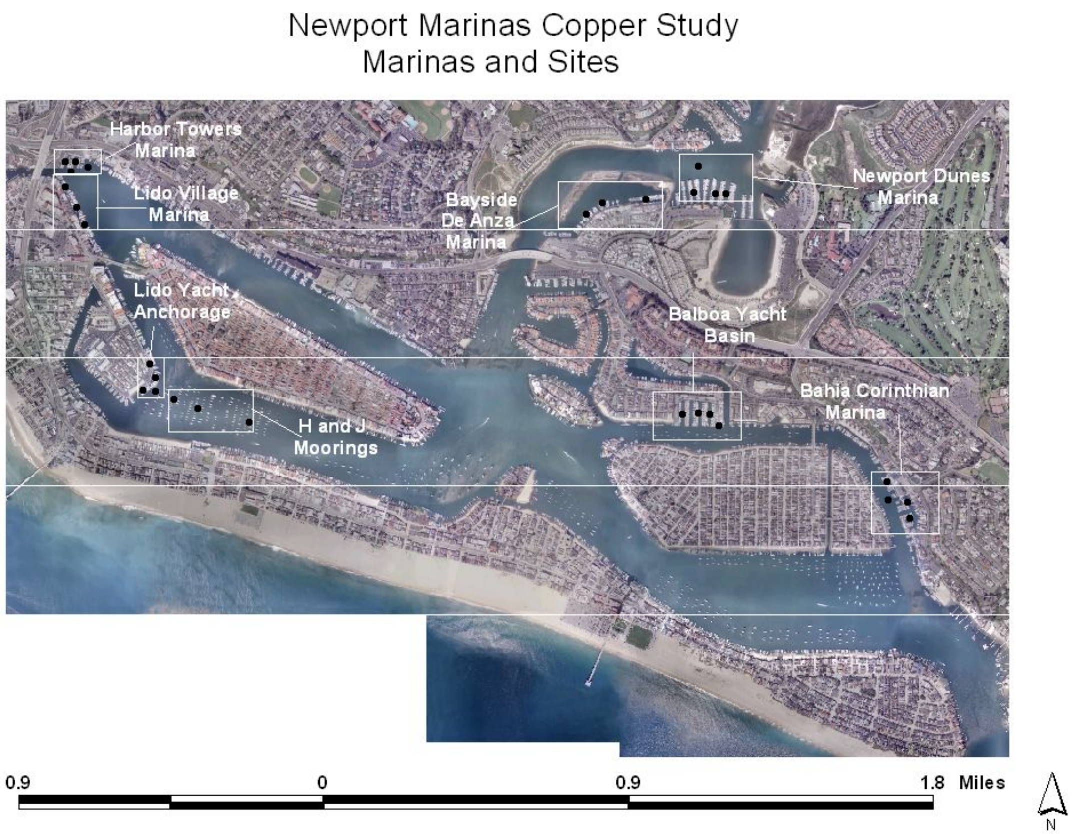
The analysis of marina vs. the adjacent cannel for sediments shows significantly higher sediment metal concentrations at the marina sites compared to the channel site at Newport Dunes for Cd, Cr, Cu, Pb, and Zn; at Bahia Corinthian Marina for all metals tested except Ag; at Lido Village Marina for Cu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

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

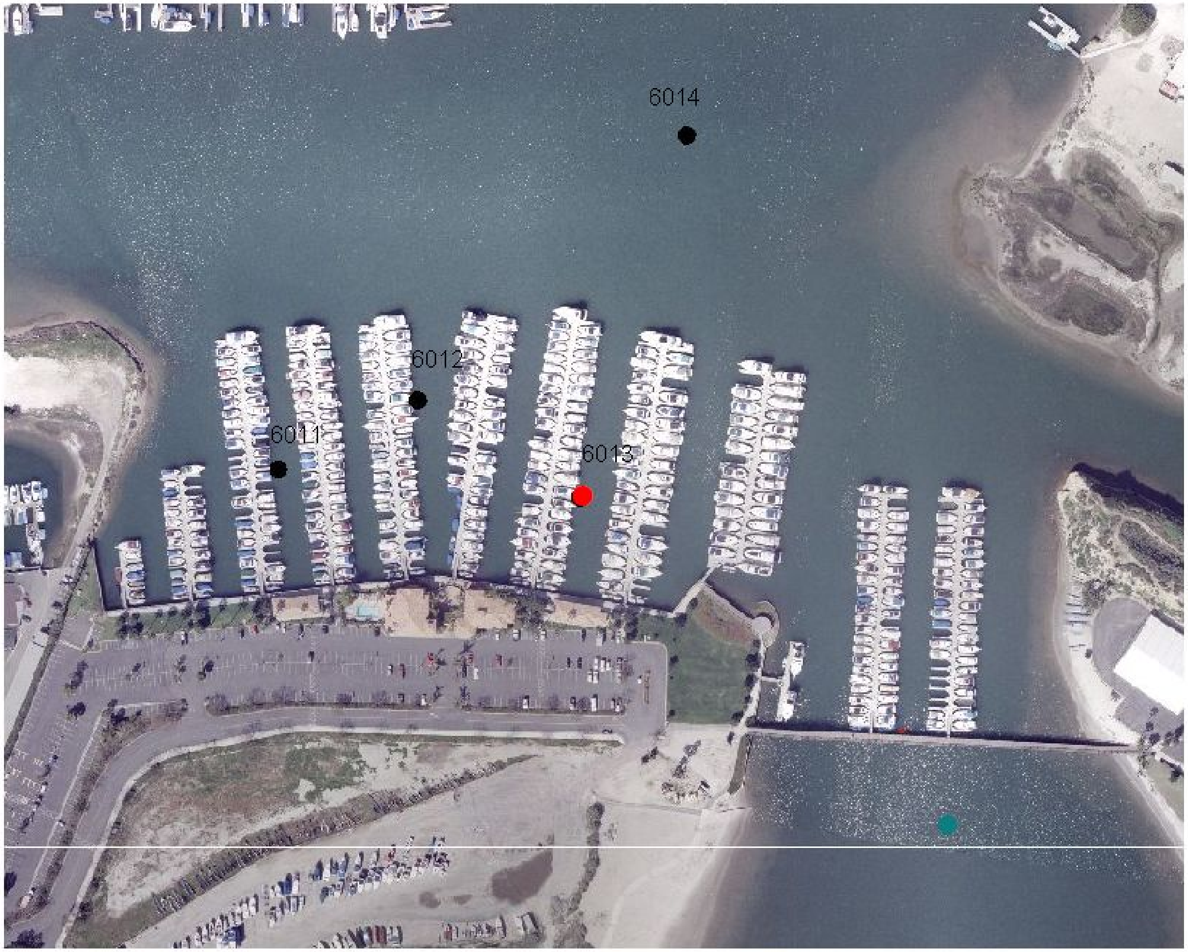
In wet weather, the Newport Dunes and DeAnza marinas showed higher levels of dissolved metals than the other marinas in the bay, which is the reverse of the trend during dry or combined wet and dry weather where significantly higher dissolved metals were found in the west bay . This could be due to the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

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

Appendix A
Sample Site Maps



Newport Dunes Marina



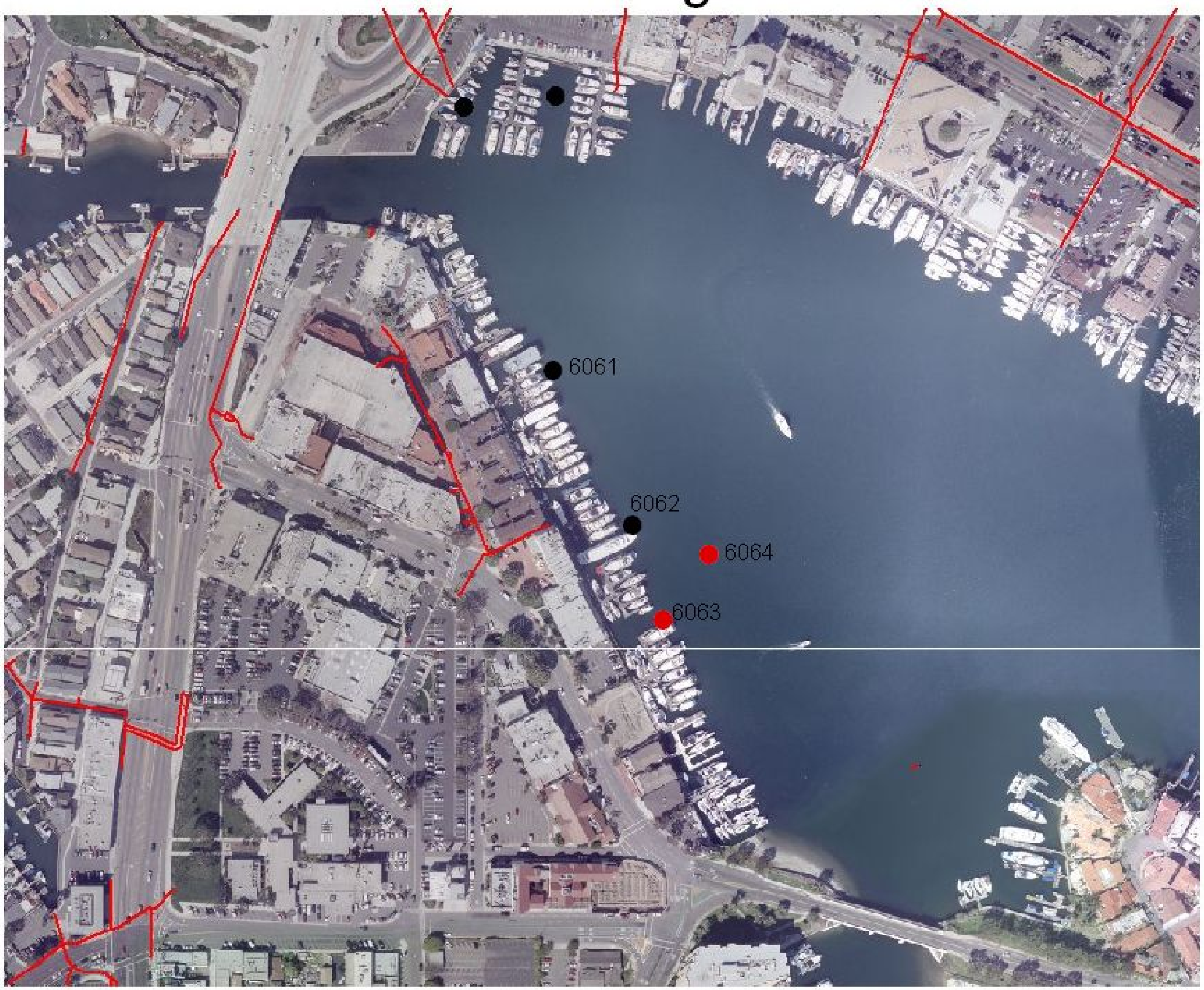
De Anza Marina

Balboa Yacht Basin

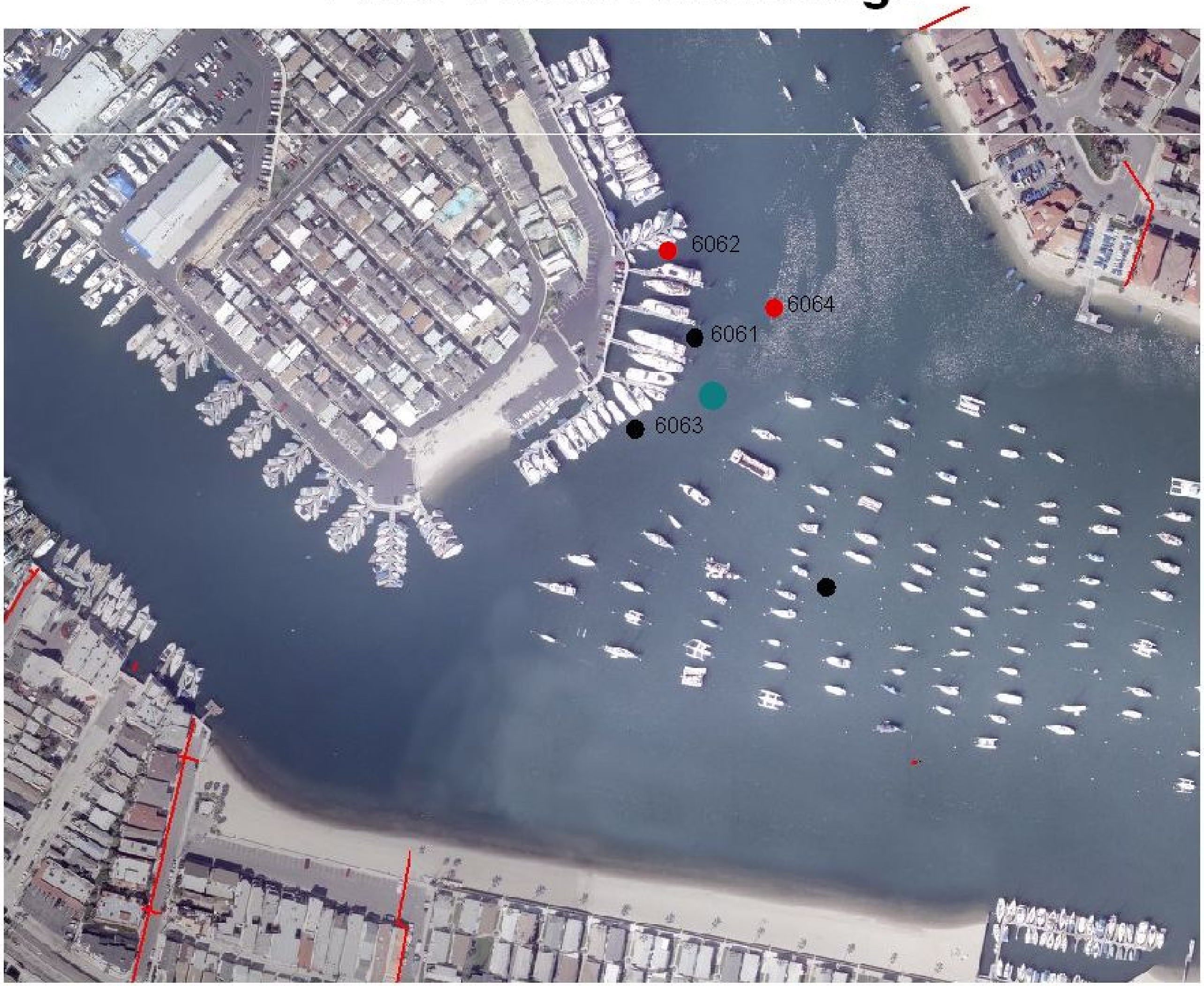
Bahia Corinthian

Harbor Marina

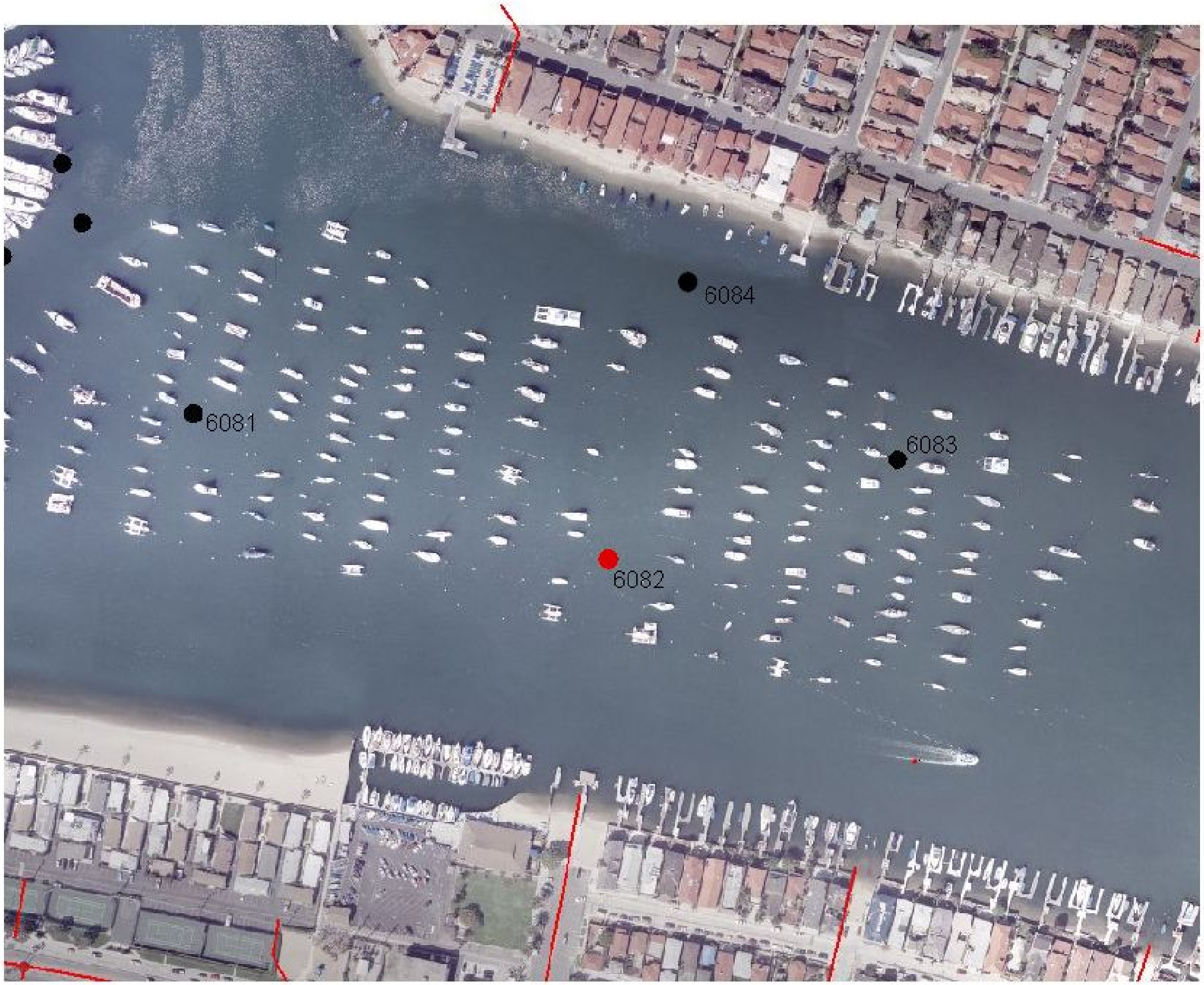
Lido Village



Lido Yacht Anchorage

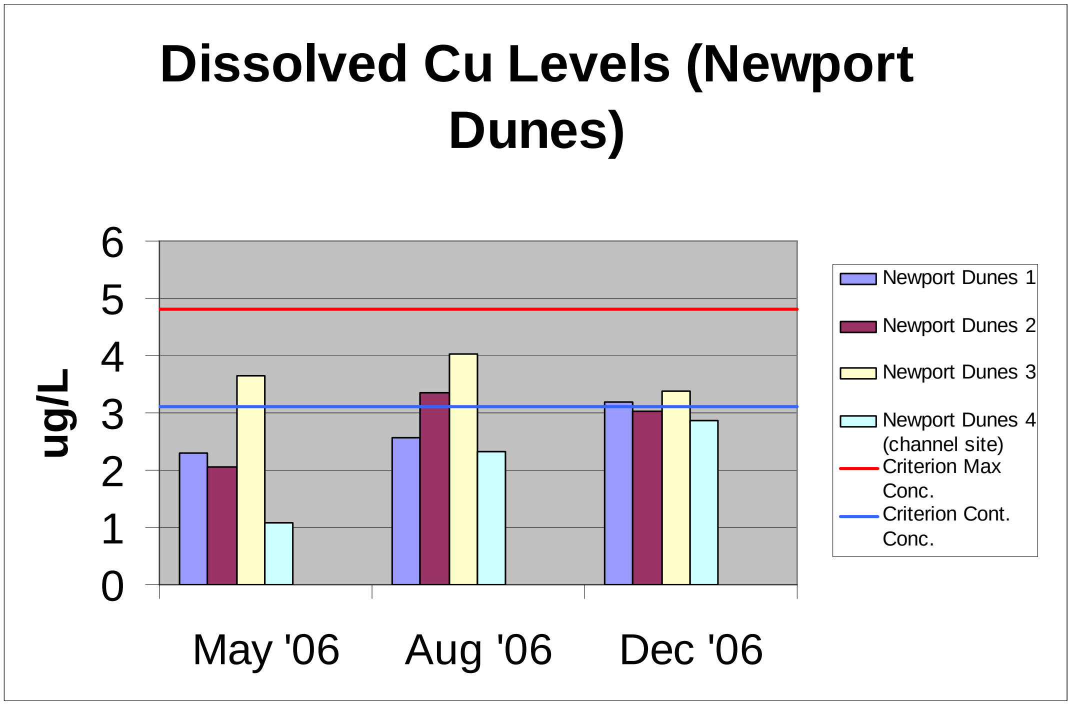


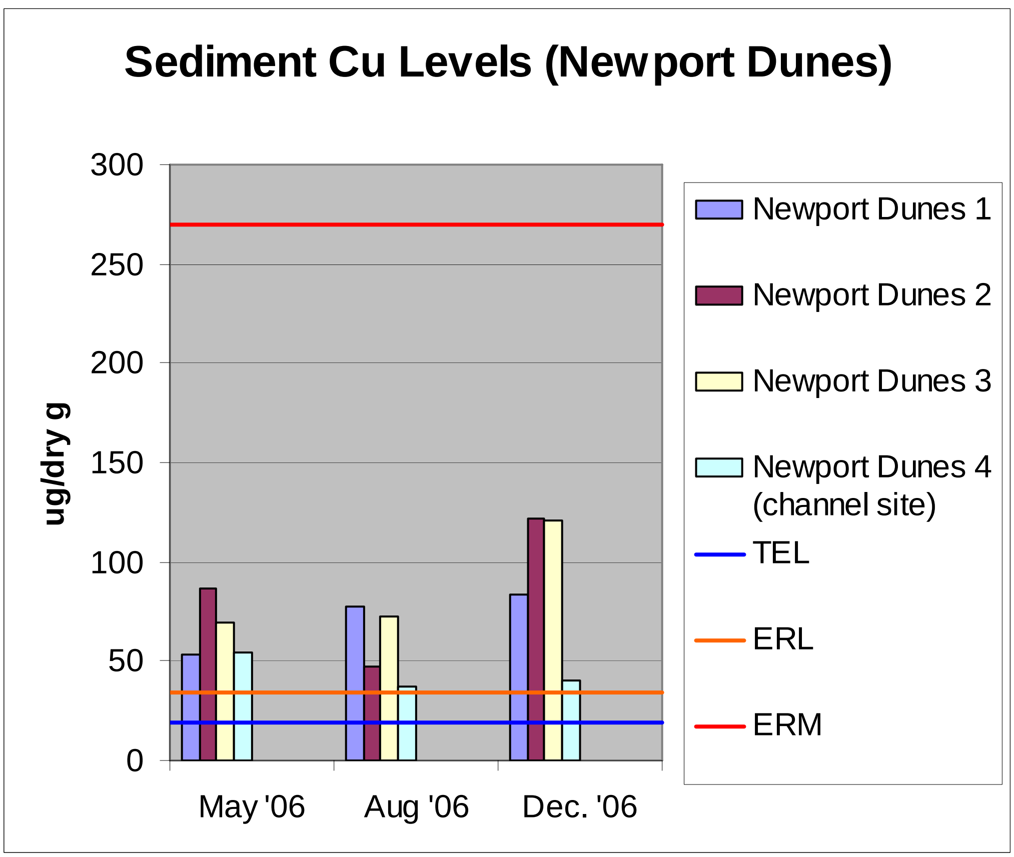
H and J Moorings

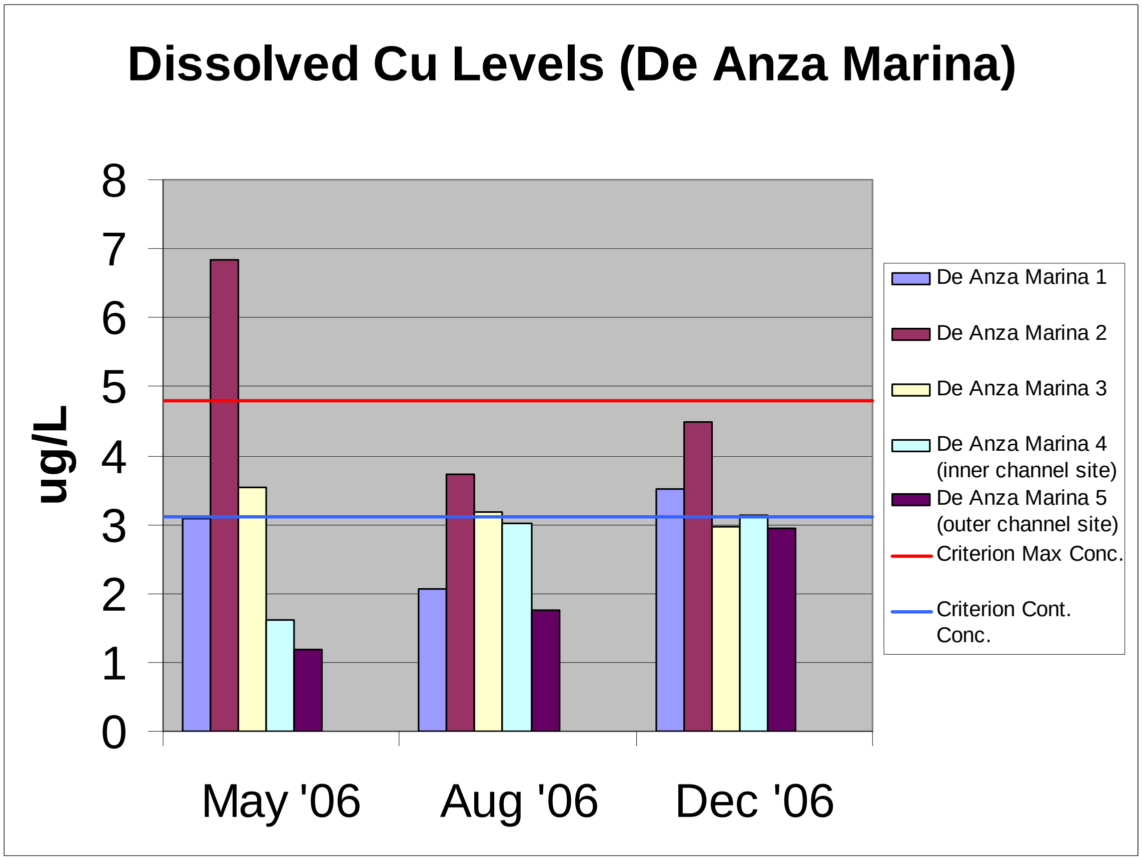


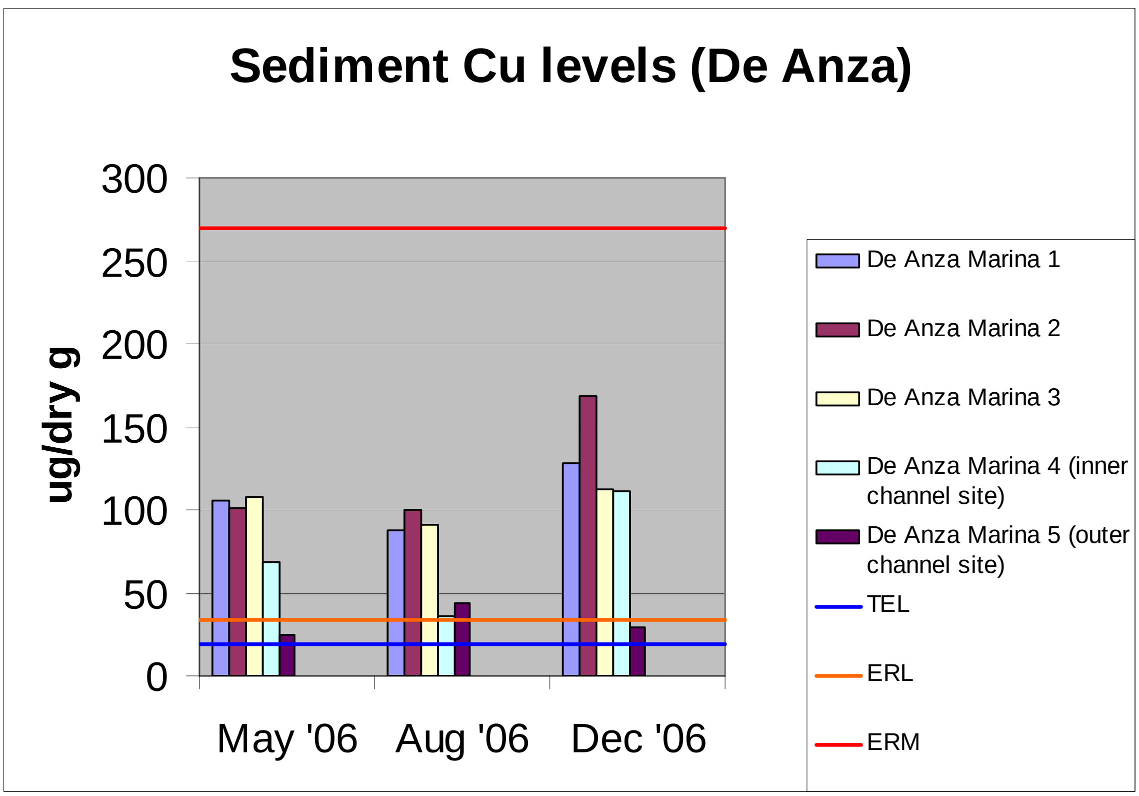
Appendix B

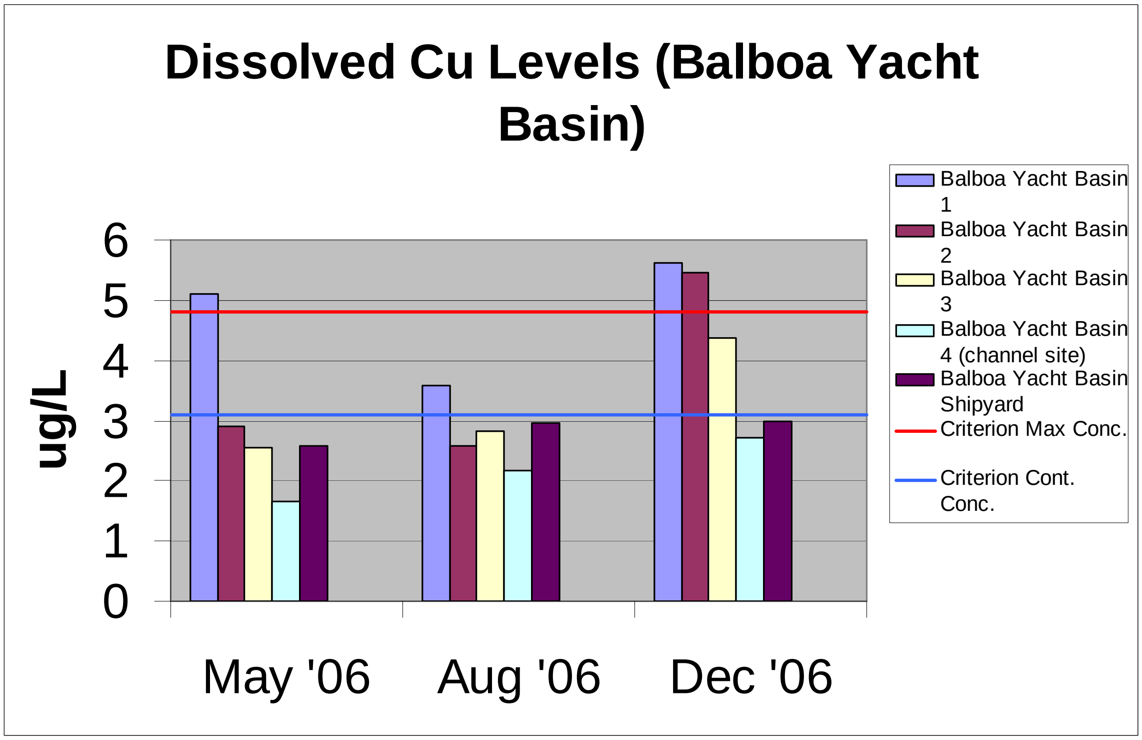
Appendix C

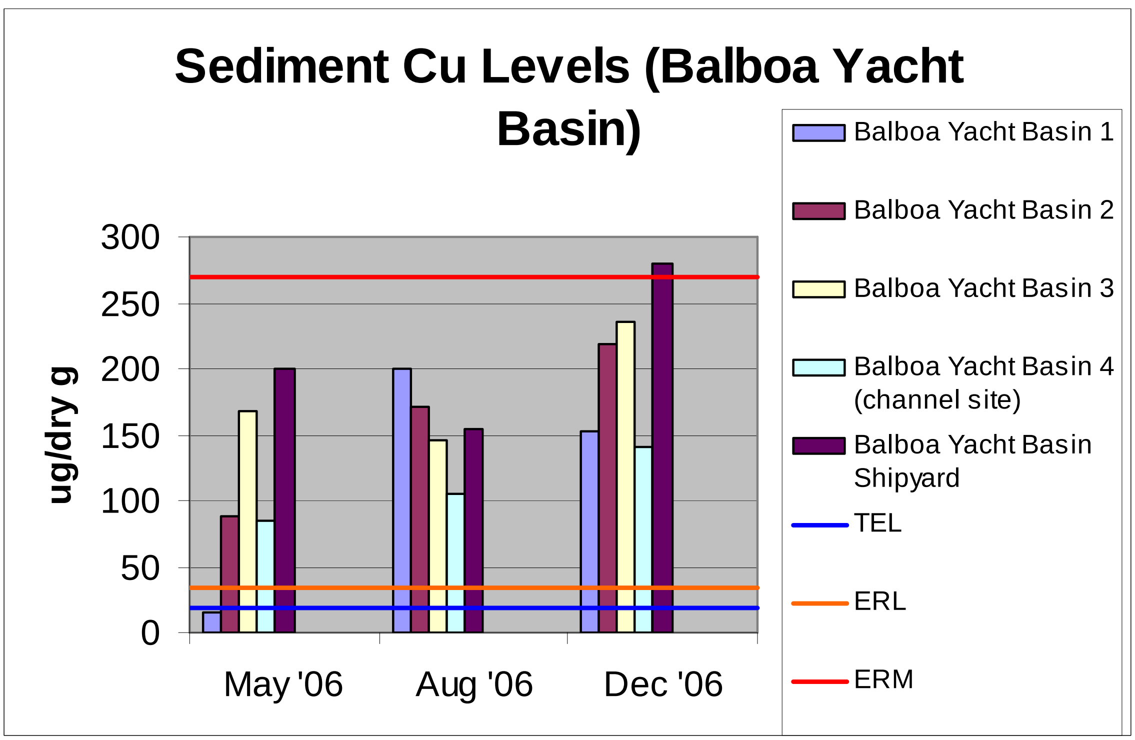

Dissolved Cu Levels (Newport Dunes)
ug/L
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
Newport Dunes 1
Newport Dunes 2
Newport Dunes 3
Newport Dunes 4 (channel site)
Criterion Max Conc.
Criterion Cont. Conc.

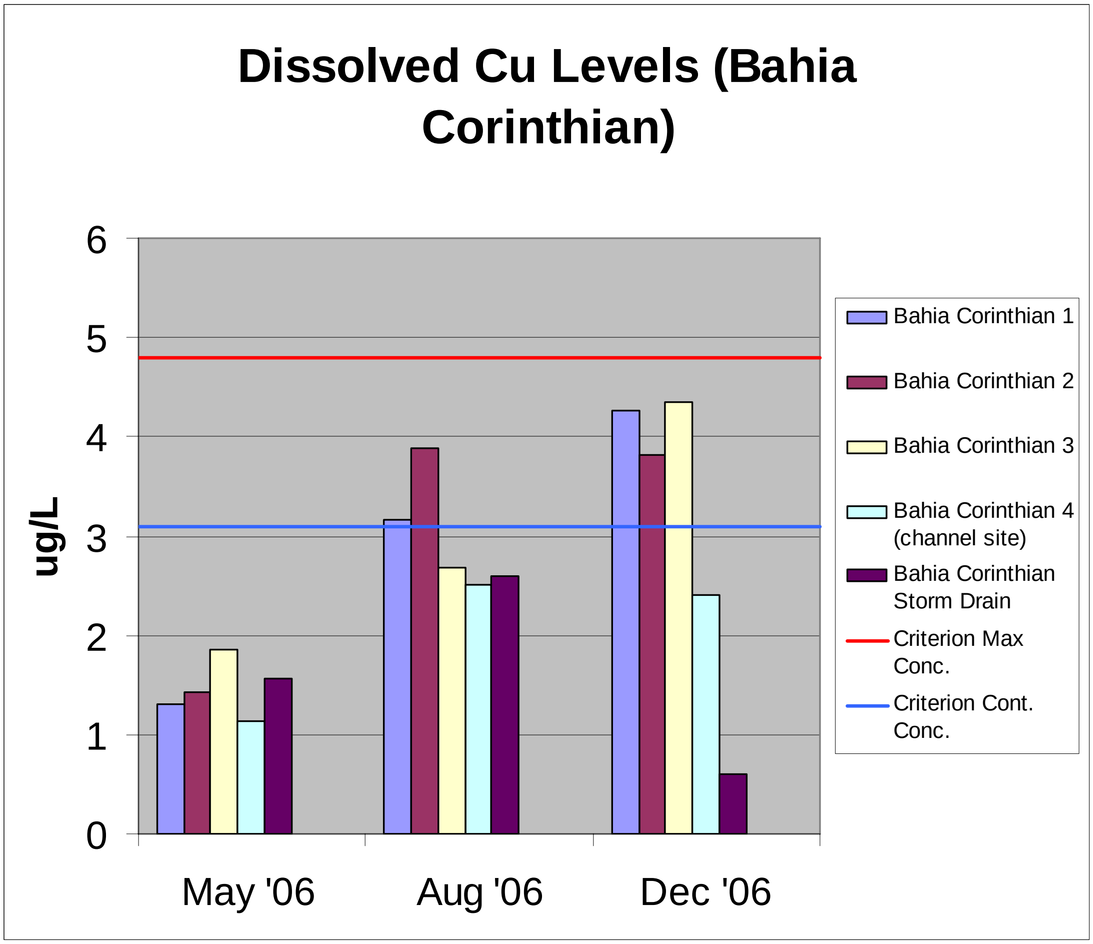

Sediment Cu Levels (Newport Dunes)
ug/dry g
300
250
200
150
100
50
0
May '06
Aug '06
Dec. '06
Newport Dunes 1
Newport Dunes 2
Newport Dunes 3
Newport Dunes 4 (channel site)
TEL
ERL
ERM

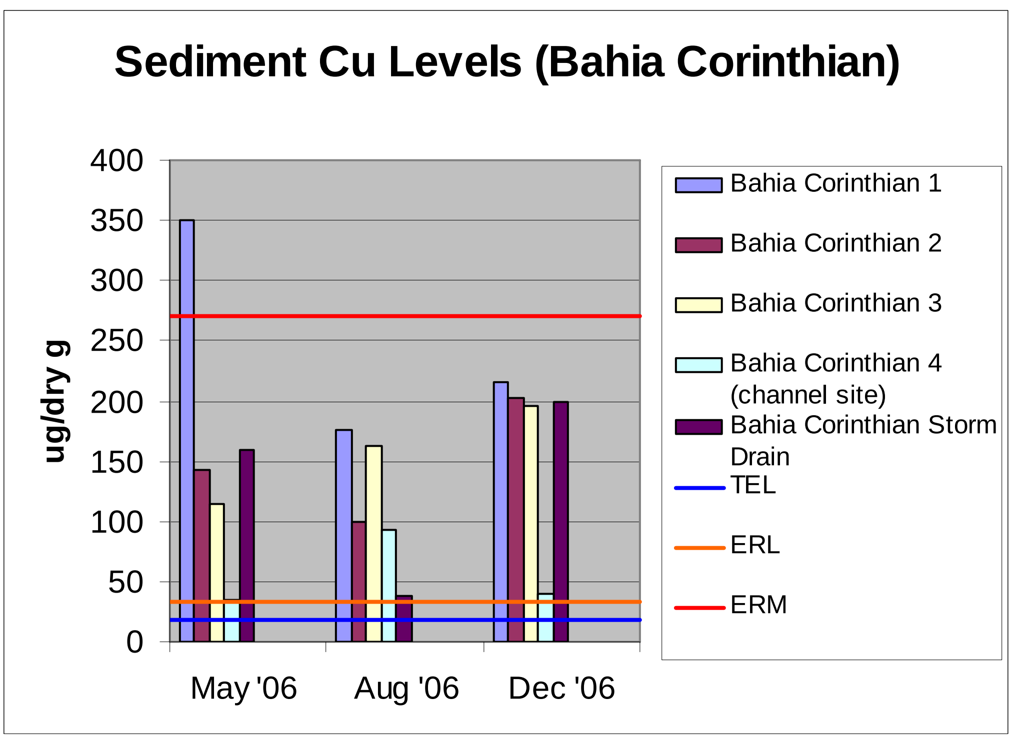

Dissolved Cu Levels (De Anza Marina)
ug/L
8
7
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
De Anza Marina 1
De Anza Marina 2
De Anza Marina 3
De Anza Marina 4 (inner channel site)
De Anza Marina 5 (outer channel site)
Criterion Max Conc.
Criterion Cont. Conc.

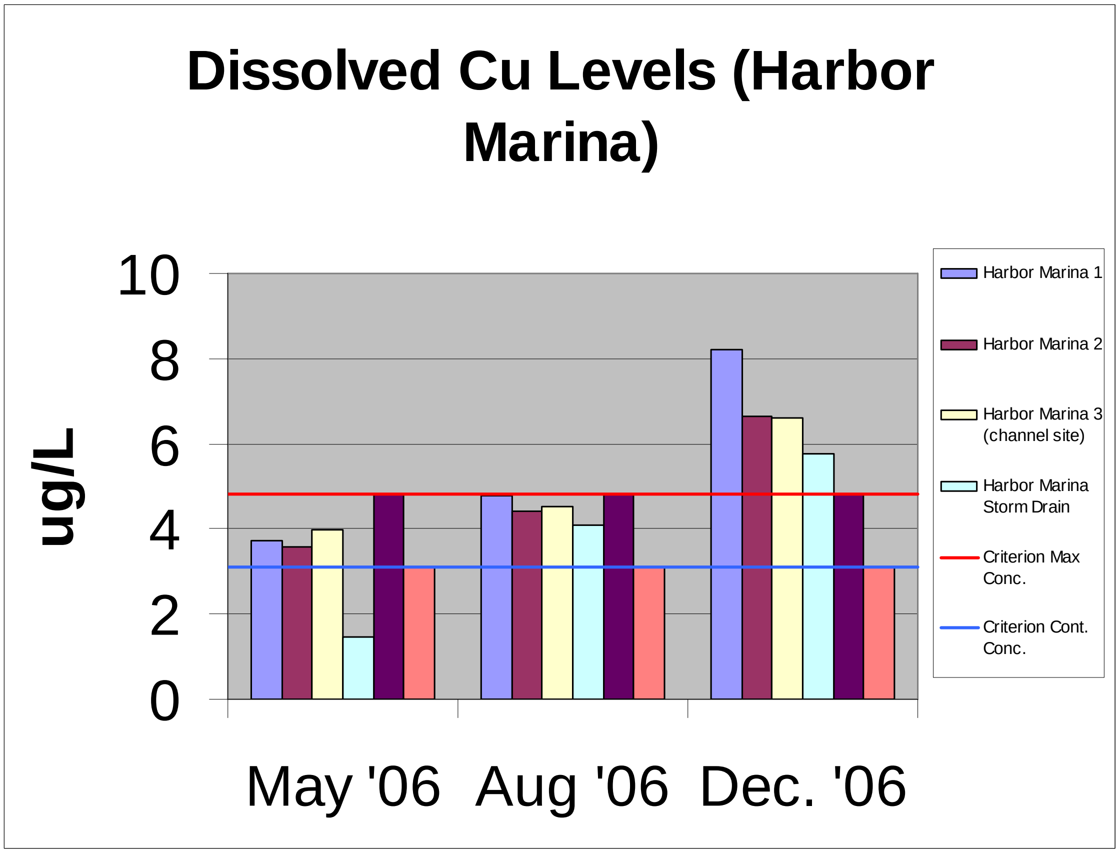

Sediment Cu levels (De Anza)
ug/dry g
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
De Anza Marina 1
De Anza Marina 2
De Anza Marina 3
De Anza Marina 4 (inner channel site)
De Anza Marina 5 (outer channel site)
TEL
ERL
ERM

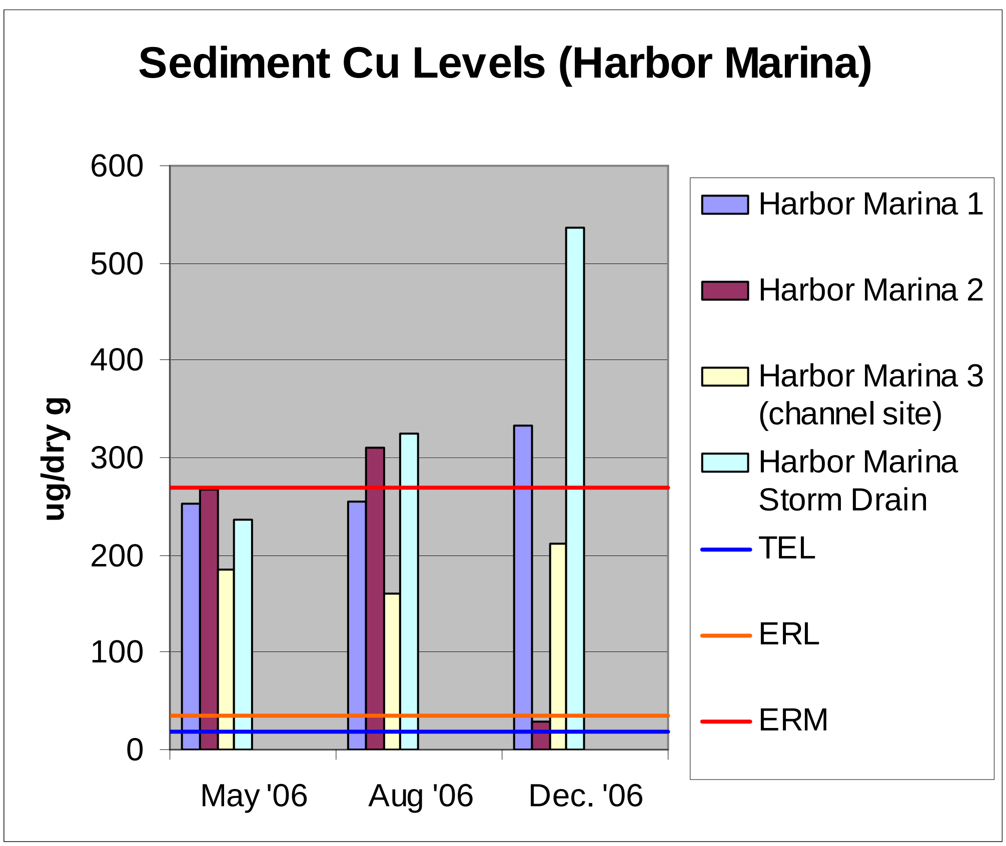

Dissolved Cu Levels (Balboa Yacht Basin)
ug/L
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
Balboa Yacht Basin 1
Balboa Yacht Basin 2
Balboa Yacht Basin 3
Balboa Yacht Basin 4 (channel site)
Balboa Yacht Basin Shipyard
Criterion Max Conc.
Criterion Cont. Conc.

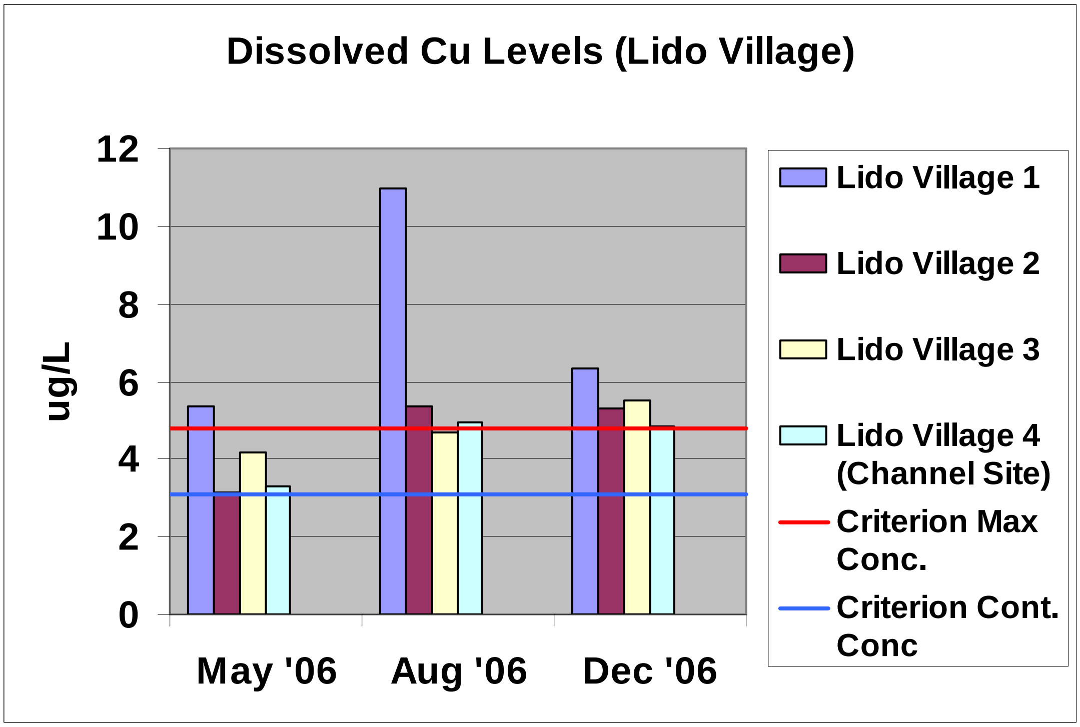

Sediment Cu Levels (Balboa Yacht Basin)
ug/dry g
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
Balboa Yacht Basin 1
Balboa Yacht Basin 2
Balboa Yacht Basin 3
Balboa Yacht Basin 4 (channel site)
Balboa Yacht Basin Shipyard
TEL
ERL
ERM

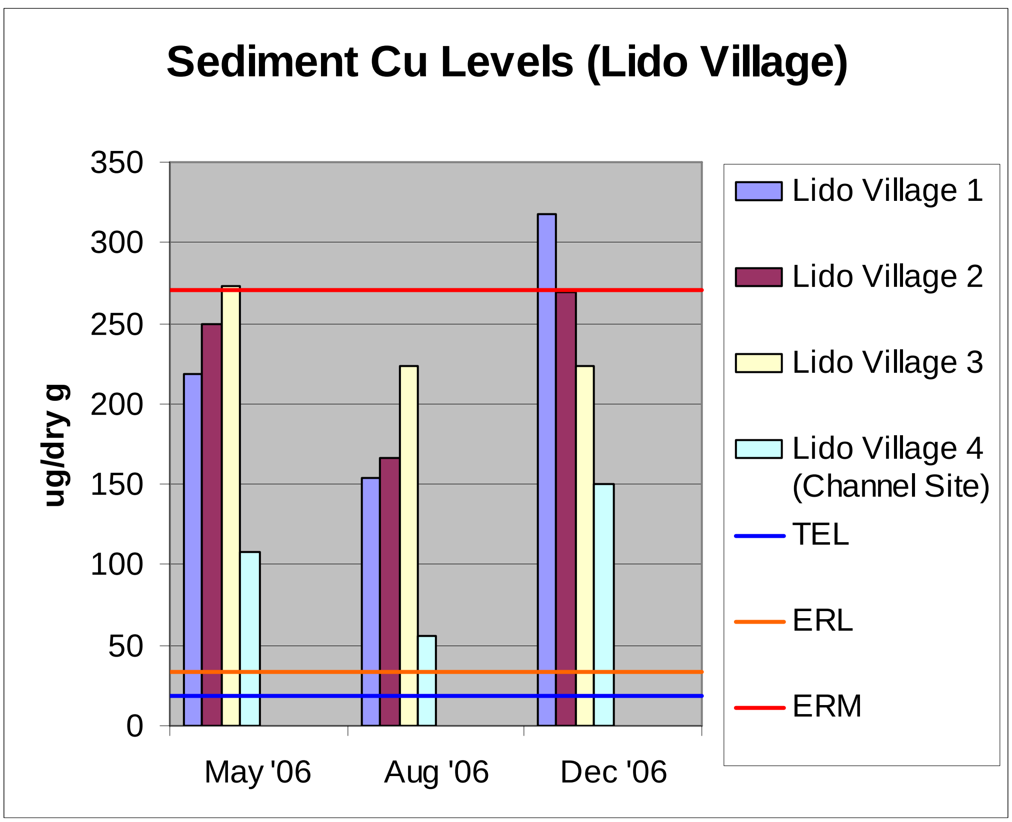

Dissolved Cu Levels (Bahia Corinthian)
ug/L
6
5
4
3
2
1
0
May '06
Aug '06
Dec '06
Bahia Corinthian 1
Bahia Corinthian 2
Bahia Corinthian 3
Bahia Corinthian 4 (channel site)
Bahia Corinthian Storm Drain
Criterion Max Conc.
Criterion Cont. Conc.

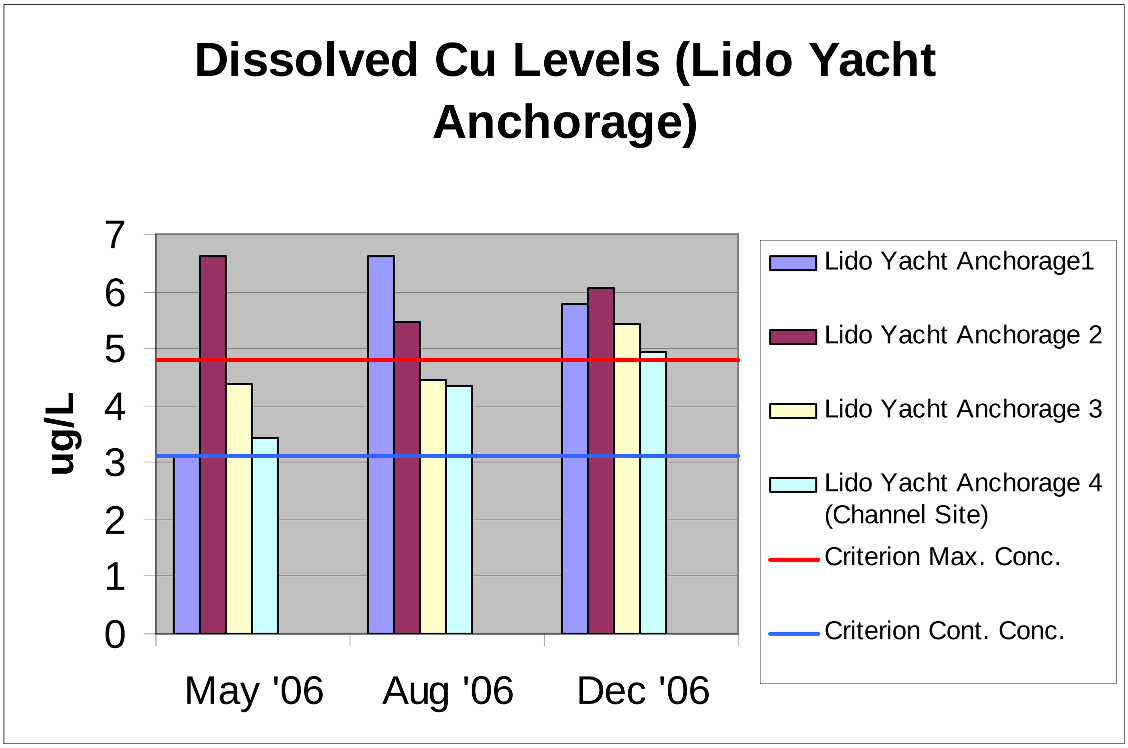

Sediment Cu Levels (Bahia Corinthian)
ug/dry g
400
350
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
Bahia Corinthian 1
Bahia Corinthian 2
Bahia Corinthian 3
Bahia Corinthian 4 (channel site)
Bahia Corinthian Storm Drain
TEL
ERL
ERM

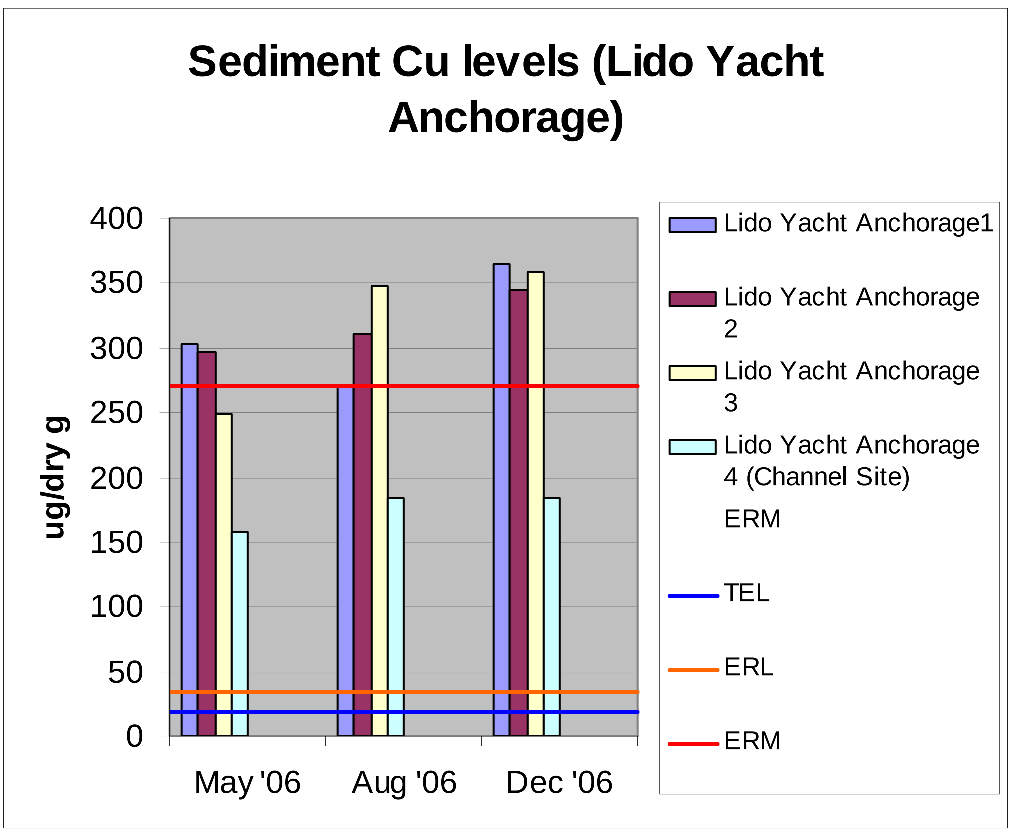

Dissolved Cu Levels (Harbor Marina)
ug/L
10
8
6
4
2
0
May '06
Aug '06
Dec. '06
Harbor Marina 1
Harbor Marina 2
Harbor Marina 3 (channel site)
Harbor Marina Storm Drain
Criterion Max Conc.
Criterion Cont. Conc.

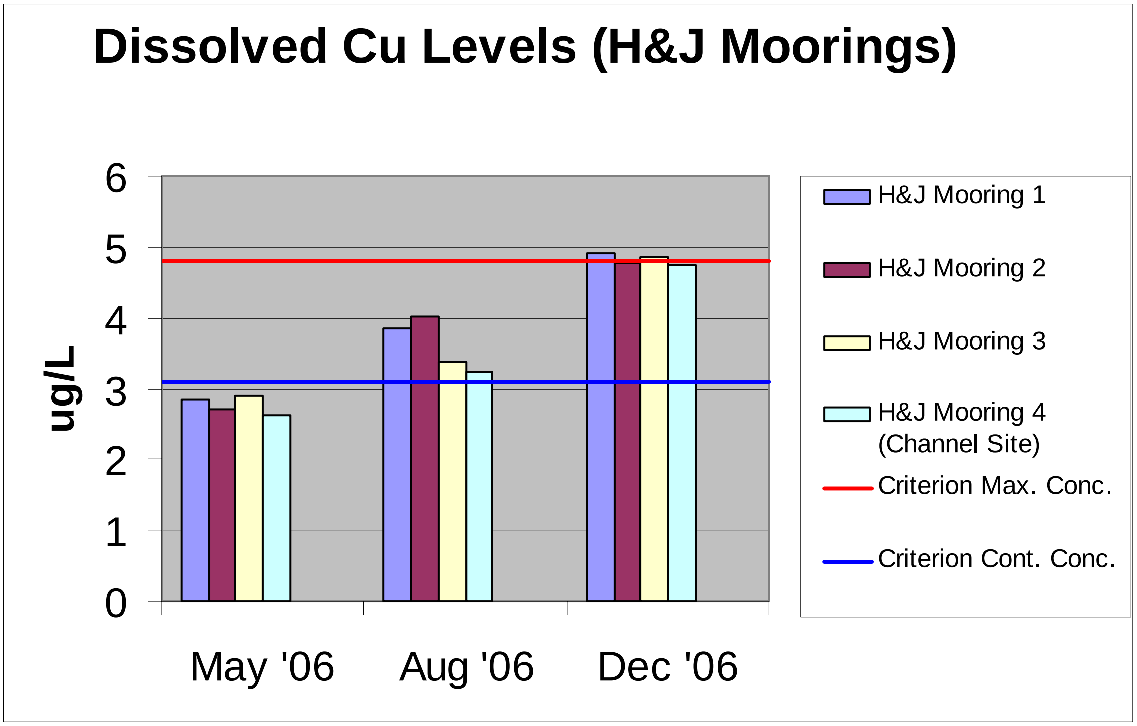

Sediment Cu Levels (Harbor Marina)
ug/dry g
600
500
400
300
200
100
0
May '06
Aug '06
Dec. '06
Harbor Marina 1
Harbor Marina 2
Harbor Marina 3 (channel site)
Harbor Marina Storm Drain
TEL
ERL
ERM

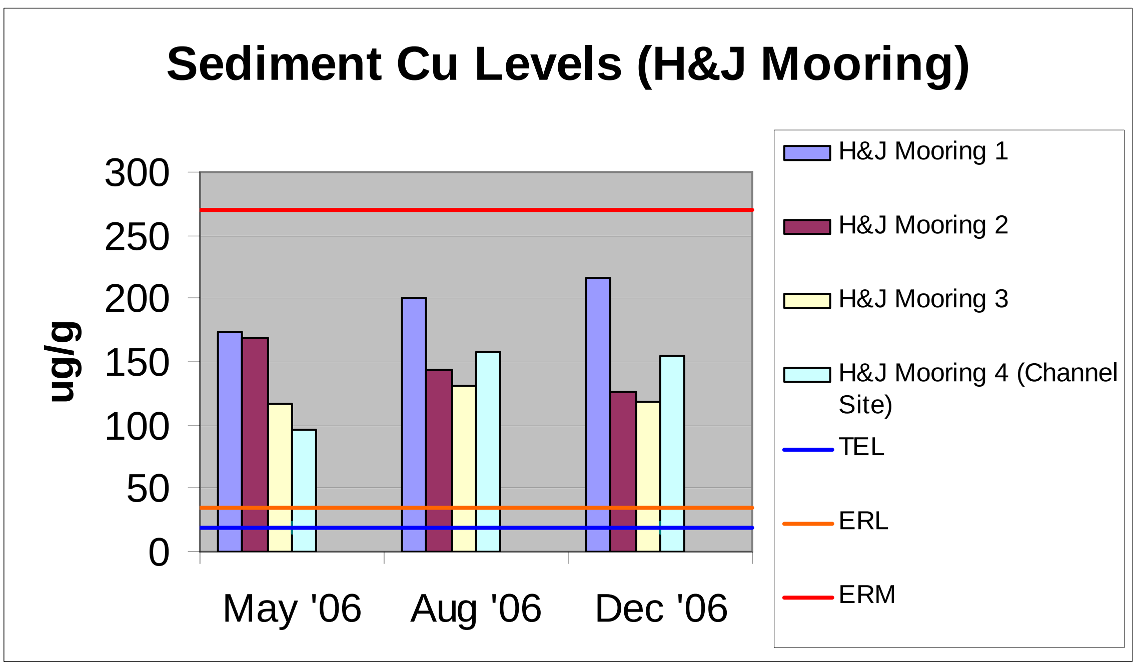

Dissolved Cu Levels (Lido Village)
ug/L
12
10
8
6
4
2
0
May '06
Aug '06
Dec '06
Lido Village 1
Lido Village 2
Lido Village 3
Lido Village 4 (Channel Site)
Criterion Max Conc.
Criterion Cont. Conc


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


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


Sediment Cu levels (Lido Yacht Anchorage)
ug/dry g
400
350
300
250
200
150
100
50
0
May '06
Aug '06
Dec '06
Lido Yacht Anchorage1
Lido Yacht Anchorage 2
Lido Yacht Anchorage 3
Lido Yacht Anchorage 4 (Channel Site)
ERM
TEL
ERL
ERM


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


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

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

Dissolved Metals Means

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

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

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

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

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

Sediment Metals Means

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

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

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

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

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

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

Newport Dunes

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

De Anza

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

Balboa Yacht Basin

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

Bahia Corinthian

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

Harbor Marina

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

Lido Village

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

Lido Yacht Anchorage

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

H&J Mooring

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

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

PAH(Seawatwer)

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

PAH (Sediment)

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

PCB (seawater)

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

PCB (sediment)

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

Grain Size

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

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

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

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

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

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

Table 9. (continued)

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

ND = Not Detected