# APPENDIX A

# Water Quality Characterization Report

# La Jolla Shores Watershed
# Urban Runoff Characterization and Watershed Characterization Study

## Final Report

Prepared For:

City of San Diego

July 2007

# La Jolla Shores Watershed
# Urban Runoff Characterization and Watershed Characterization Study

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City of San Diego

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# 1.0 URBAN RUNOFF CHARACTERIZATION

The baseline storm water runoff study was conducted to assess potential impacts from urban runoff to the La Jolla Shores Areas of Special Biological Significance (ASBS), also known as the San Diego Marine Life Refuge and the La Jolla Ecological Reserve. The purpose of this characterization study was also to identify potential constituents of issue (COI) to develop a target analyte list for the ecological assessments and a target constituent list for the evaluation of potential structural and non-structural Best Management Practices (BMPs). Potential impacts from storm water runoff to the ASBS were evaluated using a holistic approach that included water quality monitoring, toxicity testing, bioaccumulation studies, biological surveys and physical environment data. The potential storm water impact based on this holistic approach is discussed in the Watershed Management Plan following the discussion of the results of the ecological assessment and tidal studies. The results from these studies and assessments are the basis for the design approach and impact reduction goals of the proposed BMPs. The impact reduction goals of the BMPs will also be based on a comparative impact level of storm water in relation to other potential impacts to the ASBS. Other potential impacts include cross contamination from tidal flows, public use, air deposition, and physical environmental changes. Higher relative impacts should receive greater attention and resources to cost-effectively preserve the beneficial uses of the ASBS.

This baseline storm water runoff characterization includes a review of historical water quality and toxicity data collected by the City of San Diego and Scripps Institute of Oceanography (SIO). In addition to conducting the data review; storm water, ocean mixing zone (surf zone) and outer ocean (beyond the surf zone) sampling and analysis were conducted as part of this grant project to obtain additional baseline water quality, flow, and toxicity data. Storm water samples were collected at two locations within the municipal storm drain system upstream of outfalls to the ASBS. The storm drain samples were collected during a rain event, and were analyzed for the constituents listed in the Ocean Plan. Additionally, repeated water quality sampling was conducted at a single location in order to create a pollutograph detailing the point in a storm in which COIs were highest, and to determine overall constituent loads being delivered to the ASBS via the MS4. Sampling and analysis results from monitoring performed by SIO for their discharge permit is also presented in this section.

Potential constituents of issue were identified by comparing the available and grant project water quality data with water quality criteria. Water quality criteria presented in the Ocean Plan were compared to the mixing zone and outer ocean samples. The storm water samples collected from the storm drains were compared to the Basin Plan criteria. These water quality criteria were used as guidance in characterizing storm water runoff and identifying COIs. These criteria are used as guidance given that Basin Plan water quality objectives do not apply to waters within the municipal separate storm sewer system (MS4), but rather to the actual receiving waters. There are no creeks or streams in the watershed. Furthermore, the water quality criteria listed in Tables A and B of the Ocean Plan do not apply to MS4 storm water samples because they do not fully consider dilution effects in assessing the toxicity of freshwater discharges into an oceanic environment. Therefore, the water quality criteria listed in this section were used for water quality guidance only. The purpose of this comparison was to identify potential constituents of issue in order to develop the analytical priorities for the ecosystem evaluation (bioaccumulation studies). This preliminary list was also used to assess potential BMPs in the BMP evaluation section. Once a detailed evaluation of pollutants has been conducted, benchmark values for constituents of issue can be assigned and water quality goals for the ASBS can be targeted.

In order to monitor contaminant loading and to determine the most effective BMP strategies for the primary La Jolla Shores drainage areas, two sampling stations were located in different drainage basins (one in the northern, mostly residential watershed and one in the much larger southern mixed-use residential/commercial watershed) within the La Jolla Shores region (Figure 1). Compilation of baseline information also consisted of defining and calculating loadings of elevated and potentially elevated COIs, based upon analytical results from field sampling and pollutograph calculations, as well as upon previous study results from areas with similar land uses. Lastly, monitoring data from Scripps Institution of Oceanography (SIO) during the 2004-2005 wet season were evaluated and incorporated into BMP strategies.

## 1.1 Watershed and ASBS Background Information

The La Jolla Shores Coastal Watershed is located within the community of La Jolla, California, adjacent to the University of California, San Diego (UCSD). The watershed is contained within the Scripps Hydrologic Area (HA 906.30) and is comprised of 32 sub-drainages as shown on Figure 1. Also shown on Figure 1 are the locations of the sampling stations for the storm water characterization study and the monitoring points under SIO's discharge permit. Further characterization of the watershed is presented in Section 2.

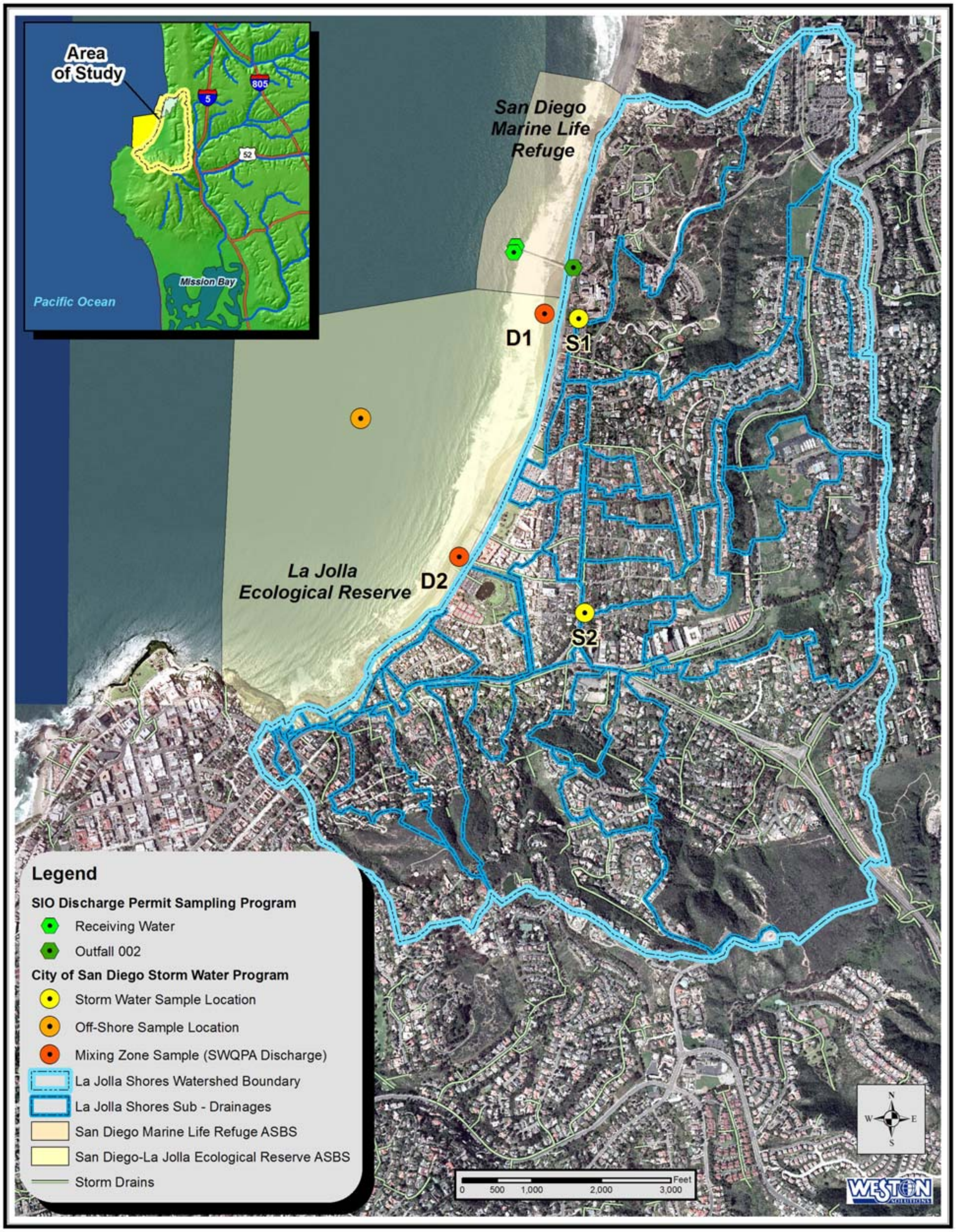

**Figure 1. Sub-drainage Areas and Location of the City of San Diego's Storm Water Study Sampling Stations and SIO's discharge permit sampling locations- La Jolla Shores ASBS**

## 1.2 Monitoring Program

In order to obtain baseline water quality data for urban runoff entering into the ASBS, samples were collected from the following locations during storm events in accordance with the Monitoring Plan and Quality Assurance Procedures Plan (QAPP) for the La Jolla Shores Coastal Watershed Management Plan: (1) urban runoff collection pipes and discharge points; (2) mixing zone in the ASBS; and (3) off-shore water in the ASBS. The sampling design consisted of installing a mass loading station within two of the largest sub-drainage areas. Ocean mixing zone (within the surf zone) and outer ocean (beyond the surf zone) grab samples were also collected to compare concentrations of constituents with the storm water samples and with applicable water quality criteria.

Storm water samples were collected from the two MS4 sampling stations using automated flow and sampling equipment installed within the manholes at locations S1 and S2 (see Figure 1). The northern sampling station (S1) was located on El Paseo Grande near its intersection with La Jolla Shores Drive, while the southern sampling station was located on the northeast corner of La Jolla Shores Drive and Paseo Dorado (S2). The storm drain outlet located at Avenida de la Playa drains the large southern drainage area of the watershed and thus captures a large portion of the watershed runoff.

Ocean outfall/mixing zone samples were collected within the mixing zone within the surf zone at the storm drain outfalls downstream of the MS4 sample station. Locations of the mixing zone samples are shown on Figure 1. The northern mixing zone sample location (D1) was at the ocean outfall due west of the intersection of El Paseo Grande and La Jolla Shores Drive, while the southern mixing zone sample location was at the ocean outfall due west of the intersection of La Vereda and Avenida de la Playa. The offshore sampling location (OFF01) was located due west of the La Jolla Shores Beach parking lot (approximately 2200 feet from shore) and is depicted in Figure 1.

### 1.2.1 Sample Frequency

The urban runoff and ocean mixing zone samples were collected during storm events occurring in San Diego’s designated wet season (October 1 through April 30). One storm event was scheduled to be sampled during the 2005-2006 wet season per the QAPP for the La Jolla Shores Coastal Watershed Management Plan (City of San Diego, 2006). The review of existing data includes previous storm sampling conducted by The City of San Diego in March and April of 2005, and the results of monitoring by SIO in January, February, and March of 2005 and February of 2006 as part of their discharging permit requirements. Sampling locations for each of these studies are shown in Figure 1.

A storm event was considered viable for monitoring activities if it exceeded 0.10 inches of rainfall. Flow-weighted composite samples were collected of the initial flush of urban runoff following a storm event from the two automated sampling stations. Flow within the MS4 was monitored and recorded at the sampling stations to provide accurate flow data for the purpose of calculating load estimations.

Samples from the two ocean mixing zone sites (D1 and D2) were collected on a time-weighted basis at the outfalls of the sub-drainage areas. The time-weighted samples were collected over the portion of the storm during which storm water samples were collected, but at set and equal intervals. Both the flow-weighted and time-weighted samples were separately composited prior to chemical and biological toxicity testing. For more detailed descriptions of sampling methods used for this study, see the QAPP (City of San Diego, 2006). Offshore water samples were collected using a Van Dorn Bottle from a water depth of 60 feet, directly offshore from the MS4 outfall at Avenida de la Playa within 24-48 hours of the end of the storm event.

During the 2005-2006 wet season, sampling was conducted on February 19, 2006 at Storm Drain sites S1 and S2, mixing zone sites D1 and D2 and the offshore sampling location. During the 2004-2005 wet season, one sampling event was conducted at S1 (4/28/05) and two sampling events were conducted at S2 (3/23/05 and 4/28/05) by The City and analyzed in the same manner as the 2006 samples. Results from each of these sampling events are included in the baseline data summary tables in Section 1.3.

Water samples collected during the storm event of April 20, 2007 were analyzed by CRG Marine Laboratories, Inc. located in Torrance, CA. For this storm event, composite samples were collected throughout the storm at D2 and S2 locations. Additionally, a series of grab samples were collected at S2 in order to create a pollutograph of the constituent loads across the duration of the storm event. An offshore sample composite was collected on April 21, 2007 approximately 16 hours after the storm had ended.

### 1.2.2 Sample Analyses

The flow-weighted storm water composite samples, the time-weighted mixing zone composite samples, and the offshore composite samples were analyzed for the constituents listed below in Table 1.

**Table 1. Chemical constituents for which laboratory analyses were performed.**

- Total Hardness as $CaCO_3$
- Total Suspended Solids (TSS)
- Total Dissolved Solids (TDS)
- Settleable Solids (SS)
- Total Organic Carbon (TOC)
- Turbidity
- Ammonia
- Total Kjeldahl Nitrogen (TKN)
- Nitrate as N
- Nitrite
- Total Phosphorus
- Orthophosphate (as P)
- Total Cyanide
- Total and Dissolved Metals
- Synthetic Pyrethroids
- Organophosphorus Pesticides
- Organochlorine Pesticides/PCBs
- Semi-Volatile Organic Compounds

Grab samples were collected for those constituents that are not conducive to composite sampling. These included pH, temperature, conductivity, oil and grease, and bacteriological indicators. The bacteriological indicators for which analyses were performed included total coliforms, fecal coliforms, and enterococci. All grab samples were collected in the manner described in the approved QAPP. In addition to conducting analyses for those constituents listed above and presented in Table 1, acute and chronic toxicity testing was also conducted on urban runoff samples in order to assess possible toxic impacts to mysid shrimp, giant kelp, and sea urchins.

### 1.2.3 Rainfall Events and Estimated Discharge Volumes

Rainfall totals in inches for each sample event and the respective discharge volumes in cubic feet are presented below in Table 2 (locations of the rain gauge where data were obtained are shown in parentheses). Discharge volumes from each drainage basin as well as the watershed's total discharge volume entering the La Jolla Ecological Reserve are also provided in Table 2. Discharge volumes were calculated using ArcGIS based upon the percentage of impervious surface area within the land area. The annual volume of runoff entering the La Jolla ASBS (based upon average annual rainfall at San Diego airport) through the S2 storm drain outfall was 12.8 million cubic feet of water while runoff entering the ASBS through the S1 storm drain outfall was approximately 4 million cubic feet of water. Overall, the annual volume of runoff entering the La Jolla Shores ASBS from the entire watershed was calculated to be slightly greater than 22 million cubic feet of water. During dry weather, the City currently diverts four of the major storm drains which have outfalls at or near the beach in La Jolla Shores into the sewer system and plans to divert others in the future (Figure 2). It should be noted, however, that during wet weather, urban runoff from storm drains is not diverted into the sewer system, but rather discharges at outfalls along the beach.

**Table 2. Rainfall and Runoff Volume Calculations for La Jolla ASBS.**

| Constituent | Impervious | Acres | Units | La Jolla ASBS | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Monitored Events | | | Average (05-06 Season) | Annual Average* |
| | | | | 03/23/05 | 04/28/05 | 02/19/06 | | |
| Rainfall (San Diego Airport) | - | - | inches | 0.53 | 0.51 | 0.19 | 4.6 | 10.5 |
| S1 Volume | 0.45 | 215 | ft3 | 126,901 | 177,426 | 83,425 | 1,621,510 | 4,053,774 |
| S2 Volume | 0.36 | 853 | ft3 | 401,328 | 561,116 | 263,836 | 5,128,081 | 12,820,204 |
| Total Preserve Volume | 0.37 | 1452 | ft3 | 694,695 | 971,286 | 456,698 | 8,876,657 | 22,191,642 |

* Based upon San Diego Airport rainfall data from 1914-2006.

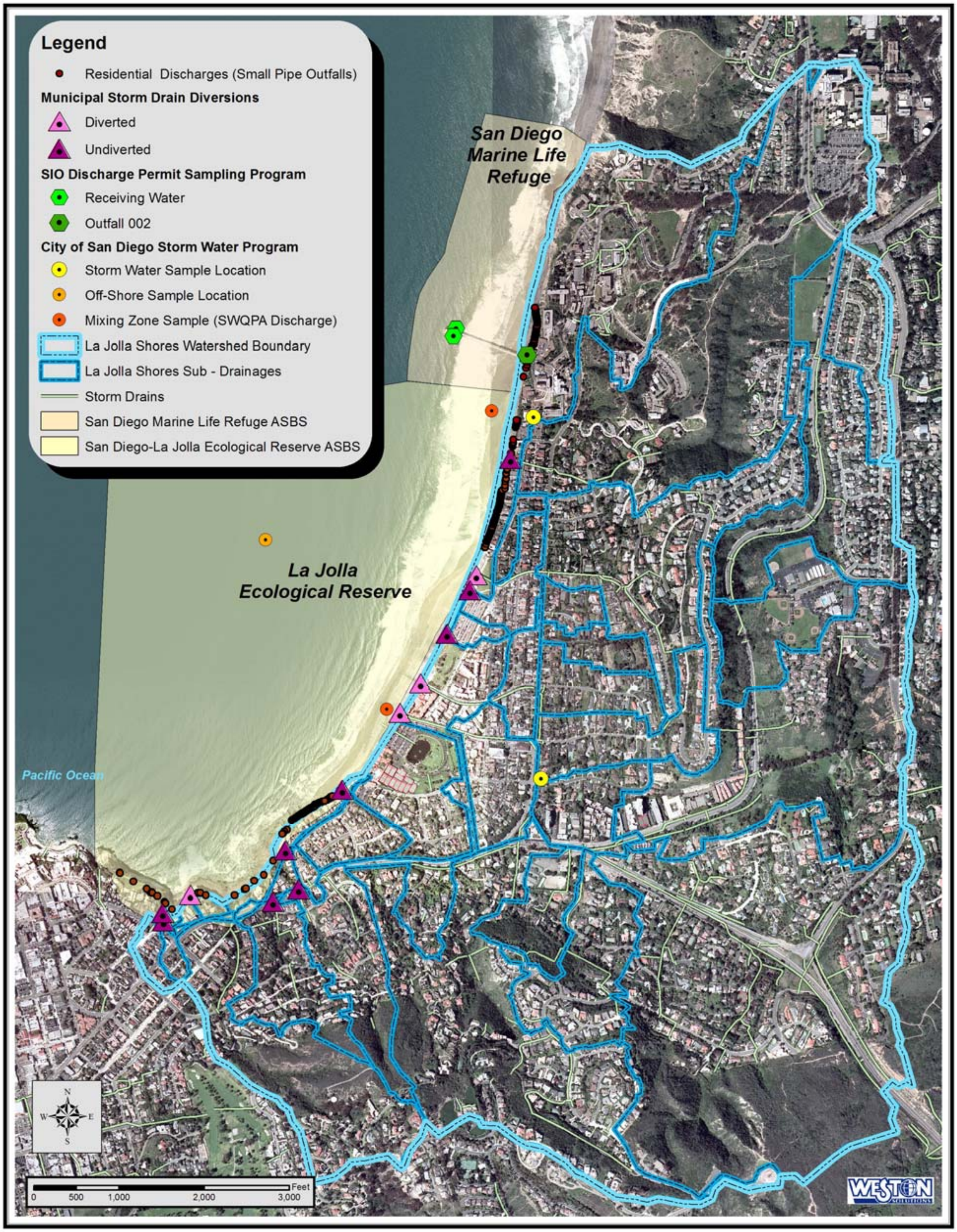

Figure 2. La Jolla Shores Watershed showing diverted and undiverted storm drains, residential discharges, and SIO and City of San Diego sampling locations.

## 1.3 Results

Results of chemical analyses, bacterial analyses, and toxicity bioassays from wet weather sampling events occurring from March 2005 through April 2007 in the La Jolla Shores watershed are discussed within this section. Chemical analysis of water collected by the City from the MS4, mixing zone, and offshore sample locations as part of their storm water characterization study, including sampling occurring under this grant project, are presented in Section 1.3.1, while results of testing performed on water samples collected by SIO between January 2005 and February 2006, as required for their discharge permit, are presented in Section 1.3.2. Bioassay results for each of these two separate sampling programs are presented following water chemistry results.

### 1.3.1 Chemistry Results from the City of San Diego's Sampling Program

Chemical analyses of wet weather samples collected for the City in order to characterize urban runoff and possible impacts to ASBS water quality are presented in Table 3. A total of four rain events were sampled under this program. Because samples collected within the MS-4 were freshwater in nature, their values were compared against San Diego Basin Plan water quality standards. As previously mentioned, a comparison to Basin Plan water quality criteria was done principally for guidance purposes, as the Basin Plan's water quality criteria were not designed for application to MS4 water quality. The mixing zone and offshore samples were compared for guidance purposes to the California Ocean Plan water quality standards. Values highlighted in yellow in Table 3 were above the San Diego Basin Plan water quality criteria and values highlighted in green were above the California Ocean Plan water quality criteria. A brief discussion of each analyte category for which analyses were performed is provided below. Emphasis is placed on those analytes detected at concentrations above the water quality criteria within the MS4 leading into the ASBS, as well as within the mixing zone and the offshore waters of the ASBS.

**Metals**

*Total Metals*

Total Copper concentrations were detected in both S1 and S2 samples (31.3 and 36.6 µg/L, respectively) on 2/19/06 at levels that were slightly above the Basin Plan water quality guidance criteria (less than 30.5 µg/L). Total copper concentrations at the two mixing zone locations (7.83 µg/L and 5.36µg/L at D1 and D2, respectively) and the offshore location (10.1 µg/L) were detected at levels below the Ocean Plan criteria of less than 30.0 µg/L. On 4/20/07, total zinc, total copper, and total lead were detected in concentrations above Ocean Plan guidance criteria in the S2 storm drain. However, mixing zone and offshore samples from this storm were below Ocean Plan guidance criteria. No other total metal concentrations were above Basin Plan or Ocean Plan criteria.

*Dissolved Metals*

Dissolved Copper concentrations were detected in S1 and S2 samples collected in 2005 at concentrations above Basin Plan guidance criteria. Samples collected from the MS4 in 2006, however, were not above Basin Plan criteria for dissolved copper. Additionally, no dissolved copper was detected in mixing zone or offshore samples. Other than copper, no other dissolved metals were detected above either Basin Plan or Ocean Plan water quality guidance criteria.

**Polynuclear Aromatic Hydrocarbons (PAHs)**
PAHs were not detected in any of the samples collected in sampling events from 2005 and 2006 (Table 3). Because method detection limits used in the analysis of the individual PAHs for the initial three storm events were above the Ocean Plan water quality criteria of 0.0088 µg/L (based upon a 30-day sample average), analyses of the 4/20/07 water samples was performed using detection limits of 0.001 µg/L. Using these lower MDLs, PAHs were detected in both S2 and D2 samples collected on 4/20/07. Total detected PAHs in the S2 storm drain and mixing zone samples were 2.086 µg/L and 0.500 µg/L, respectively. These concentrations were above the Ocean Plan's guidance criteria of 0.0088 µg/L. No PAHs were detected in offshore samples.

**Turbidity, Total Settleable Solids, Total Suspended Solids**
According to the Basin Plan, turbidity in freshwater receiving waters should be below 20 NTU more than 90 percent of the time during any one year period. Turbidity measurements of samples collected from the MS4 stations on the three sampling dates ranged from 110 NTU to 133 NTU at S1 and from 42 NTU to 93 NTU at S2 (Table 3). These concentrations are above the water quality criteria for receiving waters. High sediment load was observed in the MS4 stations during each sampling event. Prior to sampling, each station had to be cleaned out of sediment because it had covered the equipment. Turbidity measurements of mixing zone samples and the offshore sample were below 2.5 NTU and fell below the Ocean Plan guidance criteria of less than 225 NTU.

Settleable solids at the two MS4 stations, S1 and S2, ranged from 0.2 ml/L to 0.3 ml/L. Total suspended solids (TSS) at S1 ranged between 200 mg/L and 308 mg/L across two sampling dates and ranged from 94 mg/L to 465 mg/L at S2 across four sampling dates. Within the mixing zone, TSS was measured at 6.5 mg/L at D1, 10.8 mg/L and 244.7 mg/L at D2, and 2.0 mg/L and 2.7 mg/L at the offshore location. No settleable solids were detected in mixing zone or offshore samples.

## Table 3. La Jolla ASBS Preserve Storm Water & Ocean Sampling Results

| Constituent | Ocean Plan Guidance Criteria | Basin Plan Guidance Criteria | MDL for 2005/2006 analyses | Units | Paseo Grande 01 | | | Paseo Dorado 02 | | | | | | Offshore | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stormdrain-S1 | | Mixing Zone- D1 | Stormdrain-S2 | | | | Mixing Zone- D2 | | | |
| | | | | | 04/28/05 | 02/19/06 | 02/19/06 | 03/23/05 | 04/28/05 | 02/19/06 | 04/20/07 | 02/19/06 | 04/20/07 | 02/19/06 | 04/21/07 |
| **Field Measurements** | | | | | | | | | | | | | | | |
| pH | | | 0.1 | unitless | NT | 7.1 | 7.0 | 7.62 | NA | 7.2 | | 7.2 | | NT | |
| Temperature | | | 0 | °C | NT | 11.6 | 13.5 | 16.6 | NT | 12.4 | | 13.7 | | NT | |
| Conductivity (µS/cm) | | | 1 | µS/cm | NT | 620 | 46090 | 644 | NT | 464.2 | | 45810 | | NT | |
| **General Chemistry** | | | | | | | | | | | | | | | |
| Total Hardness as CaCO3 | | | | | | | | | | | 41.75 | | 4720.95 | | 7807.5 |
| Total Suspended Solids (TSS) | see plan | | 1.6 | mg/L | 308 | 200 | 6.5 | 315 | 150 | 94 | 465 | 10.8 | 244.7 | 2 | 2.7 |
| Total Dissolved Solids (TDS) | | | 42 | mg/L | NT | 818 | 35500 | NT | NT | 314 | 307 | 33700 | 21500 | 34900 | 36220 |
| Settleable Solids (SS) | 3 | | 0.1 | ml/l | NT | 0.3 | ND | NT | NT | 0.2 | NT | ND | NT | ND | NT |
| Total Organic Carbon (TOC) | | | 1 | mg/L | NT | 10.7 | 1.11 | NT | NT | 16.6 | NT | 5.15 | NT | 1.95 | NT |
| Oil & Grease | 75 | | 1.4 | mg/L | NT | 4.08 | 1.42 | NT | NT | 2.68 | NT | 2.27 | NT | 2.38 | NT |
| Turbidity | 225 | 20 for Scripps surface water HA | 0.05 | NTU | 133 | 110 | 1.94 | 93 | 57 | 42 | NT | 2.49 | NT | 0.304 | NT |
| Ammonia (as N) | 6 | | 0.2 | mg/L | 0.89 | 0.6 | 0.3 | 0.94 | 1.1 | 0.6 | NT | 0.3 | NT | 0.3 | NT |
| Total Kjeldahl Nitrogen (TKN) | | | 1.6 | mg/L | NT | 4.44 | 2.08 | NT | NT | 3.09 | NT | 2.92 | NT | 2.15 | NT |
| Nitrate as N | | | 0.04 | mg/L | NT | 4.34* | 2* | NT | NT | 8.05* | NT | 1.96* | NT | ND* | NT |
| Nitrite | | | 0.005 | mg/L | NT | 0.018 | 0.011 | NT | NT | 0.042 | NT | 0.011 | NT | 0.01 | NT |
| Total Phosphorus | | | 0.009 | mg/L | NT | 0.798 | 0.136 | NT | NT | 0.691 | NT | 0.047 | NT | 0.031 | NT |
| Orthophosphate as P | | | 0.2 | mg/L | NT | ND* | ND* | NT | NT | 2.2* | NT | ND* | NT | ND* | NT |
| Chromium+6 | 0.02 | | - | mg/L | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT |
| Total Cyanide | 10 | | 0.002 | mg/L | NT | ND | ND | NT | NT | ND | NT | ND | NT | ND | NT |
| **Total Trace Metals**** | | | | | | | | | | | | | | | |
| Aluminum (Al) | | | 6.6 | µg/L | NT | 5940 | 794 | NT | NT | 776 | 2179 | 632 | 2655 | 719 | 22 |
| Antimony (Sb) | | 10 | 1.015 | µg/L | | ND | ND | | | ND | 2.2 | ND | 0.66 | ND | 0.06 |
| Arsenic (As) | 80 | 50 | 0.4 | µg/L | | 13.7 | 1.16 | | | 2.76 | 2.6 | 1.36 | 3.37 | 1.22 | 1.96 |
| Barium (Ba) | | | 0.02 | µg/L | | 52.8 | 4.32 | | | 32.9 | 131.8 | 4.29 | NT | 4.05 | NT |
| Beryllium (Be) | | | 0.04 | µg/L | | ND | ND | | | ND | 0.2J | ND | 0.102 | ND | <0.2 |
| Cadmium (Cd) | 10 | 7.31 | 0.195 | µg/L | | ND | ND | | | ND | 1.1 | ND | 0.145 | ND | <0.2 |
| Chromium (Cr) | 20 | 644.2 | 0.189 | µg/L | | 8.3 | 1.19 | | | 1.91 | 5.9 | 1.77 | 6.715 | ND | 0.745 |
| Cobalt (Co) | | | 0.162 | µg/L | | 5.47 | 2.4 | | | 2.25 | 6.4 | 2.1 | 2.265 | 1.72 | 0.103 |
| Copper (Cu) | 30 | 30.5 | 0.393 | µg/L | | 31.3 | 7.83 | | | 36.6 | 88.8 | 5.36 | 29.16 | 10.1 | 0.49 |
| Iron (Fe) | | | 0.785 | µg/L | | 7030 | 174 | | | 691 | 4054 | 200 | 5119.2 | 53.5 | 32.6 |
| Lead (Pb) | 20 | 18.58 | 1.384 | µg/L | | 10.2 | ND | | | 6.9 | 33.85 | 2.8 | 10.919 | ND | 0.217 |
| Manganese (Mn) | | | 0.049 | µg/L | | 497 | 4.79 | | | 50 | 321.4 | 3.51 | 86.43 | 1.34 | 1.02 |
| Mercury (Hg) | 0.4 | | 0.09 | µg/L | | ND | ND | | | ND | NT | ND | NT | ND | NT |
| Molybdenum (Mo) | | | 0.122 | µg/L | | 0.85 | 7.31 | | | 2.1 | 1.2 | 6.58 | 6.05 | 5.49 | 9.318 |
| Nickel (Ni) | 50 | 168.5 | 0.268 | µg/L | | 9.91 | 2.63 | | | 3.5 | 13.7 | 2.19 | 4.833 | 2.13 | 0.311 |
| Selenium (Se) | 150 | | 0.28 | µg/L | | 1.13 | ND | | | 1.37 | 0.7 | ND | 0.18 | ND | 0.03 |
| Silver (Ag) | 7 | | 0.156 | µg/L | | ND | 0.19 | | | ND | <0.5 | ND | <0.5 | 0.17 | <0.5 |
| Thallium (Tl) | | | 1.806 | µg/L | | ND | ND | | | ND | <0.5 | ND | 0.028 | 5.3 | 0.008J |
| Tin (Sn) | | | 1.5 | µg/L | | ND | ND | | | ND | 0.2J | ND | 0.477 | 2.1 | 0.047 |
| Vanadium (V) | | | 0.476 | µg/L | | 21.5 | ND | | | 4.78 | 16.1 | ND | 13.92 | ND | 2.18 |
| Zinc (Zn) | 200 | 387.8 | 0.544 | µg/L | | 95.6 | 11.1 | | | 77.7 | 557.8 | 13.5 | 100.8 | 5.39 | 5.947 |
| **Dissolved Trace Metals**** | | | | | | | | | | | | | | | |
| Aluminum (Al) | | | 6.6 | µg/L | 9080 | 193 | 684 | 11100 | 3270 | 97.3 | 37 | 717 | 16 | 821 | 8 |
| Antimony (Sb) | | | 1.015 | µg/L | ND | ND | ND | ND | 1.1 | ND | 1.9 | ND | 0.48 | ND | 0.13 |

## Table 3. La Jolla ASBS Preserve Storm Water & Ocean Sampling Results

| Constituent | Ocean Plan Guidance Criteria | Basin Plan Guidance Criteria | MDL for 2005/2006 analyses | Units | Paseo Grande 01 | | | Paseo Dorado 02 | | | | | | Offshore | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stormdrain-S1 | | Mixing Zone- D1 | Stormdrain-S2 | | | | Mixing Zone- D2 | | | |
| | | | | | 04/28/05 | 02/19/06 | 02/19/06 | 03/23/05 | 04/28/05 | 02/19/06 | 04/20/07 | 02/19/06 | 04/20/07 | 02/19/06 | 04/21/07 |
| Arsenic (As) | | 340 | 0.4 | µg/L | 7.98 | 1.11 | 1.18 | 4.29 | 3.24 | 1.43 | 1.2 | 1.13 | 2.12 | 1 | 2.33 |
| Barium (Ba) | | | 0.02 | µg/L | 61.6 | 16.6 | 3.99 | 86.5 | 64.5 | 24 | 23.2 | 3.76 | NT | 4.89 | NT |
| Beryllium (Be) | | | 0.04 | µg/L | ND | ND | 0.156 | ND | ND | ND | ND | 0.146 | 0.14 | 0.158 | 0.16 |
| Cadmium (Cd) | | 6.22 | 0.195 | µg/L | ND | 1.22 | ND | ND | ND | ND | ND | ND | 0.249 | ND | 0.203 |
| Chromium (Cr) | | 203.6 | 0.189 | µg/L | 10.9 | ND | ND | 13.7 | 6.54 | ND | 1.1 | ND | 0.9 | ND | 0.48 |
| Cobalt (Co) | | | 0.162 | µg/L | 5.38 | ND^ | 1.73^ | 5.49 | 2.75 | 2.05^ | 0.9 | 1.69^ | 0.701 | 2.28^ | 0.329 |
| Copper (Cu) | | 29.3 | 0.393 | µg/L | 44.7 | 4.4 | ND | 56.1 | 57.1 | 22.2 | 14.5 | ND | 4.93 | ND | 0.44 |
| Iron (Fe) | | | 0.785 | µg/L | 9060 | ND | ND | 11500 | 3310 | ND | 118 | 59.6 | 20.7 | 20.4 | 3.5 |
| Lead (Pb) | | 10.95 | 1.384 | µg/L | 4.2 | ND | ND | 3.6 | 2.5 | ND | 1.4 | 3 | 0.173 | ND | 0.52 |
| Manganese (Mn) | | | 0.049 | µg/L | 367 | 12.6 | 0.781 | 197 | 96.8 | 7.09 | 96.4 | 1.2 | 24.4 | 0.301 | 0.93 |
| Mercury (Hg) | | | 0.09 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Molybdenum (Mo) | | | 0.122 | µg/L | 1.06 | 3.64 | 5.87 | 2.15 | 0.62 | 1.6 | 1.7 | 7.65 | 6.06 | 8.28 | 8.884 |
| Nickel (Ni) | | 168.2 | 0.268 | µg/L | 6.46 | 4.74 | 0.32 | 9.97 | 7.53 | 2.53 | 2.9 | ND | 2.005 | 0.75 | 1.058 |
| Selenium (Se) | | | 0.28 | µg/L | 0.704 | 0.451 | ND | 3.88 | 8.62 | 1.27 | 0.4J | ND | 0.5 | ND | 0.47 |
| Silver (Ag) | | | 0.156 | µg/L | ND | 0.77 | ND | 0.384 | ND | 0.56 | <0.5 | ND | 0.07 | ND | 0.101 |
| Thallium (Tl) | | | 1.806 | µg/L | ND | 11.4 | 8.35 | ND | ND | 14.2 | <0.1 | 16.9 | 0.016 | 9.1 | 0.02 |
| Tin (Sn) | | | 1.5 | µg/L | NT | 3.8 | ND | NT | NT | ND | 0.2J | ND | 0.024 | ND | 0.022 |
| Vanadium (V) | | | 0.476 | µg/L | 24.4 | 2.28 | ND | 31.9 | 11.8 | 3.35 | 1.7 | 0.67 | 2.98 | ND | 2.38 |
| Zinc (Zn) | | 379.3 | 0.544 | µg/L | 76.9 | 51.7 | 6.44 | 188 | 101 | 54.3 | 32.3 | 4.75 | 38.11 | 39.3 | 9.636 |
| **Synthetic Pyrethroids** | | | | | | | | | | | | | | | |
| Allethrin | | | 1 | µg/L | NT | ND | ND | NT | NT | ND | <0.005 | ND | <0.005 | ND | <0.005 |
| Bifenthrin | | | 1 | µg/L | | ND | ND | | | ND | 0.075 | ND | 0.023 | ND | <0.005 |
| Cyfluthrin | | | 1 | µg/L | | ND | ND | | | ND | <0.005 | ND | <0.005 | ND | <0.005 |
| Cypermethrin | | | 1 | µg/L | | ND | ND | | | ND | <0.005 | ND | <0.005 | ND | <0.005 |
| Danitol | | | 1 | µg/L | | ND | ND | | | ND | <0.005 | ND | <0.005 | ND | <0.005 |
| Deltamethrin | | | 5 | µg/L | | ND | ND | | | ND | <0.005 | ND | <0.005 | ND | <0.005 |
| L-Cyhalothrin | | | 1 | µg/L | | ND | ND | | | ND | <0.005 | ND | <0.005 | ND | <0.005 |
| Permethrin | | | 1 | µg/L | | ND | ND | | | ND | <0.005 | ND | <0.005 | ND | <0.005 |
| Prallethrin | | | 1 | µg/L | | ND | ND | | | ND | 0.087 | ND | <0.005 | ND | <0.005 |
| **Organochlorine Pesticides** | | | | | | | | | | | | | | | |
| 4,4'-DDD | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| 2,4'-DDD | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| 4,4'-DDE | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| 2,4'-DDE | | | 100 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| 2,4'-DDT | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| 4,4'-DDT | | | 50 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Aldrin | | | 60 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| BHC-alpha | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| BHC-beta | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| BHC-delta | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| BHC-gamma | | | 10 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Chlordane-alpha | | | 30 | ng/L | ND | ND | ND | ND | ND | 30J | 9.3 | ND | <1 | ND | <1 |
| Chlordane-gamma | | | 80 | ng/L | ND | ND | ND | ND | ND | ND | 17.9 | ND | <1 | ND | <1 |
| cis-Nonachlor | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | 7.8 | ND | <1 | ND | <1 |
| Dieldrin | | | 50 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Endosulfan Sulfate | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Endosulfan-I | | | 30 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Endosulfan-II | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Endrin | | | 50 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |

## Table 3. La Jolla ASBS Preserve Storm Water & Ocean Sampling Results

| Constituent | Ocean Plan Guidance Criteria | Basin Plan Guidance Criteria | MDL for 2005/2006 analyses | Units | Paseo Grande 01 | | | Paseo Dorado 02 | | | | | | Offshore | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stormdrain-S1 | | Mixing Zone- D1 | Stormdrain-S2 | | | | Mixing Zone- D2 | | | |
| | | | | | 04/28/05 | 02/19/06 | 02/19/06 | 03/23/05 | 04/28/05 | 02/19/06 | 04/20/07 | 02/19/06 | 04/20/07 | 02/19/06 | 04/21/07 |
| Endrin Ketone | | | NT | ng/L | NT | NT | NT | NT | NT | NT | <1 | NT | <1 | NT | <1 |
| Heptachlor | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Heptachlor Epoxide | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Methoxychlor | | | 60 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Mirex | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Oxychlordane | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| trans-Nonachlor | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Endrin Aldehyde | | | 20 | ng/L | ND | ND | ND | ND | ND | ND | <1 | ND | <1 | ND | <1 |
| Toxaphene | | | 4000 | ng/L | ND | ND | ND | ND | ND | ND | <10 | ND | <10 | ND | <10 |
| **Polychlorinated Biphenyls (PCBs) by Aroclor grouping** | | | | | | | | | | | | | | | |
| Aroclor 1016 | | | 4000 | ng/L | ND | ND | ND | ND | ND | ND | <10 | ND | <10 | ND | <10 |
| Aroclor 1221 | | | 4000 | ng/L | ND | ND | ND | ND | ND | ND | <10 | ND | <10 | ND | <10 |
| Aroclor 1232 | | | 4000 | ng/L | ND | ND | ND | ND | ND | ND | <10 | ND | <10 | ND | <10 |
| Aroclor 1242 | | | 4000 | ng/L | ND | ND | ND | ND | ND | ND | <10 | ND | <10 | ND | <10 |
| Aroclor 1248 | | | 2000 | ng/L | ND | ND | ND | ND | ND | ND | <10 | ND | <10 | ND | <10 |
| Aroclor 1254 | | | 2000 | ng/L | ND | ND | ND | ND | ND | ND | <10 | ND | <10 | ND | <10 |
| Aroclor 1260 | | | 2000 | ng/L | ND | ND | ND | ND | ND | ND | <10 | ND | <10 | ND | <10 |
| **Organophosphorus Pesticides** | | | | | | | | | | | | | | | |
| Bolstar (Sulprofos) | | | 0.07 | µg/L | NT | ND | ND | NT | NT | ND | <0.002 | ND | <0.002 | ND | <0.002 |
| Chlorpyrifos | | | 0.03 | µg/L | | ND | ND | | | ND | <0.001 | ND | <0.001 | ND | <0.001 |
| Demeton | | | 0.15 | µg/L | | ND | ND | | | ND | <0.001 | ND | <0.001 | ND | <0.001 |
| Diazinon | | | 0.03 | µg/L | | ND | ND | | | ND | 0.247.3 | ND | 0.0581 | ND | <0.002 |
| Dichlorvos | | | 0.05 | µg/L | | ND | ND | | | ND | <0.003 | ND | <0.003 | ND | <0.003 |
| Dimethoate | | | 0.04 | µg/L | | ND | ND | | | ND | <0.003 | ND | <0.003 | ND | <0.003 |
| Disulfoton | | | 0.02 | µg/L | | ND | ND | | | ND | <0.001 | ND | <0.001 | ND | <0.001 |
| Ethoprop (Ethoprofos) | | | 0.04 | µg/L | | ND | ND | | | ND | <0.001 | ND | <0.001 | ND | <0.001 |
| Fenchlorophos (Ronnel) | | | 0.03 | µg/L | | ND | ND | | | ND | <0.002 | ND | <0.002 | ND | <0.002 |
| Fensulfothion | | | 0.07 | µg/L | | ND | ND | | | ND | <0.001 | ND | <0.001 | ND | <0.001 |
| Fenthion | | | NT | µg/L | | NT | NT | | | NT | <0.002 | NT | <0.002 | NT | 0.0104 |
| Malathion | | | 0.03 | µg/L | | ND | ND | | | ND | 0.473 | ND | 0.342 | ND | <0.003 |
| Merphos | | | 0.09 | µg/L | | ND | ND | | | ND | <0.001 | ND | <0.001 | ND | <0.001 |
| Methyl Parathion | | | 0.03 | µg/L | | ND | ND | | | ND | <0.001 | ND | <0.001 | ND | <0.001 |
| Mevinphos (Phosdrin) | | | 0.3 | µg/L | | ND | ND | | | ND | <0.008 | ND | <0.008 | ND | <0.008 |
| Phorate | | | 0.04 | µg/L | | ND | ND | | | ND | <0.006 | ND | <0.006 | ND | <0.006 |
| Tetrachlorvinphos (Stirofos) | | | 0.03 | µg/L | | ND | ND | | | ND | <0.002 | ND | <0.002 | ND | <0.002 |
| Tokuthion | | | 0.06 | µg/L | | ND | ND | | | ND | <0.003 | ND | <0.003 | ND | <0.003 |
| Trichloronate | | | 0.04 | µg/L | | ND | ND | | | ND | <0.001 | ND | <0.001 | ND | <0.001 |
| **Polynuclear Aromatic Hydrocarbons (PAHs)** | | | | | | | | | | | | | | | |
| 1-Methylnaphthalene | | | 2.18 | µg/L | ND | ND | ND | ND | ND | ND | 0.0144 | ND | 0.0061 | ND | <0.001 |
| 1-Methylphenanthrene | | | 6.29 | µg/L | ND | ND | ND | ND | ND | ND | 0.0354 | ND | 0.0091 | ND | <0.001 |
| 2,3,5-Trimethylnaphthalene | | | 4.4 | µg/L | ND | ND | ND | ND | ND | ND | 0.0115 | ND | <0.001 | ND | <0.001 |
| 2,6-Dimethylnaphthalene | | | 3.31 | µg/L | ND | ND | ND | ND | ND | ND | 0.0116 | ND | <0.001 | ND | <0.001 |
| 2-Methylnaphthalene | | | 2.25 | µg/L | ND | ND | ND | ND | ND | ND | 0.0383 | ND | 0.0132 | ND | <0.001 |
| Acenaphthene | | | 2.2 | µg/L | ND | ND | ND | ND | ND | ND | 0.0212 | ND | <0.001 | ND | <0.001 |
| Acenaphthylene | | | 2.02 | µg/L | ND | ND | ND | ND | ND | ND | 0.0097 | ND | <0.001 | ND | <0.001 |
| Anthracene | | | 4.04 | µg/L | ND | ND | ND | ND | ND | ND | 0.0282 | ND | <0.001 | ND | <0.001 |
| Benzo[a]anthracene | | | 7.68 | µg/L | ND | ND | ND | ND | ND | ND | 0.097 | ND | 0.0128 | ND | <0.001 |
| Benzo[a]pyrene | | | 6.53 | µg/L | ND | ND | ND | ND | ND | ND | 0.0889 | ND | 0.0138 | ND | <0.001 |
| Benzo[b]fluoranthene | | | NT | µg/L | NT | NT | NT | NT | NT | NT | 0.1121 | NT | 0.0229 | NT | <0.001 |

## Table 3. La Jolla ASBS Preserve Storm Water & Ocean Sampling Results

| Constituent | Ocean Plan Guidance Criteria | Basin Plan Guidance Criteria | MDL for 2005/2006 analyses | Units | Paseo Grande 01 | | | Paseo Dorado 02 | | | | | | Offshore | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stormdrain-S1 | | Mixing Zone- D1 | Stormdrain-S2 | | | | Mixing Zone- D2 | | | |
| | | | | | 04/28/05 | 02/19/06 | 02/19/06 | 03/23/05 | 04/28/05 | 02/19/06 | 04/20/07 | 02/19/06 | 04/20/07 | 02/19/06 | 04/21/07 |
| Benzo[e]pyrene | | | 7.67 | µg/L | ND | ND | ND | ND | ND | ND | 0.1166 | ND | 0.027 | ND | <0.001 |
| Benzo[g,h,i]perylene | | | 6.5 | µg/L | ND | ND | ND | ND | ND | ND | 0.132 | ND | 0.0249 | ND | <0.001 |
| Benzo[k]fluoranthene | | | 7.36 | µg/L | ND | ND | ND | ND | ND | ND | 0.1033 | ND | 0.0218 | ND | <0.001 |
| Biphenyl | | | 2.43 | µg/L | ND | ND | ND | ND | ND | ND | 0.0238 | ND | 0.0124 | ND | <0.001 |
| Chrysene | | | 7.49 | µg/L | ND | ND | ND | ND | ND | ND | 0.2112 | ND | 0.0414 | ND | <0.001 |
| Dibenzo[a,h]anthracene | | | 6.19 | µg/L | ND | ND | ND | ND | ND | ND | 0.0242 | ND | <0.001 | ND | <0.001 |
| Dibenzothiophene | | | NT | µg/L | NT | NT | NT | NT | NT | NT | 0.0519 | NT | 0.0244 | NT | <0.001 |
| Fluoranthene | | | 6.9 | µg/L | ND | ND | ND | ND | ND | ND | 0.349 | ND | 0.0685 | ND | <0.001 |
| Fluorene | | | 2.43 | µg/L | ND | ND | ND | ND | ND | ND | 0.0117 | ND | 0.0052 | ND | <0.001 |
| Indeno[1,2,3-c,d]pyrene | | | 6.27 | µg/L | ND | ND | ND | ND | ND | ND | 0.0807 | ND | 0.0141 | ND | <0.001 |
| Naphthalene | | | 1.52 | µg/L | ND | ND | ND | ND | ND | ND | 0.027 | ND | 0.0146 | ND | <0.001 |
| Perylene | | | 6.61 | µg/L | ND | ND | ND | ND | ND | ND | 0.0495 | ND | 0.0269 | ND | <0.001 |
| Phenanthrene | | | 4.15 | µg/L | ND | ND | ND | ND | ND | ND | 0.1757 | ND | 0.0831 | ND | <0.001 |
| Pyrene | | | 3.55 | µg/L | ND | ND | ND | ND | ND | ND | 0.2613 | ND | 0.058 | ND | <0.001 |
| Total Detected PAHs | 0.0088 | | N/A | µg/L | | | | | | | 2.0862 | | 0.5002 | | 0 |
| **Base Neutral Extractable Organic Compounds** | | | | | | | | | | | | | | | |
| 1,2,4-Trichlorobenzene | | | 1.44 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 1,2-Dichlorobenzene | | | 1.63 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 1,3-Dichlorobenzene | | | 1.65 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 1,4-Dichlorobenzene | | | 2.3 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 2,4-Dinitrotoluene | | | 1.49 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 2,6-Dinitrotoluene | | | 1.93 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 3,3'-Dichlorobenzidine | | | 2.43 | µg/L | ND | NT | NT | ND | ND | NT | NT | NT | NT | NT | NT |
| 2-Chloronaphthalene | | | 2.41 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 4-Bromophenylphenylether | | | 4.04 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 4-Chlorophenylphenylether | | | 3.62 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Azobenzene | | | NT | µg/L | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT |
| Benzidine | | | - | µg/L | ND | NT | NT | ND | ND | NT | NT | NT | NT | NT | NT |
| bis(2-Chloroethoxyl)methane | | | 1.57 | µg/L | NT | ND | ND | NT | NT | ND | NT | ND | NT | ND | NT |
| bis(2-Chloroethyl)ether | | | 2.62 | µg/L | NT | ND | ND | NT | NT | ND | NT | ND | NT | ND | NT |
| bis(2-Chloroisopropyl)ether | | | 8.95 | µg/L | NT | ND | ND | NT | NT | ND | NT | ND | NT | ND | NT |
| Hexachlorobenzene | | | 4.8 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Hexachlorobutadiene | | | 2.87 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Hexachlorocyclopentadiene | | | - | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Hexachloroethane | | | 3.55 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Nitrobenzene | | | 1.52 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| N-Nitrosodi-n-propylamine | | | 1.63 | µg/L | NT | ND | ND | NT | NT | ND | NT | ND | NT | ND | NT |
| N-Nitrosodiphenylamine | | | 2.96 | µg/L | NT | ND | ND | NT | NT | ND | NT | ND | NT | ND | NT |
| **Phthalates** | | | | | | | | | | | | | | | |
| bis(2-Ethylhexyl) Phthalate | | | 10.43 | µg/L | ND | 10.43J | 10.43J | ND | ND | ND | NT | ND | NT | ND | NT |
| Butylbenzyl Phthalate | | | 4.77 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Dibutyl Phthalate | | | 6.39 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Diethyl Phthalate | | | 6.97 | µg/L | ND | 6.97J | 6.97J | ND | ND | ND | NT | ND | NT | ND | NT |
| Dimethyl Phthalate | | | 3.26 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Di-n-octyl Phthalate | | | 8.59 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| **Acid Extractable Organic Compounds** | | | | | | | | | | | | | | | |
| 2,4,6-Trichlorophenol | | | 1.75 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 2,4-Dichlorophenol | | | 1.95 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 2,4-Dimethylphenol | | | 1.32 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |

## Table 3. La Jolla ASBS Preserve Storm Water & Ocean Sampling Results

| Constituent | Ocean Plan Guidance Criteria | Basin Plan Guidance Criteria | MDL for 2005/2006 analyses | Units | Paseo Grande 01 | | | Paseo Dorado 02 | | | | | | Offshore | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stormdrain-S1 | | Mixing Zone- D1 | Stormdrain-S2 | | | | Mixing Zone- D2 | | | |
| | | | | | 04/28/05 | 02/19/06 | 02/19/06 | 03/23/05 | 04/28/05 | 02/19/06 | 04/20/07 | 02/19/06 | 04/20/07 | 02/19/06 | 04/21/07 |
| 2,4-Dinitrophenol | | | 6.07 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 2-Chlorophenol | | | 1.76 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 2-Methyl-4,6-dinitrophenol | | | 4.29 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 2-Nitrophenol | | | 1.88 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 4-Chloro-3-methylphenol | | | 1.34 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 4-Nitrophenol | | | 3.17 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Pentachlorophenol | | | 5.87 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| Phenol | | 10 | 2.53 | µg/L | ND | ND | 4 | ND | ND | ND | NT | 3.7 | NT | 5.3 | NT |
| 2,4,5-Trichlorophenol | | | 1.66 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 2,4,6-Tribromophenol | | | NT | µg/L | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT |
| 2-Methylphenol | | | 1.51 | µg/L | ND | ND | ND | ND | ND | ND | NT | ND | NT | ND | NT |
| 3-Methylphenol | | | 4.44 | µg/L | ND | NT | ND | ND | ND | NT | NT | ND | NT | ND | NT |
| **Dioxins and Furans** | | | | | | | | | | | | | | | |
| TCDD equivalents | 30 | | | pg/L | NT | ND | ND | NT | NT | ND | 8.89 | ND | 4.67 | ND | 1.94 |
| **Microbiology** | | | | | | | | | | | | | | | |
| Total Coliform | 10,000 | | | CFU or MPN/100 Ml | NT | 11000 | 1600J | NT | NT | 22000 | S1 Composite water not tested | 4500 | S2 not tested | 10J | <20 |
| Fecal Coliform | 400 | 400 | | CFU or MPN/100 Ml | NT | 3000 | 140J | NT | NT | 2300 | | 170J | | <10 | <20 |
| Enterococcus | 105 | | | CFU or MPN/100 Ml | NT | NT | 240 | NT | NT | NT | | 490 | | <10 | <20 |

| Legend |
|---|
| ** =Water Quality guidance criteria for total and dissolved metal fractions based on Total Hardness (as CaCO3) |
| 🟩 Above Saltwater Water Quality Criteria according to California Ocean Plan |
| 🟨 Above Freshwater Water Quality Criteria according to San Diego Basin Plan |

NT = not tested; ND = Not detected; < indicates value was below method detection limit; NS = Not Sampled; J = estimated, qualitative identification without quantitative certainty.

* = Quality control check standards were not within limits. Check samples had recoveries of 124%, The allowable upper limit is 110%.

^ = Cobalt recoveries in blank samples above MDL(MDL= 0.16 uG/L). Also, Replicate analysis relative percent difference (RPD) was greater than 25%

Ocean Plan and Basin Plan metals criteria based on Hardness of >400

### Oil and Grease

Oil and grease concentrations were detected in storm drain samples, mixing zone samples, and the offshore sample collected on 02/19/06 (Table 3). Oil and grease concentrations ranged from 2.68 mg/L to 4.08 mg/L in the storm drains, 1.42 mg/L to 2.27 mg/L in the mixing zones, and were 2.38 mg/L in the offshore sample. Each of these measurements fell below the Ocean Plan's guidance criteria of 75 mg/L.

### Ammonia as Nitrogen

Total ammonia was detected in all the storm water samples collected within the MS4 for sampling events (Table 3 and Table 4). Ammonia and nitrogen concentrations in the ocean samples were below Ocean Plan water quality guidance criteria. In addition to total ammonia, the un-ionized fraction of ammonia was calculated from total ammonia values in order to compare the un-ionized ammonia levels detected in the storm drain samples with water quality values contained in the Basin Plan. The calculated un-ionized ammonia concentrations for both of the storm drain samples were below Basin Plan guidance criteria.

**Table 4. Total and un-ionized ammonia results from storm drain, mixing zone, and offshore samples.**

| Constituent | WQO-Ocean Plan | WQO-Basin Plan | MDL | Units | Paseo Grande 01 | | | Paseo Dorado 02 | | | | Offshore |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stormdrain-S1 | | Mixing Zone-D1 | Stormdrain-S2 | | | Mixing Zone-D2 | |
| | | | | | 04/28/05 | 02/19/06 | 02/19/06 | 03/23/05 | 04/28/05 | 02/19/06 | 02/19/06 | 2/19/06 |
| Total Ammonia (as N) | 6 | | 0.2 | mg/L | 0.89 | 0.6 | 0.3 | 0.94 | 1.1 | 0.6 | 0.3 | 0.3 |
| Ammonia (Un-ionized) | | 0.025 | - | mg/L | ** | 0.0019 | NA | 0.014 | ** | 0.0025 | NA | NA |

Storm drain sample results compared to the Basin Plan water quality criteria were calculated from the total ammonia result.

**pH, temp, and salinity results were not available for use in the calculation

### Synthetic Pyrethroids

Bifenthrin was detected in S2 storm drain and mixing zone samples during the 4/20/07 storm event (Table 3). Prallethrin was detected in the mixing zone on 4/20/07. No synthetic pyrethroids were detected in any of the samples collected from the offshore site.

### Organochlorine and Organophosphorus Pesticides and PCBs

No organochlorine pesticides or PCBs were detected in any of the storm drain, mixing zone or offshore samples across all four sampling dates with the exception of alpha and gamma chlordane and cis-nonachlor in the S2 storm drain on 4/20/07 (Table 3). The organophosphorus pesticides diazinon and malathion were detected in storm drain and mixing zone samples collected on 4/20/07, while fenthion was detected in the offshore sample from 4/21/07. No other pesticides were detected.

### Phenols, Phthalates, and Base/Neutral Extractable Compounds

No phthalates or base/neutral extractable compounds were detected in any of the samples collected from the storm drains, the mixing zones or the offshore site across all three sampling dates (Table 3). Phenol was detected in mixing zone and offshore samples on 2/19/06, but concentrations were below Basin Plan guidance criteria.

### 1.3.2 Chemistry Results from SIO Sampling Program

Scripps Institution of Oceanography was founded in the early twentieth century and has been discharging seawater used in their aquarium tanks into the ocean in the vicinity of its pier since 1910. SIO discharges seawater associated with its seawater system pursuant to Order No. 99-83, National Pollutant Discharge Elimination System (NPDES) permit No. CA0107239.

The seawater system at Scripps has the capacity to pump approximately 1.25 million gallons per day of seawater from an intake pump located on the seaward end of SIO Pier. The seawater is filtered through high-speed sand filters located at the foot of SIO Pier and is stored in two concrete storage tanks located near the filters with any overflow water discharged across the beach near the foot of the pier. The filtered water is delivered to the laboratories and aquaria of SIO, the Stephen Birch Aquarium-Museum, and the National Marine Fisheries Service aquaria. After circulation through the various aquaria, the water is discharged back into the ocean at two outfalls. SIO also discharges waste from the intake flume and from the storage tank after filtering the backwash. In 2004 the seawater system discharges into the municipal storm water system were discontinued.

As part of SIO's discharge permit monitoring, storm water samples were collected from Outfall 002 (Figure 3) during four wet weather sampling events. These samples were analyzed for metals, PAHs, pesticides and PCBs, turbidity, oil and grease, ammonia, organotins, phenols, dioxins/furans, phthalates, and base/neutral extractable compounds. Outfall 002, located approximately 20 feet north of Scripps Pier, discharges storm water runoff from the MS4 in and around SIO and does not discharge wastewater from the Scripps seawater system. A summary of the chemistry results from these storm events is provided in Table 5.

**Figure 3. Outfall 002**

# Table 5. Wet Weather Monitoring Water Sample Results Collected from SIO Outfall 002 (storm water outfall) in 2005 and 2006.

| Constituents of Issue | Basin Plan Guidance Criteria | 01/28/05 | 2/11/05 | 3/22/05 | 2/27/06 |
|---|---|---|---|---|---|
| Oil & Grease | No visible film | 87.20 mg/L | 1.9 mg/L J (DNQ) | ND | 3.5 mg/L (DNQ) |
| Total Settleable Solids | | 19 mL/L | ND | 0.2 mL/L | ND |
| Turbidity | 20 for Scripps HA | 256 NTU | 68.8 NTU | 27.9 NTU | 82.3 NTU |
| Ammonia as Nitrogen | | 320 ug/L | 220 ug/L | 210 ug/L | 140 ug/L |
| Copper | 30.5 ug/L | 177 ug/L | 61.4 ug/L | 50.1 ug/L | 35.9 ug/L |
| Total Residual Chlorine | | 20 J (DNQ)[1] | 60 ug/L[1] | 360 ug/L[1] | ND[2] |
| PAHs | | 0.84 ug/L | 0.0677 ug/L | ND | 0.3134 ug/L |
| TCDD Equivalents | $3x10^{-8}$ | 8.17E-06 | 2.20E-06 | 1.89E-07 | 1.05E-07 |

J = Estimated value, below the reporting limit and above the method detection limit.
DNQ = Detected, Not Quantified
ND = Not Detected
Yellow highlighting indicates value is above Basin Plan guidance criteria
[1] Based on laboratory results from method SM 4500-CL with potential false positive detections from matrix interferences.
[2] Method for total residual chlorine changed to EPA 330.5 to reduce matrix interferences

The storms that were monitored for these four events varied considerably in intensity and size. The initial storm event (1/28/05) was small and of short duration, depositing 0.08 inches of rain in the La Jolla area (based on National Weather Service rain gauge data from Del Mar) while the storm of 2/11/05 was considerably larger, dropping 1.65 inches of rain in the vicinity of La Jolla. The storms of 3/22/05 and 2/27/06 were medium-sized storms and dropped 0.39 inches and 0.65 inches of rain, respectively in the La Jolla area. For most of the analyzed constituents, samples collected during the storm event of 1/28/05 provided the most elevated analyte concentrations (Table 5). Constituent concentrations in this initial storm event may have been higher than in subsequent storm events due to the initial storm's small size and limited rainfall. Water from the initial storm event likely carried a similar or slightly lesser amount of constituents of issue into the MS4 in comparison to water from larger, subsequent storms. However, as a result of the much lower volume of water in the initial storm event, the concentration of constituents in samples collected from the MS4 during this small storm had higher concentrations relative to those of subsequent larger storm events.

In 2005, total residual chlorine (ranging from 60 µg/L to 360 µg/L) was detected in the storm water samples. These "detections" however were suspect due to possible matrix interferences associated with the analytical method used (SM 4500-Cl). As a result, a different method was used for measuring total residual chlorine (EPA 330.5) on samples collected in February 2006. No total residual chlorine was detected in the storm water samples using this method.

Ammonia concentrations at the SIO Outfall 002 ranged from 140 ug/L to 320 ug/L across all four storm events, while turbidity ranged from 27.9 NTU on 3/22/05 to 256 NTU on 1/28/05 (Table 5). Copper concentrations (ranging from 35.9 µg/L to 177 µg/L) were detected above Ocean Plan and Basin Plan guidance criteria for each monitored rain event. Total PAHs were detected in three of the four storm events, and ranged from 0.0677 µg/L to 0.84 µg/L. It should be mentioned that the Basin Plan does not provide criteria for Total PAHs and the Ocean Plan criteria (0.0088 µg/L) is based on a 30-day average. PAH levels in water collected from SIO Outfall 002 were above Ocean Plan guidance criteria. It should be noted, however, that dilution of the SIO discharge at Outfall 002 is not considered when comparing MS4 samples to Ocean Plan criteria. Dioxins and furans were detected and ranged from 1.05E-07 to 2.20E-06 TCDD equivalents. In general, PCBs, pesticides, organotins, phenols, and phthalates were measured at or below method detection limits.

Dioxins and furans, expressed as TCDD equivalents were measured above Basin Plan criteria in Outfall 002 samples (Table 5). Only one isomer group of dioxins (octa chlorinated dibenzo-p-dioxins), however, was detected in laboratory analyses. These octa-dioxins are primarily formed through combustion of fossil fuels and are most likely the result of aerial deposition from wild fires, recreational bonfires, air emissions, and diesel exhaust.

Receiving Water Results from SIO Sampling Program

Wet weather monitoring of the receiving water next to Scripps Pier was performed within the ASBS just beyond the surf zone. The prevailing longshore current at the time of sampling determined from which side of the pier the samples were collected. All samples were collected up-current of the pier. For receiving water sample analyses, samples were collected four times during a 24-hour period and equally composited by the lab into a single sample (with the exception of analyses requiring a single grab such as VOCs). Constituents of Issue concentrations from sampling events that occurred in March, 2005 and February, 2006 are provided below in Table 6.

**Table 6. Wet Weather Monitoring Water Sample Results Collected from SIO Receiving water**

| Constituents of Issue | Receiving Water Sample Date | |
|---|---|---|
| | 03/22/05 | 2/28/06 |
| Oil & Grease | ND | ND |
| Total Settleable Solids | ND | ND |
| Turbidity | ND | 1.7 NTU (DNQ) |
| Ammonia as Nitrogen | ND | ND |
| Copper | 0.32 µg/L | 0.091 µg/L |
| Total Residual Chlorine | ND | ND |
| PAHs | ND | ND |
| TCDD Equivalents | 7.66E-07 | 0.00E-00 |

DNQ = Detected, Not Quantified
ND = Not Detected
Green highlighting = value above Ocean Plan guidance criteria for human health

Analysis of the Scripps Pier receiving water sample composites did not detect oil and grease, total settleable solids, total ammonia, PAHs, or total residual chlorine for either sampling event. Trace quantities of total copper were detected in both receiving water composite samples; however in each instance, concentrations were below Ocean Plan guidance criteria. Turbidity was detected in the 2/28/06 sample (1.7 NTU), but was not quantified since the value was below the reporting limit of 2.0 NTU. Dioxins and furans, expressed as TCDD equivalents were measured above Ocean Plan criteria for human health in receiving water samples (Table 6). Only octa-chlorinated dibenzo-p-dioxins were detected. These dioxin isomers, which were also detected in Outfall 002 samples, are primarily formed through combustion of fossil fuels and are most likely the result of aerial deposition from wild fires, recreational bonfires, air emissions, and diesel exhaust.

### 1.3.3 Fecal Indicator Bacteria Results

*City of San Diego Sampling Program*

Storm drain samples collected during the rain events of February 19, 2006 and April 20, 2007 were analyzed for Fecal Indicator bacteria (fecal coliforms and enterococci) concentrations. Samples collected from the S1 and S2 storm drains had fecal coliform concentrations above the Basin Plan's water quality guidance criteria while samples collected S2 also had total coliform and enterococci concentrations above guidance criteria. Samples collected from the mixing zone (D1 and D2) and offshore were each below the Ocean Plan's guidance criteria of less than 400 CFU or MPN/100 mL (Table 7). Enterococci concentrations at D1 (240 MPN/100 mL) and D2 (490 MPN/100 mL) were above the Ocean Plan's guidance criteria of less than 104 CFU or MPN/100 mL. In the offshore sample, concentrations of enterococci were below detection limits. Total coliform concentrations were 11,000 MPN/100 mL in the S1 sample and 22,000 MPN/100 mL and 48,700 in S2 samples. In D1 and D2 mixing zone samples, total coliform concentrations were measured at 1,600 MPN/100 mL and 4,500 MPN/100 mL, respectively. Mixing zone and offshore concentrations of total coliforms were below Ocean Plan guidance criteria.

**Table 7. Bacterial concentrations from storm drain, mixing zone, and offshore samples.**

| Constituent | WQO-Ocean Plan Criteria | WQO-Basin Plan Criteria | MDL | Units | Paseo Grande 01 | | Paseo Dorado 02 | | | | Offshore | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Storm Drain-S1 | Mixing Zone-D1 | Storm Drain-S2 | | Mixing Zone-D2 | | | |
| | | | | | 02/19/06 | 02/19/06 | 02/19/06 | 4/20/07 | 02/19/06 | 4/20/07 | 2/19/06 | 4/21/07 |
| Total Coliform | 10,000 | - | 10 | CFU or MPN/100 mL | 11,000 | 1,600J | 22,000 | 48,700* | 4,500 | NT | 10J | <20 |
| Fecal Coliform | 400 | 400 | 10 | CFU or MPN/100 mL | 3,000 | 140J | 2,300 | 7,050* | 170J | | <10 | <20 |
| Enterococcus | 104 | - | 10 | CFU or MPN/100 mL | NT | 240 | NT | 71,929* | 490 | | <10 | <20 |

*Average based on analyses of 14 discreet samples collected over course of entire storm
J = estimated value above the detection limit, but below the reporting limit.
NT = Not Tested
Yellow highlighting indicates value is above the Basin Plan guidance criteria
Green highlighting indicates value is above the Ocean Plan guidance criteria

### *SIO Sampling Program*

Water samples collected from Scripps Outfall 002 during storm events on March 22, 2005 and February 27, 2006 were analyzed for fecal indicator bacteria. Fecal coliform bacteria concentrations during these storm events ranged from 700 CFU or MPN/100 mL on 3/22/05 to 1600 CFU or MPN/100 mL on 2/27/06 (Table 8). Although fecal coliform concentrations were detected above the Basin Plan guidance criteria of 400 CFU or MPN/100mL, it should be stressed that Basin Plan criteria were not designed for application to an MS4. Total coliform concentrations were measured at 30,000 CFU or MPN/100mL on both sampling dates. Enterococci concentrations in samples collected from Outfall 002 ranged from 1246 CFU/100 mL to 6400 CFU/100 mL. Interestingly, receiving water collected just beyond the surf zone at locations that were either just north or just south of Scripps Pier had fecal coliform and enterococcus concentrations that were at or below the method reporting limit. Thus, elevated levels of bacteria detected in the mixing zone were not detected outside of the surf zone (Table 9). This occurrence may be explained by prevailing longshore currents at La Jolla Shores Beach preventing effluent from being carried further out to sea.

**Table 8. Bacterial concentrations from Scripps Outfall 002 storm drain samples.**

| Constituents of Concern | WQO-Basin Plan Criteria | Units | 1/28/05 | 2/11/05 | 3/22/05 | 2/27/06 |
|---|---|---|---|---|---|---|
| Total Coliform | - | CFU or MPN/100 mL | NT | NT | 30,000 | 30,000 |
| Fecal Coliform | 400 | CFU or MPN/100 mL | NT | NT | 700 | 1600 |
| Enterococcus | - | CFU or MPN/100 mL | NT | NT | 1246 | 6400 |

NT = Not Tested

Yellow highlighting indicates value is above the Basin Plan guidance criteria

**Table 9. Bacterial concentrations from receiving water samples collected at Scripps Pier.**

| Constituents of Concern | WQO-Basin Plan Criteria | Units | 3/22/05 | 2/28/06 |
|---|---|---|---|---|
| Total Coliform | - | CFU or MPN/100 mL | 70 | 12 |
| Fecal Coliform | 400 | CFU or MPN/100 mL | 20 | ND |
| Enterococcus | - | CFU or MPN/100 mL | <10 | ND |

ND = Not detected

### 1.3.4 Pollutograph Sampling

Repeated sampling of the MS4 was conducted throughout the storm event of 4/20/07 at the Dorado Street sampling location in order to create a pollutograph. Of the fifteen grab samples collected over the course of the 3-hour storm, 10 were selected to undergo chemical analysis. Samples were analyzed for general chemistry, total and dissolved metals, synthetic pyrethroids, chlorinated pesticides, aroclor PCBs, organophosphorus pesticides, and PAHs (Table 10). In addition to chemical analyses of the water samples, loading estimates for selected constituents were calculated for the MS4 based upon measured flow rates throughout the storm.

**Table 10. Pollutograph grab sampling conducted on 4/20/07 at Dorado Street in La Jolla, CA.**

| | | Sample Time and Sample ID | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12:40 | 13:05 | 13:30 | 14:00 | 14:15 | 14:30 | 14:45 | 15:00 | 15:20 | 15:50 |
| Constituent | MDL | SD 01 | SD 03 | SD 05 | SD 07 | SD 08 | SD 09 | SD 10 | SD 11 | SD 12 | SD 14 |
| **Field Measurements** | | | | | | | | | | | |
| pH | | 7.17 | 7.59 | 7.67 | 7.60 | 7.60 | 7.57 | 7.57 | 7.61 | 7.56 | 7.71 |
| Temperature ($^{o}$C) | | 17.3 | 17.1 | 17.1 | 16.8 | 14.9 | 15.0 | 15.0 | 14.7 | 14.8 | 15.1 |
| Conductivity (uS/cm) | | 717 | 704 | 714 | 341 | 197 | 140 | 140 | 153 | 143 | 195 |
| **General Chemistry (mg/L)** | | | | | | | | | | | |
| Total Dissolved Solids | 0.1 | 579 | 703 | 734 | 311 | 158 | 164 | 157 | 116.5 | 157 | 184 |
| Total Hardness as CaCO3 | 1 | 118.8 | 147 | 142.5 | 63.9 | 31.5 | 33.3 | 24.2 | 21.3 | 24.5 | 35 |
| Total Suspended Solids | 0.5 | 372 | 57.3 | 52 | 198.7 | 780 | 962.7 | 297 | 181.3 | 190 | 99 |
| **Total Metals (ug/L)** | | | | | | | | | | | |
| Aluminum (Al) | 5 | 1880 | 514 | 416 | 1218 | 3167 | 2363 | 1550 | 1113 | 1019 | 472 |
| Antimony (Sb) | 0.1 | 4.3 | 4.9 | 7.3 | 8.6 | 3.8 | 2.1 | 2.2 | 1.9 | 1.5 | 1.6 |
| Arsenic (As) | 0.2 | 3.1 | 2.3 | 2.4 | 2.6 | 3.3 | 2.4 | 1.5 | 1.3 | 1.3 | 1.3 |
| Barium (Ba) | 0.2 | 129.4 | 65.3 | 70.4 | 104.8 | 226.7 | 109.7 | 65.8 | 48.6 | 34.7 | 23.4 |
| Beryllium (Be) | 0.2 | 0.2J | ND | ND | 0.1 ND | 0.3J | 0.2J | 0.1 ND | 0.1 ND | ND | ND |
| Cadmium (Cd) | 0.2 | 1.4 | 0.7 | 0.8 | 0.9 | 1.7 | 0.9 | 0.7 | 0.7 | 0.3J | 0.4 |
| Chromium (Cr) | 0.1 | 7.8 | 3.8 | 4.5 | 6.4 | 8.8 | 5.1 | 4.7 | 3.5 | 3 | 2.1 |
| Cobalt (Co) | 0.1 | 4.5 | 1.5 | 1.7 | 2.6 | 8.2 | 5.7 | 2.6 | 2 | 1.5 | 0.7 |
| Copper (Cu) | 0.4 | **125.1** | **83.9** | **110.4** | **125.9** | **177.5** | **77.7** | **48.7** | **35.5** | 27.4 | 24.5 |
| Iron (Fe) | 5 | 3478 | 755 | 614 | 1945 | 6177 | 3403 | 2472 | 1769 | 1540 | 724 |
| Lead (Pb) | 0.05 | **31.09** | 5.86 | 6.95 | 18.54 | **62.16** | **61.34** | **23.47** | 15.65 | 12.81 | 5.46 |
| Manganese (Mn) | 0.2 | 280.1 | 98.4 | 108.2 | 156 | 443.3 | 263.7 | 128.3 | 99.1 | 68.5 | 37.8 |
| Molybdenum (Mo) | 0.2 | 4.6 | 5.2 | 7.7 | 5.7 | 1.6 | 0.7 | 2.1 | 0.7 | 0.7 | 1.2 |
| Nickel (Ni) | 0.2 | 19.4 | 12.3 | 16 | 16.3 | 17.5 | 8.6 | 5.5 | 4.1 | 3.2 | 2.4 |
| Selenium (Se) | 0.2 | 2.2 | 3 | 2.7 | 1.4 | 0.7 | 0.4J | 0.4J | 0.3J | 0.2J | 0.4J |
| Silver (Ag) | 0.5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Strontium (Sr) | 0.1 | 551 | 519.9 | 537.4 | 291.4 | 324.6 | 177 | 111.4 | 91.2 | 87.7 | 119.8 |
| Thallium (Tl) | 0.1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Tin (Sn) | 0.1 | 0.4J | 0.3J | 0.2J | 0.5 | 0.3J | 0.1J | 0.1J | 0.1J | 0.1J | 0.1J |
| Titanium (Ti) | 0.2 | 51.8 | 19.7 | 16.5 | 37.5 | 59.3 | 52.3 | 57.2 | 48.8 | 43.9 | 26.7 |
| Vanadium (V) | 0.2 | 16.9 | 8.3 | 8 | 12.6 | 18.1 | 13.6 | 8.7 | 6.9 | 5.8 | 4.1 |
| Zinc (Zn) | 0.1 | **533.1** | **216.5** | **301.4** | **492.3** | **1109.9** | **349.8** | **214.6** | 146.1 | 94.3 | 65.6 |
| **Dissolved Metals (ug/L)** | | | | | | | | | | | |
| Aluminum (Al) | 5 | 77 | 81 | 78 | 85 | 24 | 54 | 38 | 39 | 56 | 91 |
| Antimony (Sb) | 0.1 | 4.4 | 4.3 | 7.1 | 7.6 | 2.8 | 1.6 | 1.4 | 1.2 | 1.1 | 1.3 |
| Arsenic (As) | 0.2 | 2 | 2 | 2.4 | 2.1 | 1.2 | 1.1 | 1 | 0.9 | 1 | 1.3 |
| Barium (Ba) | 0.2 | 53.6 | 53.7 | 61.3 | 45 | 23.4 | 17.2 | 15.2 | 12.3 | 11.4 | 14.4 |

## Table 10. Pollutograph grab sampling conducted on 4/20/07 at Dorado Street in La Jolla, CA.

| | | Sample Time and Sample ID | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | 12:40 | 13:05 | 13:30 | 14:00 | 14:15 | 14:30 | 14:45 | 15:00 | 15:20 | 15:50 |
| Constituent | MDL | SD 01 | SD 03 | SD 05 | SD 07 | SD 08 | SD 09 | SD 10 | SD 11 | SD 12 | SD 14 |
| Beryllium (Be) | 0.2 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Cadmium (Cd) | 0.2 | 0.6 | 0.6 | 0.8 | 0.6 | 0.3J | 0.2J | 0.3J | 0.3J | 0.2J | 0.2J |
| Chromium (Cr) | 0.1 | 2.3 | 2.1 | 2.6 | 3 | 1 | 1.1 | 1.5 | 1.2 | 1.2 | 1.2 |
| Cobalt (Co) | 0.01 | 2.1 | 1.3 | 1.4 | 1.5 | 0.7 | 0.7 | 0.2J | 0.2J | 0.1J | 0.1J |
| Copper (Cu) | 0.4 | **38.2** | **60.3** | **78.9** | **56.1** | 12.4 | 10.7 | 14.7 | 12.5 | 13.5 | 16.8 |
| Iron (Fe) | 5 | 360 | 198 | 199 | 253 | 106 | 85 | 60 | 50 | 64 | 101 |
| Lead (Pb) | 0.05 | 2.13 | 1.56 | 1.98 | 1.56 | 0.9 | 1.16 | 0.89 | 0.84 | 0.98 | 1.04 |
| Manganese (Mn) | 0.2 | 160.3 | 85.6 | 99.8 | 103.9 | 95.4 | 59.1 | 20.6 | 15.4 | 12.1 | 9.2 |
| Molybdenum (Mo) | 0.2 | 6.7 | 6.2 | 9.3 | 7.9 | 2.1 | 1.4 | 1.2 | 1 | 1 | 1.3 |
| Nickel (Ni) | 0.2 | 12.6 | 11.5 | 14.5 | 12.3 | 2.2 | 1.9 | 1.8 | 1.5 | 1.5 | 1.8 |
| Selenium (Se) | 0.2 | 2 | 2.8 | 2.7 | 1.3 | 0.4J | 0.3J | 0.3J | 0.3J | 0.5 | 0.8 |
| Silver (Ag) | 0.5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Strontium (Sr) | 0.1 | 468.1 | 517.4 | 536.2 | 260 | 123.7 | 112.7 | 85.9 | 72.1 | 78.3 | 116 |
| Thallium (Tl) | 0.1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Tin (Sn) | 0.1 | 0.2J | 0.2J | 0.2J | 0.3J | 0.1J | 0.1J | 0.1J | 0.1J | 0.1J | 0.1J |
| Titanium (Ti) | 0.2 | 1.6 | 2.1 | 2.7 | 2.8 | 1.4 | 3.3 | 2.3 | 2 | 2.7 | 4.9 |
| Vanadium (V) | 0.2 | 5 | 5.7 | 5.6 | 6.3 | 2.1 | 2 | 1.8 | 1.6 | 1.9 | 2.1 |
| Zinc (Zn) | 0.1 | 219.1 | 169.3 | 250.9 | 258.8 | 53 | 38.8 | 52.9 | 43.2 | 35.3 | 40.7 |
| **Synthetic Pyrethroids** | | | | | | | | | | | |
| Allethrin | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Bifenthrin | 5 | 140 | 26 | ND | ND | 156 | 86 | 51 | 39 | 36 | 26 |
| Cyfluthrin | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Cypermethrin | 5 | ND | ND | ND | ND | 477 | ND | ND | ND | ND | ND |
| Danitol | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Deltamethrin | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Esfenvalerate | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Fenvalerate | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| L-Cyhalothrin | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Permethrin | 5 | ND | ND | ND | ND | 127 | 43 | ND | ND | ND | 29 |
| Prallethrin | 5 | ND | ND | ND | ND | 495 | 225 | ND | ND | ND | ND |
| **Chlorinated Pesticides (ng/L)** | | | | | | | | | | | |
| 2,4'-DDD | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 2,4'-DDE | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 2,4'-DDT | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 4,4'-DDD | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 4,4'-DDE | 1 | ND | ND | ND | ND | 26.7 | ND | ND | ND | ND | ND |
| 4,4'-DDT | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Aldrin | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| BHC-alpha | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| BHC-beta | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| BHC-delta | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| BHC-gamma | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Chlordane-alpha | 1 | 12 | ND | ND | 18.5 | 42.1 | 20.1 | 7.5 | ND | ND | ND |
| Chlordane-gamma | 1 | 13.5 | ND | ND | 10.7 | 47.9 | 16.8 | 7.4 | ND | ND | ND |
| cis-Nonachlor | 1 | ND | ND | ND | ND | 29.3 | ND | ND | ND | ND | ND |
| DCPA (Dacthal) | 5 | 11.3 | ND | 8.2 | ND | ND | ND | ND | ND | ND | ND |
| Dicofol | 50 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Dieldrin | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Endosulfan Sulfate | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Endosulfan-I | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

## Table 10. Pollutograph grab sampling conducted on 4/20/07 at Dorado Street in La Jolla, CA.

| Constituent | MDL | Sample Time and Sample ID | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12:40 | 13:05 | 13:30 | 14:00 | 14:15 | 14:30 | 14:45 | 15:00 | 15:20 | 15:50 |
| | | SD 01 | SD 03 | SD 05 | SD 07 | SD 08 | SD 09 | SD 10 | SD 11 | SD 12 | SD 14 |
| Endosulfan-II | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Endrin | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Endrin Aldehyde | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Endrin Ketone | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Heptachlor | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Heptachlor Epoxide | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Methoxychlor | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Mirex | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Oxychlordane | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Perthane | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Total Chlordane | | 44.3 | 0 | 0 | 35.3 | 158.8 | 60.2 | 23.1 | 0 | 0 | 0 |
| Total Detectable DDTs | | 0 | 0 | 0 | 0 | 26.7 | 0 | 0 | 0 | 0 | 0 |
| Toxaphene | 10 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| trans-Nonachlor | 1 | 18.8 | ND | ND | 6.1 | 39.5 | 23.3 | 8.2 | ND | ND | ND |
| **Aroclor PCBs (ng/L)** | | | | | | | | | | | |
| Aroclor 1016 | 10 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Aroclor 1221 | 10 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Aroclor 1232 | 10 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Aroclor 1242 | 10 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Aroclor 1248 | 10 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Aroclor 1254 | 10 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Aroclor 1260 | 10 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| **Organophosphorus Pesticides (ng/L)** | | | | | | | | | | | |
| Bolstar (Sulprofos) | 2 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Chlorpyrifos | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Demeton | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Diazinon | 2 | ND | 131 | 132.7 | 531.8 | 194.4 | 113 | 212.6 | 336.4 | 173.1 | 122.9 |
| Dichlorvos | 3 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Dimethoate | 3 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Disulfoton | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Ethoprop (Ethoprofos) | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Fenchlorphos (Ronnel) | 2 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Fensulfothion | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Fenthion | 2 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Malathion | 3 | 1407.2 | 952.2 | 536 | 875.9 | 488.5 | 386.8 | 685.3 | 392.4 | 329 | 326.8 |
| Merphos | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Methyl Parathion | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Mevinphos (Phosdrin) | 8 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Phorate | 6 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Tetrachlorvinphos (Stirofos) | 2 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Tokuthion | 3 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Trichloronate | 1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| **Polynuclear Aromatic Hydrocarbons (ng/L)** | | | | | | | | | | | |
| 1-Methylnaphthalene | 1 | 48.9 | 25.8 | 12.8 | 41.8 | 28.6 | 13.8 | 10.4 | 7.4 | 6.3 | ND |
| 1-Methylphenanthrene | 1 | 45.3 | ND | ND | 69.9 | 105.2 | 38.8 | 21.5 | 14.3 | 13.8 | 10.8 |
| 2,3,5-Trimethylnaphthalene | 1 | ND | ND | ND | 29.5 | 20.1 | 11.3 | ND | ND | 10.3 | ND |
| 2,6-Dimethylnaphthalene | 1 | 22.5 | ND | ND | 31.5 | 30.3 | 14.3 | 9.2 | 8.4 | 10.4 | ND |
| 2-Methylnaphthalene | 1 | 81.2 | 47.9 | 31 | 68.5 | 48 | 43.7 | 25.1 | 27.1 | 30.5 | 36.9 |

## Table 10. Pollutograph grab sampling conducted on 4/20/07 at Dorado Street in La Jolla, CA.

| Constituent | MDL | Sample Time and Sample ID | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12:40 SD 01 | 13:05 SD 03 | 13:30 SD 05 | 14:00 SD 07 | 14:15 SD 08 | 14:30 SD 09 | 14:45 SD 10 | 15:00 SD 11 | 15:20 SD 12 | 15:50 SD 14 |
| Acenaphthene | 1 | ND | ND | ND | 20.9 | 38.7 | 12.6 | ND | 7.7 | ND | ND |
| Acenaphthylene | 1 | 14.1 | ND | ND | 18 | 29 | 10.5 | 8.5 | 5.9 | 3.8 | 2.6 |
| Anthracene | 1 | 35.3 | ND | ND | 49.4 | 121 | 23.3 | 15.1 | 12.1 | ND | 8.7 |
| Benz[a]anthracene | 1 | 46.8 | 12.2 | 14.9 | 62.9 | 336.6 | 37.3 | 21.6 | 15 | 7.5 | 6.9 |
| Benzo[a]pyrene | 1 | 65.1 | 7.9 | ND | 72.5 | 374.6 | 40.2 | 26.9 | 25.9 | 11.8 | 5.9 |
| Benzo[b]fluoranthene | 1 | 82.4 | 9.6 | 15.1 | 88 | 467.7 | 51.4 | 38.7 | 28.2 | 15.8 | 8.6 |
| Benzo[e]pyrene | 1 | 113.7 | 18.4 | 19.2 | 121.9 | 453.3 | 76.6 | 44.9 | 38.8 | 21.4 | 7.2 |
| Benzo[g,h,i]perylene | 1 | 113.3 | 26.4 | 22.9 | 156.7 | 483.2 | 93.3 | 59.5 | 43.3 | 25.5 | 13.5 |
| Benzo[k]fluoranthene | 1 | 67.9 | ND | ND | 81.2 | 432.4 | 44.9 | 33.1 | 20.7 | ND | 6.2 |
| Biphenyl | 1 | 76.4 | 60.8 | 45.1 | 52.5 | 54.4 | 21 | 14.9 | 10.6 | 8.3 | 6.9 |
| Chrysene | 1 | 175.6 | 33.7 | 39.2 | 214.5 | 797.5 | 131.5 | 83.6 | 53.9 | 34.2 | 25.4 |
| Dibenz[a,h]anthracene | 1 | 11.6 | ND | ND | 15.5 | 96.9 | 14.2 | ND | ND | ND | ND |
| Dibenzothiophene | 1 | 128.2 | 84.6 | 100.2 | 131.4 | 99.2 | 62.4 | 47 | 41.4 | 34.7 | 30.5 |
| Fluoranthene | 1 | 255.2 | 39.2 | 47.3 | 310.8 | 1450.6 | 168.6 | 126.8 | 88.2 | 52.9 | 27.4 |
| Fluorene | 1 | 31.1 | 17.4 | 17.3 | 22.3 | 38.3 | 10.6 | 9.2 | 9.7 | ND | 4.9 |
| Indeno[1,2,3-c,d]pyrene | 1 | 65.3 | ND | ND | 65.9 | 355.5 | 44 | 21.7 | 27.2 | 10.9 | 6.4 |
| Naphthalene | 1 | 77.6 | 29.6 | 18.2 | 68.2 | 78.8 | 29.7 | 19.3 | 16 | 8.6 | 6.6 |
| Perylene | 1 | 106.6 | ND | 16.7 | 145 | 176 | 87.4 | 51.4 | 34.5 | 24.2 | 7.6 |
| Phenanthrene | 1 | 183.4 | 40.4 | 22.3 | 199.6 | 78.9 | 122.9 | 86.9 | 62.6 | 41 | 24.4 |
| Pyrene | 1 | 233.6 | 42.1 | 47.4 | 330.7 | 1087.3 | 167.9 | 114.4 | 74.3 | 49.7 | 31.3 |
| Total Detectable PAHs | | 2081.1 | 496 | 469.6 | 2469.1 | 7282.1 | 1372.2 | 889.7 | 673.2 | 421.6 | 278.7 |
| **Bacteria (MPN/100mL)** | | | | | | | | | | | |
| Total Coliform | 20 | 110,000 | 50,000 | 130,000 | 17,000 | 17,000 | 50,000 | 22,000 | 28,000 | 8,000 | 30,000 |
| Fecal Coliform | 20 | 1,400 | 1,100 | 5,000 | 1,700 | 1,300 | 30,000 | 8,000 | 4,000 | 5,000 | 23,000 |
| Enterococci | 20 | 50,000 | 50,000 | 50,000 | 80,000 | 17,000 | 22,000 | 17,000 | 22,000 | 344,464E | 110,000 |

**Bold** indicates value above California Ocean Plan guidance criteria
ND indicates analyte was not detected
E indicates value exceeded upper reporting limit

### *Results of Pollutograph Sampling*

Calculated storm water flows within the La Jolla Shores MS4 peaked after approximately one hour and 45 minutes of rainfall. Within 90 minutes of the peak storm flow, water levels in the MS4 had nearly returned to pre-storm levels. In this storm event, 0.36 inches of rain fell in the La Jolla Shores watershed (SIO pier weather station). In general, metal concentrations in the storm water runoff were highest during the initial stages of the storm. Total and dissolved copper (Figure 4) and total zinc (Figure 5) concentrations followed this pattern. Concentrations of dissolved copper peaked after approximately one hour of rainfall before declining to nearly baseline levels prior to the peak storm flow. Total copper was also high in the initial stages of the storm event but still peaked during the highest storm flow. Immediately following the peak storm flow, total copper concentrations declined significantly. A similar pattern was observed in total zinc concentrations which were elevated during the initial stages of the storm before markedly declining after the period of peak flow (Figure 5). For bacteria, total coliform and enterococci levels peaked during the initial phase of the storm while fecal coliforms levels were highest after the peak of the storm had passed. Enterococci concentrations spiked again at the end of the storm event (Figure 6).

Total suspended solids concentrations were closely correlated to the rate of flow through the MS4 (Figure 7). TSS concentrations were highest immediately following the period of peak flow. As flow declined, TSS concentrations also declined. The majority of total PAHs were transported during the peak storm flow (Figure 8). Immediately after the peak flow occurred, total PAHs in the storm water runoff declined by 81 percent. This pollutograph information may prove useful in the selection of BMPs for the La Jolla Shores watershed.

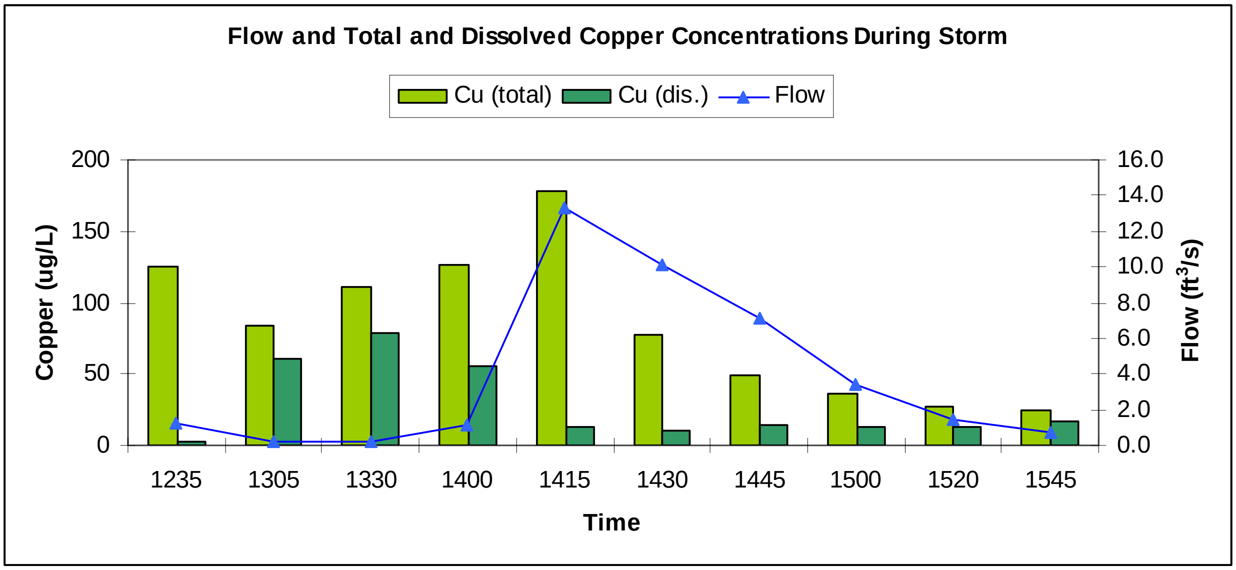

**Figure 4. Comparison of total and dissolved copper versus flow over course of storm event**

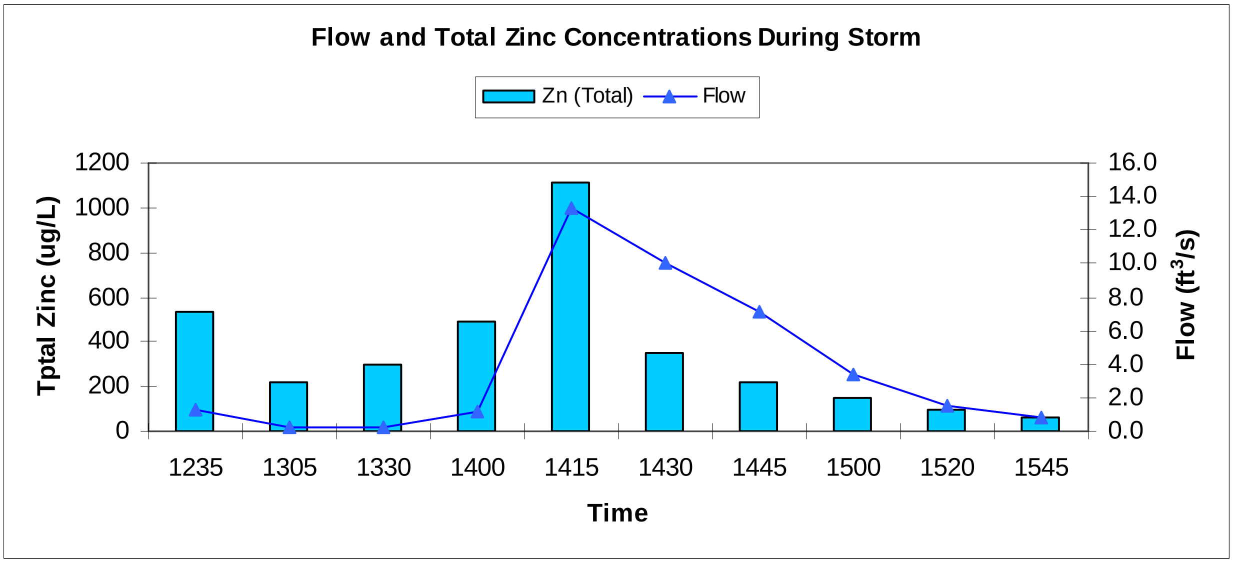

**Figure 5. Comparison of total zinc versus flow over course of storm event**

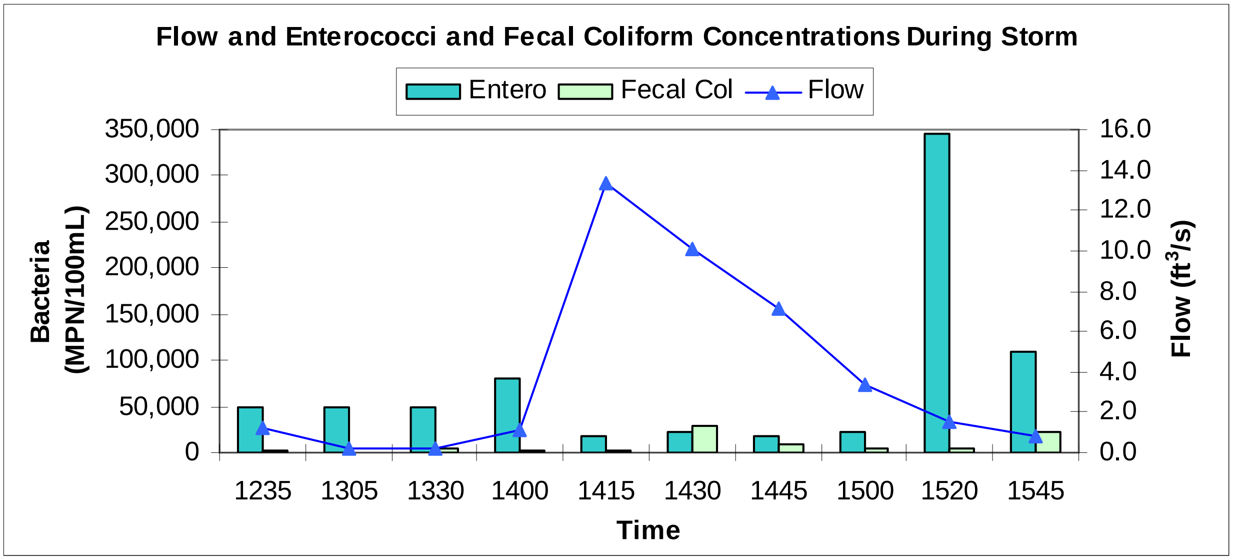

**Figure 6. Comparison of enterococci and fecal coliform concentrations versus flow over course of storm event**

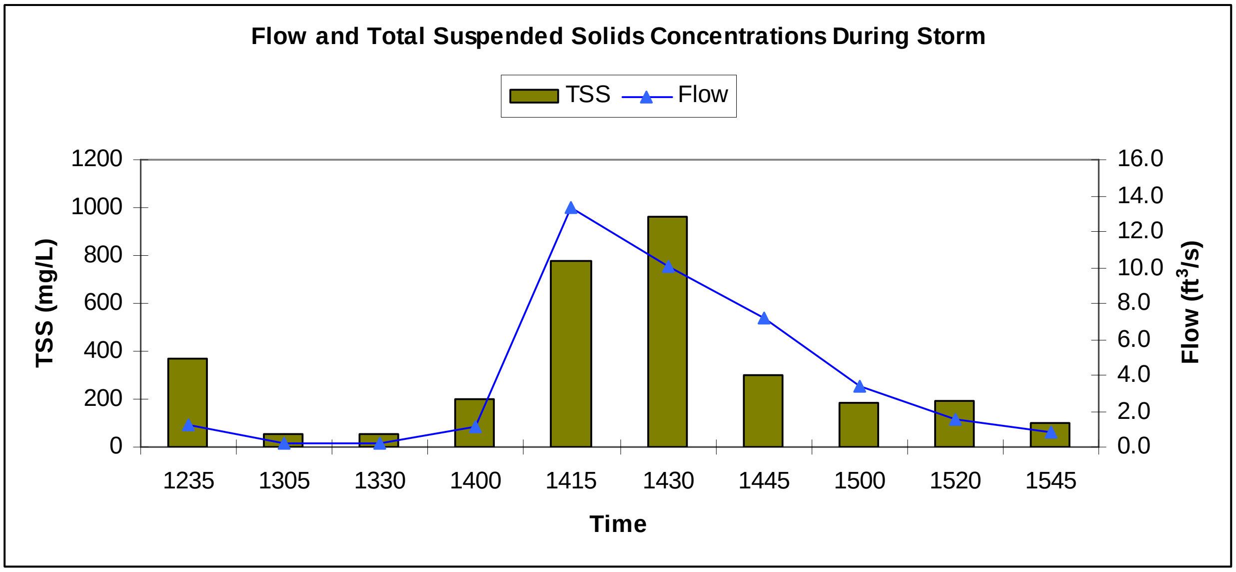

**Figure 7. Comparison of total suspended solids versus flow over course of storm event**

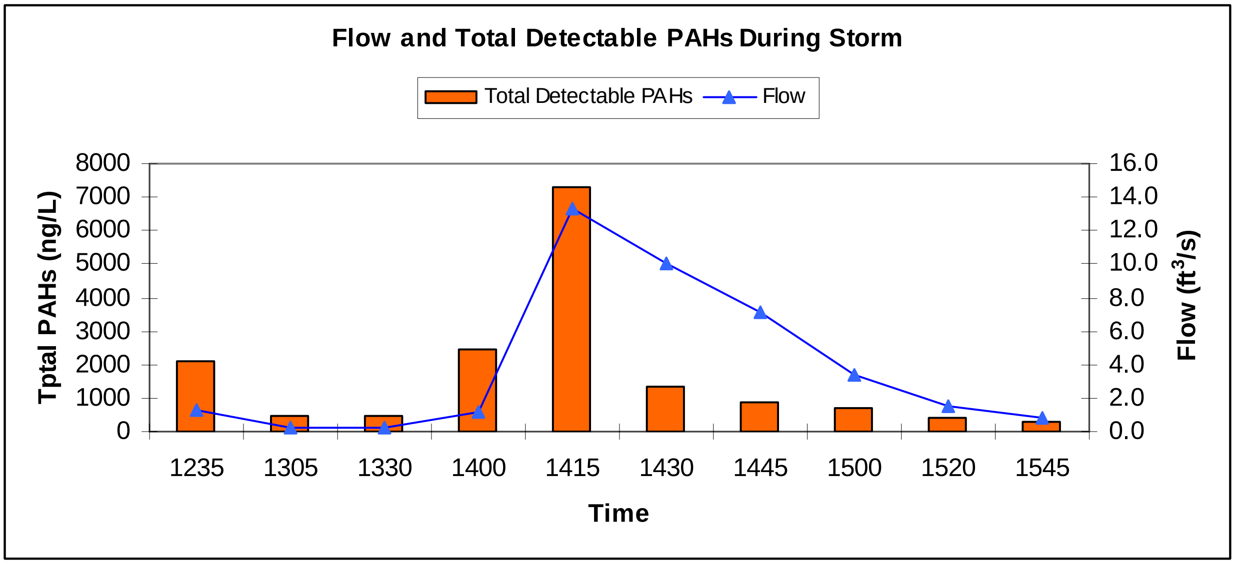

**Figure 8. Comparison of total detectable PAHs versus flow over course of storm event**

Loads for several COIs were calculated based on flow measurements and grab sample concentrations. Over the course of the entire 3-hour storm event, 108.9 grams of total copper (which included 15.3 grams of dissolved copper), were calculated to have washed through the MS4 (Table 11). Additionally, 46.5 grams of total lead, 583.5 grams of total zinc, 3.31 grams of total PAHs, and 630.7 kg of total suspended solids were calculated to have passed through the MS4 via storm water runoff.

**Table 11. Calculated load concentrations over the course of the storm for COIs**

| Time span | Total Copper | Dissolved Copper | Total Lead | Total Zinc | TSS | Total Detectable PAHs |
|---|---|---|---|---|---|---|
| 1235-1305 | 8.03 | 0.13 | 2.00 | 34.22 | 23881 | 0.13 |
| 1305-1330 | 0.88 | 0.63 | 0.06 | 2.27 | 601 | 0.01 |
| 1330-1400 | 1.39 | 0.99 | 0.09 | 3.79 | 654 | 0.01 |
| 1400-1415 | 3.57 | 1.59 | 0.53 | 13.94 | 5627 | 0.07 |
| 1415-1430 | 60.35 | 4.22 | 21.13 | 377.35 | 265189 | 2.48 |
| 1430-1445 | 19.99 | 2.75 | 15.78 | 90.00 | 247691 | 0.35 |
| 1445-1500 | 8.87 | 2.68 | 4.27 | 39.07 | 54077 | 0.16 |
| 1500-1520 | 4.10 | 1.44 | 1.81 | 16.89 | 20956 | 0.08 |
| 1520-1545 | 1.74 | 0.86 | 0.81 | 5.99 | 12062 | 0.03 |
| **Total load from MS4 in grams for 3-hour storm** | **108.9** | **15.3** | **46.5** | **583.5** | **630,738** | **3.31** |

Percentages of the total and dissolved copper loads were calculated over the storm's duration (Figure 9). Greater than 80 percent of the total copper and 65 percent of the dissolved copper was contained in runoff occurring in first two hours of the storm. For TSS, the period of highest flow (between 14:00 and 14:45) contained greater than 80 percent of the suspended solids (Figure 10).

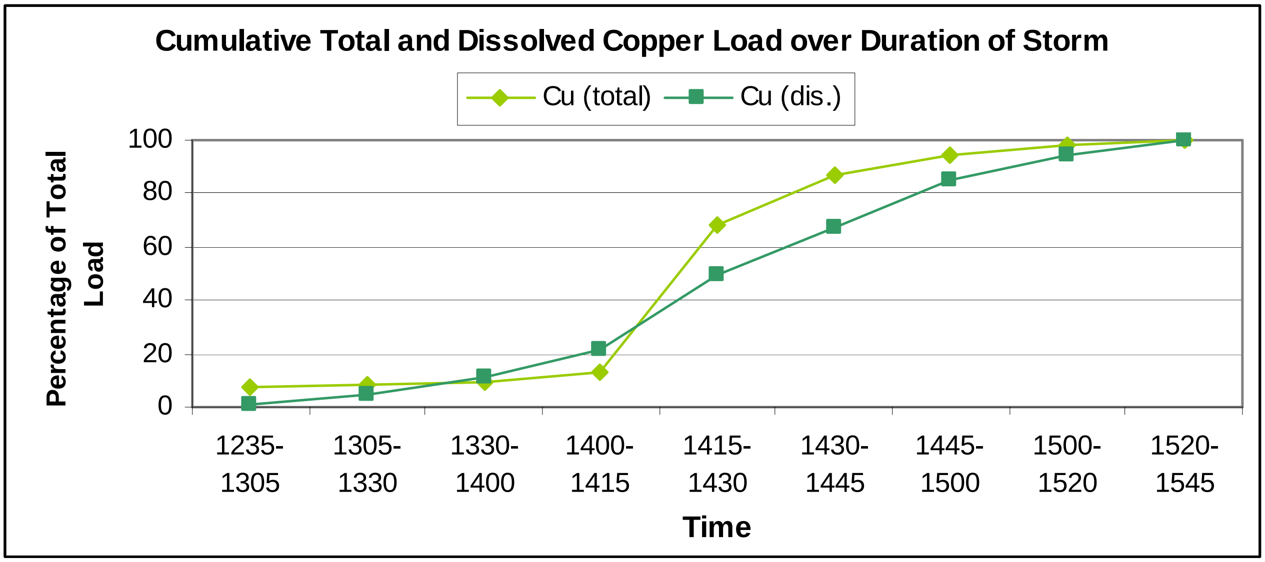

**Figure 9. Cumulative total and dissolved copper loads in storm water runoff over time.**

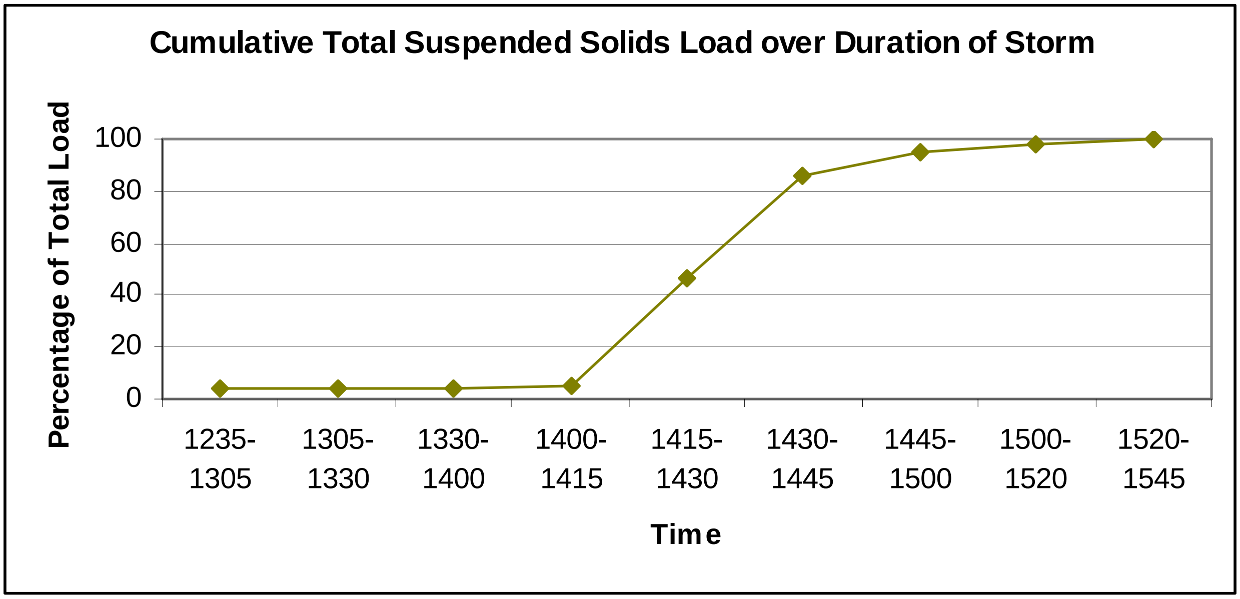

**Figure 10. Cumulative TSS loads in storm water runoff over time.**

### 1.3.5 Toxicity Testing

As part of the urban runoff characterization study, toxicity testing was performed using four approved ocean species (mysid shrimp, fish, giant kelp, and purple sea urchins) to help determine biological impacts from storm water runoff to animal and algae phyla living within the ASBS marine ecosystem. The toxicity testing included both acute and chronic bioassays. Acute testing was performed on mysid shrimp while chronic testing was performed on giant kelp, mysid shrimp, and purple sea urchins (Table 12). The rationale for performing both acute and chronic testing was that acute testing would represent short-term conditions (such as storm water entering the ASBS) and would examine acute impacts (such as mortality) from short-term exposures to storm water effluent and its receiving water. Chronic testing, on the other hand, would focus on longer term exposures that may be more typical of ocean samples and would examine both lethal (mortality) and sub-lethal endpoints (growth and reproduction) in test organism exposures to MS4 discharge, mixing zone, and receiving water samples.

**Table 12. Bioassay testing performed on the City's MS4, mixing zone, and offshore samples and on SIO outfall 002 and SIO receiving water samples.**

| Test Organism | Acute Testing | Test End Point | Samples Tested | Chronic Testing | Test End Points | Samples Tested |
|---|---|---|---|---|---|---|
| **Mysid Shrimp**<br>(*Mysidopsis bahia*) | X | Survival | **The City**: MS4, Mixing Zone, and Offshore samples<br>**SIO**: None | X | Survival, Biomass | **The City**: MS4, Mixing Zone, and Offshore samples<br>**SIO**: Outfall 002, Receiving Water |
| **Fish**<br>(*Menidia beryllina*) | X | Survival | **The City**: None<br>**SIO**: Outfall 002, Receiving Water | X | Survival, Growth | **The City**: None<br>**SIO**: Outfall 002, Receiving Water |
| **Giant Kelp**<br>(*Macrocystis pyrifera*) | | | | X | Germination, Growth | **The City**: MS4, Mixing Zone, and Offshore samples<br>**SIO**: Outfall 002, Receiving Water |
| **Purple Sea Urchin**<br>(*Strongylocentrotus purpuratus*) | | | | X | Fertilization | **The City**: MS4, Mixing Zone, and Offshore samples<br>**SIO**: Outfall 002, Receiving Water |

### *Acute Bioassay Results- The City of San Diego*

Acute bioassay test results for mysid shrimp exposed to sample water collected from storm drains, mixing zones, and offshore within the ASBS are provided below in Table 13. As presented in Table 13, storm water and ocean samples collected from the City's storm drain, mixing zone, and offshore locations produced no toxicity to the mysid shrimp, *Mysidopsis bahia,* in acute toxicity testing. No observable effect concentrations (NOECs) were statistically determined to be the highest concentration that was tested for each of the water samples. Due to the salinities of the samples falling outside of the acceptable test range for *M. bahia*, salinity adjustments were necessary according to USEPA testing methods. As a result, a brine solution was added to samples with low salinities and a diluted saline solution was added to samples with high salinities. Consequently, the maximum concentration for which the samples could be tested in acute tests with this species ranged from 65 to 75 percent sample. Although no toxicity was detected, because the NOEC values were not greater than 100 percent test concentration, the Basin Plan guidance criteria were not met for City storm drain samples collected at S1 and S2. Similarly, despite a lack of toxicity in acute tests with *M. bahia*, acute toxic units ($TU_a$s) ranged from 0.82 to 0.91 and did not meet the Ocean Plan guidance criteria of less than 0.3 toxic units. It should be noted that these results do not indicate that toxicity was present in the sample but instead are explained by the fact that the maximum concentration tested in this study could not be 100 percent sample concentration. As a result of the need to adjust the sample salinities in order to properly run acute toxicity tests with *M. bahia,* the maximum testable sample concentrations were less than 100 percent. Thus, because the maximum sample exposure concentrations were equivalent to the NOEC values, no actual toxicity occurred in any urban runoff water samples collected in the mixing zone or offshore from the La Jolla Shores storm drain outfalls.

**Table 13. Acute toxicity results for mysid shrimp exposed to storm drain, mixing zone, and offshore water samples.**

| Sample | Water Quality Guidance Criteria ($TU_a$) | Acute *Mysidopsis bahia* Bioassay | | | |
|---|---|---|---|---|---|
| | | $TU_a$ | NOEC (%) | LOEC (%) | Maximum Concentration of Sample Tested (%) |
| Storm Drain S1 | NOEC>100 | 0.87 | 70 | >70 | 70 |
| Mixing Zone D1 | <0.3 | 0.82 | 75 | >75 | 75 |
| Storm Drain S2 | NOEC>100 | 0.91 | 65 | >65 | 65 |
| Mixing Zone D2 | <0.3 | 0.82 | 75 | >75 | 75 |
| ASBS Offshore | <0.3 | 0.82 | 75 | >75 | 75 |

### *Acute Bioassay Results- SIO*

Acute toxicity to Atlantic silverside fish (*Menidia beryllina*) was not observed in bioassay test results from water collected at SIO Outfall 002 or in receiving water adjacent to the SIO outfall during a rain event on February 28, 2006 (Table 14). NOECs were at 100 percent test concentration while lowest observable effect concentrations (LOECs) were greater than 100 percent test concentration for each of the water samples. Because the testing laboratory used sea salt rather than a brine solution to increase the salinity of the sample water, 100 percent test concentrations were able to be used in each of the SIO acute toxicity bioassays.

**Table 14. Acute toxicity results for mysid shrimp exposed to SIO Outfall 002 discharge and receiving water samples**

| Sample | Date | Water Quality Guidance Criteria ($TU_a$) | Acute *Menidia beryllina* Bioassay | | | |
|---|---|---|---|---|---|---|
| | | | $TU_a$ | NOEC (%) | LOEC (%) | Maximum Concentration of Sample Tested (%) |
| SIO Outfall 002 | 2/28/06 | NOEC>100 | 0.41 | 100 | >100 | 100 |
| SIO Receiving Water | 2/28/06 | <0.3 | 0.0 | 100 | >100 | 100 |

Chronic Test Results

Chronic bioassay test results for mysid shrimp, giant kelp, and sea urchins exposed to sample water collected from storm drains, mixing zones, and offshore within the ASBS are provided below in Table 15. Chronic toxicity testing was conducted on S2 storm drain sample, D2 mixing zone sample, and the offshore sample for the City's storm water monitoring program and on Outfall 002 and receiving water samples for SIO's discharge permit. The ocean samples (mixing zone, receiving water, and offshore) were the focus of the chronic testing as these better represented the longer term or chronic condition. Storm water samples used in chronic toxicity testing were analyzed for comparison purposes.

**Table 15. Chronic toxicity results for giant kelp, mysid shrimp, and sea urchins exposed to storm drain, mixing zone, and offshore water samples.**

| Chronic Toxicity Tests for City of San Diego (2/28/06) | | | | | | |
|---|---|---|---|---|---|---|
| **Test** | **Sample** | **Endpoint** | **NOEC (%)** | **LOEC (%)** | **EC50 (%)** | **TUc** |
| *Macrocystis pyrifera*<br>(Giant Kelp) | Storm Drain S2 | Germination | 60 | >60 | >60 | 1.67 |
| | | Growth | <6.25 | 6.25 | >60 | >16 |
| | Mixing Zone | Germination | 6.25 | 12.5 | >100 | 16 |
| | | Growth | 25 | 50 | >100 | 4 |
| | ASBS Offshore | Germination | 100 | >100 | >100 | 1 |
| | | Growth | 100 | >100 | >100 | 1 |
| *Mysidopsis bahia*<br>(Mysid Shrimp) | Storm Drain S2 | 7-Day Survival | 65 | >65 | >65 | 1.54 |
| | | Biomass | 65 | >65 | >65 | 1.54 |
| | Mixing Zone D2 | 7-Day Survival | 75 | >75 | >75 | 1.33 |
| | | Biomass | 75 | >75 | >75 | 1.33 |
| | ASBS Offshore | 7-Day Survival | 75 | >75 | >75 | 1.33 |
| | | Biomass | 75 | >75 | >75 | 1.33 |
| *Strongylocentrotus purpuratus*<br>(Purple Sea Urchin) | Storm Drain S2 | Proportion Fertilized | 50 | 60 | >60 | 2 |
| | Mixing Zone D2 | Proportion Fertilized | 100 | >100 | >100 | 1 |
| | ASBS Offshore | Proportion Fertilized | 100 | >100 | >100 | 1 |

## The City of San Diego Storm Drain, Mixing Zone, and Offshore samples

### *Giant Kelp- Germination and Growth Endpoints*

No toxicity was observed in chronic toxicity tests for germination and growth using the giant kelp *Macrocystis pyrifera* (*M. pyrifera)* in the ASBS offshore sample (Table 15). The NOEC was 100 percent of the sample concentration for germination while the LOEC and the Effect Concentration needed to inhibit germination by 50 percent ($EC_{50}$) was greater than 100 percent. Similar results were observed for the growth endpoint. The kelp growth NOEC was 100 percent of the sample concentration, while the LOEC and $EC_{50}$ values were greater than 100 percent of the sample concentration. The calculated toxic units chronic ($TU_c$) value of one met the water quality criteria outlined in the California Ocean Plan and demonstrated that there was no toxicity in this water sample.

In the kelp germination test for the storm drain sample, the NOEC value was determined to be 60 percent of the sample concentration, while the LOEC and $LC_{50}$ values were determined to be greater than 60 percent of the sample concentration. As was the case in the acute testing with *M. bahia*, salinity adjustments were required to bring the sample within the acceptable salinity range for this test species (*M. pyrifera*). Because of this, a 60 percent sample concentration was the maximum concentration that could be tested. Thus, although the $TU_c$ of 1.67 was above the Basin Plan's guidance criteria of a $TU_c \geq 1$, no real toxicity was observed. Slight toxicity was observed, however, in the chronic toxicity test using *M. pyrifera* growth as an endpoint in exposures to the storm drain sample. Specifically, the NOEC was less than 6.25 percent, the LOEC was 6.25 percent, and the $TU_c$ was greater than 16. However, because the $EC_{50}$ value was greater than 60 percent (i.e. the highest concentration tested due to salinity adjustments) and the embryos in the 60 percent samples were only 10 percent smaller than the control embryos, toxicity to *M. pyrifera* in chronic exposure to storm drain water was considered slight. As discussed previously, the storm water sample collected from the MS4 was selected for chronic toxicity testing for comparison purposes and represents more of a shorter term or acute condition. Because dilution effects from the receiving water are not considered in testing these samples, the actual impact to the ASBS from storm water may be less than is represented in the storm water toxicity results. The results of chronic toxicity tests on mixing zone and ocean samples did not indicate toxic effects. All results of the toxicity tests from storm water samples will be used in the overall assessment of potential impacts to the ASBS.

Chronic tests on the mixing zone sample using *M. pyrifera* also resulted in slight toxicity, measured as reductions in growth and germination. The NOEC value for germination was 6.25 percent sample concentration, while the LOEC was 12.5 percent sample concentration. The $TU_c$ was calculated to be 16, which exceeds the water quality standard of $TU_c = 1$. However, because the $EC_{50}$ value for germination was greater than 100 percent, and germination in the 100 percent sample concentration was less than 9 percent lower than germination in control samples, toxicity was considered to be relatively low. For the growth endpoint, $TU_c$ was calculated to be 4, the NOEC was 25, the LOEC was 50, and the $EC_{50}$ value was greater than 100 percent sample concentration. Thus, a slight reduction in growth of *M. pyrifera* embryos occurred as a result of exposure to water from the mixing zone.

The chronic giant kelp bioassay was repeated using sample water from the 4/20/07 storm event. In this test, a modified procedure was performed alongside the normal procedure due to concerns that physical debris may be preventing kelp embryos from adhering to the bottom of the petri dishes. In this modified test, sample water was allowed to settle for approximately 12 hours prior to test initiation. As a result of heavy debris in the storm drain and mixing zone samples, which interferes with the microscopic assessment of kelp germination and tube growth, it was not possible to measure the effect of storm water from storm drain and mixing zone composite samples on kelp germination and growth in the highest two to three concentrations of these kelp bioassays. Thus, the modified test results were used for the storm drain (SD) and mixing zone (MZ) samples to assess toxicity to germination and growth of kelp embryos.

**Table 16. Chronic toxicity results for giant kelp exposed to storm drain, mixing zone, and offshore water samples collected from the storm of 4/20/07.**

| Chronic Toxicity Tests for City of San Diego (4/20/07) | | | | | | |
|---|---|---|---|---|---|---|
| **Test** | **Sample** | **Endpoint** | **NOEC (%)** | **LOEC (%)** | **EC50 (%)** | **TUc** |
| *Macrocystis pyrifera*<br>(Giant Kelp) | Storm Drain S2 (modified) | Germination | 59 | >59 | >59 | 1.69 |
| | | Growth | <12.5 | 12.5 | >59 | >8 |
| | Mixing Zone (modified) | Germination | 75 | >75 | >75 | 1.33 |
| | | Growth | 50 | 75 | >75 | 2 |
| | ASBS Offshore | Germination | 100 | >100 | >100 | 1 |
| | | Growth | <6.25 | 6.25 | >100 | >16 |

## Results

### *Storm Drain (SD) Composite*

There was no significant effect on germination of kelp embryos exposed to SD composite samples for 48 hrs; the median effective concentration (EC50) and the lowest observable effect concentration (LOEC) were higher than the highest concentration of storm water tested (>59% test concentration), and the no observable effect concentration (NOEC) was the highest concentration tested (59% test concentration). Significant toxicity was observed in the growth endpoint of this bioassay; growth of kelp germination tubes exposed to all concentrations (12.5 - 59%) of the SD composite sample for 48 hrs was significantly reduced relative to growth of controls. While the EC50 for growth was >59%, because the length of germination tubes of kelp in any treatments was not 50% reduced relative to those of the controls, the NOEC was <12.5% and the LOEC was 12.5%.

### *Mixing Zone (MZ) Composite*

There was no significant effect on germination of kelp embryos exposed to MZ composite samples for 48 hrs; the EC50 and the LOEC were higher than the highest concentration of storm water tested (>75% test concentration), and the NOEC was the highest concentration tested (75% test concentration). Slight toxicity was observed in the growth endpoint of this bioassay; growth of kelp germination tubes exposed to only the highest concentration (75%) of the MZ composite sample for 48 hrs was significantly reduced relative to growth of controls. The EC50 for growth was >75%, because the length of germination tubes of kelp in any treatments was not 50% reduced relative to those of the controls, the NOEC was <50%, and the LOEC was 75%.

### *ASBS Offshore (OS) Composite*

There was no significant effect on germination of kelp embryos exposed to OS composite samples for 48 hrs; the EC50 and the LOEC were higher than the highest concentration of storm water tested (>100% test concentration), and the NOEC was the highest concentration tested (100% test concentration). Significant toxicity was observed in the growth endpoint of this bioassay; growth of kelp germination tubes exposed to all concentrations (6.25 - 100%) of the OS composite sample for 48 hrs was significantly reduced relative to growth of controls. While the EC50 for growth was >100%, because the length of germination tubes of kelp in any treatments was not 50% reduced relative to those of the controls, the NOEC was <6.25% and the LOEC was 6.25%.

*Mysid Shrimp- Mortality and Biomass Endpoints*

In chronic test exposures to storm drain, mixing zone, and offshore samples, *Mysidopsis bahia* did not have statistically significant reductions in biomass or mortality (Table 12). As a result, the NOECs for all of the samples were equivalent to the maximum concentration of sample tested (ranging from 65 to 75 percent), while the LOECs and $EC_{50}$s for all samples were greater than the maximum concentration of sample tested (i.e., greater than 65 to 75 percent). Similar to acute toxicity tests, samples collected near the storm drain, in the mixing zone, or offshore, had salinities above or below those used in acute toxicity tests with *M. bahia.* Consequently, salinities were adjusted according to USEPA protocols prior to test initiation as described above. Because of these salinity adjustments, the maximum concentration of sample that could be tested in acute tests with this species was 65 to 75 percent. Despite any observed toxicity, the calculated $TU_c$ values ranged from 1.33 to 1.54, and thus samples collected in the mixing zone and offshore (i.e., La Jolla 02 MZ and ASBS Offshore) were slightly elevated above Ocean Plan water quality standards ($TU_c$ less than or equal to 1). Similarly, for the sample collected near the storm drains (i.e., La Jolla Prsv 02), NOEC values were slightly above water quality standards outlined in the San Diego Basin Plan (NOEC greater than 100 percent). These values above water quality standards are considered artificially high due to necessary salinity adjustments and subsequent reductions in the sample concentrations that could be tested in this investigation.

*Purple Sea Urchin- Mortality and Biomass Endpoints*

In chronic toxicity tests using the purple sea urchin, *Strongylocentrotus purpuratus,* no sublethal toxicity, measured as percent fertilization of eggs, was observed in exposures to samples collected in the mixing zone or at the offshore site. Specifically, the NOECs for these samples were 100 percent of the sample concentrations, and the LOECs and $EC_{50}$s were greater than 100 percent, while the calculated $TU_c$s were 1. In the sample collected near the storm drain, slight sublethal toxicity was observed. For this sample the NOEC value was 50 percent of the water sample, the LOEC was 60 percent of the sample, and the $EC_{50}$ was greater than 60 percent of the sample. As a result, the $TU_c$ was calculated to be 2, a value above the Ocean Plan water quality guidance standard of 1.0 $TU_c$.

## SIO Outfall 002 and Receiving Water

*Giant Kelp- Germination and Growth Endpoints*

In testing conducted on water samples collected at Scripps Outfall 002 during storm events on February 28, 2006, toxicity to giant kelp was calculated to be less than 1.4$TU_c$ for germination and growth, while receiving water toxicity was calculated to be 1.0 $TU_c$ for germination and growth, respectively (Table 17). Because it was necessary to add a brine solution to the Outfall 002 sample, the highest concentration of sample water that could be tested was 68.9 percent. NOEC values in kelp growth and germination tests were at the highest concentrations tested and therefore indicate there was no observable toxicity in Outfall 002 discharge or SIO receiving water samples.

**Table 17. Chronic Toxicity Results for giant kelp, fish, and sea urchins exposed to SIO Outfall 002 discharge and receiving water samples.**

| Chronic Toxicity Tests for SIO | | | | | |
|---|---|---|---|---|---|
| **Test** | **Sample** | **Endpoint** | **NOEC (%)** | **LOEC (%)** | **TUc** |
| *Macrocystis pyrifera*<br>(Giant Kelp) | SIO receiving water | Germination | 100.0 | >100.0 | 1.0 |
| | | Growth | 100.0 | >100.0 | 1.0 |
| | Scripps Outfall 002 | Germination | 68.9 | >68.9 | <1.4 |
| | | Growth | 68.9 | >68.9 | <1.4 |
| *Menidia beryllina*<br>(Fish | SIO receiving water | Survival | 100.0 | >100.0 | 1.0 |
| | | Biomass | 100.0 | >100.0 | 1.0 |
| | Scripps Outfall 002 | *Survival* | 100.0 | >100.0 | 1.0 |
| | | *Biomass* | 100.0 | >100.0 | 1.0 |
| *Strongylocentrotus purpuratus*<br>(Purple Sea Urchin) | SIO receiving water | *Proportion Fertilized* | 100 | >100 | 1.0 |
| | Scripps Outfall 002 | *Proportion Fertilized* | 100 | >100 | 1.0 |

*Fish- Mortality and Biomass Endpoints*
In testing conducted on water samples collected at Scripps Outfall 002 during storm events on February 28, 2006, toxicity to fish was calculated to be 1.0 $TU_c$ for survival and biomass, while receiving water toxicity was calculated to be 1.0 $TU_c$ for survival and biomass, respectively (Table 14). NOECs for both tests were at the 100 percent concentration, indicating there was no observable toxicity in Outfall 002 discharge or SIO receiving water samples.

*Fish- Mortality and Biomass Endpoints*
In testing conducted on water samples collected at Scripps Outfall 002 during storm events on February 28, 2006, toxicity to fish was calculated to be 1.0 $TU_c$ for survival and biomass, while receiving water toxicity was calculated to be 1.0 $TU_c$ for survival and biomass, respectively (Table 14). NOECs for both tests were at the 100 percent concentration, indicating there was no observable toxicity in Outfall 002 discharge or SIO receiving water samples.

*Sea Urchin- Fertilization Endpoint*
In testing conducted on water samples collected at Scripps Outfall 002 during storm events on February 28, 2006, toxicity to purple sea urchins was calculated to be 1.0 $TU_c$ for egg fertilization. Receiving water toxicity was also calculated to be 1.0 $TU_c$ for egg fertilization (Table 17). The NOEC in this test was at the 100 percent concentration, indicating there was no observable toxicity in either Outfall 002 discharge or SIO receiving water samples.

**Summary of Bioassay results**
No acute toxicity was observed in bioassay testing using mysid shrimp in exposures to City of San Diego storm drain, mixing zone, and offshore samples. Similarly, no acute toxicity was observed in bioassay testing using fish in exposures to samples collected from SIO Outfall 002 and SIO receiving water. In chronic testing, no chronic toxicity was observed in bioassays using mysid shrimp and purple sea urchins in exposures to City of San Diego storm water, mixing zone, and offshore samples. In the giant kelp bioassays using germination and growth as

endpoints, decreased growth was observed in exposures to storm drain and mixing zone samples. Decreased germination was observed in exposure to the mixing zone sample. No chronic toxicity was observed in bioassay testing of SIO Outfall 002 and receiving water samples. In exposures to SIO Outfall 002 discharge and SIO receiving water, fish, mysid shrimp, and giant kelp had NOECs equal to the highest test concentration. Bioassay results will be used in a weight of evidence approach to identify constituents of issue within the watershed. A watershed characterization is presented in Section 2.

# 2.0 WATERSHED CHARACTERIZATION

## 2.1 Watershed Boundaries

The La Jolla Shores Coastal Watershed is located in La Jolla, California, within the limits of the City of San Diego. The watershed is 1,639 square acres and is roughly bounded by the Pacific Ocean shoreline to the west, La Jolla Scenic Drive to the east, the intersection of La Jolla Shores Drive and Torrey Pines Road to the north, and South Via Casa Alta Road to the south. The land rises from sea level along the coast to an elevation of approximately 800 feet at Mt. Soledad. Within the watershed boundaries there are 32 distinct sub-drainage areas (Figure 11).

## 2.2 ASBS

The receiving waters in the area of SIO Pier were designated a Marine Wildlife Refuge in 1929 by California Department of Fish and Game (CDFG). CDFG altered the designation to a Marine Protected Area (MPA) in 1957, and renamed the area the San Diego – Scripps State Marine Conservation Area. In 1974 the Scripps State Marine Conservation Area was split into two areas and renamed the San Diego Marine Life Refuge and La Jolla Ecological Preserve. Each of these was included on a list of 31 Areas of Special Biological Significance (ASBS) throughout the state of California by the State Board. Under the ASBS designation, discharges into an ASBS are prohibited if the discharge alters the receiving water’s natural water quality characteristics. There are currently 110 direct discharges (mostly from small pipes and weep holes through sea walls) into the ASBS. The vast majority of these originate from privately owned homes. Waste water discharges from SIO are commingled with urban runoff within the municipal separate storm sewer system (MS4).

## 2.3 Key Drainage Infrastructure

The La Jolla Shores Coastal Watershed discharges into the two ASBS areas in several ways: the MS4, direct discharges from overland sheet flow, and natural drainage features. There are no natural streams that flow directly into the ASBS due to the urbanization of the lower watershed. Drainage areas in the upper watershed drain open space and convey storm water into natural drainage features before directing it into the MS4. The majority of the urban runoff within the watershed is conveyed through the MS4 and subsequently discharged into the ASBS via 17 outfalls located along its shoreline. In total, the annual average volume of runoff entering the La Jolla Shores Coastal Watershed was calculated to be slightly greater than 22 million cubic feet of water, based on average annual rainfall at the San Diego Airport (1914-2006). Greater than 75 percent of that runoff (16.8 million cubic feet) was discharged by two storm drain outfalls (D1 and D2, see Figure 1) within the watershed. The approximate annual volume of runoff entering the La Jolla ASBS through the D1 storm drain outfall was calculated to be 12.8 million cubic feet of water, while runoff entering the ASBS through the D2 storm drain outfall was approximated to be four million cubic feet of water. Each of these outfalls (D1 and D2) was sampled during the 2005-2006 wet weather monitoring season. Discharge volumes were calculated using ArcGIS based upon the percentage of impervious surface area within the watershed according to SANDAG land use data (SANDAG, 2003).

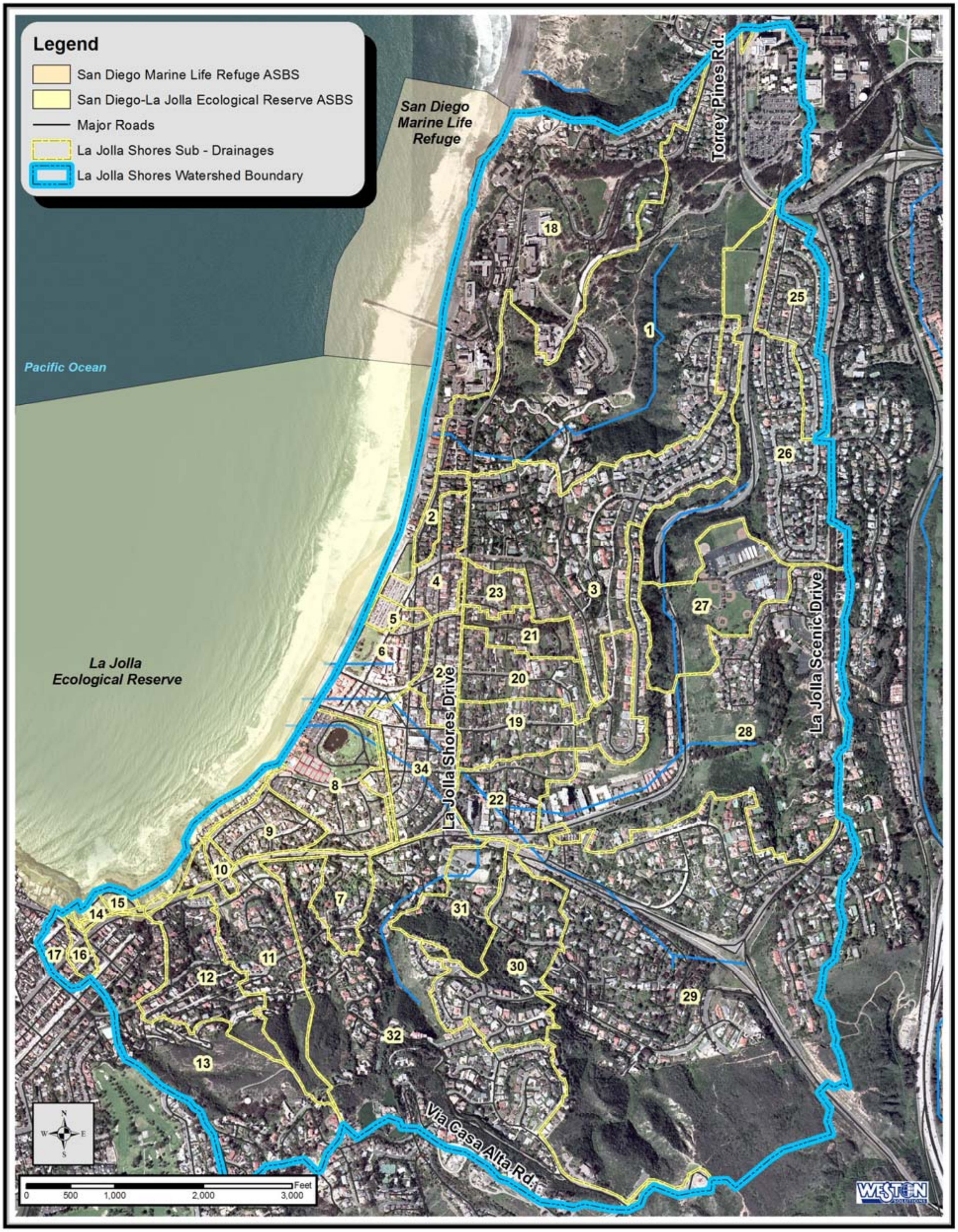

Figure 11. Sub-drainages within the La Jolla Shores Coastal Watershed.

**Figure 12. A storm water catchment basin located on the beach at Avenida de la Playa.**

Urban runoff from the watershed is generally directed into the MS4 through curb inlets. In some drainage areas, runoff travels as sheet flow along streets to adjacent drainage areas where it is collected in storm inlets and catch basins. For example, urban runoff along Avenida de la Playa drains to the catch basin located directly on the beach. This catch basin has a dry weather flow diversion system that when filled, pumps the dry weather flows to the sanitary sewer system (Figure 12).

Currently, there are 110 direct discharges into the ASBS (Figure 13). Most of these originate from privately owned homes which discharge irrigation via pipes, outfalls, and weep holes embedded in the sea walls. Scripps Institution of Oceanography (SIO) also discharges waste seawater, pursuant to their NPDES permit (No. CA0107239), directly into the ocean at two of the major outfalls along the sea wall. The water discharging from the Scripps outfalls is seawater which has been pumped directly from the Pacific Ocean at Scripps Pier, filtered, and then circulated through the laboratories and aquaria of SIO, Stephen Birch Aquarium-Museum, and National Marine Fisheries Service aquaria. After circulation, the seawater is then discharged across the beach directly into the San Diego Marine Life Refuge ASBS. Prior to 2004, this system discharged into the MS4.

Although the vast majority of the urban runoff at La Jolla Shores reaches the ASBS via outfalls from pipes and weep holes, several natural drainage features may also discharge urban runoff within the watershed directly onto beaches and off of cliffs. These natural systems, however, are ephemeral in nature and transport urban runoff only during storm events.

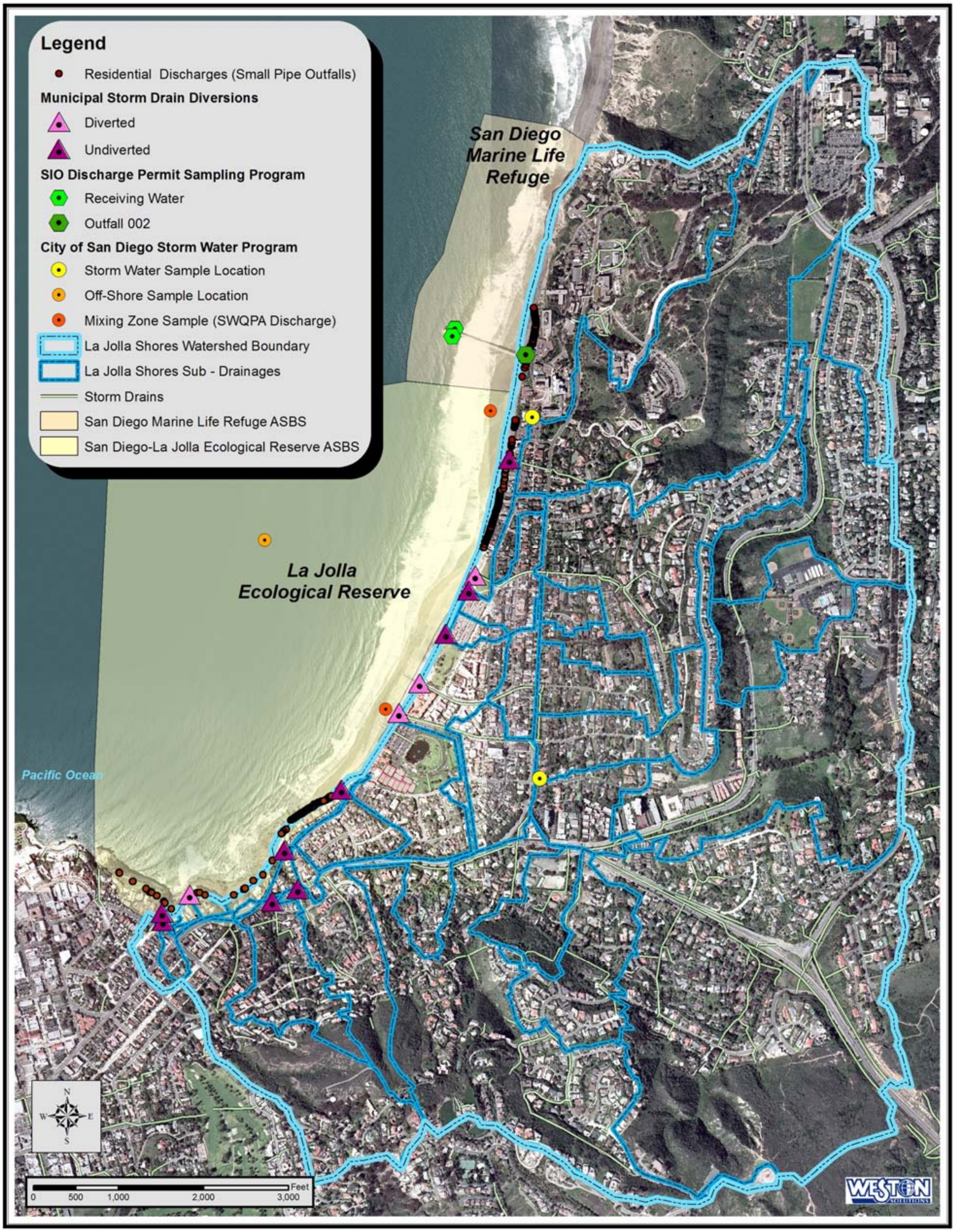

Figure 13. Discharges within La Jolla Shores Coastal Watershed.

## 2.4 Constituents of Issue

The chemical and biological results presented in Section 1 indicate that the primary constituents of issue contained in storm water runoff from the La Jolla Shores Coastal Watershed are copper, fecal indicator bacteria, dioxins/furans, and turbidity. In four wet season sampling events conducted over a two-year time period, these were the only constituents that were detected more than once above Basin Plan water quality guidance criteria. Enterococci bacteria, total PAHs, and dioxins/furans (expressed as TCDD equivalents) were the only constituents detected above Ocean Plan guidance criteria in water collected from mixing zone and offshore sampling locations.

Detectable levels of organophosphorus pesticides and synthetic pyrethroids were found in storm drain and mixing zone samples during one of the four monitored storm events. As a result, pesticides have been included as a constituent of issue for the La Jolla Shores Coastal Watershed. Pesticides, including chlorinated and OP pesticides and synthetic pyrethroids, are currently considered to be emerging contaminants that have the potential to be a long-term issue within the City of San Diego and a future COI within the La Jolla Shores Coastal Watershed. Previous monitoring performed in Chollas Creek found detectable levels of pesticides in areas of urban and residential use (Weston Solutions, 2006). Based upon its predominantly residential land use, the La Jolla Shores Coastal Watershed would be expected to contain, at a minimum, trace amounts of these pesticides in its urban runoff.

As stated in the previous section, the identification of constituents of issue based on the results of the storm water characterization study was to develop a target analyte list for the ecological assessments, and a target constituent list for the evaluation of potential structural and non-structural Best Management Practices (BMPs). Potential impacts from storm water to the ASBS are evaluated using a holistic approach that includes assessment of water quality monitoring, toxicity testing, bioaccumulation studies, biological surveys and physical properties data. The potential storm water impact based on this holistic approach is discussed in the Watershed Management Plan following the discussion of results from the ecological assessment and tidal studies. The results of these studies and assessments are the basis for the design approach and impact reduction goals of the proposed BMPs. The impact reduction goals of the BMPs will also be based on the relative impact of storm water as it relates to other potential impacts to the ASBS. These other potential impacts include such things as cross contamination from tidal flows, public use, air deposition, land use, and physical environmental changes. Higher relative impacts should receive greater attention and resources to cost-effectively preserve the beneficial uses of the ASBS.

Oil and grease, total settleable solids, PAHs, turbidity and copper are common pollutants found in storm water. Run-off from roads and parking lots contribute oil and grease to storm water while sources for copper, settleable solids, and turbidity may include sediments, soils, vegetation, and atmospheric deposition. Although copper occurs from both natural and anthropogenic sources, it primarily occurs in storm water through atmospheric deposition of vehicle emissions and brake pad dust. Similarly, although polycyclic aromatic hydrocarbons (PAHs) can occur naturally, they are primarily the result of anthropogenic activities related to the incomplete burning of coal and fossil fuels and in products such as asphalt, coal tar, crude oil, creosote, and roofing tar. Atmospheric deposition of contaminants that accumulate in storm water flow is also a possible source of the detected PAHs.

### 2.4.1 Turbidity and Sedimentation

Turbidity is included as a constituent of issue for the ASBS based upon the findings of the storm water characterization study. The results of this study include turbidity levels measured in the storm water samples from the City of San Diego's sampling locations (S1 and S2) and from SIO Outfall 002 that were above the water quality guidance criteria, in addition to the results of the toxicity tests that indicated a possible toxic response in giant kelp. Turbidity levels in storm water could impact the ASBS if they were to produce a long-term reduction of light penetration. A significant attenuation of light within the ASBS over an extended period of time could impact phytoplankton and macroalgal growth. While this scenario is possible, it should be noted that although storm drain turbidity levels were above Basin Plan guidance criteria, turbidity levels measured in the mixing zone and ocean samples for the same storm event were approximately two orders of magnitude below Ocean Plan guidance criteria.

Sediment transport from the watershed to the MS4 was evident by repeated burial of sampling equipment mounted in the storm drains from sediment loading. This occurred at both of the MS4 monitoring locations (S1 and S2). Much of this loading may be coming from the upper watershed areas that are characterized by undeveloped canyon and open space land uses. Erosion from development, ground destabilization from invasive species, and minor ground disturbances around these open spaces may be the source of the sediment loads.

To determine if impacts occur from suspended sediment loads entering the ASBS via storm water outfalls, further study may be required. At this time, it remains unclear what dilution factor is involved when the suspended sediment in storm water enters the mixing zone. Additionally, if it is determined that impacts may occur as a result of storm water entering the ASBS, it is unclear how long the potential condition or impact would remain. Determining the types of sediment contained in the solid fraction of storm water as well as what constituents may be complexed with them in the water column is recommended. If the sediments are primarily coarse grain material, they may benefit the ASBS through beach replenishment as coarse grain materials generally are not a transport mechanism for other constituents of issue. If the sediments are predominantly finer particles, however, they may result in higher turbidity and TSS, and may complex with other constituents that adsorb to fine particulates.

### 2.4.2 Copper

Copper is both a micronutrient and toxin that is known to strongly adsorb to organic matter as well as to carbonates and clay. Although copper sorption to particulates significantly reduces its bioavailability, copper remains highly toxic in aquatic environments and has the capacity to bioconcentrate in the organs of both fish and mollusks (Owen, 1981). Copper also effectively acts as an algaecide when combined with sulfate, chloride or other compounds. Single-cell and filamentous algae and cyanobacteria are particularly susceptible to acute effects of copper, resulting in reductions in photosynthesis and growth, loss of photosynthetic pigments, disruption of potassium regulation, and mortality (USEPA, 2006).

Total and dissolved copper levels in City storm water samples and total copper levels in SIO Outfall 002 samples were detected at concentrations above the 30.5 mg/L total copper and 29.3

mg/L dissolved copper guidance criteria listed in the Basin Plan. However, the City's mixing zone and offshore copper concentrations as well as SIO's receiving water copper concentrations were all below Ocean Plan guidance criteria. Therefore, although concentrations in storm water within the City's MS4s and SIO's MS4 are above Basin Plan water quality criteria, the dilution of these discharges within the mixing zone may result in lower concentrations in the ocean waters within the ASBS. Dilution study results are presented within this Watershed Management Plan as part of the discussion of tidal studies and potential impact from cross tidal currents.

As discussed above, potential impacts from storm water entering the ASBS will be evaluated using a holistic approach that includes an assessment of water quality monitoring, toxicity testing, bioaccumulation studies, biological surveys and physical properties data. The potential storm water impact based upon this holistic approach is addressed within this Watershed Management Plan following the discussion of the results of the ecological assessment and tidal studies. The results from these studies and assessments are the basis for the design approach and impact reduction goals of the proposed BMPs.

### 2.4.3 Fecal Indicator Bacteria

Fecal indicator bacteria are used to identify waters that may be at risk for containing disease causing pathogens. Thus, if relatively high numbers of fecal indicator bacteria are measured in an environment, it is assumed that there is an increased likelihood of pathogens being present as well. Fecal coliform levels within the City's MS4s were elevated above Basin Plan guidance criteria at sampling locations S1 and S2, and at SIO's Outfall 002, but were below Ocean Plan guidance criteria in the mixing zone and offshore samples. Enterococci bacterial concentrations within the mixing zone at sites D1 and D2 were above Ocean Plan guidance criteria while analysis of SIO receiving water samples did not detect enterococci. Prevailing longshore currents, dilution effects, and toxicity from seawater may prevent bacteria in storm drain effluent from reaching beyond the mixing zone.

### 2.4.4 Land Use

Within the La Jolla Shores Coastal Watershed drainage area, land is used primarily for residential housing, followed by transportation, parks, and public facilities (Table 18). Approximately 50 percent of the land is dedicated to residential housing while transportation and parking facilities comprise about 18 percent of total land use. Parks and public facilities comprise an additional 16 and 12 percent of the land use within the watershed, respectively, while two percent is characterized as vacant and two percent is used commercially by restaurants and retail stores. Less than one percent of the watershed is currently undergoing construction activity. Land use is listed in Table 18 and depicted graphically in Figure 14.

**Table 18. Land use within La Jolla Shores Coastal Watershed.**

| Category | Total Acres | % Total Area |
|---|---|---|
| Residential | 1,074.42 | **65.57%** |
| ➢ Single Family Residence | 985.92 | 60.17% |
| ➢ Multi-Family Residence | 88.50 | 5.40% |
| Parking Lot | 18.49 | **1.13%** |
| Open Space | 413.10 | **25.21%** |
| Commercial | 132.49 | **8.09%** |
| Grand Total | 1,638.50 | 100% |

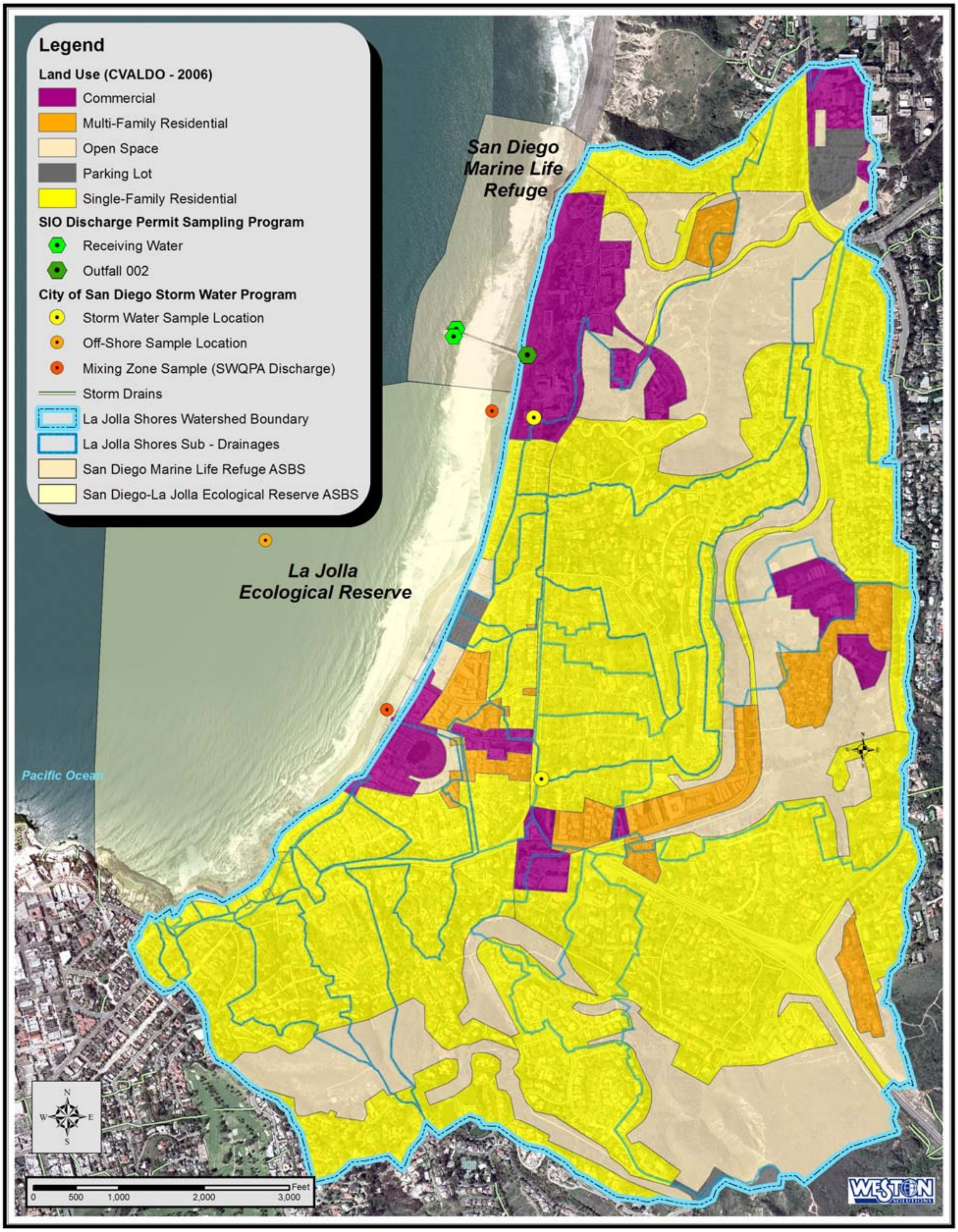

Figure 14. Land use within the La Jolla Shores Coastal Watershed.

### 2.4.5 Potential COI Sources

Each of the 32 sub-drainages is numbered and its boundaries outlined in Figure 15. Within this figure, potential sources for each of the COIs (copper, turbidity, bacteria, and pesticides) for the La Jolla Shores Coastal Watershed are also depicted. During the three monitored rain events in 2005-2006, turbidity was detected at levels above the Basin Plan's water quality guidance criteria in both of the sampled sub-watersheds and within the SIO drainage leading to Outfall 002. Potential sources of turbidity within the La Jolla Shores Coastal Watershed include urban and residential land uses as well as transportation uses such as roads, highways, and parking facilities. Sediment loading to storm water may result from land disturbance activities at residences that include landscaping, construction activities, and exposed un-vegetated soils. Construction activities would likely generate the largest sediment load and are regulated under the SUSUMP. Road grit and finer particles not collected through street sweeping can also be a source of sediment loading in storm water. Each of these land uses is common throughout the watershed. The plant nursery in sub-drainage 18 and the golf course in sub-drainages 8 and 9 could also potentially be contributing suspended sediment to the ASBS during rain events. Another likely source of sediment is erosion of canyon and open space areas within the watershed. Areas of increased storm water flows and velocities have resulted from development around open space areas and lead to higher rates of erosion. The introduction of invasive plant species and disturbances from public access can also lead to increased erosion and sediment loading. Also, copper, lead, and zinc concentrations in storm water have been shown to have strong statistical correlations to total suspended solids.

Total and dissolved copper concentrations were detected at levels higher than their respective hardness-based Basin Plan WQO in both sub-drainage areas sampled during the 2005-2006 wet weather monitoring season. Aerially deposited contaminants that accumulate and subsequently wash off from dry weather or wet weather flows are one suspected source of these metals. Urban roadways within both the northern and southern sub-drainages are one source of aerially deposited total and dissolved copper. Brake pad discharge in particular, has been estimated to be responsible for 80 percent of copper in urban storm water runoff (Woodward-Clyde Consultants, 1994). The nursery in sub-drainage 18 may also potentially be a source for total and dissolved copper. The slightly higher levels of both total and dissolved copper detected in the samples from the southern drainage may be related to the higher traffic density in these sub-drainage areas. The fueling station located at the junction of sub-drainages 22, 32, and 34 may also be a potential source of metals.

Fecal indicator bacteria were detected at concentrations above the Basin Plan water quality objective in samples from both the northern and southern sub-drainages sampled within the watershed. Potential sources of bacteria within the watershed's urban runoff include residential activities (dog waste, over-irrigation, waste management). Slightly higher levels of bacteria were detected in the northern sub-drainage, where a nursery is located, than in the southern sub-drainage. Other potential sources of fecal coliforms and enterococci include the cluster of restaurants around sub-drainage 34.

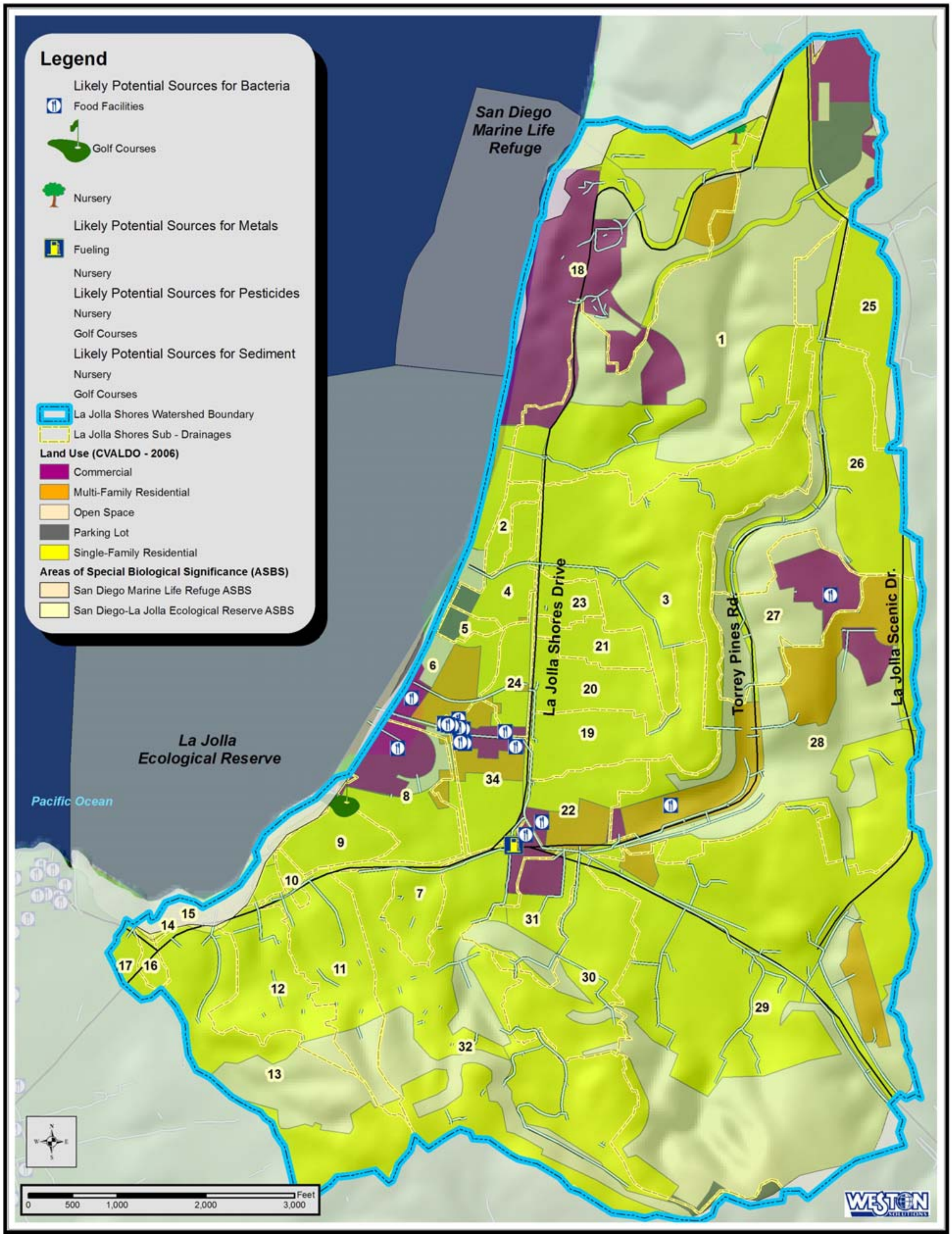

Figure 15. Potential sources of COIs within La Jolla Shores Coastal Watershed.

Pesticides (synthetic pyrethroids, OP pesticides, or organochlorine pesticides) were detected in samples from only one of the four monitored storm events. The April 2007 storm had detectable concentrations of chlordane, diazinon, malathion, bifenthrin, and prallethrin. Potential sources for these and other pesticides include residences, nurseries, and golf courses that may use them for maintaining their landscaping. A nursery is located within sub-drainage 18 and a small golf course resides in sub-drainages 8 and 9. Residential use of pesticides would likely be the largest potential source of pesticides given the predominately residential land use in the watershed.

### 2.4.6 Potential COI Impacts to the ASBS

Turbidity, total and dissolved copper, fecal indicator bacteria, and pesticides have been identified as constituents of issue based on the storm water quality study. These constituents will be further assessed using a holistic approach to determine potential impacts to the ASBS. This assessment will evaluate the results of the water quality, toxicity, bioaccumulation, dilution, tidal, and mass balance studies in determining the potential impacts. The relative impact of storm water compared to cross contamination from tidal currents, air deposition, and public use will also be evaluated. For the discussion presented below, the potential impact of specific constituents of issue will be addressed. Assessment of any single impact to the ASBS will be based upon its relative influence upon the overall health of the ecosystem.

Turbidity levels detected in each of the major sub-drainages may impact the ASBS by reducing light penetration necessary for phytoplankton and macroalgal growth. Sediment transport through the storm drain system occurred during each rain event, as evidenced by repeated burial of sampling equipment mounted in the storm drains at both the northern and southern sub-drainage sample locations. Turbidity concentrations in storm drain samples used for bioassay testing may have contributed to some of the observed toxicity in the chronic kelp test, as decreased light penetration through storm drain sample water may have affected the growth of kelp embryos. The results may also indicate other factors such as physical debris preventing embryo attachment to the petri dish. Based on wet weather sampling data provided in this report for the La Jolla Shores ASBS, turbidity levels measured in the mixing zone and outer ocean samples were below the Ocean Plan guidance criteria.

Total and dissolved copper concentrations detected in urban runoff from each of the major sub-drainages within the watershed could potentially affect the ASBS through direct toxic impacts to fish and algae. Similar to the pattern observed in turbidity analyses, dissolved and total copper concentrations within the MS4 were above the Basin Plan guidance criteria while mixing zone and offshore waters had concentrations below Ocean Plan guidance criteria. As noted previously, the Basin Plan criteria are applied to receiving waters and not the MS4. Copper is both a micronutrient and toxin that is known to strongly adsorb to organic matter as well as to carbonates and clay. Although its sorption to particulates significantly reduces its bioavailability, copper is considered toxic in aquatic environments and has the capacity to bioconcentrate in the organs of both fish and mollusks (Owen 1981). The results of the bioaccumulation studies are discussed in later sections of the Watershed Management Plan. These studies will help to identify if copper is bio-available and accumulating in sand crabs and mussels. Copper also effectively acts as an algaecide when combined with sulfate, chloride or other compounds. Single-cell and filamentous algae and cyanobacteria are particularly susceptible to acute effects of copper, resulting in reductions in photosynthesis and growth, loss of photosynthetic pigments, disruption of potassium regulation, and mortality (USEPA 2006). Further toxicity testing of storm water and mixing zone samples should be performed to assess if copper concentrations are resulting in toxic effects.

Fecal coliform levels above Basin Plan guidance criteria were detected in both of the sampled sub-drainages as well as in samples collected from Scripps Outfall 002. Enterococci concentrations above Ocean Plan guidance criteria were detected in the mixing zones at both sampling outfall locations. The presence of sufficient numbers of these bacteria may indicate an increased health risk to recreational users of the ASBS during wet weather events. Fecal indicator bacteria are used to identify waters that may be at risk for disease-causing pathogens. If relatively high numbers of fecal indicator bacteria are measured in an environment, an increased likelihood of pathogens being present is assumed.

Trace amounts of pesticides were detected in storm drain and mixing zone samples during the April 2007 storm event. Because pesticides have the ability to bioconcentrate within the food web, they will remain a COI for the La Jolla Shores ASBS into the foreseeable future since pesticide runoff into the ASBS has the potential to affect algal growth as well as to compromise the health of vertebrate and invertebrate populations.

These potential impacts represent possible effects from the constituents of issue. The actual impact assessment, however, is based on considering the results of various studies in a holistic approach. Water quality is one of several potential impacts to the ASBS. The impact assessment for the La Jolla Shores ASBS is presented in the Watershed Management Plan following the presentation of the ecological assessment and the tidal and dilution studies. The results of these studies will then be assessed with the water quality, watershed characterization, and potential source evaluation presented in this section.

As stated previously, the identification of constituents of issue is based upon the results of the storm water characterization study. The purpose of this study was to develop a target analyte list for the ecological assessments, and a target constituent list for the evaluation of potential structural and non-structural Best Management Practices (BMPs). The results from these studies and assessments are the basis for the design approach and impact reduction goals of the proposed BMPs. The impact reduction goals of the BMPs will also be based on the comparative impact of storm water in relation to the other potential impacts to the ASBS. Future investigations examining the relationship between COC metal concentrations in sediment contained within La Jolla Shores' urban runoff are recommended. If metals bound to fine sediment in urban runoff are the driving factor in toxic responses observed in kelp, reducing fine grained sediment loads should be considered critical to selecting effective BMPs. Other potential impacts include cross contamination from tidal flows, public use, air deposition, and physical environmental changes. Higher relative impacts should receive greater attention and resources to cost effectively preserve the beneficial uses of the ASBS.

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# APPENDIX B

# Bioaccumulation and Circulation Study of La Jolla Bay

# DRAFT BIOACCUMULATION AND CIRCULATION STUDY
# LA JOLLA BAY

**Prepared by**

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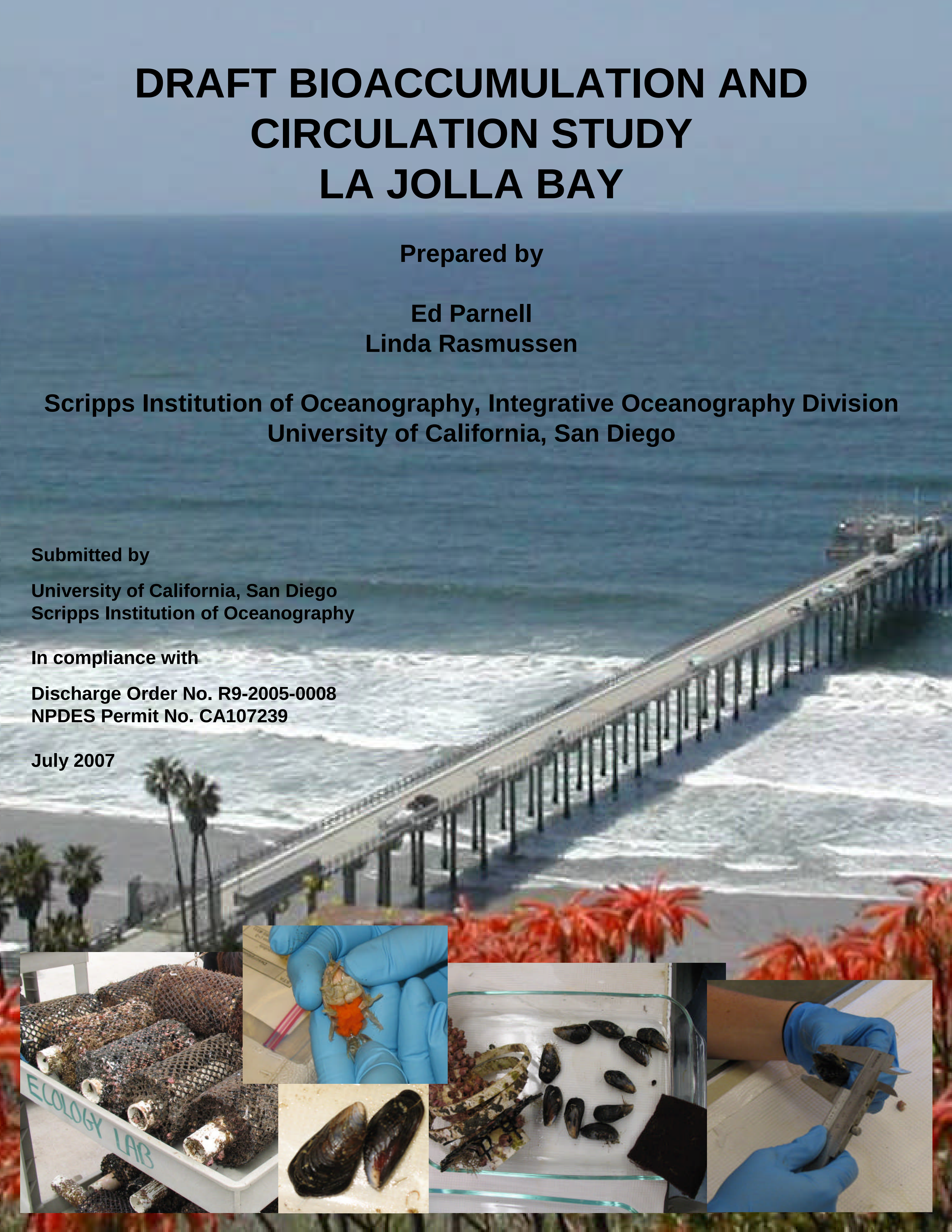
**Submitted by**

**University of California, San Diego**
**Scripps Institution of Oceanography**

**In compliance with**

**Discharge Order No. R9-2005-0008**
**NPDES Permit No. CA107239**

**July 2007**



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**APPENDIX B – LIST OF CONSTITUENTS**

## EXECUTIVE SUMMARY

Scripps Institution of Oceanography (SIO) conducted a bioaccumulation study in the San Diego Marine Life Refuge (SDMLR) Area of Special Biological Significance (ASBS) as part of the Monitoring and Reporting Program (MRP) for the seawater and stormwater discharges from SIO permitted under NPDES Permit No. CA0107239. As specified in Condition C.4.f of MRP No. R9-2005-0008,

> *"Within four and half-years of the adoption of this Order, a bioaccumulation study using sand crabs (Emerita analoga) and mussels (Mytilus californianus) must be conducted to determine the concentrations of metals near field and far field (up and down coast, and offshore) in the ASBS. This Regional Board, in consultation with the Division of Water Quality, must approve the study design. Based on the study results, the Regional Board, in consultation with the Division of Water Quality, may limit the bioaccumulation test organisms, required in subsequent permits, to only sand crabs or mussels (State Board Resolution No. 2004-0052, 3.1)."*

The purpose of this bioaccumulation study was to assess the impact of seawater and stormwater discharges on the health of the SDMLR ASBS ecosystem. Specifically, the study evaluated the accumulation of metals in the tissue of mussels and sand crabs from May through July 2006 (12 weeks). There was one rain event during this time period and several rain events in April, just prior to the study.

The study area, referred to throughout this report as the La Jolla Bay, included the SDMLR ASBS (herein referred to as ASBS No. 31) and the La Jolla Ecological Reserve (herein referred to as ASBS No. 29). In addition, mussels from the mouth of the San Diego Bay in Pt. Loma (an area with documented contamination) were evaluated for comparison purposes. The study was performed in accordance with the Bioaccumulation Study Sampling and Analysis Plan that was submitted to the San Diego Regional Water Quality Control Board (RWQCB) on February 27, 2006 and approved by the RWQCB on March 2, 2006.

Bioaccumulation is a useful indicator of pollution and provides a relative measure of biologically available pollutants in time and space. Bioaccumulation was studied in two species that feed on suspended particles, the California mussel, *Mytilus californianus,* and the sand crab, *Emerita analoga*. Suspension feeders are useful for bioaccumulation studies because they feed on all forms of suspended particulate organic matter and absorb dissolved organic matter. Mussels can therefore integrate contamination over time within their tissues. Circulation within La Jolla Bay was studied to determine likely fates of contaminants loaded within the ASBS and to give a first-order approximation of circulation patterns and transport rates within the Bay. Circulation was measured using four Acoustic Doppler Current Profilers at two shallow and two deep sites which were deployed for 4 months, including the period the bioaccumulation study was underway.

## Bioaccumulation Studies

The bioaccumulation of metals, pesticides, PAHs, and PCBs by mussels was studied along approximately 12 kilometers (km) of coastline from La Jolla to Del Mar, extending well north and south of the two ASBS located within La Jolla Bay using caged mussels that were deployed for three months. Mussels were also outplanted near the mouth of San Diego Bay in Pt. Loma, outside of the study area, for comparison. The bioaccumulation of metals and PAHs by sand crabs was studied by sampling crabs at sandy beaches over nearly the same spatial scale. The mussel and sand crab sampling stations are depicted on Figure ES.

### ***<u>Mussel Results</u>***

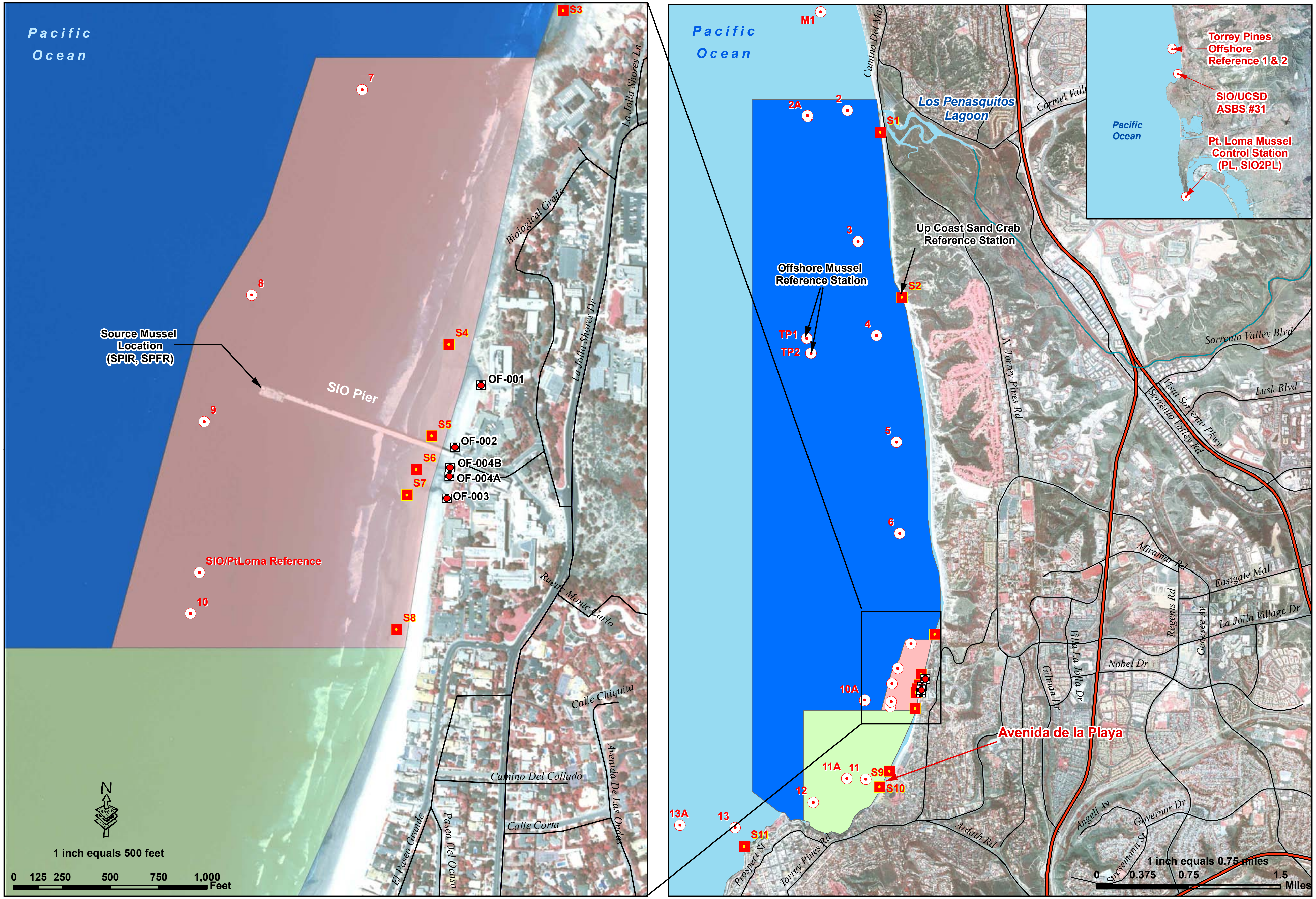
Mussel bioaccumulation results indicated no statistically significant contamination by chlorinated pesticides, organophosphorous pesticides, PAHs, or PCBs off La Jolla and Del Mar (the study area). Metal concentrations in the mussel tissue were higher at the following sites relative to other sites within the study:

1. Site 9, located immediately south of Scripps Pier within ASBS 31. The mussels from this site accumulated elevated concentrations of nickel, iron, manganese, and chromium.

2. The sample area between the Caves in southern La Jolla Bay (Site 12 located on the southern boundary of ASBS 29) extending out around Pt. La Jolla and down to the southern extent of the study off the Children's Pool (Site 13). Mussels located between the Caves and the Children's Pool had greater concentrations of arsenic, cadmium, lead, and zinc.

3. Site SIO2PL, located near the mouth of San Diego Bay in Pt. Loma, outside of the two ASBS. The mussels from this site accumulated elevated concentrations of aluminum, iron, lead, manganese, nickel, selenium, and zinc. In addition, mussels at this site also had high concentrations of the PAH, phenanthrene.

Mussels placed near the mouth of San Diego Bay in Pt. Loma and at study sites located between the Caves (southern boundary of ASBS 29) and Children's Pool (outside of ASBS) appeared stressed exhibiting lower lipid concentrations and growth. However, the mussels sited nearest the Scripps Pier exhibited no sign of stress despite having higher concentrations of chromium, nickel, iron, and manganese relative to other sites within the ASBS. Metal contamination near the Scripps Pier appeared to be highly localized. Mussels with elevated tissue concentrations of arsenic, cadmium, lead, and zinc exhibited decreased growth rates compared to the other mussels in the study, however it is not known if this is a cause and effect. The mussels within the two ASBS did not exhibit signs of stress.



## Legend

| | |
|---|---|
| ⊠ | Permitted Outfalls at SIO |
| 🟥 | Sand Crab Sample Station |
| ⊙ | Mussel Sample Station |
| — | Rivers |
| — | Major Freeways |
| 🟦 | Lagoons |

**State Water Quality Protection Areas**

| | |
|---|---|
| 🟩 | La Jolla Ecological Reserve (ASBS 29) |
| 🟦 | Underwater Park |
| 🟥 | San Diego Marine Life Refuge (ASBS 31) |

## Map Notes

Data Source
AMEC - Sampling Locations
AMEC - Preserve Boundaries created from SD RWQCB maps
SANDAG - Freeways, Local Roads
SANDAG - 2000 2-foot Infrared Imagery

Projection:
Stateplane, California 406, NAD 83, Feet

Date: 05/02/2007
Path: W: martin\sd05\aquatics\ucsd\sampling_locations_actual_mussel_sandcrab_es.mxd

Site Map - Mussel and Sand Crab Sampling Station Locations
Scripps Institution of Oceanography, University of California at San Diego

FIGURE
ES

The data from this study was also compared to data from mussels sampled along the entire west coast of the United States under the Mussel Watch Program (see Figures 35-46). Relative to other sites located along the entire west coast, chromium, nickel, and arsenic appear to be the metals of most concern in the present study.

**TABLE ES-1: Constituents of Interest Based on Mussel Results**

| Sampling Station ID | Location | Constituents that are higher compared to other sites in the study | Constituents that are higher compared to West Coast Mussel Watch Program data | Decreased Growth Rates observed at this Site? |
|---|---|---|---|---|
| Site 12 | Southern Boundary of ASBS 29 | Arsenic, Cadmium, Lead, and Zinc | Arsenic | YES |
| Site 13 | Outside of both ASBS, to the south | Arsenic, Cadmium, Lead, and Zinc | Arsenic | YES |
| Site 9 | ASBS 31, south of Scripps Pier | Chromium, Nickel, Iron, and Manganese | Chromium and Nickel | NO |
| SIO2PL | Source mussels from Scripps Pier Outplanted in Pt. Loma | Aluminum, Iron, Lead, Manganese, Selenium, Nickel, Zinc, and Phenanthrene (PAH) | Nickel | YES |

## ***Sand Crab Results***

Bioaccumulation results for sand crabs included:

1. Fourteen of the 15 metals analyzed for were observed at concentrations greater than the analytical method reporting limits; and

2. PAHs were not detected above the laboratory method reporting limits in any of the samples collected within the two ASBS. Of the 46 PAHs that were analyzed for, only one sample at the site located several km north of both ASBS had a concentration of a single PAH greater than its reporting limit (2,6 Dimethylnapthalene).

The sand crab metal bioaccumulation results were difficult to interpret due to the strong dependence of some metals on size and gravid condition (egg-bearing or not). It was not possible to sample sand crabs of similar sizes and gravid compositions at the sites because sand crab populations were patchy and composed of different sized animals. Significant negative relationships between metal concentrations and size/gravid condition were observed for antimony, arsenic, and lead. In other words, sites with sand crabs that had higher concentrations of antimony, arsenic, and lead compared to the other sampling stations in the study had fewer gravid females and smaller sand crabs then the other sampling stations. Sites with higher concentrations of aluminum, beryllium, nickel, and zinc compared to the other sampling stations in the study, on the other hand, had larger sand crabs and a higher abundance of gravid females compared to the other sites (positive relationship).

There were no distinct spatial patterns of metal concentrations after accounting for size/gravid dependencies. However, the station located immediately south of Scripps Pier had elevated concentrations of nickel, cadmium, and chromium. This site was located immediately onshore of the mussel site where mussels also had elevated concentrations of nickel and chromium in addition to other metals. There was an abundance of large and gravid female sand crabs at this site compared to other sites.

Comparisons with a previous sand crab study conducted over a spatial scale of approximately 400 km in central California showed that metal concentrations in sand crabs from this study were distinct from sand crabs further north. Crabs in this study were characterized by higher concentrations of arsenic, zinc, and selenium, while crabs in the central California study were characterized by higher concentrations of cadmium, manganese, copper, and aluminum. The variability of sand crab metal compositions among sites within the smaller scale of this study (~12 km) was equivalent to that for the larger scale study in central California.

Sand crabs are not recommended for future studies in the La Jolla Bay because of the dependence of metal concentrations on the size and gravid condition of the crabs which could not be controlled and varied at each sampling station.

### Circulation Studies

Four Acoustic Doppler Current Meters (ADCPs) were deployed in La Jolla Bay for approximately 17 weeks from April to July 2006 to help determine circulation patterns within the bay. The circulation observed during this limited time period was characterized by (a) moderately high velocity flow at all sites, (b) weak tidal currents relative to the mean flow, (c) frequent vertically sheared flow (different flow directions between surface and mid-bottom currents), (d) a shallow wind-driven surface layer, (e) a large degree of temporal variability in direction, and (f) fairly strong coherence between sites. The complex topography of the region is likely to be a factor in the variability of the circulation.

Tidal current magnitudes were small relative to the magnitude of subtidal (periods longer than a tidal cycle) currents. Generally, tidal currents reverse in direction over a tidal cycle such that major tidal components effectively move contaminants back and forth along the shoreline, while subtidal currents represent a larger scale mean flow and provide an indication of contaminant removal from the system. In La Jolla Bay, subtidal current magnitudes were five to ten times greater than tidal currents.

Surface and subsurface flows were markedly different at all locations. The surface layer in which currents were significantly correlated with winds comprised only the top 2-5 meters of the water column. At mid-depths and lower, subtidal currents were coherent between sites, but highly uncorrelated with wind. Lower water column current directions were often in opposition to surface currents. Tidal currents also showed a large degree of variability with depth, with direction rotating as much as 180 degrees between the surface and mid-depths. It is not known what physical processes are responsible for the vertical variability in current direction. However, the topography of La Jolla Bay is complex, with curvature of the coastline, a headland, and two large submarine canyons, and is likely to play a strong role in the current variability.

Analysis of the ADCP data time series indicated a predominant circulation pattern in the alongshore direction within the region. This pattern (referred to as Mode 1 in this report) accounts for 84% of the variability at the surface, but decreases with depth to 54% at the bottom. It is also notable that the reversal in current direction at depth appears in the Mode 1 pattern. Other patterns (referred to as Modes 2-4 in this report) account for 10-21% of the current variability at the bottom. The increasing variability in pattern deeper in the water column suggests that topographic effects unique to this area may significantly influence transport pathways within the La Jolla bay.

Transport times were estimated for storm events that occurred during the study. During the largest storm (5 April 2006) advective transport through the ASBS would have taken approximately 1-2 hours at the surface, and up to 8 hours near the bottom. However, as frequently seen in the ADCP time series, during this period the direction of transport at the surface was opposite that near the bottom (in this case, surface velocity was northward, bottom velocity southward).

Based on the data from the circulation study, pollutants on the surface of the water in the La Jolla Bay would generally be transported northward in the alongshore direction within the region. Pollutants near the bottom, on the other hand, are frequently transported in the opposite direction (southward). There is a great deal of variability in the current patterns throughout the water column, most likely as a result of the varying topography in the La Jolla Bay (e.g., two submarine canyons, coastline curvature, and a headland).

## SECTION 1.0 – BIOACCUMULATION STUDIES

Bioaccumulation is the process of organisms taking up substances from their environment and has been extensively utilized in studies of environmental pollution. For substances to bioaccumulate, they must be in forms suitable for uptake across the cell membrane. Such forms are referred to as bioavailable. The anthropogenic release of toxic bioavailable substances, and their transformational precursors, into the environment can affect natural systems ranging from changes to the physiology of individuals within a species to dramatic alterations in ecosystems via cascading effects of altered interactions among species. Because of their importance to ecosystem health, the concentration of toxic bioavailable pollutants can be a useful indicator of the extent that a particular area or ecosystem is impacted by anthropogenic activities.

The Mussel Watch Project, administered under the National Status and Trends Program of NOAA, uses select species of bivalve mollusks as sentinels of environmental pollution in aquatic systems. Bivalves, such as mussels, are particularly useful as recorders of environmental pollution because of their feeding mode. These animals feed by filtering suspended particles including phytoplankton, zooplankton, and all other forms of suspended particulate organic matter (SPOM) and absorb dissolved organic matter (DOM). Many contaminants associated with SPOM and DOM are then biomagnified by bivalves and incorporated - ‘recorded’ - into their tissues. Temporal trends in environmental contaminants at multiple sites in lakes, estuaries, and nearshore waters have been followed as part of the Mussel Watch Project since its inception in 1986.

In the present study, the bioaccumulation of metals, pesticides, PAHs, and PCBs by the California mussel (*Mytilus californianus*), was studied along a ~12 km section of coastline, which included the San Diego Marine Life Refuge (ASBS 31) and the La Jolla Ecological Reserve (ASBS 29) as shown on Figure ES and Figure 1. The goal of this study was to determine the concentrations of metals and a few selected constituents (e.g., PAHs) near field and far field (up and down coast, and offshore) in and adjacent to both ASBS in the La Jolla Bay. This study differed from the Mussel Watch Project (MWP) because mussels within a narrow size range were caged and outplanted to various sites rather than sampled from available populations as is done in the MWP. This was done because much of the area is sandy and therefore not appropriate habitat for mussels. The size range was narrow to control for size and growth dependence on contaminant uptake kinetics. The spatial range and spacing of sampling stations and their locations relative to known sources of surface runoff were chosen to provide adequate spatial resolution to characterize the accumulation of the selected constituents both near field and far field within the ASBS and north and south of the La Jolla Bay. The watershed of La Jolla Bay is small compared to watersheds located to the north and south. Therefore, these remote watersheds may be more important sources of pollutants within La Jolla Bay. Mussel contaminant concentrations from this study were also compared to contaminant levels observed in mussels along the west coast of the U.S. to determine the relative levels of contamination in waters offshore of La Jolla and Del Mar.

Bioaccumulation of metals and PAHs by sand crabs (*Emerita analoga*) was also studied as part of this project. Sand crabs are suspension feeders that live in the swash zone of sandy beaches and are therefore potentially useful bioaccumulators in this common habitat. They are directly exposed to surface runoff as it enters the coastal zone. Sand crabs were studied at sites located to address the same goals as for the mussel component except that sand crab sites were necessarily limited to soft bottom intertidal areas. Concentrations of metals and PAHs were compared to concentrations observed over a much larger spatial scale (~400 km) in Central California (Dugan et al., 2005) to gauge the relative levels of contamination at beaches in La Jolla and Del Mar.

## 1.1 Mussels

### 1.1.1 Methods

#### 1.1.1.1 Field Program

Source mussels for all the sites within the study, except one (see next paragraph) were collected from the intertidal zone of pilings supporting the SIO pier. These mussels were collected on April 24, 2006. A randomly selected sample of these source mussels was immediately frozen for later analysis (SPIR). At the end of the study, another sample was collected from the source mussel location (Scripps pier pilings) on August 1, 2006 and frozen immediately for analysis (SPFR).

Mussels were also collected from the riprap at Zuniga Point in Pt. Loma, located on the eastern margin of the entrance to San Diego Bay, to gauge the uptake and depuration of contaminants from mussels. Previous studies have indicated that uptake of contaminants within mussel tissue occurs within a few weeks (Peven et al., 1996). Therefore, comparisons of contaminant concentrations between mussels harvested at Pt. Loma and transplanted to La Jolla with mussels harvested in La Jolla and deployed back to La Jolla and Pt. Loma (Site SIO2PL) are useful for gauging the uptake/depuration of mussels exposed to these different contamination climates. The mussels that were harvested off Pt. Loma were collected on April 25, 2006 and deployed to Site PL2SIO, located along the 8 m contour near the SIO pier. A randomly selected sample of the mussels harvested off Pt. Loma was collected and immediately frozen for chemical analysis (PLIR).

Mussels were outplanted at twenty three sampling stations located along the 8 m and 16 m contours ranging from southern Del Mar to La Jolla and at one sampling station in Pt. Loma (see Figs. 1 and 2, and Table 1) from April 29 through May 2, 2006. Stations along the 8 m contour ('nearshore sites') were located approximately 1200 to 1500 m apart outside the ASBS, and were spaced ~300-400 m inside the ASBS. Mussels were caged to prevent predation by fishes. Spacing of the study sites outside the ASBS represented an optimization between analytical costs and adequate spatial resolution of different water masses known to bathe this section of coastline (P.E. Parnell and L.A. Levin, unpublished data). Coastal water masses frequently have different chemical constituents and plankton associated with them

**Table 1. List of Study Site Details for California Mussels**

| Site ID | Site Type | Bottom Depth (m) | Mussel Depth (m) | Mussel Location | Mussels per Cage /Reps | Bottom Type | Other Site Identifiers |
|---|---|---|---|---|---|---|---|
| 1 | NS/25B | 8 | 7 | B | 10/3 | H | |
| 2 | NS/25B | 8 | 7 | B | 15/3 | S | |
| 2A | OS/50B | 16 | 7 | B | 10/3 | S | 2a |
| 2AM | OS/Moor | 16 | 15 | M | 10/3 | S | 2} |
| 3 | NS/25B | 8 | 7 | B | 10/3 | S | |
| 4 | NS/25B | 8 | 7 | B | 10/3 | S | |
| TP | Ref/Moor | 33 | 7 | M | 15/6 | S | tp |
| 5 | NS/25B | 8 | 7 | B | 10/3 | S | |
| 6 | NS/25B | 8 | 7 | B | 10/3 | S | |
| 7 | NS/25B | 8 | 7 | B | 15/3 | S | |
| 8 | NS/25B | 8 | 7 | B | 10/3 | S | |
| PL2SIO | NS/25B | 8 | 7 | B | 10/3 | S | ps |
| 9 | NS/25B | 8 | 7 | B | 15/3 | S | |
| 10 | NS/25B | 8 | 7 | B | 15/3 | S | |
| 10A | OS/50B | 16 | 15 | B | 10/3 | S | 10a |
| 10AM | OS/Moor | 16 | 7 | M | 10/3 | S | 10} |
| 11 | NS/25B | 8 | 7 | B | 15/3 | S | |
| 11A | OS/50B | 16 | 15 | B | 10/3 | S | 11a |
| 11AM | OS/Moor | 16 | 7 | M | 10/3 | S | 11} |
| 12 | NS/25B | 8 | 7 | B | 10/3 | S | |
| 13 | NS/25B | 8 | 7 | B | 10/3 | H/S | |
| 13A | OS/50B | 16 | 15 | B | 10/3 | H | 13a |
| 13AM | OS/Moor | 16 | 7 | M | 10/3 | H | 13} |
| SIO2PL | NS/25B | 8 | 7 | B | 10/3 | H | sp |
| SPIR | Harv/Ref | Intertidal | Intertidal | SIO Pier Piling | 20/3 | H | sp1 |
| SPFR | Harv/Ref | Intertidal | Intertidal | SIO Pier Piling | 20/3 | H | sp2 |
| PLIR | Harv/Ref | Intertidal | Intertidal | Zuniga Pt. Riprap | 20/3 | H | pl |

Non-harvest sites are ordered by location (north to south). Site type: NS (nearshore), OS (offshore), Harv (mussel harvest site), 25B (bottom sites at 8 m), 50B (bottom sites at 16 m), Moor (mussels suspended on moorings). Mussel location: B (on bottom module), M (suspended on mooring), SIO Pier Piling (collected from intertidal zone of SIO pier pilings), Zuniga Pt. riprap (collected from breakwater rocks at Zuniga Pt., the eastern margin of the entrance to San Diego Bay). Mussels per cage/Reps: the number of mussels in each cage and the number of cages at each site. Bottom type: H (hard bottom), S (soft bottom), H/S (both hard and soft bottom). Other site identifiers were used for some graphs in this report due to space limitations.

(see Parnell, 2001). The range of stations from Del Mar to La Jolla was designed to include water quality influences from Los Peñasquitos Lagoon to the north and water mass distributions affected by the complex circulation offshore of the Pt. La Jolla headland. Spacing within the ASBS was at higher spatial resolution and sites were located at the edges of the ASBS as well as offshore of known sources of surface runoff such as the outfalls located on both sides of the Scripps pier and off Avenida de la Playa. Four sites ('offshore sites') were located along the 16 m contour directly offshore from a subset of the 8 m sites. These sites were chosen for comparison with their 'companion' sites nearer shore and were located to include both ASBS as well as the largest sources of surface runoff in the area, which include the Peñasquitos Lagoon and the storm drain at Avenida de la Playa. There was also an offshore site located just south of Pt. La Jolla to characterize particle-associated pollutants south of the headland. Mussels were placed within a meter of the bottom in cages (three cages per site) at the nearshore and offshore sites. Cages (three per site) were also hung on moorings at the offshore sites at ~7 m deep to correspond with the depth of mussels placed near the bottom at the nearshore sites. Bottom cages at the nearshore and offshore sites were attached to 3 m PVC pipes jetted into the sand at soft-bottom sites and PVC pipes embedded into concrete modules at hard bottom sites. All PVC pipes and concrete modules were deployed for at least one month before mussel deployment. Mussel cages, constructed of PVC and Vexar mesh, were soaked in running seawater for at least 1 month before mussels were deployed.

Two sites were established off Torrey Pines along the 33 m contour as controls/reference sites to both the offshore and nearshore sites. These sites were located ~1500 m from shore and therefore remote from the influence of nearshore buoyant plumes typically produced by surface runoff in southern California during all but the most extreme rainstorms. Mussels at these sites were suspended ~7 m deep on moorings at these sites (3 replicates per site), away from the bottom thereby minimizing their exposure to resuspended particles within the nepheloid layer. The Torrey Pines sites were intended to characterize the background particle contaminant climate of offshore waters. Two sites were established in this area (spaced ~100 m apart) to ensure that at least one control site was intact by the end of the study. Since both sites survived the deployment, mussels from randomly chosen pairs of cages (one from each site) were combined to produce three sets of mussels (three replicates) for chemical analysis.

A remote 8 m nearshore site was established off Pt. Loma (~23 km from SIO, Site SIO2PL), near the mouth of San Diego Bay on the western margin of the ship channel, for comparisons with the study sites off La Jolla and Del Mar. In previous work, mussels deployed off Pt. Loma were more contaminated with PCBs and metals than mussels deployed off La Jolla (P.E. Parnell and B.J. Becker, unpublished data). Therefore, the Torrey Pines and Pt. Loma sites represent reference sites, the former a pristine reference and the latter a contaminated reference.

Mussels that were deployed at the study sites were measured for length, width, and height. The mussels were also cleaned of epiphytes, blotted with paper towels, and then weighed. Individual mussels were marked with numbers using a handheld grinding tool (Dremel). Size measurements and weights were recorded both prior to deployment and upon retrieval for growth determinations.

Thermistors (Onset Computer Inc., Tidbits) were deployed with each set of mussel cages (except at Sites 6 and 13AM due to an insufficient number of sensors). The thermistors were programmed to sample at 5 min intervals. (N.B., the sensor at Site 6 failed).

#### 1.1.1.2 Chemical Analyses

Analytes that mussels were analyzed for are listed by site in Table 2. Specific compounds within these groups are listed, with reporting limits, in Appendix B. Mussels were transferred to AMEC Earth & Environmental Inc. (San Diego, CA) and shipped frozen to STL Burlington (Colchester, VT) for analysis. Chain of custody, an analytical summary, data, and analytical procedures are provided in Appendix C. Analytical methodologies including tissue preparation and homogenization were based on the NOAA Mussel Watch program and EPA SW-846 protocols. All results presented in this study are reported on a dry weight basis, consistent with the Mussel Watch Program studies.

#### 1.1.1.3 Statistical Analyses

The present study was designed to address two primary goals, (1) determining spatial patterns of contamination in the vicinity of the ASBS, if present, and comparing these patterns to known sources of surface runoff, and (2) comparisons of contaminant concentrations in mussels from our study with those from other studies along the west coast of the United States (NOAA Mussel Watch program).

##### 1.1.1.3.1 SIO study

Mussel growth was analyzed using PCA analysis to combine changes in length, width, height, and weight into one component for analysis. Principal components were calculated for both pre-deployment and post-deployment measurements. The first principal component accounted for >80% of variation in both data sets (see results) and factor loadings for principal component 1 (PC1) were nearly identical for both analyses. Loadings of the first principal component from the retrieval data were applied to the pre-deployment data. The difference (PC1 retrieval minus PC1 deployment) was used as an estimate of growth for all subsequent analyses involving growth.

Samples were only included in the analysis if analyte concentrations were above reporting limits (see Table A1 for reporting limit ranges). Eleven metals were detected above the analytical method reporting limits for most sites, while only one PAH and one chlorinated pesticide were detected above the method reporting limits (see Results). Therefore, most of

### Table 2. Constituents Analyzed at Each Sampling Site for California Mussels

| SiteID | Metals[1] | PAHs[2] | Chlorinated Pesticides[3] | OrganPhos Pesticides[4] | PCBs | %Lipid |
|---|---|---|---|---|---|---|
| 1 | X | | | | | |
| 2 | X | X | X | X | X | X |
| 2A | X | | | | | |
| 2AM | X | | | | | |
| 3 | X | | | | | |
| 4 | X | | | | | |
| TP | X | X | X | X | X | X |
| 5 | X | | | | | |
| 6 | X | | | | | |
| 7 | X | X | | | | X |
| PL2SIO | X | | | | X | X |
| 8 | X | | | | | |
| 9 | X | X | X | X | X | X |
| 10 | X | X | | | | X |
| 10A | X | | | | | |
| 10AM | X | | | | | |
| 11 | X | X | X | X | X | X |
| 11A | X | | | | | |
| 11AM | X | | | | | |
| 12 | X | | | | | |
| 13 | X | | | | | |
| 13A | X | | | | | |
| 13AM | X | | | | | |
| SIO2PL | X | | | | X | X |
| SPIR | X | X | X | X | X | X |
| SPFR | X | X | X | X | X | X |
| PLIR | X | X | X | X | X | X |

1. Metals analyzed by EPA method 3050/6010/6020 (ICP/ICP-MS)
2. Low level PAHs analyzed by EPA method 8270 single ion monitoring (SIM) isotope dilution
3. Chlorinated Pesticides analyzed by EPA method 8081
4. Organo Phosphate Pesticides analyzed by EPA method 8141

the mussel contaminant analysis consisted of analyzing metals. Metal concentrations were first compared among sites by calculating z-scores among sites for each metal and plotting the results using Matlab. Next, metal, PAH, lipid, and pesticide concentrations were compared among sites using Kruskal-Wallis tests in R. Multiple comparison tests =(alpha=0.05) were conducted and boxplots were generated for each metal using maximum likelihood estimation using R. Principal component analysis was then conducted on all of the metal data at all of the sites also using R.

The effects of temperature and site type were analyzed using analysis of covariance (ANCOVA). The difference in the first principal component of size/weight data was the response variable and root mean square temperature (RMS) was the covariate. Root mean square temperature was used because it includes both average and variance components. Site type (three levels) was the factor in the ANCOVA and sites were nested within the site type factor. Multiple comparisons of growth (PCA difference) among site types were conducted using R (alpha=0.05).

Lipid concentrations were compared among sites using multiple comparisons tests in R, and growth (PCA differences) was correlated with lipid concentrations.

Linear models of metal concentration dependence on mussel growth (PCA difference) and temperature (RMS) were conducted for each metal to determine the importance of these two factors on metal concentrations. Z-scores of metal concentrations were then calculated among sites for each metal and plotted using Matlab. Principal components analysis was then conducted for all metals among the "25B" sites (bottom sites at 8 m) using R. Multiple comparison tests of metal concentrations, and concentrations of the single detected PAH and chlorinated pesticide were conducted among all sites. Finally, multiple comparisons of metal, PAH, and chlorinated pesticide concentrations were conducted among the mussel sampling locations (mussels sampled from Pt. Loma and Scripps Pier).

#### 1.1.1.3.2 Comparisons with Mussel Watch

Contaminant concentrations of mussel tissue from this study and from the NOAA Mussel Watch Program on the west coast were compared by plotting cumulative distribution frequencies of contaminant concentrations for both sets of data on the same plot for each analyte. Data was retrieved from the National Centers for Coastal Ocean Science (NOAA) website (http://www8.nos.noaa.gov/cit/nsandt/download/mw_monitoring.aspx) for the years 2002, 2003, and 2004. Statistical analysis comparing analytes between the two data sets was precluded because the reporting limits from this study were typically much greater than the lower quartiles of contaminant concentrations in the NOAA dataset. Averages and 95% confidence limits for each analyte from this study were plotted against the NOAA dataset for each analyte (Figs. 47 and 48), enabling a graphical comparison of analyte averages between the two datasets – points above the unit diagonal indicate those analytes whose means were greater in the ASBS dataset than in the NOAA dataset.

### 1.1.1.4 Results of Mussel Studies

#### 1.1.1.4.1 SIO Study

Arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, selenium, and zinc were detected above reporting limits at all sites. Aluminum concentrations were above reporting limits at 22 sites. Perylene and 4,4'-DDE were the only PAH and chlorinated pesticide (respectively) that were detected above method reporting limits at a majority of sites (see Tables 3 and 4 for summary stats of other PAHs and chlorinated pesticides detected above method reporting limits). No PCBs were detected above method reporting limits at a majority of sites (see Table 5 for summary statistics of PCBs detected above reporting limits). Organophosphorous pesticides were not detected at any of the sites.

**Table 3. Summary Statistics of PAHs, Besides Perylene, with Concentrations above Method Reporting Limits for California Mussels**

| Analyte | Site | Mean | Standard Dev. | N[1] |
|---|---|---|---|---|
| Benzo(a)pyrene | 2 | 27 |  | 1 |
| Benzo(a)pyrene | SIOPIR | 14 |  | 1 |
| Benzo(b)fluoranthene | SIOPIR | 13 |  | 1 |
| Benzo(e)pyrene | 2 | 27 |  | 1 |
| Phenanthrene | 9 | 14 |  | 1 |
| Phenanthrene | SIO2PL | 52.5 | 37.47666 | 2 |

[1] = Number of samples/replicates that had concentrations of the analyte above the method reporting limit

**Table 4. Summary Statistics of Chlorinated Pesticides, Besides 4,4'-DDE, with Concentrations above Method Reporting Limits for California Mussels**

| Analyte | Site | Mean | Standard Dev. | N[1] |
|---|---|---|---|---|
| alpha-Chlordane | 9 | 7.7 |  | 1 |
| alpha-Chlordane | PL2SIO | 9.033333 | 0.750555 | 3 |
| alpha-Chlordane | SPIR | 34.5 | 13.43503 | 2 |
| alpha-Chlordane | SPFR | 28.66667 | 1.527525 | 3 |
| beta-BHC | PLIR | 14.5 | 2.12132 | 2 |
| gamma-Chlordane | TP | 65 |  | 1 |

[1] = Number of samples/replicates that had concentrations of the analyte above the method reporting limit

**Table 5. Summary Statistics of PCBs Detected Above Method Reporting Limits for California Mussels**

| Analyte | Site | Mean | Standard Dev. | N[1] |
|---|---|---|---|---|
| BZ#101 | PL2SIO | 2.433333 | 0.305505 | 3 |
| BZ#101 | PLIR | 4.166667 | 0.208167 | 3 |
| BZ#118 | PLIR | 3.7 | 0.264575 | 3 |
| BZ#138 | PL2SIO | 2 | 0.141421 | 2 |
| BZ#138 | PLIR | 4.933333 | 0.23094 | 3 |
| BZ#153 | PL2SIO | 3.8 |  | 1 |
| BZ#153 | PLIR | 7.766667 | 0.472582 | 3 |
| BZ#187 | PLIR | 2.4 | 0.141421 | 2 |
| BZ#52 | PL2SIO | 2.166667 | 0.288675 | 3 |
| BZ#52 | SIO2PL | 4.1 |  | 1 |
| BZ#52 | TP | 2.1 |  | 1 |

[1] = Number of samples/replicates that had concentrations of the analyte above the method reporting limit

### 1.1.1.4.1.1 Mussel Growth

Mussel growth was variable (see Fig. 3) and significantly different among sites (Kruskal-Wallis, p=3.91e-6). Mussel growth at Sites 12, 13, 13AM, and SIO2PL was significantly less than the remaining sites (Fig. 4). Site 12 is located on the southern boundary of ASBS 29 and Sites 13 and SIO2PL are outside of both ASBS. Mussel growth also differed significantly among types of sites (Fig. 5). Mussel growth at the "50B" sites (16 meter bottom sites) was significantly less than growth at the "25B" and "MOOR" (16 meter mid-water mooring) sites. These differences appeared to be dependent on temperature and site type (see Table 6). Lipid composition was also significantly different among sites (Kruskal-Wallis, p=1.95e-2). Lipid compositions of mussels at Site "SIO2PL" were significantly lower than the remaining sites where lipids were analyzed (see Fig. 6). Mussel growth (PCA difference) was positively correlated (Fig. 7) with percent lipid composition (r=0.839, p<0.01). The mussels at Site "SIO2PL" both grew less and had lower lipid compositions that at the remaining sites where lipids were analyzed.

**Table 6. ANCOVA Results of Temperature and Site Type Effects on Mussel Growth**

| | d.f. | Sum Sq | Mean Sq | F value | Pr(>F) |
|---|---|---|---|---|---|
| Temperature (RMS) | 1 | 56.84 | 56.84 | 45.9041 | 3.02E-11 |
| SiteType | 2 | 24.29 | 12.14 | 9.8075 | 6.46E-05 |
| SiteType:SiteID | 16 | 221.48 | 13.84 | 11.1798 | < 2.2e-16 |
| Residuals | 589 | 729.28 | 1.24 | | |

"SiteType:SiteID" is site nested within site type.

### 1.1.1.4.1.2 Metals

Metal concentrations were highly variable among sites (Fig. 8). Only a subset of the sites appeared to have elevated metal concentrations relative to the others. These include Site 9, located just south of the Scripps Pier, and Site SIO2PL, the site where mussels were transplanted from Scripps Pier to Pt. Loma. Concentrations of aluminum and iron were elevated at Site 1, located north of Los Penasquitos Lagoon. Some metal concentrations were also elevated in initial source mussel samples collected from both the SIO Pier and Pt. Loma. The relationships between concentrations of chromium and nickel, and between lead and zinc were highly correlated (Fig. 9; $p<0.01$ for both relationships). Metal concentrations were significantly negatively dependent on growth for arsenic, cadmium, lead, and zinc (Table 7).

**Table 7. Results of Linear Model of Metal Concentrations as a Function of Growth and Temperature for California Mussels**

| Metal | Growth (PCA diff) coeff/p value | Temperature (RMS) coeff/p value | Overall Model | |
|---|---|---|---|---|
| | | | Multiple $R^2$ | p |
| Arsenic | -3.278e-1/7.83e-4 | NS | 0.3084 | 5.7e-5* |
| Cadmium | -7.875e-2/1.01e-5 | NS | 0.3166 | 4.194e-5* |
| Chromium | NS | NS | 0.0581 | 2.046e-1 |
| Copper | NS | NS | 0.0385 | 3.533e-1 |
| Iron | NS | NS | 0.0609 | 1.89e-1 |
| Lead | -7.538e-2/1.42e-8 | NS | 0.5508 | 6.143e-10* |
| Manganese | NS | NS | 0.0176 | 6.254e-1 |
| Nickel | NS | NS | 0.0526 | 2.386e-1 |
| Selenium | NS | NS | 0.0427 | 3.146e-1 |
| Zinc | -3.162/4.75e-7 | NS | 0.4482 | 1.436e-7* |

Significant coefficients are given along with p values. "NS" refers to non-significant p values ($p>0.05$). "*" indicates overall model significant.

The biplot of PCA components for metal concentrations at 25B sites as well as the Torrey Pines control site (Fig. 10), indicate that mussels at SIO2PL and at Site 9 had metal compositions that were the most different from all other sites. Mussels at SIO2PL were characterized by higher concentrations of selenium, lead, zinc, nickel, manganese, iron, and aluminum (not on biplot). Site 9 was characterized by higher concentrations of chromium, iron, nickel, and manganese. Sites 12 and 13 appeared to separate out from other sites, characterized by relatively high concentrations of arsenic, cadmium, lead, and zinc and low concentrations of nickel, chromium and copper. By contrast, the Torrey Pines control/reference site, and Sites 3, 4, 5, 10, and 11 had relatively low concentrations of all metals. Estimated distributions of metal concentrations and multiple comparison results are shown by site for each metal in Figures 11-20.

There was generally good correspondence between 25B sites with their 50B companion sites. The offshore 50B sites typically had lower metal concentrations than the more inshore 25B sites, but these differences were not significant in most cases as companion sites generally grouped together in the multiple comparisons analysis (see Figs. 11-20). Concentrations of arsenic, lead, and zinc in mussels at the 25B and 50B sites off the Children's Pool (Sites 13 and 13A) were greater than the rest of the 25B/50B coupled sites, but this difference was only significant for arsenic (Fig. 11).

Comparisons of metal concentrations among the source mussel reference samples (SPIR, SPFR, and PLIR) were variable (Figs. 21-30). Maximal concentrations of cadmium, copper, and lead exceeded maximal concentrations at the outplanted sites suggesting these metals depurated during the study to reflect the conditions in the sample station location. Concentrations of all other metals were within the range of outplanted sites. Initial source mussel samples from the SIO Pier (SPIR) had significantly higher concentrations arsenic, cadmium, lead, selenium, and zinc, while final source mussel samples collected from SIO Pier at the end of the study (SPFR) had significantly higher concentrations of iron and nickel. Among initial source mussel samples, those collected from SIO Pier (SPIR) had significantly higher concentrations of cadmium and those collected from Pt. Loma (PLIR) had significantly higher concentrations of lead.

#### 1.1.1.4.1.3 PAHs and Chlorinated Pesticides

Concentrations of perylene were not significantly different among sites where it was detected above method reporting limits (Fig. 31). However, there appeared to be a north to south gradient in median and estimated distributions with higher concentrations to the north. Concentrations of 4,4'-DDE, a breakdown product of the chlorinated pesticide DDT, were also not significantly different among sites where it was detected (Fig. 32). However, 4,4'-DDE concentrations were significantly greater at 25B sites than the Torrey Pines control site. No significant differences in 4'4-DDE concentrations were observed among reference samples (Fig. 34).

### 1.1.1.4.2 Comparisons with Mussel Watch

Comparisons of cumulative distributions (Figs. 35-46) between mussel concentrations from the present study with those from the Mussel Watch program (west coast, 2002-2004) show that the distributions of arsenic, chromium, nickel, and perylene concentrations in mussels from the SIO study were greater. Reporting limits for some analytes were problematic for this type of comparison because they were higher in the SIO study relative to the lower quartile of concentrations in the Mussel Watch data. This was especially true for chromium, manganese, perylene, and 4,4'-DDE. Mean concentrations of chromium, nickel, and arsenic were greater in the SIO study than for Mussel Watch data (Figs. 47 and 48). Mean concentrations of the remaining analytes were equivalent to or lower in the SIO study than in the data from Mussel Watch.

### 1.1.1.5 Discussion of Mussel Results

The most important findings from the mussel bioaccumulation study included: (1) distinctive spatial patterns of mussel analyte concentrations were observed that corresponded well with known contaminated areas (near San Diego Bay) or circulation features, such as cross-shore circulation near the La Jolla headland (Parnell et al., 2006), (2) mussel growth and lipid compositions corresponded well with this spatial pattern, (3) there was a significant negative relationship between mussel growth and concentrations of arsenic, cadmium, lead, and zinc, (4) some metal concentrations at the site closest to Scripps Pier (Site 9) were significantly greater than other sites in the waters off La Jolla and Del Mar, (5) concentrations of all but one PAH and one chlorinated pesticide were below reporting limits at a majority of sites, no PCBs were greater than method reporting limits at a majority of the sites, and organophosphorous pesticides were not detected at any of the sites, (6) of the PCBs detected above method reporting limits, the highest concentrations were observed at the Pt. Loma reference site (PLIR) and at the Pt. Loma outplant site (Site SIO2PL).

We know of no previously published studies in which mussel growth and metal concentrations were studied in the field. Our results indicate that the mussels off Pt. Loma and just south of the La Jolla headland were stressed. Decreased mussel growth and lipid compositions were significantly related to concentrations of arsenic, cadmium, lead, and zinc raising the possibility that at least one of these metals is toxic to mussels. Mussel concentrations of arsenic and zinc were highly correlated with one another and a similar relationship was observed between lead and cadmium (Fig. 9) thereby making it difficult to assess the importance of individual metals. Arsenic tissue concentrations have been negatively correlated with shell length in the mussel *Mytilus galloprovencialis* off Croatia and with body size in the Norway lobster, *Nephrops norvegicus* (Klaric et al., 2004). Zinc has been negatively correlated with the ratio of tissue weight to shell weight (Lobel and Wright, 2004). Our results could also be due to suboptimal nutrition whose spatial distribution coincides with the spatial patterns of bioavailable metals off San Diego.

There was good concordance of metal compositions in mussels with proximity to San Diego Bay (a large source of contaminants) and with known circulation features off the La Jolla headland. These results indicate that the metal data are robust and mussel bioaccumulation is a good indicator of metal climate. Dugan et al., based on previous sediment studies, argue that metal concentrations in sand crabs are likely forced by local geological sources (Daskalakis and O'Connor, 1994). While this may be true for waters and sediments not exposed to high levels of metal pollution, the anomalously high concentrations of some metals off Scripps Pier, located in the middle of the study sites, and the high concentrations near the mouth of San Diego Bay suggest that mussels are useful indicators of anthropogenic metal climate.

Possible sources of high concentrations of chromium, iron, manganese, and nickel in mussels outplanted at Site 9, located approximately 90 m SSW of Scripps Pier, include non-point source runoff of surface waters, the Scripps Pier, or the corroding remains of equipment either abandoned or lost. These results could also be erroneous resulting from mussel handling or laboratory analysis. However, both are unlikely because (1) mussels were handled similarly among sites, (2) high concentrations of metals were found in all three replicates from Site 9, and (3) replicate sets were not known by the lab (STL Burlington). Surface runoff is also unlikely given the dynamic nature and circulation within La Jolla Bay, which make it physically unlikely for contamination to be so localized.

The most likely source of these metals is the Scripps Pier. The present pier, supported by concrete pilings, has been in place since 1988 when it was built to replace the old pier, built in 1915, which was supported by wooden pilings. The process of building the new pier included the construction of a temporary steel pier to support a railway facilitating construction of the new pier and subsequent demolition of the old pier. The steel pier was supported by large diameter steel tube pilings driven deep into the sand. Upon completion of the new pier these pilings and the old wooden pilings were removed. However, many of the pilings could not be fully removed by lifting and were therefore cut off somewhere below the sand surface. Therefore the bases of many steel and wooden pilings are still in place next to the present pier. Arsenic and chromium are commonly used for treating wood and it has been shown that leachates from wooden pilings can bioaccumulate in aquatic organisms (e.g., Wendt et al. 2004). The plume of contaminated sediments would likely move southward towards Site 9 because the wave climate in La Jolla Bay is forced by northern and western swell since southern seas and swell are blocked by the La Jolla headland. Bioaccumulation in outplanted mussels should be repeated near the pier and Site 9 to rule out a Type II error. If the same pattern is observed, sediments should be sampled along a distance gradient to help identify the source. Finally, it would be expected that the reference mussels sampled at the pier (SPIF and SPFR) would also have elevated concentrations of the same metals if the pier was the source. However, this was true only for the final reference samples and not the initial reference samples.

Our results also indicate the waters from northern La Jolla to southern Del Mar are not greatly impacted by PCBs, PAHs, or pesticides since most forms of all three groups were not detected. Concentrations of analytes detected above method reporting limits for these groups were less than the 85th percentile of mussel analytes from the Mussel Watch program. By contrast, the waters off Pt. Loma appear to be affected by some forms of PCBs.

## 1.2 Sand Crabs

### 1.2.1 Methods

#### 1.2.1.1 Field Program

Sand crabs (*Emerita analoga*) were sampled from the beach at 11 sites during low tide on June 19, 2006. Sampling sites were chosen to target known areas of runoff from natural and anthropogenic sources (see Mussel sampling methods) and to cover a spatial gradient along the shoreline throughout the range of interest for both the mussel and the sand crab studies. Sites ranged from the estuary at Los Peñasquitos to south Casa Beach (see Figs. 49 and 50). Sand crabs were sampled by shoveling sand with sand crabs into mesh goody bags (mesh size ~4 mm) and then sieving the samples through the goody bag mesh in ankle deep water. After sieving, sand crabs were immediately placed into glass jars, which were then placed into ice-filled coolers. Duplicate samples were taken from each site. At least 150g of sand crabs were sampled for each replicate. Upon return to the lab, sand crabs were measured to the nearest 5 mm size class and inspected for gravid condition. Only adult crabs (>10 mm) were included in the analysis. After measurement, sand crabs were placed into Teflon bags and then frozen. The crabs were then transferred to AMEC Environmental Inc. (San Diego, CA) and shipped frozen to STL Burlington (Colchester, VT) for analysis. Chain of custody, the analytical summary, data, and analytical procedures are provided in Appendix C.

#### 1.2.1.2 Chemical Analyses

Sand crabs in each sample were homogenized prior to analysis. Samples from all sites were analyzed for metals. Samples from a subset of the sites were analyzed for lipids and PAHs (see Table 8). Analytical methodologies from the NOAA Mussel Watch program were followed.

#### 1.2.1.3 Statistical Analyses

Only metal concentrations were analyzed statistically because most concentrations of PAHs in sand crabs were below method reporting limits. Metal concentrations were first compared among sites by calculating z-scores among sites for each metal and plotting the results using Matlab. Next, metal concentrations were compared among sites using Kruskal-Wallis tests in R. Multiple comparison tests (alpha=0.05) were conducted and boxplots were generated for each metal using maximum likelihood estimation using R. Principal component analysis was then conducted on all of the metal data at all of the sites also using R. Finally, possible relationships between crab size and gravid condition, which were variable among samples, on metal concentrations were tested using linear effects models and redundancy analysis. Both types of analyses were conducted using R. For the linear effects models, weighted linear regression was conducted in which each metal was regressed onto mean gravid and non-gravid sizes for each sample and the regression was weighted by the fraction of crabs that were gravid in each sample. However, model-fitting procedures revealed that non-gravid averages were not important in any of the models. Therefore, the models were modified to only include gravid size averages weighted by the fraction of gravid individuals.

**Table 8. Constituents Analyzed**
**at Each Sampling Location – Sand Crabs**

| Station ID | Metals[1] | PAH[2] | % Lipid |
|---|---|---|---|
| S1 | X | | |
| S2 | X | X | X |
| S3 | X | | |
| S4 | X | | |
| S5 | X | | |
| S6 | X | X | X |
| S7 | X | | |
| S8 | X | X | X |
| S9 | X | | |
| S10 | X | X | X |
| S11 | X | | |

1. Metals analyzed by EPA method 3050/6010/6020 (ICP/ICP-MS)
2. Low level PAHs analyzed by EPA method 8270 single ion monitoring (SIM) isotope dilution

Redundancy analysis was used to determine the effects of different gravid and size compositions of the samples on all metal concentrations in a multivariate manner. Redundancy analysis is an ordination method that extends multiple regression to multivariate response data. In redundancy analysis, multiple response variables (metal concentrations in this case) are regressed onto explanatory variables (gravid size, non-gravid size, and the fraction of crabs gravid in each sample).

Metal concentrations in sand crabs from the present study were compared to concentrations observed in a similar study of sand crabs sampled from 19 beaches over a large geographic range from central California to the northern margin of the Southern California Bight (Dugan et al., 2005). The report for the study by Dugan et al. is available at

**www.swrcb.ca.gov/swamp/docs/sandcrab.pdf.**

Figures of average metal concentrations for the study sites in Dugan et al. were digitized using ImageJ (NIH software). Metal concentrations from the present ASBS study and the study by Dugan et al. were combined to conduct principal components analysis using R.

This was not possible for the mussel data due to the relatively high reporting limits for metal concentrations in the ASBS study mussels.

### 1.2.2 Results of Sand Crab Study

Metals were detected above reporting limits for 14 of the 15 metals at all of the study sites. These included aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Only thallium was not detected above method reporting limits. See Fig. 51 for z-scores of metals among sites.

Only one PAH, 2,6 Dimethylnaphthalene, was detected above the method reporting limits, but it was detected in only one sample at Site S2 (10.0 µg/kg) and both samples at Site S6 (9.4 and 13.0 µg/kg). Laboratory personnel at STL Burlington believe the results for 2,6 Dimethylnaphthalene represent false positives as these concentrations are at the very low end of sensitivity for the analysis (see Appendix 3).

#### 1.2.2.1 Effects of Size and Gravid Condition

Regressions of mean gravid size weighted by the fraction of individuals in each sample that were gravid were significant ($p<0.05$) for aluminum, antimony, beryllium, chromium, lead, nickel, and zinc (see Table 9). The importance of this relationship varied among metals accounting for a quarter to more than half of the variability in metal concentrations (for metals whose regressions were significant). Regression coefficients were positive and significant for aluminum, beryllium, nickel, and zinc. Regression coefficients for antimony, arsenic, and lead were negative and significant.

**Table 9. Results of Weighted Linear Regressions of Metal Concentrations Onto Average Gravid Size Weighted by Fraction of Crabs That Were Gravid In Each Sample**

There were 1 and 20 degrees of freedom for each F-test and 20 d.f. for each linear regression model. Asterisks refer to the probability of Gravid.Avg coefficients (“*”= 0.05<p<0.01, “**” = 0.01<p<0.005, “***” p<0.0005).

| Metal | Overall Model | | Gravid. Avg. Coefficient | Multiple R-Squared |
|---|---|---|---|---|
| | F-statistic | p | | |
| Aluminum | 5.066 | 0.035 | 9.504e0* | 0.2021 |
| Antimony | 17.33 | ~0 | -5.045e-3*** | 0.4642 |
| Arsenic | 3.819 | 0.065 | -4.464e-3* | 0.1184 |
| Beryllium | 27.99 | ~0 | 1.1130e-3*** | 0.5833 |
| Cadmium | 1.842 | 0.19 | NS | 0.0844 |
| Chromium | 8.85 | 0.007 | 6.505e-1** | 0.3067 |
| Copper | 2.317 | 0.146 | NS | 0.1038 |
| Iron | 7.025 | 0.015 | 1.459e1** | 0.2599 |
| Lead | 11.34 | 0.003 | -1.627e-2** | 0.3619 |
| Manganese | 14.68 | 0.001 | 5.242e1** | 0.4232 |
| Nickel | 7.459 | 0.013 | 1.413e-1 | 0.2716 |
| Selenium | 1.432 | 0.245 | NS | 0.0668 |
| Silver | 1.654 | 0.213 | NS | 0.0763 |
| Zinc | 6.429 | 0.019 | 2.964e-1* | 0.2432 |

### 1.2.2.1 Spatial Patterns of Metals

The results of Kruskal-Wallis tests to compare metal concentrations in sand crabs among sites are given in Table 10. There were significant differences among sites for aluminum, beryllium, cadmium, iron, lead, and manganese. Multiple comparisons are presented in Figs. 52-65. Significant groupings were observed for antimony and copper in the multiple comparison tests even though the Kruskal-Wallis tests for these metals were not significant at an alpha of 0.05 – p-values were close to significance however (see Table 10).

**Table 10. Results of Kruskal-Wallis Tests among Sites for Metal Concentrations in Sand Crabs**

There were 10 degrees of freedom for all tests.

| Metal | Chi-Square | p |
|---|---|---|
| Aluminum | 19.0 | 0.040 |
| Antimony | 17.0 | 0.074 |
| Arsenic | 12.4 | 0.258 |
| Beryllium | 16.8 | 0.080 |
| Cadmium | 18.8 | 0.043 |
| Chromium | 15.9 | 0.099 |
| Copper | 17.6 | 0.061 |
| Iron | 19.1 | 0.038 |
| Lead | 20.1 | 0.028 |
| Manganese | 18.9 | 0.041 |
| Nickel | 14.7 | 0.144 |
| Selenium | 17.0 | 0.073 |
| Silver | 15.8 | 0.106 |
| Zinc | 13.2 | 0.214 |

Principal components analysis of the metals data (Fig. 66) revealed 5 groupings of sites. (The first two components accounted for ~61% of the total variation.) Sites S2, S5 and S11 each formed a group, Sites S1 and S6 together formed another group, while the remainder of sites composed a large grouping. Site S2 had relatively high concentrations of aluminum and iron, while Site S5 had relatively high concentrations of beryllium and antimony. Site S11 had high concentrations of silver and selenium and low concentrations of lead. Sites S1 and S6 had relatively high concentrations of manganese and copper.

The relationships between metal concentrations with gravid and size compositions across samples are shown in Figure 67. The redundancy analysis plot shows the positive correlation between average size of gravid individuals and concentrations of chromium, nickel, silver, iron, aluminum and manganese. The relationship between average gravid size with concentrations of antimony and beryllium were negative. The RDA biplot also shows the extent of the variation in sample content among sites for gravid and size compositions.

### 1.2.2.3 Comparisons with Central California

Comparisons of metal concentrations in sand crabs from the present study with sand crabs sampled by Dugan et al. are shown in Figs. 68-70. The biplot of principal components (Fig. 68) indicates that sand crab metal compositions were different between the two studies.

However, total variability in metal concentrations within the scale of the present study (~12 km) appeared to roughly equal the variability in metal concentrations among sites at the much larger scale of sampling by Dugan et al. (~400 km). Figures 69 and 70 show that average concentrations of silver, selenium, nickel, arsenic, chromium and zinc were greater for crabs off the La Jolla/Del Mar coastline, and the concentrations of cadmium, copper, manganese, and aluminum were greater up north. Concentrations of lead were approximately equivalent.

### 1.2.3 Discussion of Sand Crab Results

#### 1.2.3.1 Effects of Size and Gravid Composition

The utility of bioaccumulation by sand crabs as an indicator of local contamination depends on many factors. Of these, gravid condition and sample age structure are two factors that could be a source of variability that complicates the interpretation of contaminant concentrations. This should be of great concern because unlike outplanted mussels, which can be selected by size, the choice of crab size is limited to what is available at each site. This can be problematic due to the patchy distribution of sand crabs in time and space and due to the variation in age structure among patches. Dugan et al. 2005 addressed this concern by separately analyzing juvenile and overwintered adults at a subset of their sites. They found no significant relationship between analyte concentration and age for many analytes including DDT and PAHs. However, they observed that chromium and nickel concentrations were greater in older adult crabs. We found a similar result for chromium, but found no similar relationship for nickel. However, our analysis was different because the best model fit for the data was average gravid size weighted by the fraction of gravid crabs. The relationship between non-gravid size and metal concentrations was not significant in our study and was therefore dropped from the model. It is also important to note juveniles were not sampled as part of this study, only adult crabs (>10 mm).

We observed significant relationships for other metals including positive regression coefficients for aluminum, beryllium, nickel and zinc, and negative relationships for antimony, arsenic, and lead. These relationships accounted for 20 to 58% of the total variability in metal concentrations among sites. These findings suggest that variation in size and gravid condition among and within sites complicates the interpretation of contaminant concentrations, especially in areas where contaminant levels are low. In an effort to remove the effect of size/gravid composition on metal concentrations, residuals from the weighted regression models were analyzed using principal components analysis. The results showed that the variation in residuals within sites was equivalent to or greater than that among sites. In other words, there was little spatial structure in metal concentrations after the removing the effect of varying size/gravid compositions.

The biplot of the first two redundancy analysis components (Fig. 67) summarizes the findings of metal concentrations and the size/gravid compositions of the different samples. In most cases, replicate samples within sites clustered together, but for one site, S11, the gravid/size compositions of the samples were quite different as were the resulting metal compositions. Crabs at this site were sampled from different crab patches on the same beach. But the patches had crabs that were of different sizes and gravid states. Sampling similar size/gravid compositions among the patches was rendered impossible by the availability of crabs.

### 1.2.3.2 Spatial Patterns of Metals

There appeared to be spatial structure of metal concentrations before the removal of size/gravid effects. However, the importance of this structure is questionable, since so much variation was accounted for by size and gravid state. The biplot of principal components among sites (Fig. 66) shows that Sites S3, S4, S7, S8, S9, and S10 were fairly similar in their crab metal compositions. Sites S1 and S6 were characterized by high concentrations of manganese, zinc, nickel, chromium, and copper. Site S6 was located south of Scripps pier where concentrations of nickel, manganese and chromium were also high in mussels directly offshore. Sites S2, S5, and S11 were the most different from each other and from the rest of the stations. Site S2 was characterized by high concentrations of aluminum and iron. Site S5, located immediately south of Scripps Pier, was characterized by high concentrations of antimony and beryllium. However, beryllium was not detected in the mussels sampled at any of the locations as part of the mussel study (antimony was not included as an analyte in the mussel study). Site S11 was characterized by high concentrations of silver, selenium, cadmium and copper. The difference in metal compositions of sand crabs between Site S11, located south of the Pt. La Jolla headland, from the sites to the north is large. The same is true for mussel growth and metal compositions of mussels indicating there is a distinct boundary in the physicochemical environment offshore of the La Jolla headland. This finding is also consistent with previous studies of circulation off the La Jolla headland (Parnell et al., 2006) where there are high cross-shore flows that might contribute to a cross-shore coastal front in the area.

### 1.2.3.3 Comparisons with Central California

Comparisons with sand crabs studied by Dugan et al. show that average concentrations of six metals were greater in this study, and were lower for four metals (see Figs. 69 and 70 and Table 11 below). Average concentrations of lead were similar.

**Table 11. Comparison of Sand Crab Metal Accumulation between the La Jolla Study and the Central California Study**

| Metal | Study with Higher Concentration of Metal in Sand Crab Tissue | | |
|---|---|---|---|
| | SIO La Jolla Bay Study | Dugan Central Coast Study | Similar |
| Aluminum | | X | |
| Antimony | | No data | |
| Arsenic | X | | |
| Berylium | | No data | |
| Cadmium | | X | |
| Chromium | X | | |
| Copper | | X | |
| Iron | | No data | |
| Lead | | | X |
| Manganese | | X | |
| Mercury | Not detected above method reporting limit | | |
| Nickel | X | | |
| Selenium | X | | |
| Silver | X | | |
| Zinc | X | | |

The biplot of PCA components (Fig. 68) clearly shows that the two sets of sites are distinctive from one another. Of particular interest was the finding that variation among our sites, which ranged along ~12 km of shoreline, was similar to the variability among sites ranging over ~400 km of coastline. This indicates that either (1) the scale of sampling in the Dugan et al. study may have led to aliasing in metal concentrations in sand crabs, (2) there is relatively large variability of metals in the beaches of San Diego County, or (3) the dependence of crab metal compositions on size/gravid compositions introduces equivalent variances among sites regardless of spatial scale. A combination of factors 1 and 3 is the most likely explanation for this result.

# SECTION 2.0 – CIRCULATION STUDY

The Ecosystem Assessment circulation study was designed to help provide much needed data on flow direction, circulation patterns, and current magnitude in the two ASBS. In the absence of long term data prior to this study, one season of survey data will only provide a limited view of the actual conditions within the ASBS because of the area's high variability both interannually and seasonally. However, the survey is a first step in helping to determine patterns of circulation in this area that affect transport of both stormwater discharges and other substances of ecologically significance (e.g., marine larvae, phytoplankton, sediment, etc.).

## 2.1 Instrument Deployment

Four Nortek Aquadopp acoustic Doppler current profilers (ADCPs) were deployed from April 4 to July 24, 2006. Two were located at approximately 32 m depth along the outer boundaries of the ASBS, and two were located at the 14 m isobath in the interior (Figure 71). The instruments were upward looking, mounted on Sea Spider tripods, and sampled at 5-minute intervals. Velocities were averaged over 2.5 m depth bins (deep sites) and 1.0 m bins (shallow sites) for a total of 12 depth layers after accounting for instrument height over bottom and tidal fluctuations.

**Table 12. ADCP Deployment Sites**

| Latitude | Longitude | Site | Description |
|---|---|---|---|
| 32.872429 | -117.260097 | ADCP-1 | Scripps 32 m (100 ft) |
| 32.864580 | -117.267681 | ADCP-2 | LJ Shores 32 m (100ft) |
| 32.862700 | -117.261811 | ADCP-3 | LJ Shores 14 m (40ft) |
| 32.854953 | -117.269182 | ADCP-4 | LJ Cove 14 m (40ft) |

## 2.2 Results

Maximum surface velocities during this period were approximately 60-70 cm/s, with the highest magnitudes at ADCP-2, the deep La Jolla Shores site (max. 80-90 cm/s), followed by ADCP-4, the La Jolla Cove site. Maximum velocities subsurface (> 5 m depth at deep sites, > 2 m depth at shallow sites) are approximately 10-20 cm/s at all sites and all subsurface depths. Figures 72a-d shows the time series for each of the four ADCPs for all four sites. Vertical and horizontal axes indicate N-S and E-W compass directions. Velocity magnitude is represented by distance along the axes as directional stick plots, with magnitude given by line length. Figures 73a-c shows the velocities at individual depths for the whole time period as scatter plots.

### 2.2.1 Tidal Circulation

Tidal analysis shows the M2 semi-diurnal component is dominant (period 12.42 hr). The mean magnitude of the tidal velocity is approximately 8 cm/s near the surface, decreasing to approximately 1-2 cm/s at depths below 2-5 meter. Maximum tidal surface velocities range from approximately 6 cm/s at A1 in the north, to 20 cm/s at the inshore sites (A2, A4), and > 30 cm/s at the deep La Jolla Shores site (A2). Maximum subsurface tidal velocities are approximately 3 cm/s throughout. Figure 74 shows the tidal ellipses defining the direction and magnitude of the M2 tide at ADCP 1, from surface to bottom.

The direction as well as the magnitude of the tidal flow varies considerably with depth. It is not known at this time what causes the change in directions, although the effects of canyons, ridges, and the Point La Jolla headland may be contributing factors.

The tidal components are small compared to the total current velocity. Figure 75 shows the original time series for ADCP-1 northward velocity, with the tidal components extracted and plotted in the center panel. Note the tenfold difference in scale between the raw and de-tided velocity and the tidal velocities. The bottom panel is the raw data with the tidal components removed, and shows very little change from the raw data.

The data were also low-pass filtered to remove components at tidal frequencies and higher, in order to isolate the mean direction and magnitude of currents that are not driven by tides. Mean subtidal surface velocities (absolute magnitude) range from 11 cm/s at the far northern site (A1) to 18 cm/s at the inshore sites (A3, A4), and 41 cm/s at the deep La Jolla Shores site (A2). Subsurface velocity means are 3-7 cm/s throughout at depths greater than 2-5 m. The mean direction of the subtidal surface flows are to the ENE, but then vary with depth, turning to the ESE just below the surface, then to the N between mid-depth and bottom.

The magnitude of the subtidal flows suggests a moderately vigorous circulation within the ASBS, even at the shallower sites, in surface layer. In the subsurface, velocities at the inshore sites are comparable to those further offshore.

### 2.2.2 Local Wind-driven Circulation

Hourly wind data from SIO Pier (Figures 76 a-d) were compared to the current velocities from the four ADCPs. The maximum wind speed during the period April-July was 9.5 m/s, with a mean of 2.6 m/s. Prevailing directions were to the east, northeast and southeast (i.e., onshore winds). Surface current velocity had a high correlation with wind velocity (0.6-0.7), but the correlation decreased rapidly with depth to near zero in the lower two-thirds of the water column at all sites (Figures 77 a-d).

Previous observations and analysis (e.g., Pringle & Riser, 2003; Lentz & Winant, 1986), as well as the ROMS San Diego Coastal model, have shown that remote wind forcing is an important driver of currents in the San Diego coastal region, and for sub-surface circulation may be more important than local winds.

### 2.2.3 Circulation Modes

Empirical orthogonal function (EOF) analysis was done to determine the dominant modes of circulation during the ADCP deployment. EOF analysis breaks down a set of data into the axes along which most of the variability lies. For ADCP data, this translates into the dominant current directions over the time period of interest. For example, if the currents were usually flowing in the North-South direction, that would be the axis along which most of the variability lies (Mode 1). When the direction that accounts for the greatest variability is determined, the analysis removes that component of the data and determines the direction that accounts for the second most degree of variability, and so forth. Each of these is called modes of circulation, with Mode 1 accounting for the greatest degree of variability, etc. The circulation modes give the major directions over the whole time period analyzed. At any particular point in time magnitude of a mode of circulation could be positive or negative, large or small. For instance in our example, on a particular day Mode 1 might be 4 cm/s to the north (+4), while on another day it is 18 cm/s to the south (-18). The exact direction and strength of the actual current will be a sum of all the modes at that point in time.

EOFs can be calculated for horizontal planes (e.g., dominant surface current direction at each of the 4 sites, dominant current direction at mid-depth at each of the four sites, etc.) or for the vertical water column at a single site (e.g., dominant current directions at each depth for ADCP 1, for ADCP 2, etc.).

Horizontal modes were calculated for the field of four ADCPs using the low-pass filtered data. Figures 78 and 79 show the first two horizontal modes of circulation for four depths from surface to bottom. The first mode, an alongshore circulation pattern, accounts for the 84% of the variability in the data at the surface. The contribution of Mode 1 decreases with depth to 54% at bottom. The direction of the Mode 1 bottom circulation also reverses with respect to the surface.

**Table 13. Variability Accounted for by Modes 1-4**

| Mode | Surface | Near-surface | Mid-depth | Bottom |
|---|---|---|---|---|
| 1 | 84% | 71% | 65% | 54% |
| 2 | 11% | 15% | 20% | 21% |
| 3 | 3% | 9% | 9% | 14% |
| 4 | 2% | 5% | 6% | 10% |

The Mode 2 flow at ADCP-1 in the north, and ADCP-4 in the south showed a convergence over the center of the region, and the Mode 2 contribution to the observed variability increases with depth, 11% at the surface to 21% at the bottom. ADCP-1 and ADCP-4 are the two sites near the steepest topography, and it is possible the Mode 2 circulation may have been influenced by one of the two submarine canyons or other features. The contribution of Modes 3 and 4 also increased with depth, suggesting that bottom topography was more important in all of the lower modes.

Vertical modes were also calculated for each of the four sites (Figures 80 a, b). The vertical profiles of the eigenvectors are almost identical for Mode 1 and Mode 2, with the exception of ADCP 4 which deviates strongly from the others in the subsurface. This may also indicate the influence of topography as this site is bounded on three sides by the edge of La Jolla Canyon, the curved coastline of La Jolla Cove, and the tip of Pt. La Jolla.

### 2.2.4 Transport of Stormwater

During the circulation study there were three rainfall events with totals greater than 0.05 inches.

**Table 14. Events with Rainfall > 0.05 Inches**

| Date | Rain [inches | Max. Wind Speed [m/s] |
|---|---|---|
| 04/05/2006 | 0.27 | 9.5 N |
| 04/14/2006 | 0.12 | 6.2 NNW |
| 05/22/2006 | 0.09 | 7.6 N |

During all events the wind was to the north or northwest, although winds in this direction are common. Only during the April 5th event was the magnitude significantly stronger than normal (the maximum for the whole period April-July occurred on April 5). Also note that the peak wind speed during the April 14th event did not occur until the following day. Surface currents were in the same direction as the wind, with strongest currents (near 1 m/s) at ADCP-2, and fairly strong currents at the shallow Sites ADCP-3 and ADCP-4. Maximum currents during or immediately following the storm event ranged between 3-8 cm/s. A few meters below the surface (5-7.5 m depth at ADCP-1,2 and 2-3 m depth at ADCP-3,4) velocities drop off rapidly and are no longer tied to surface winds. In some cases subsurface currents are in opposing direction to the surface current. Figures 81 a,b show the velocity magnitude and direction during the April 5th event, for surface and mid-depth.

Surface current velocity at ADCP-4 (closest to Avenida de la Playa and downtown La Jolla) was approximately 50 cm/s to the north. Assuming a buoyant plume of stormwater confined to the surface, advection through the ASBS at this rate would total about 1800 m in an hour. (The distance between ADCP-1 at the north, and ADCP-4 at the south is 2100 m.) Subsurface velocities are significantly lower however, and in the lower part of the water column are southward (toward the beach at La Jolla Cove). Maximum velocities at mid-depth and deeper during this event were approximately 5-8 cm/s. At 8 cm/s, transport through advection would total 288 m in an hour.

## 2.3 Discussion of Circulation Study Results

Vertical profiles of current data were collected over a period of approximately 4 months at 4 sites within the ASBS during the late spring-early summer of 2006. The circulation observed during this time period was characterized by (a) moderately high velocity flow at all sites, decreasing with depth; (b) weak tidal currents relative to the mean flow; (c) frequent vertically sheared flow (different flow directions between surface and mid- to bottom currents); (d) a shallow locally wind-driven surface layer; (e) a large degree of temporal variability in current direction; and (f) strong coherence between sites in the dominant circulation mode. The relatively vigorous current flow through the ASBS is consistent with findings from the bioaccumulation studies, which show little evidence of high retention of pollutants.

There are limitations in this data set due to the spatial resolution and the single season of deployment. The topography of La Jolla Bay is complex, with curvature in the coastline, a headland, and two large submarine canyons. Surface and subsurface flows were markedly different at all locations, and the influence of the complex topography of the region may be a factor in the spatial variability of the circulation. Variability is also likely on both seasonal and interannual time scales from changes in local and remote wind patterns, storm systems, and El Nino oscillations. EOF analysis suggests that a combination of several major physical forcing mechanisms are at work, particularly in the subsurface and at Site 4 which is situated near all three major topographic irregularities: Pt. La Jolla, the edge of La Jolla Canyon, and the coastline curvature at La Jolla Cove.

## SECTION 3.0 REFERENCES

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# APPENDIX A – FIGURES

# FIGURES

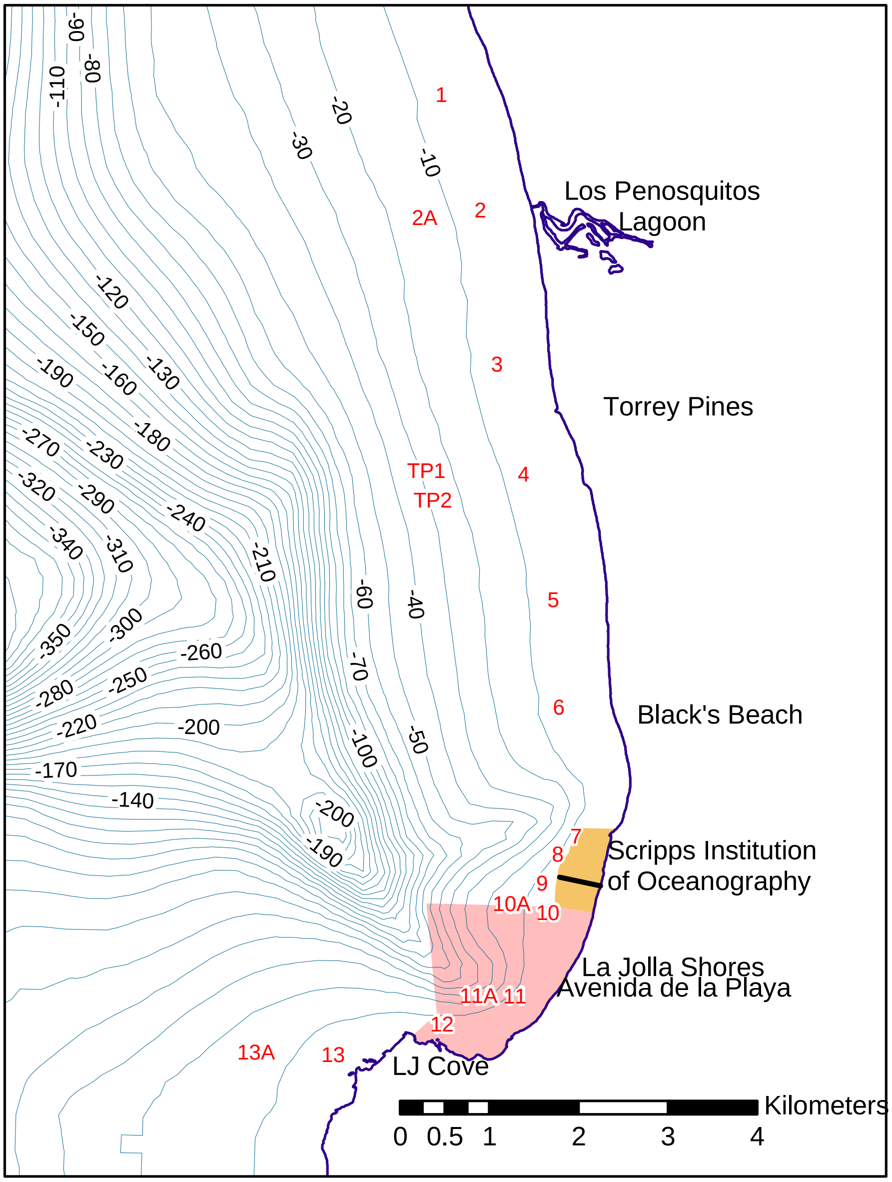


Figure 1. Map of study area. The San Diego-Scripps MCA ASBS is shown in gold and the La Jolla MCA ASBS is shown in peach. Sites are indicated by site names (in red). Sites with names ending in "A" had mussel cages on modules on the bottom and had mussel cages suspended ~8m deep on moorings. Contour units are meters.

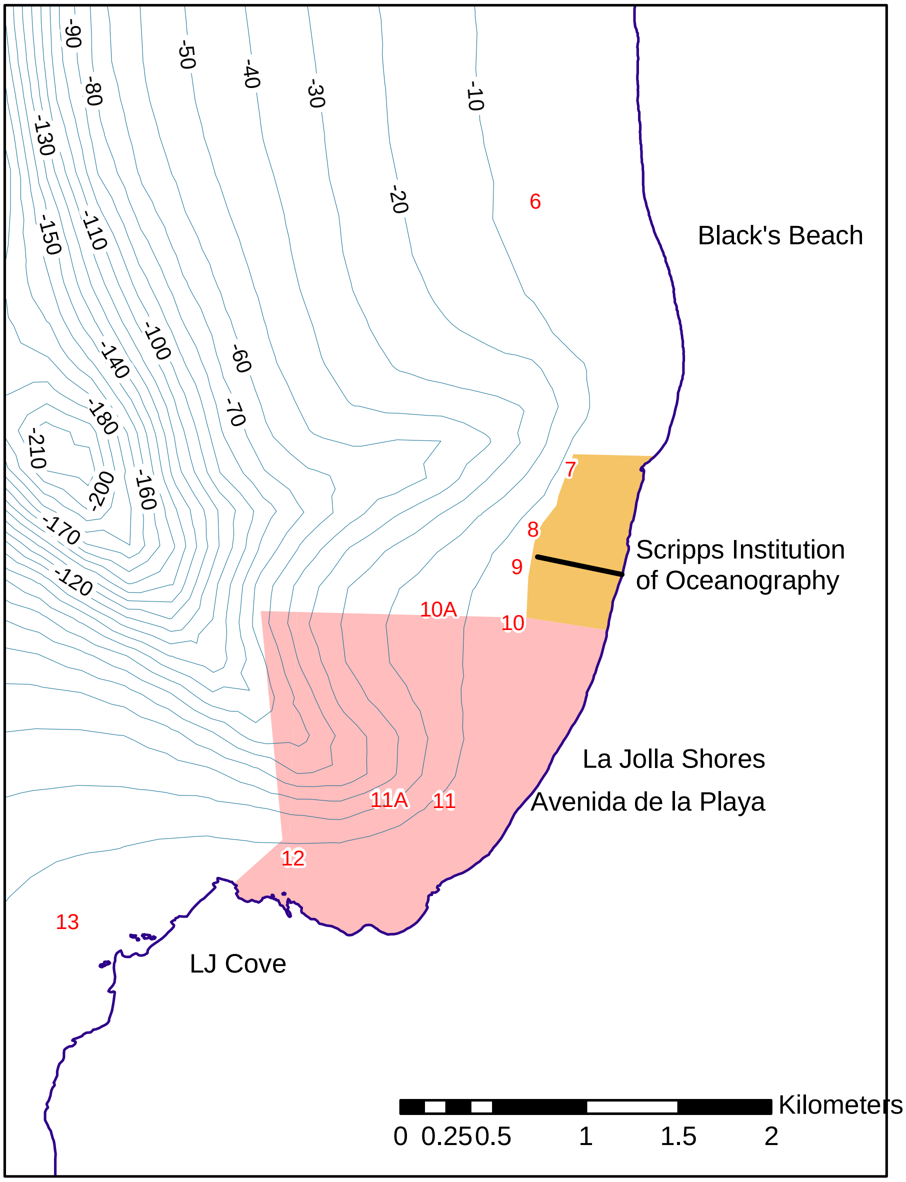


Figure 2. Close up of study area near the ASBSs. The San Diego-Scripps MCA ASBS is shown in gold and the La Jolla MCA ASBS is shown in peach. Sites are indicated by site names. Sites with names ending in "A" had mussel cages on modules on the bottom and mussel cages suspended ~8m deep on moorings. Contour units are meters.

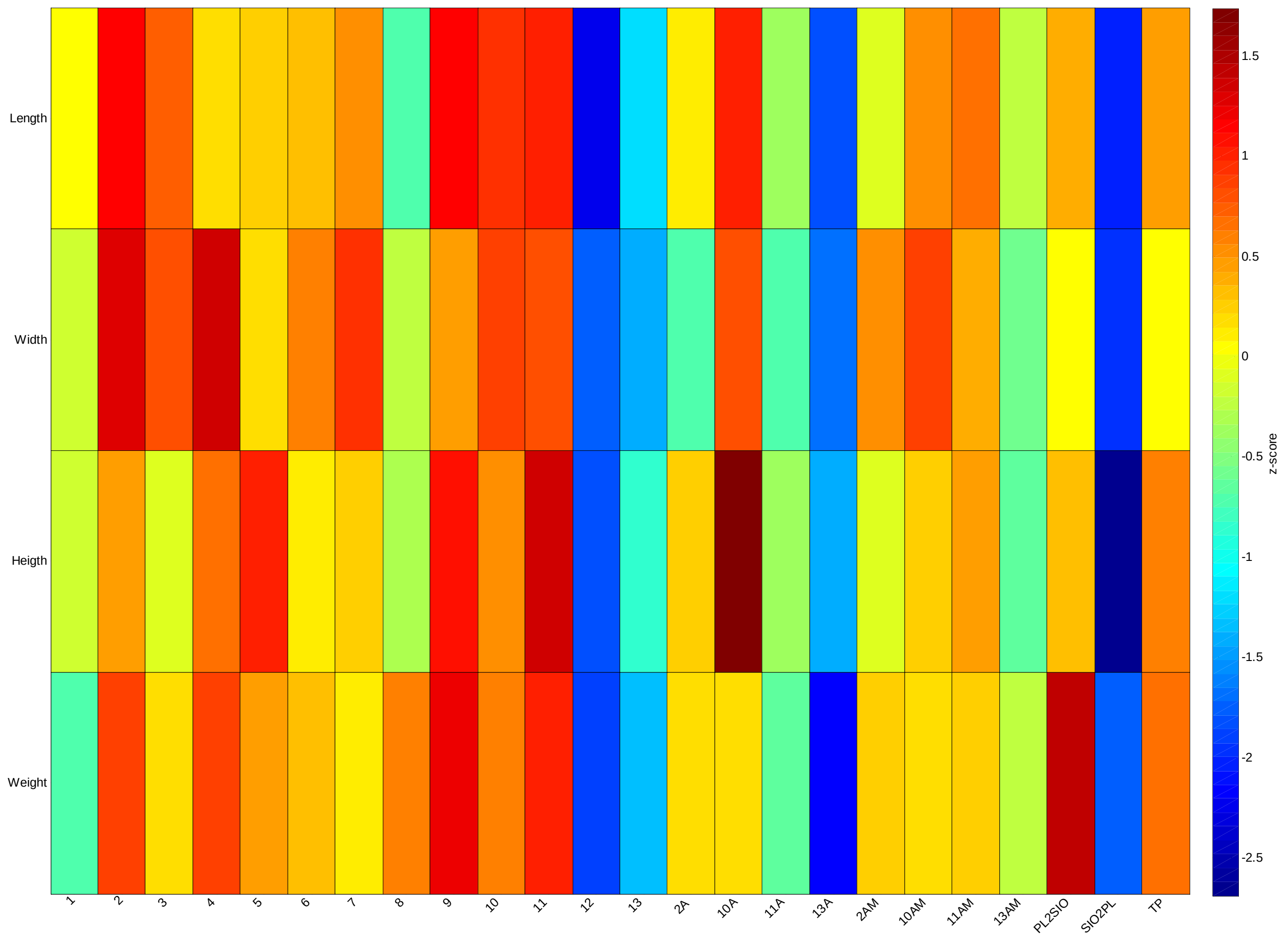


Figure 3. Z-scores of mussel growth parameters (length, width, height, and weight) at all of the study sites. Values represent differences of site averages from overall mean in units of standard deviation.

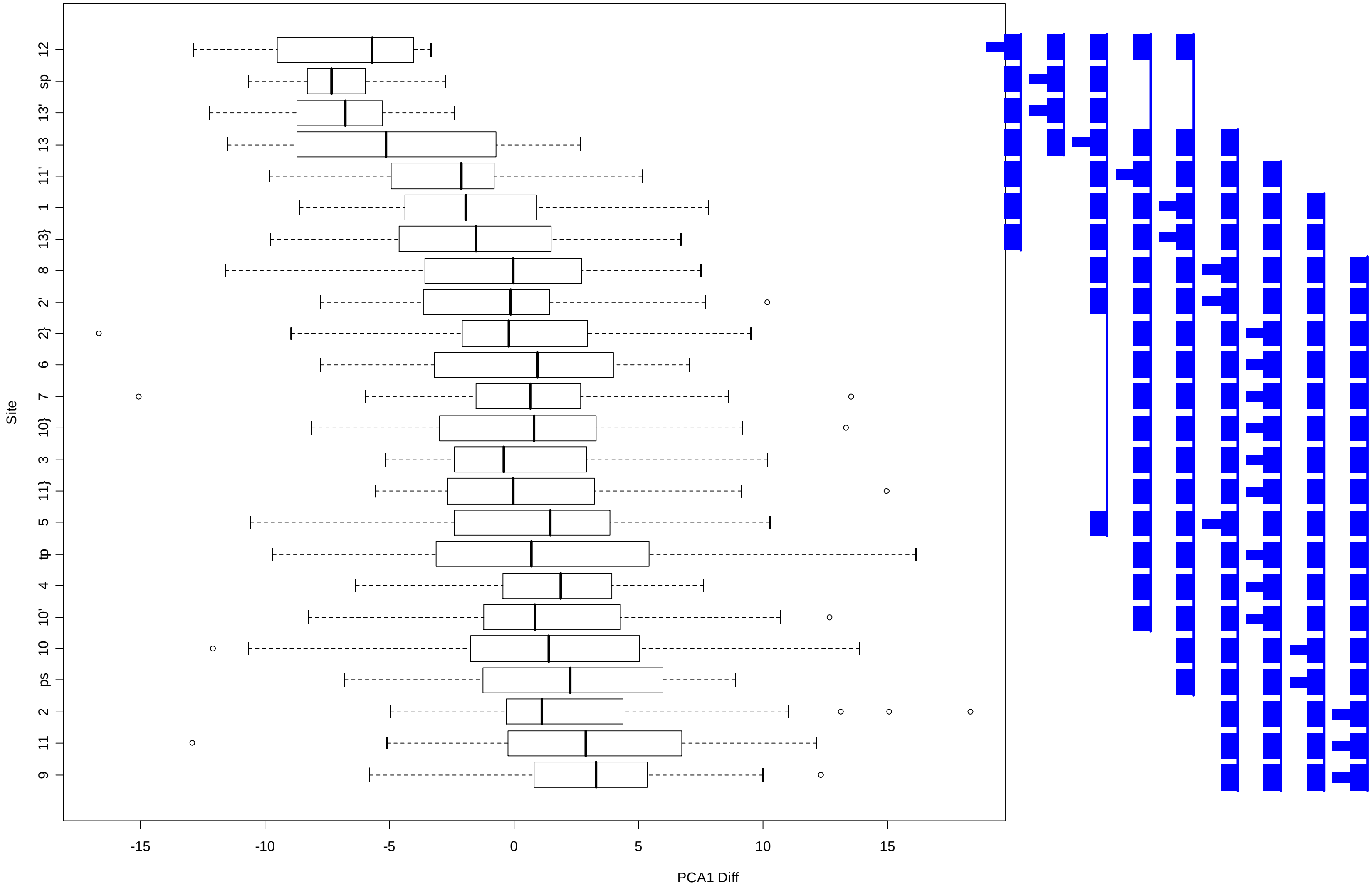


Figure 4. Boxplot of mussel growth (difference in first PCA component – see text) among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name references.

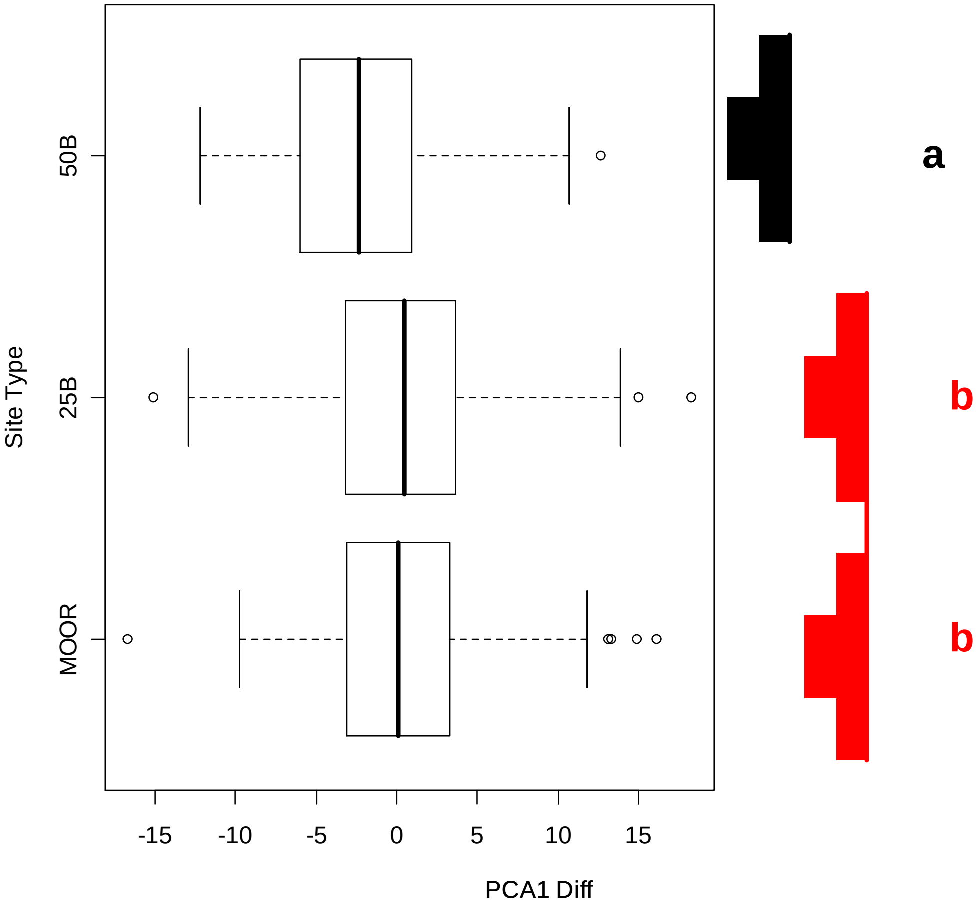


Figure 5. Boxplots of mussel growth (difference in first principal component – see text) compared among types of stations. 25B= bottom module sites at 25FSW (8m deep), 50B= bottom module sites at 50FSW (16m deep), MOOR= mooring sites with mussels 8m deep. Groupings (right side) are from multiple comparisons denoting site types that were significantly different ($p<0.05$). T-shaped boxes identify the "base" of the "T" for each comparison. Linked boxes indicate lack of significant difference among site types. Letters refer to significant groupings. Vertical bars are medians, boxes indicate 25th and 75th percentiles, whiskers indicate smallest and largest non-outliers, circles indicate outliers.

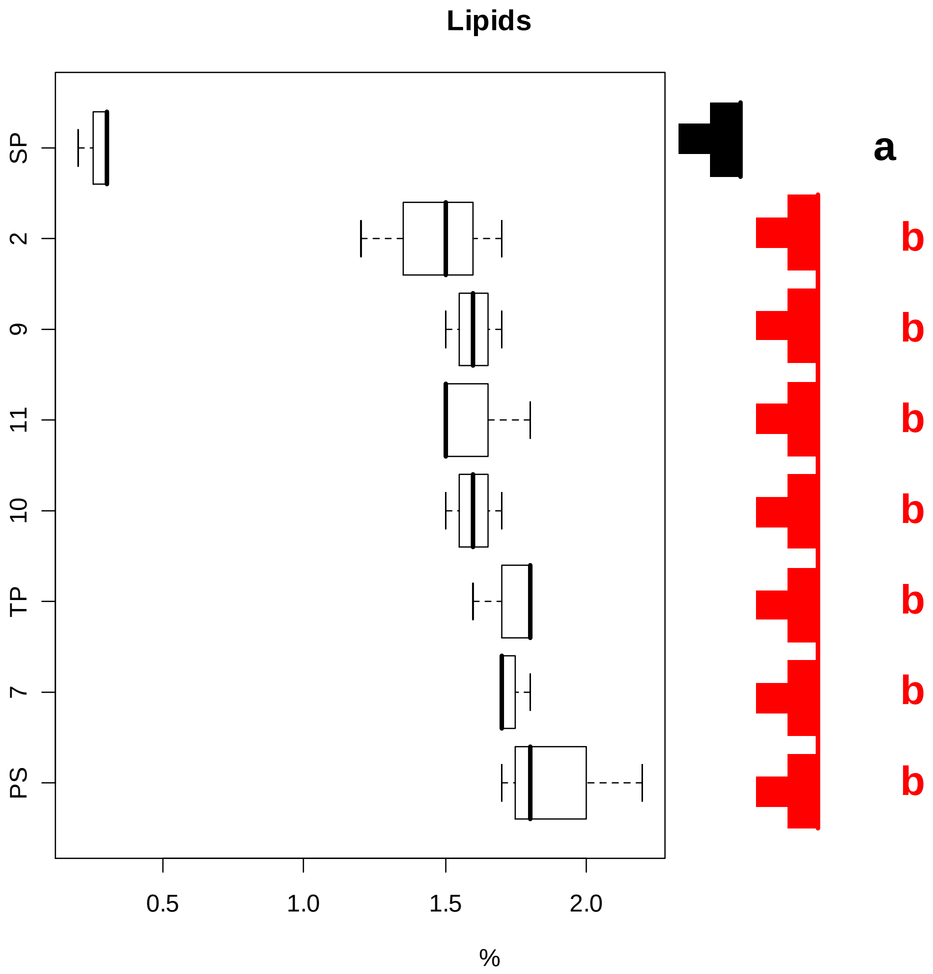


Figure 6. Boxplot and multiple comparisons of lipid composition of mussel tissue from 25B sites (the subset of 25B sites where lipids were analyzed) and the control site off Torrey Pines (TP). "SP" refers to mussels transplanted from SIO to Pt. Loma and "PS" refers to mussels transplanted from Pt. Loma to SIO. Lipid concentration was significantly different among these sites (Kruskal-Wallis test, p=0.039).

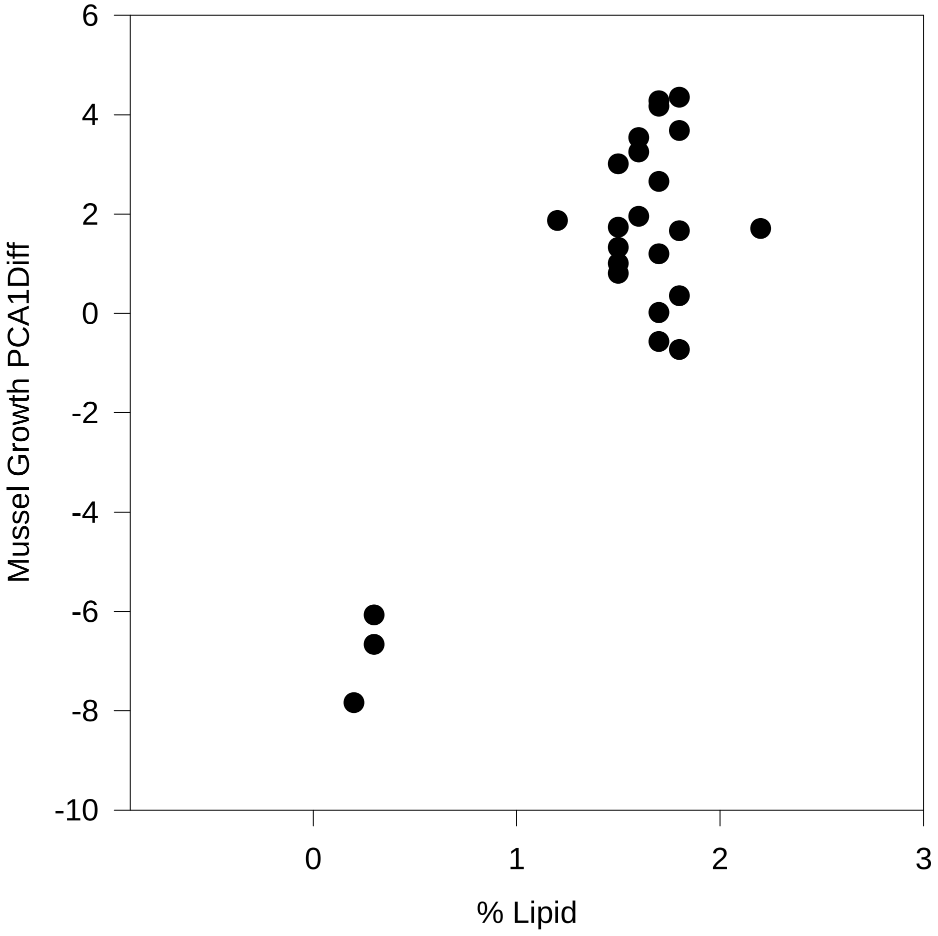


Figure 7. Relationship between lipid composition and mussel growth (r=0.839). The cluster of points in the lower left hand corner represent the mussels transplanted from SIO to Pt. Loma.

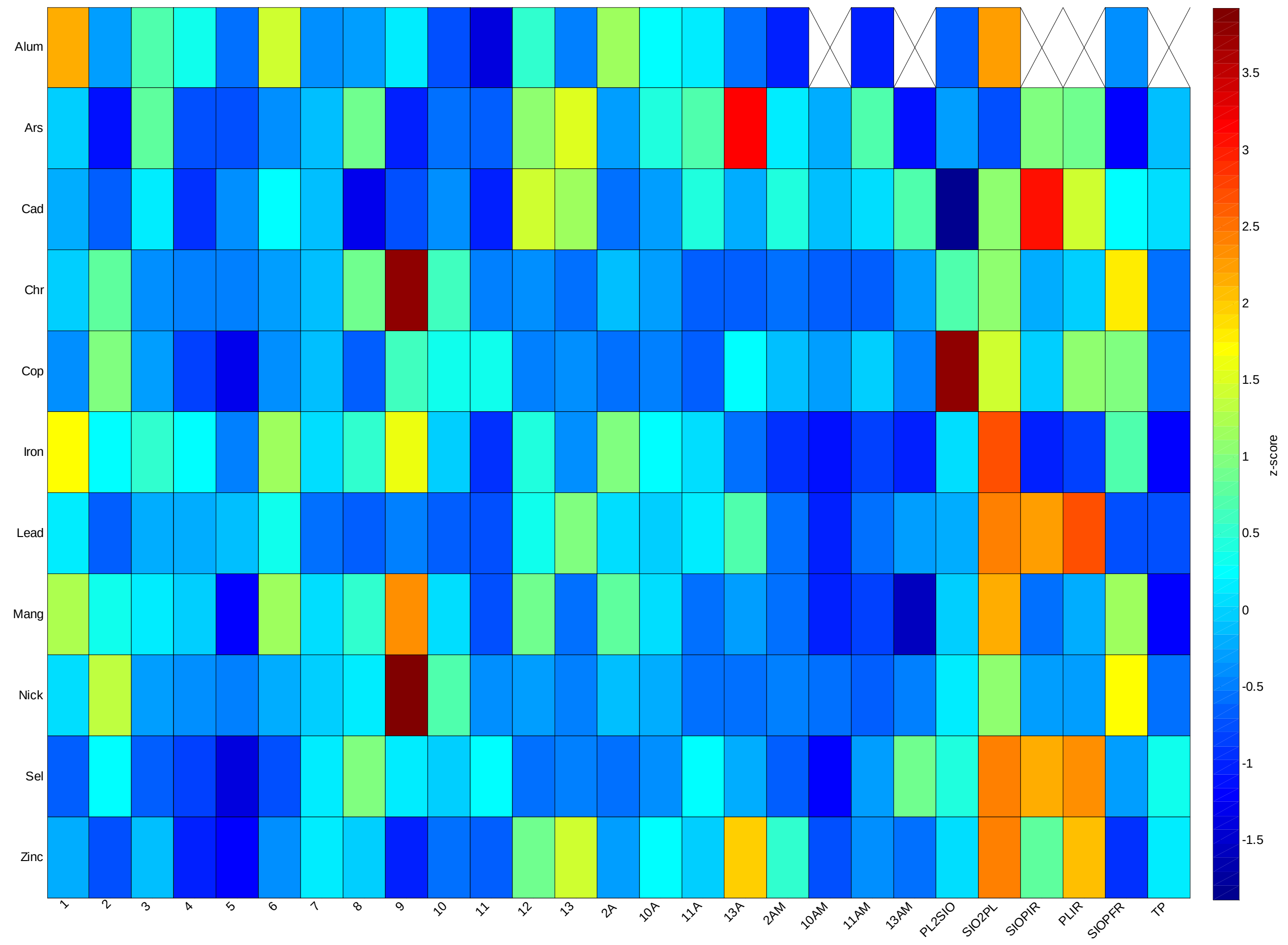


Figure 8. Z-scores of metal concentrations in mussel tissue at all sites. Missing values are indicated by crossed diagonal lines.

Figure 9. Pairs plot of metal concentrations in mussels at all sites. Units are mg/kg.

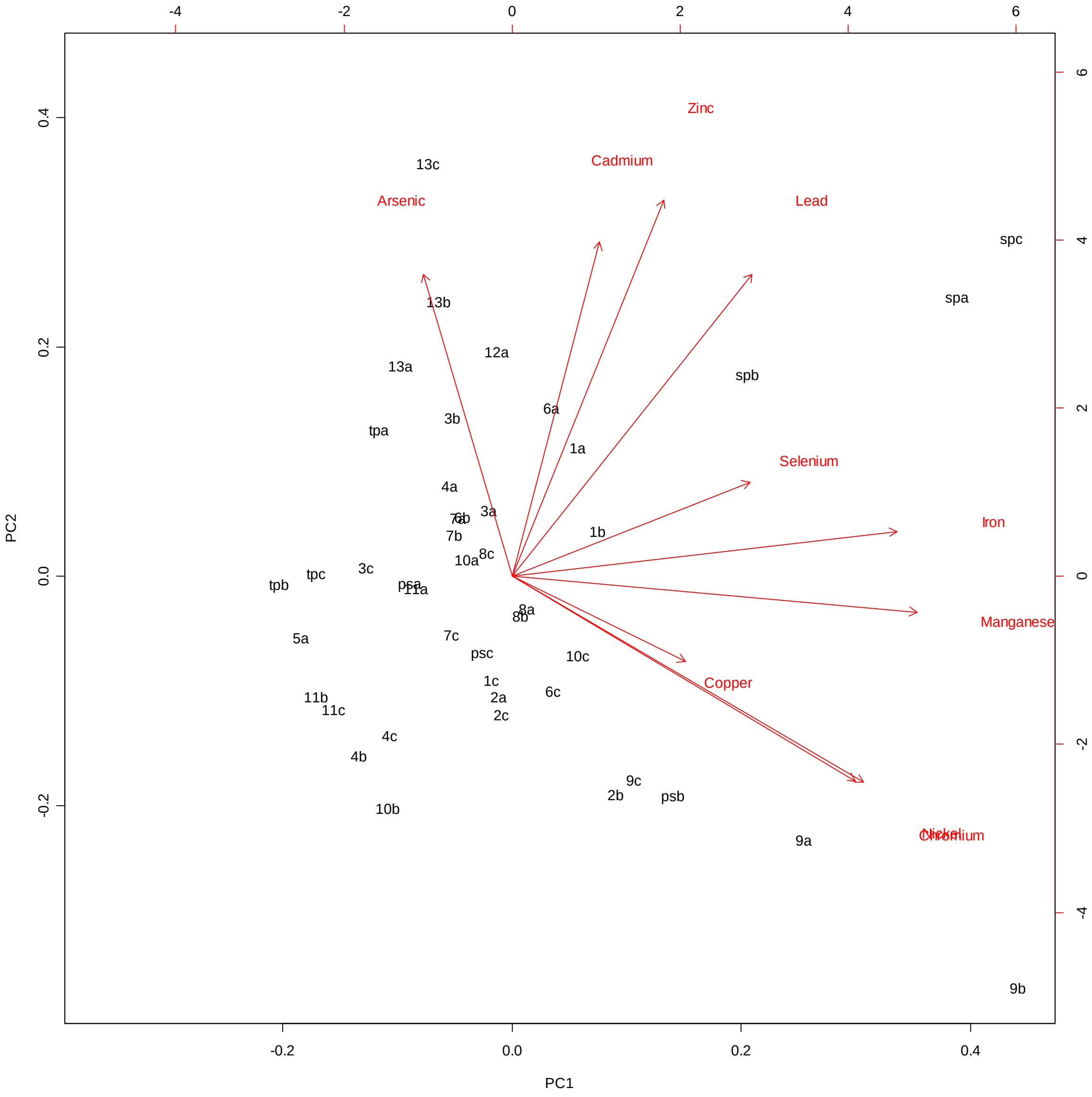


Figure 10. PCA of metals at shallow bottom sites (25B). First two principal components account for >64% of variation. Site replicates are denoted as "a", "b", and "c" preceded by the site number. "sp" denotes mussels transplanted from SIO Pier and transplanted to Pt. Loma, and "ps" refers mussels transplanted from Pt. Loma to La Jolla.

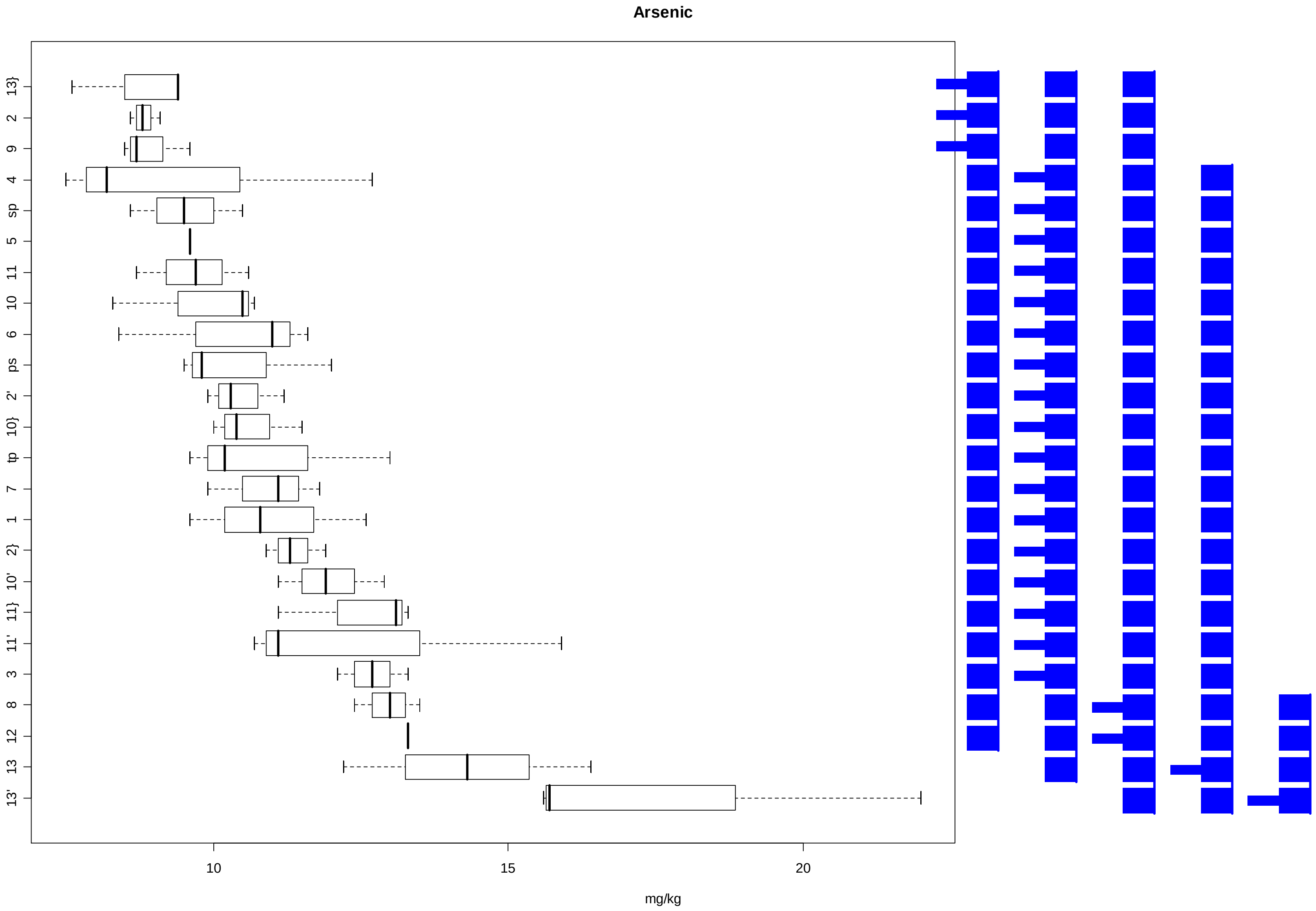


Figure 11. Multiple comparisons and boxplots of arsenic concentrations in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name reference. Boxes and whiskers calculated using MLE estimation.

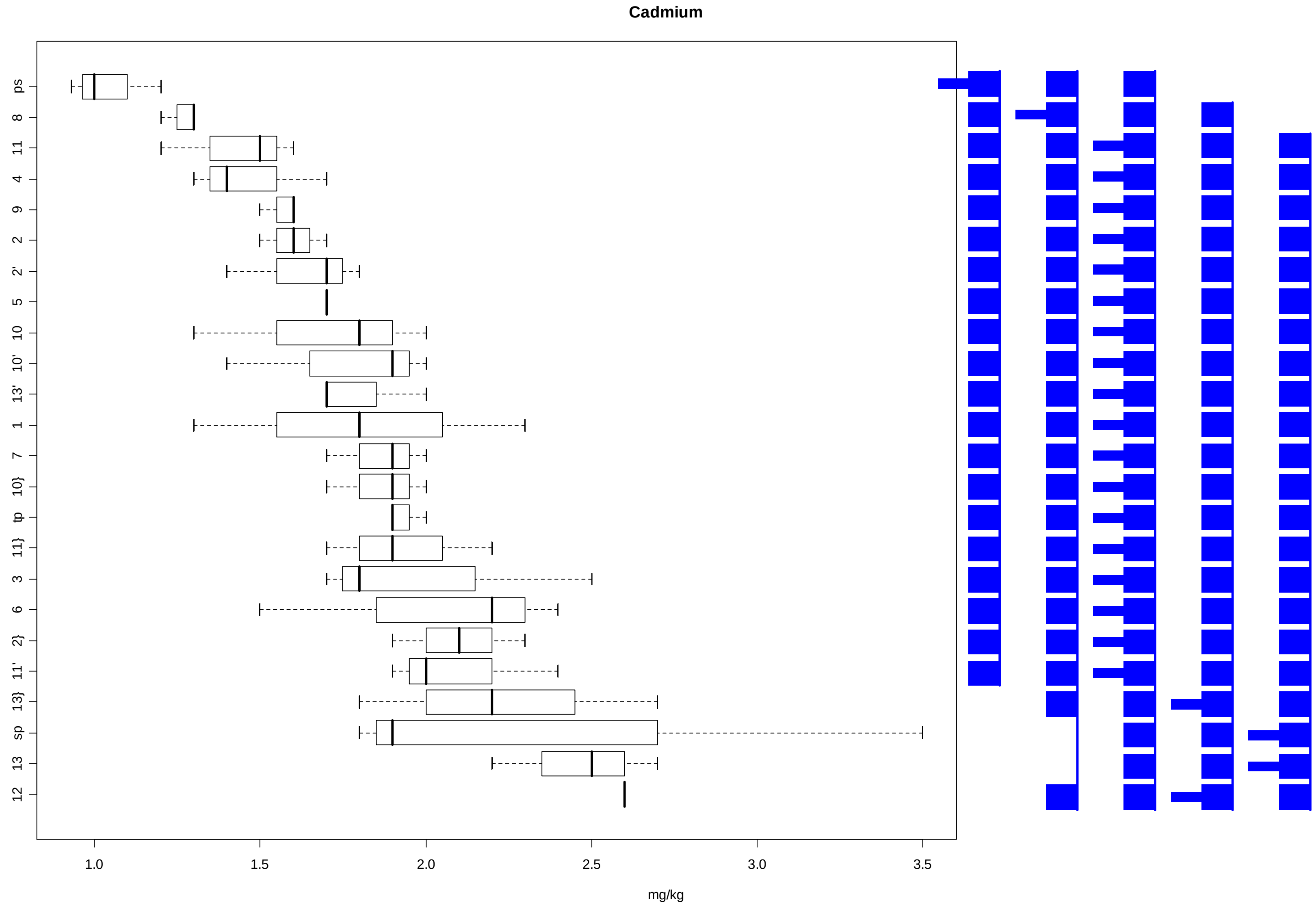


Figure 12. Multiple comparisons and boxplots of cadmium concentrations in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name reference. Boxes and whiskers calculated using MLE estimation.

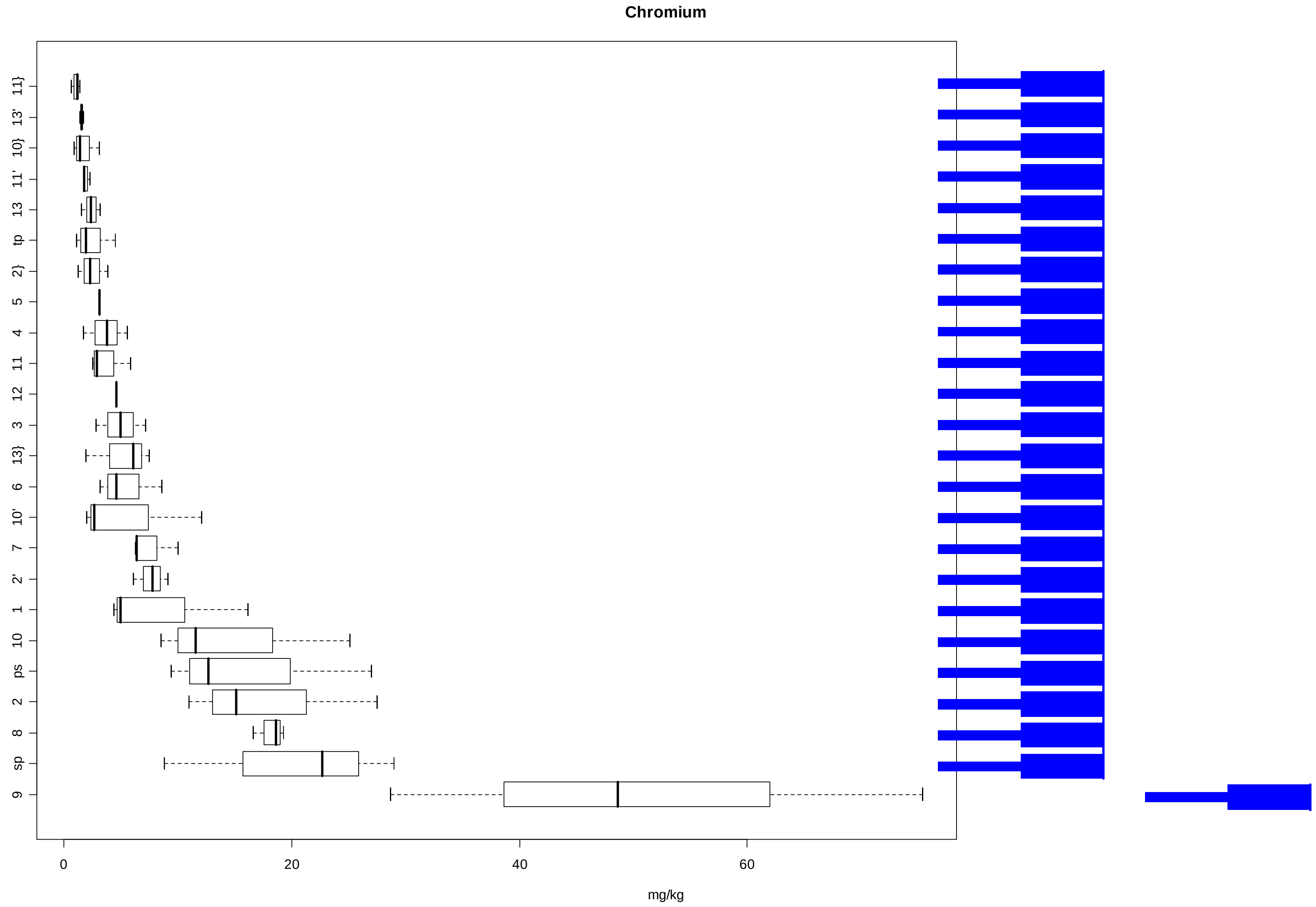


Figure 13. Multiple comparisons and boxplots of chromium concentrations in mussel tissue by site. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site names. Boxes and whiskers calculated using MLE estimation.

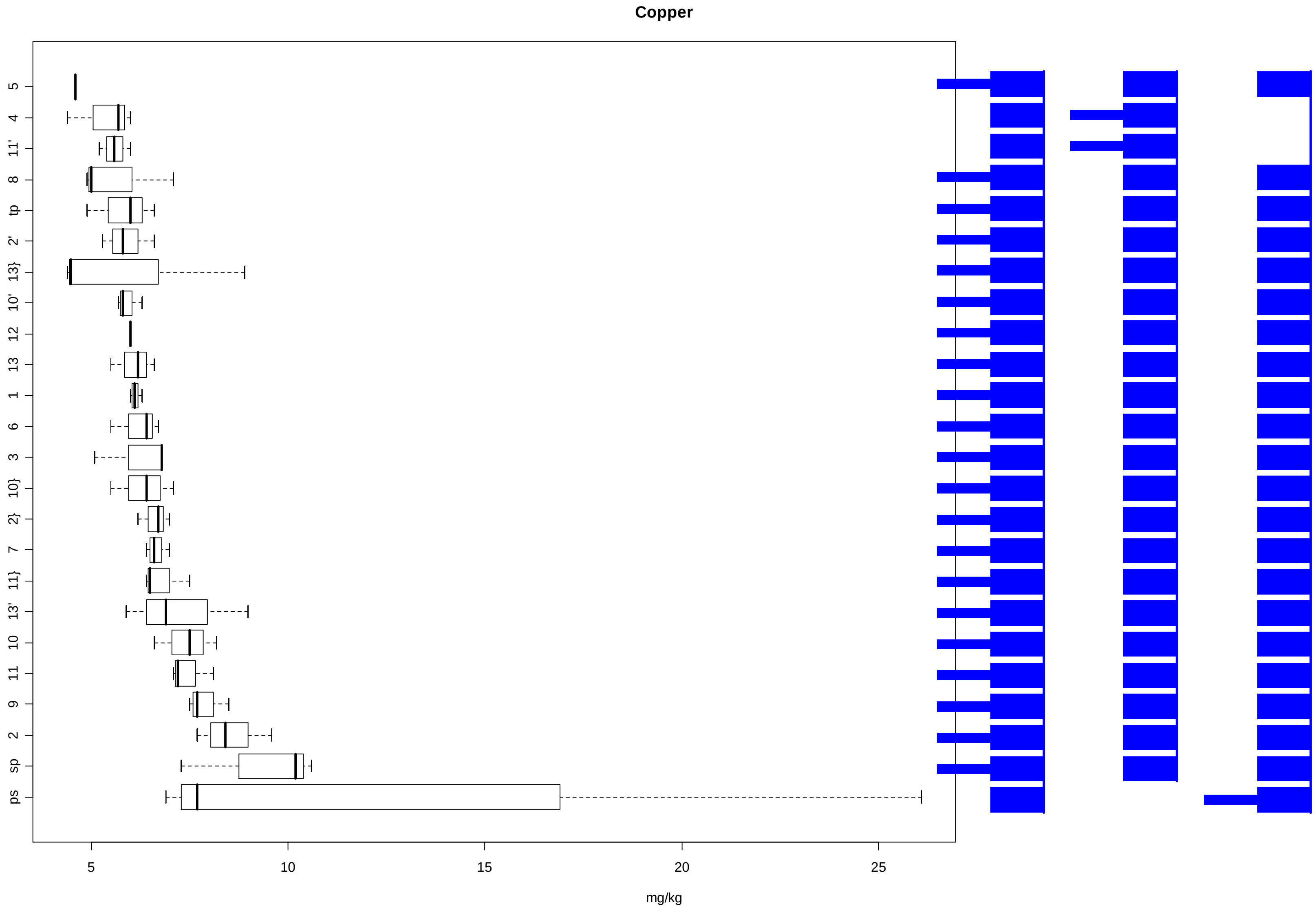


Figure 14. Multiple comparisons and boxplot of copper concentrations in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name reference. Boxes and whiskers calculated using MLE estimation.

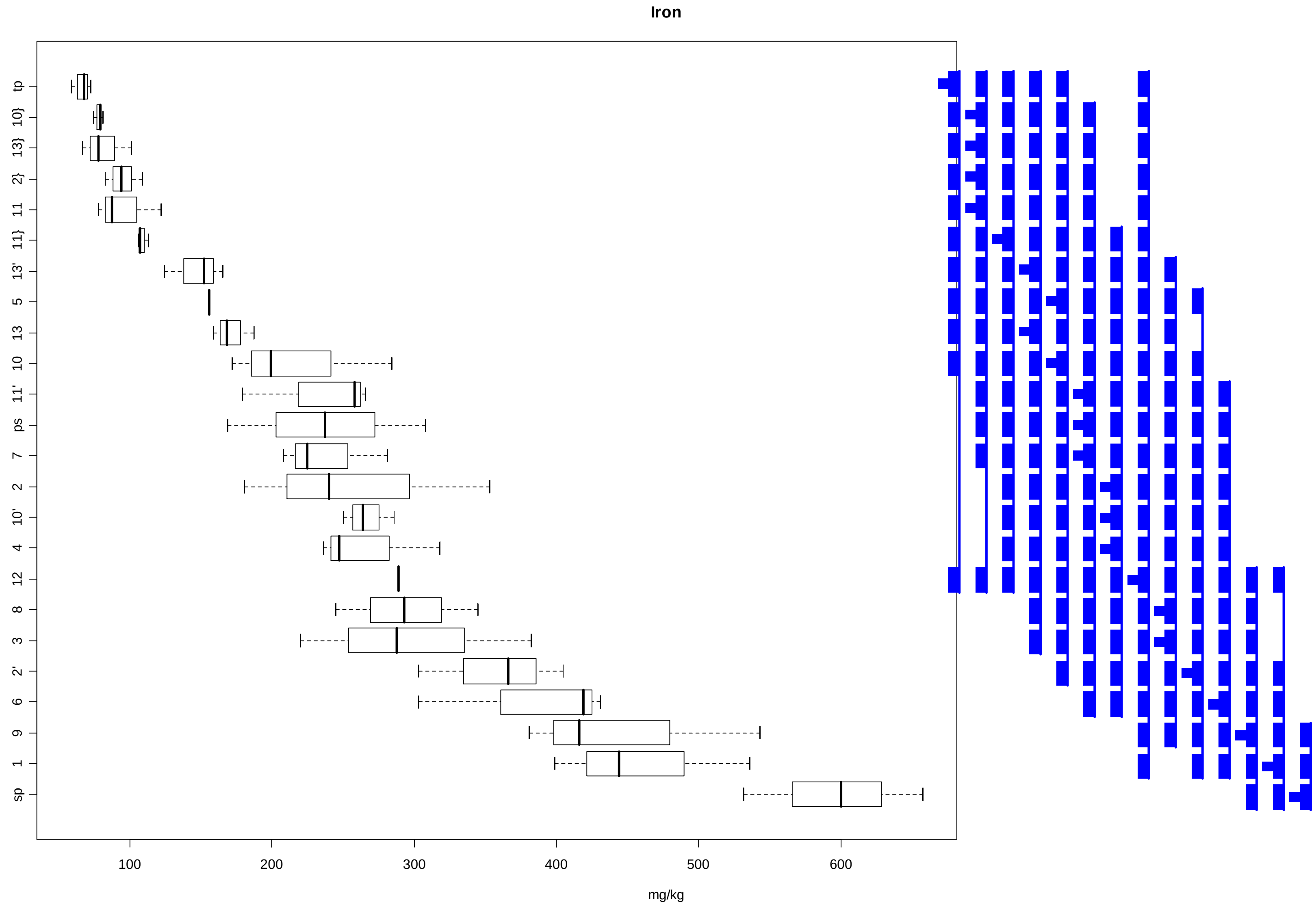


Figure 15. Multiple comparisons and boxplots of iron concentration in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name reference. Boxes and whiskers calculated using MLE estimation.

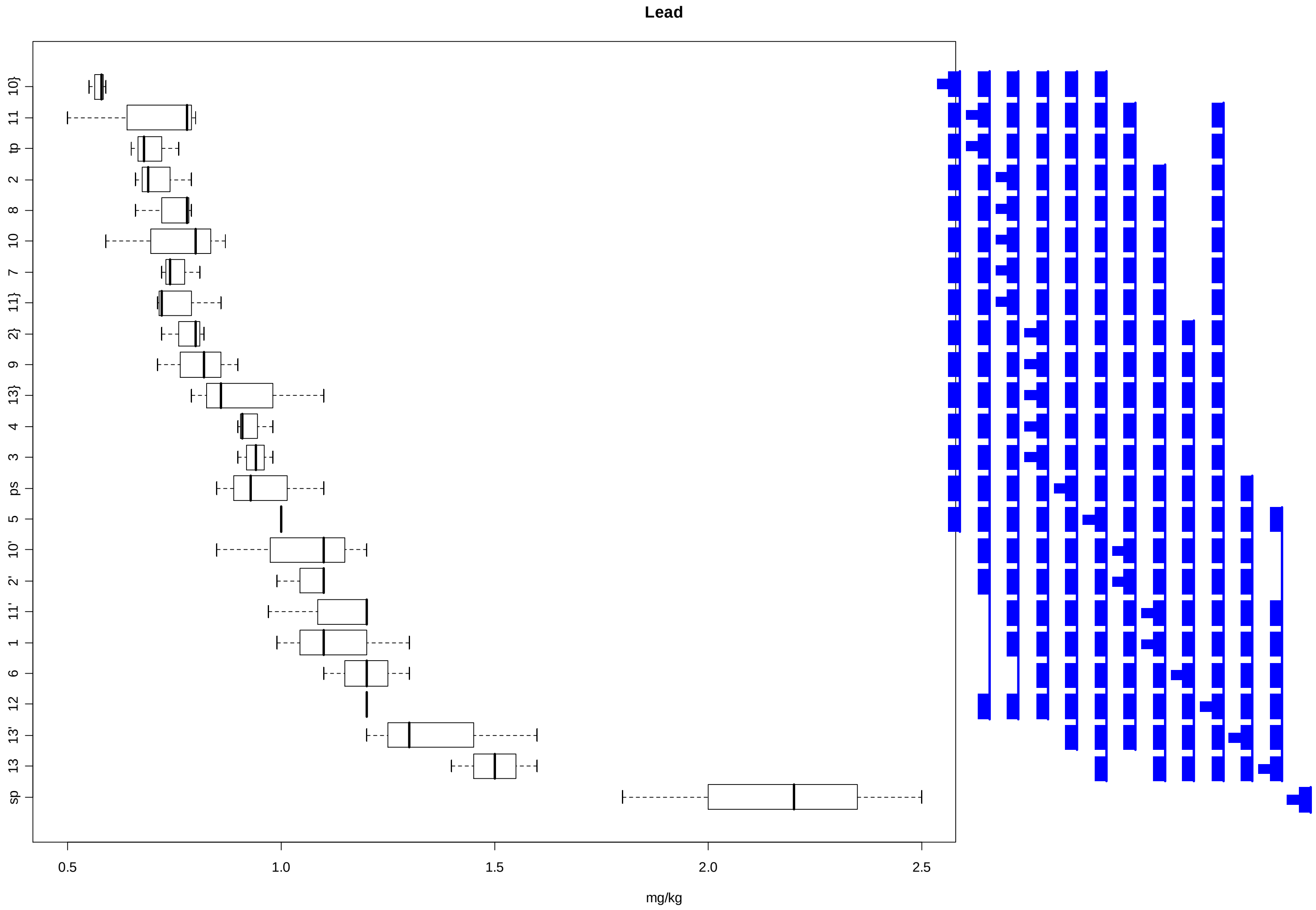


Figure 16. Multiple comparisons and boxplots of lead concentration in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name reference. Boxes and whiskers calculated using MLE estimation.

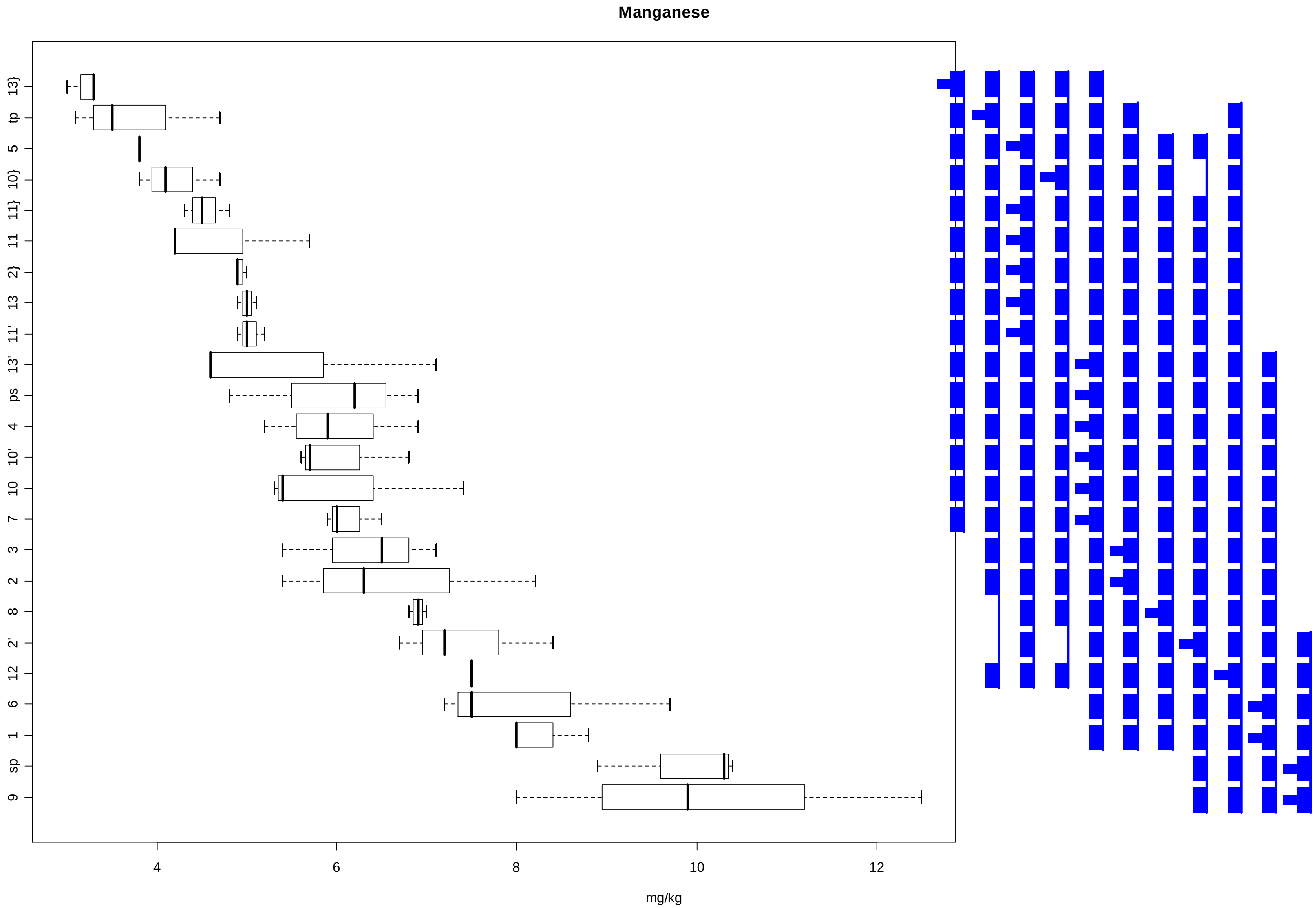


Figure 17. Multiple comparisons and boxplots of manganese concentration in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site names. Boxes and whiskers calculated using MLE estimation.

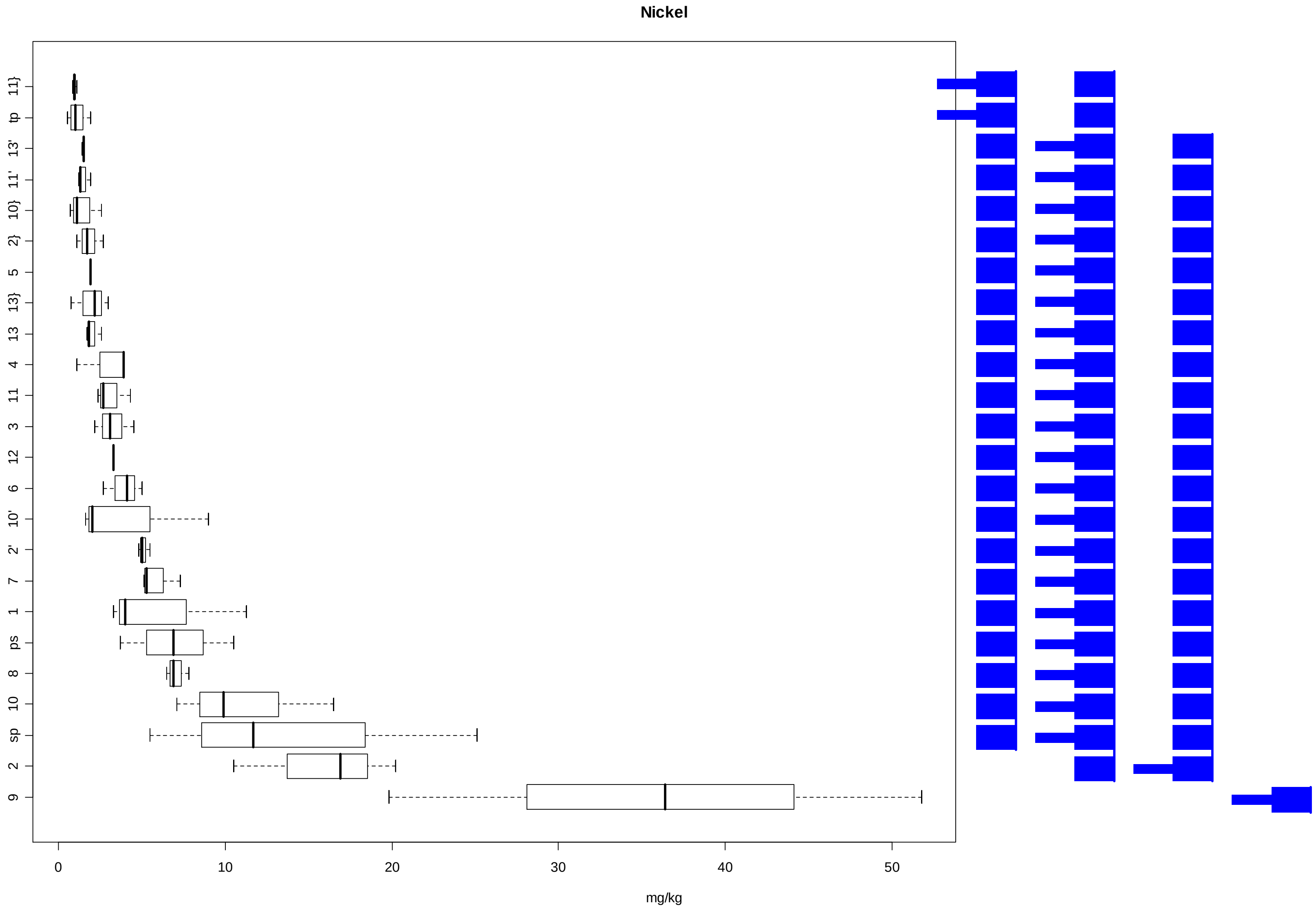


Figure 18. Multiple comparisons and boxplots of nickel concentration in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name reference. Boxes and whiskers calculated using MLE estimation.

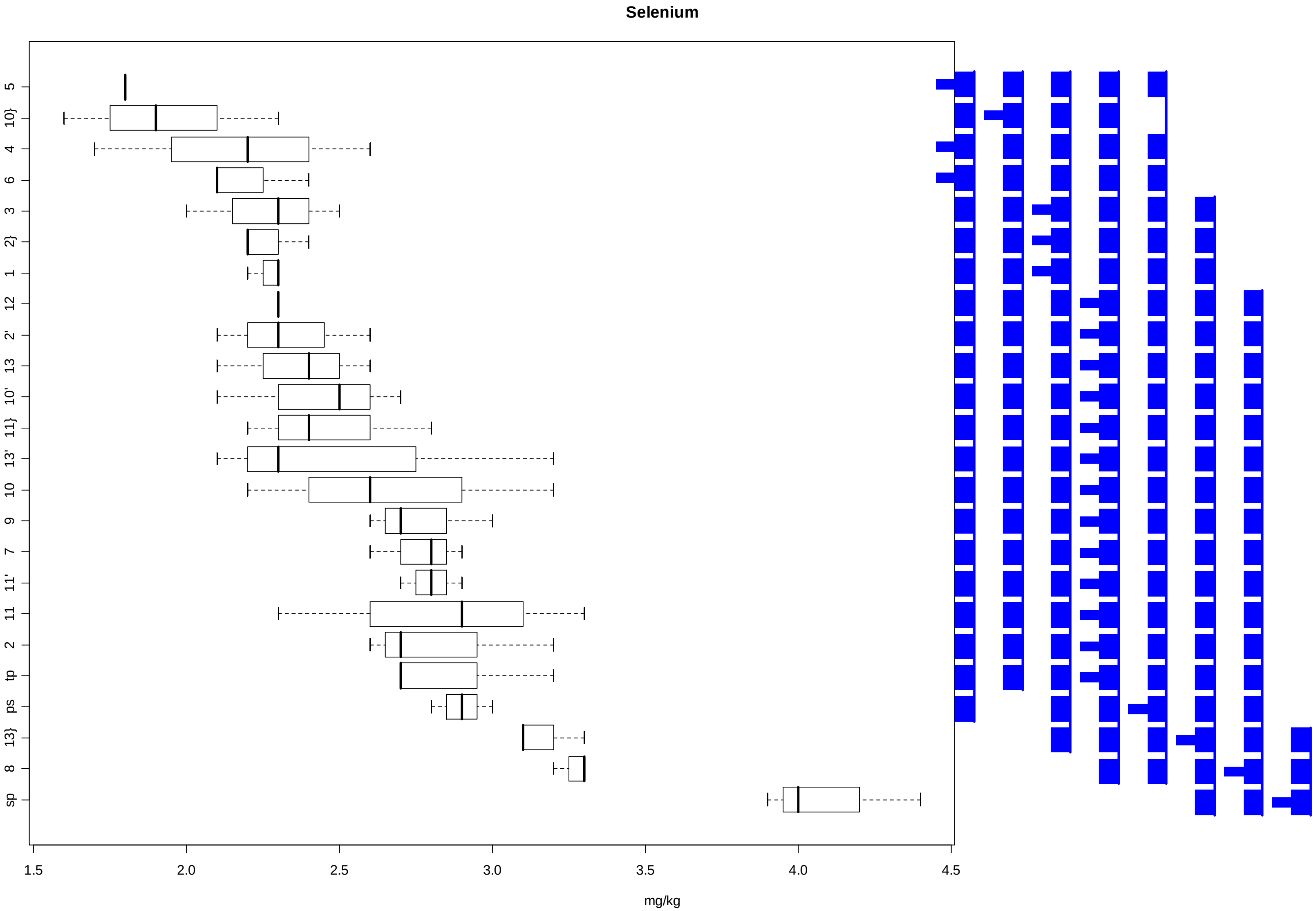


Figure 19. Boxplot of selenium concentration in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name reference. Boxes and whiskers calculated using MLE estimation.

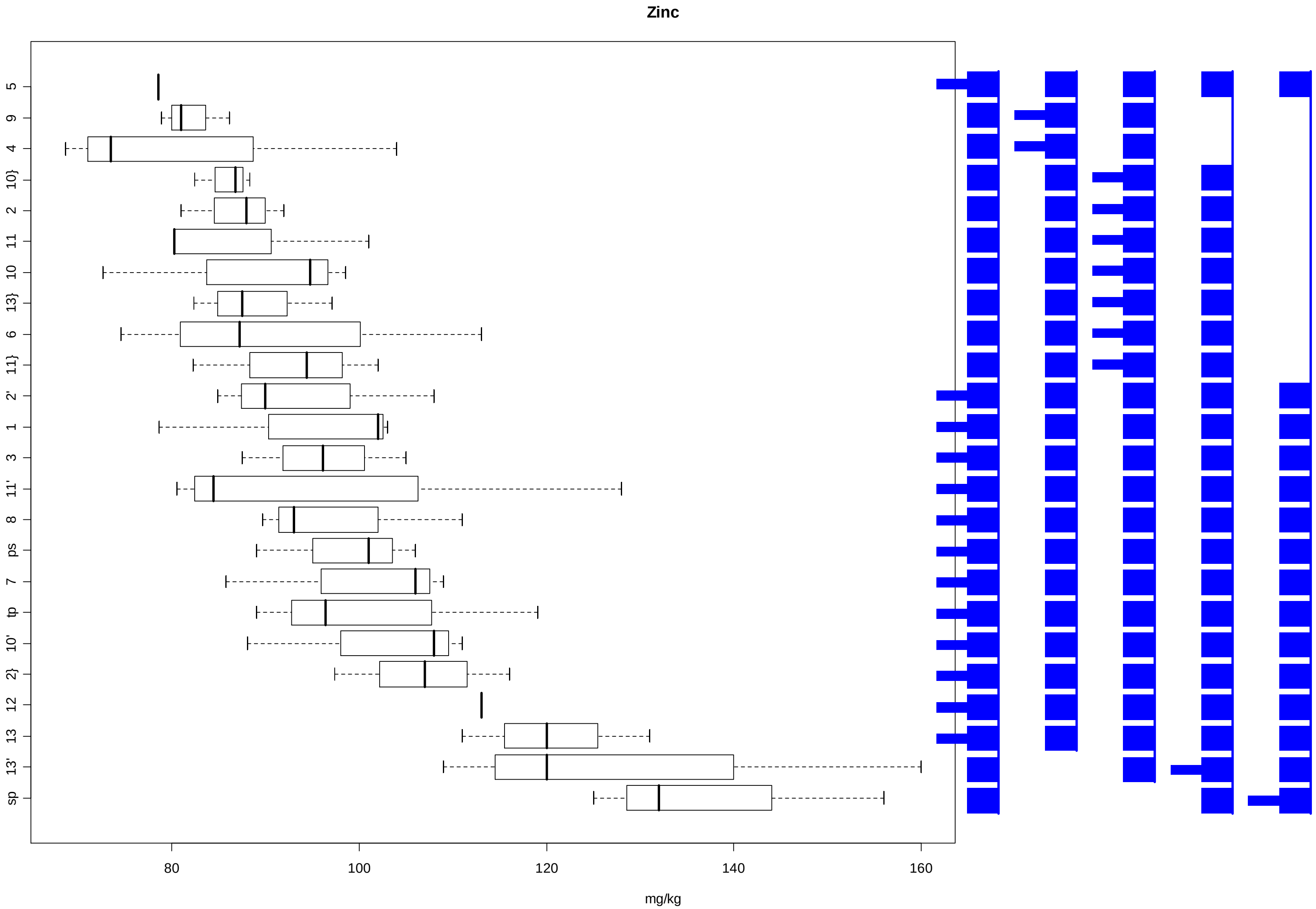


Figure 20. Multiple comparisons and boxplots of zinc concentration in mussel tissue among sites. See Figure 5 for an explanation of how groupings are indicated. Site names were modified for fit, see Table 1 for site name reference. Boxes and whiskers calculated using MLE estimation.

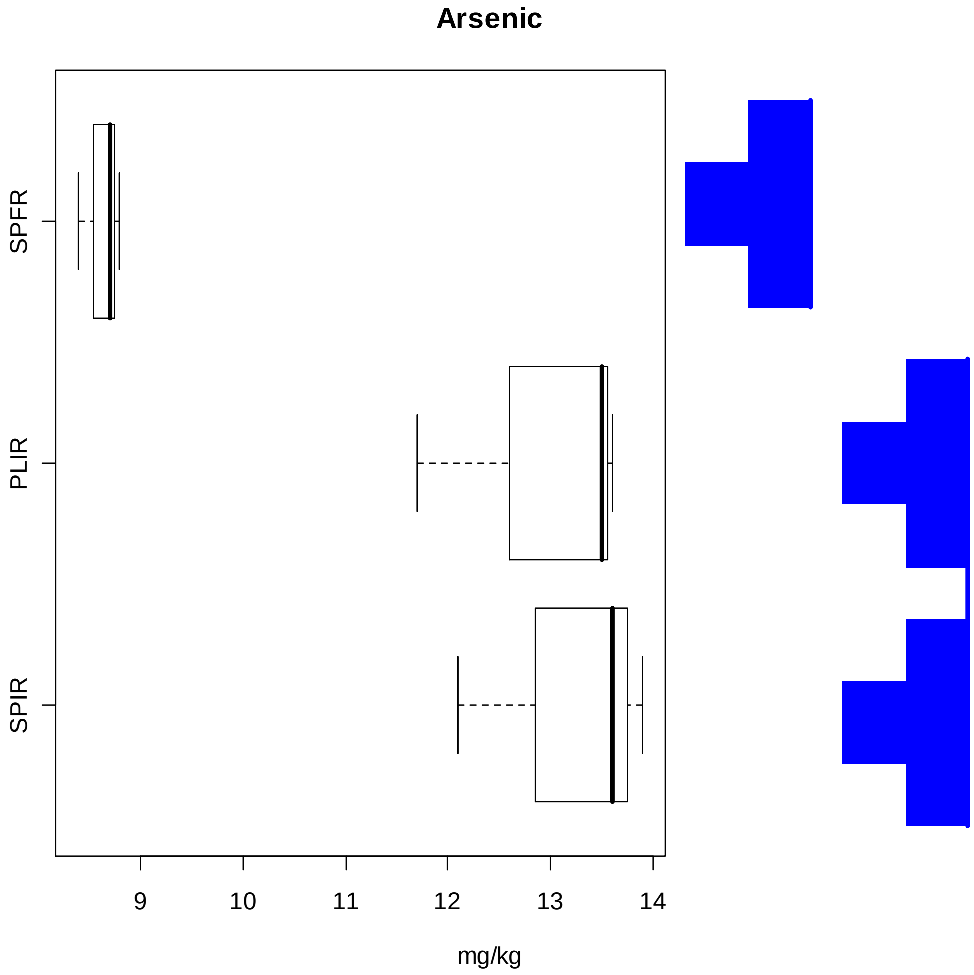


Figure 21. Boxplot of arsenic concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

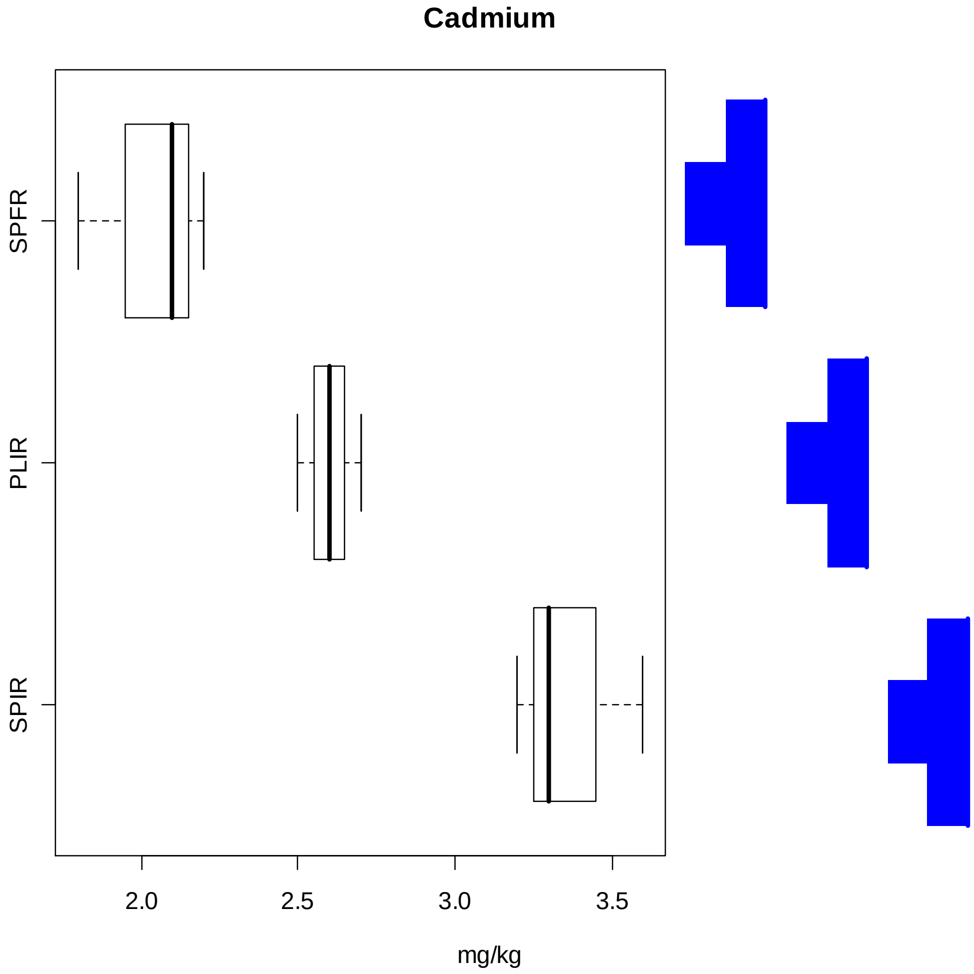


Figure 22. Boxplot of cadmium concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

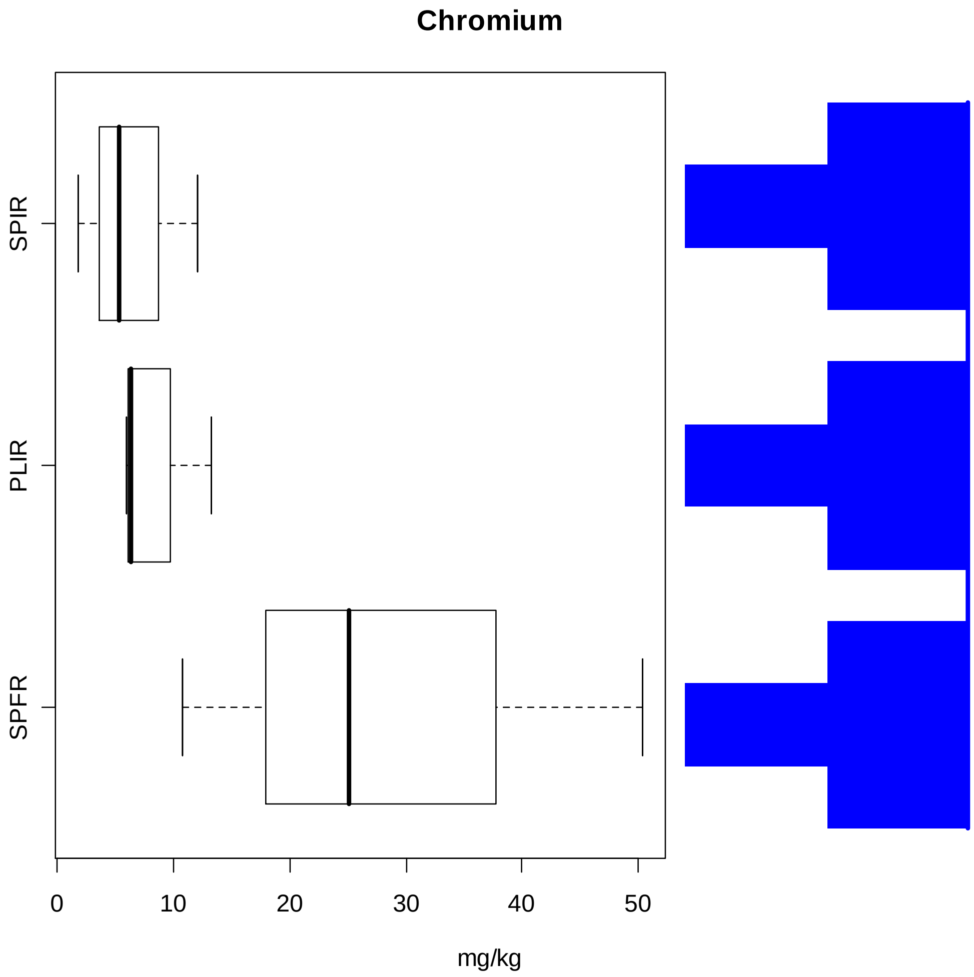


Figure 23. Boxplot of chromium concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

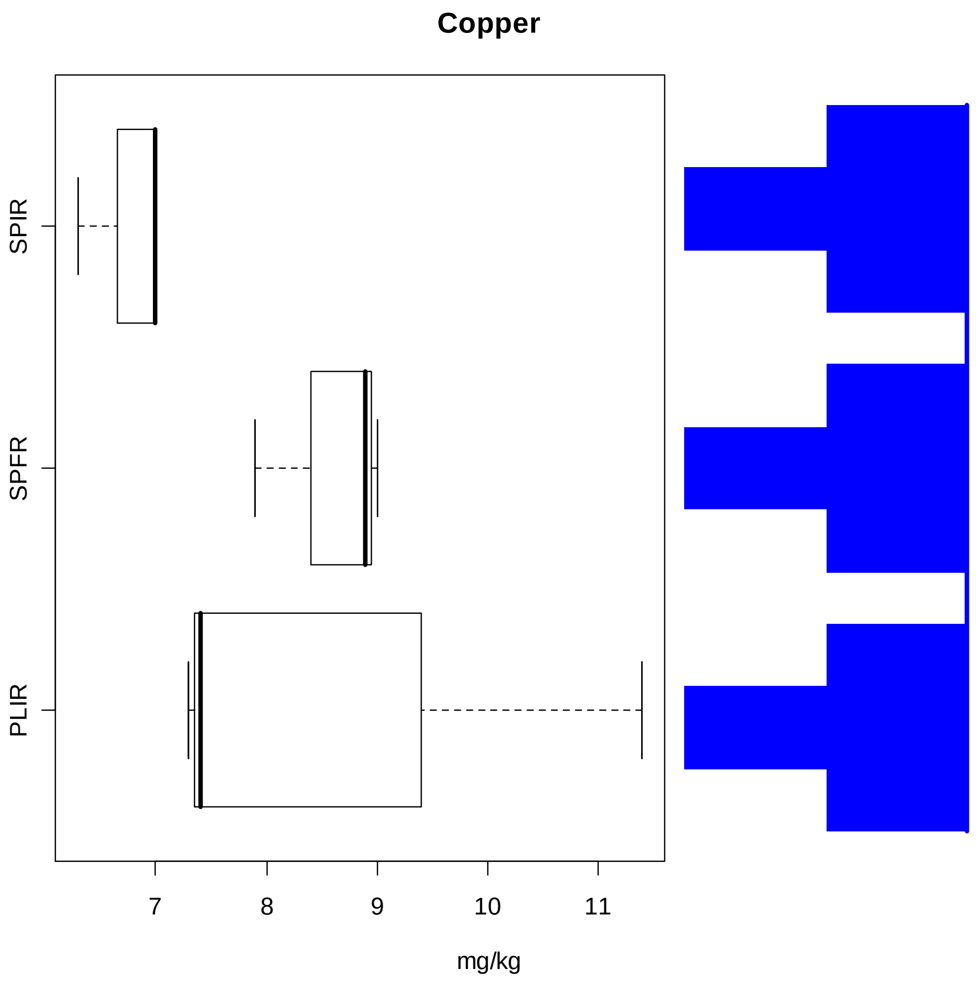


Figure 24. Boxplot of copper concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

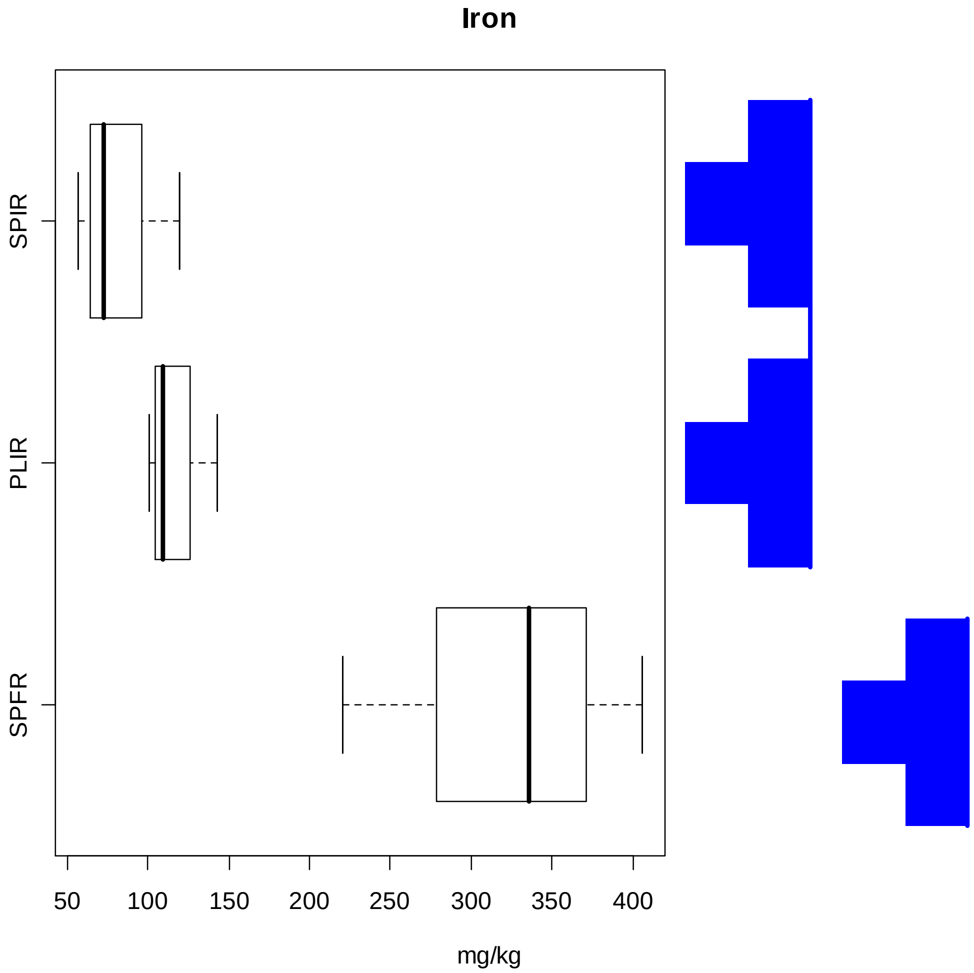


Figure 25. Boxplot of iron concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

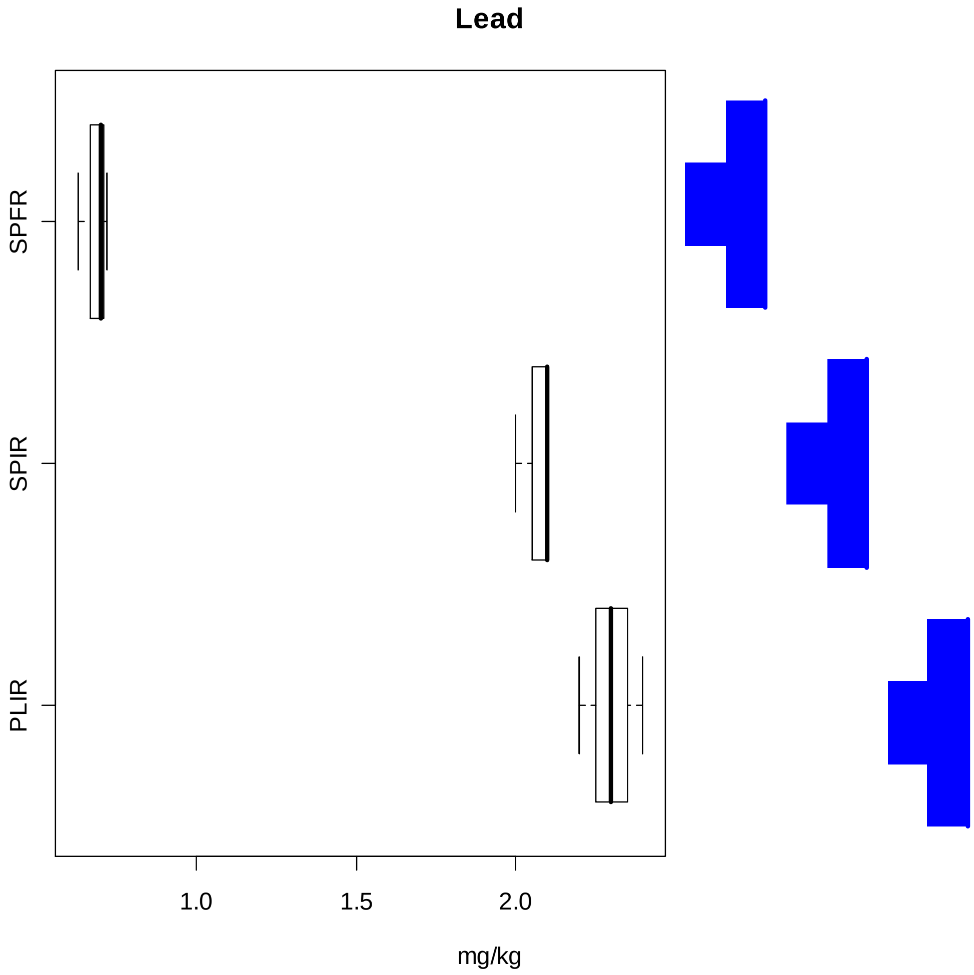


Figure 26. Boxplot of lead concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

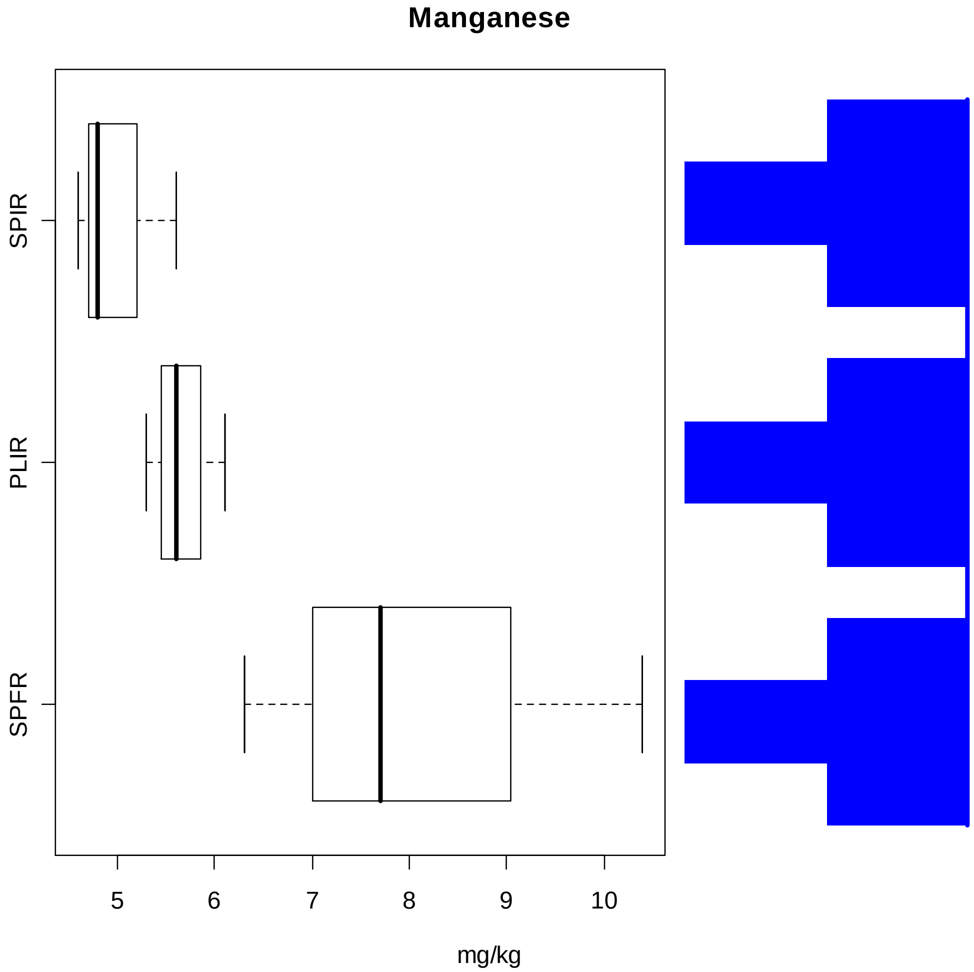


Figure 27. Boxplot of manganese concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

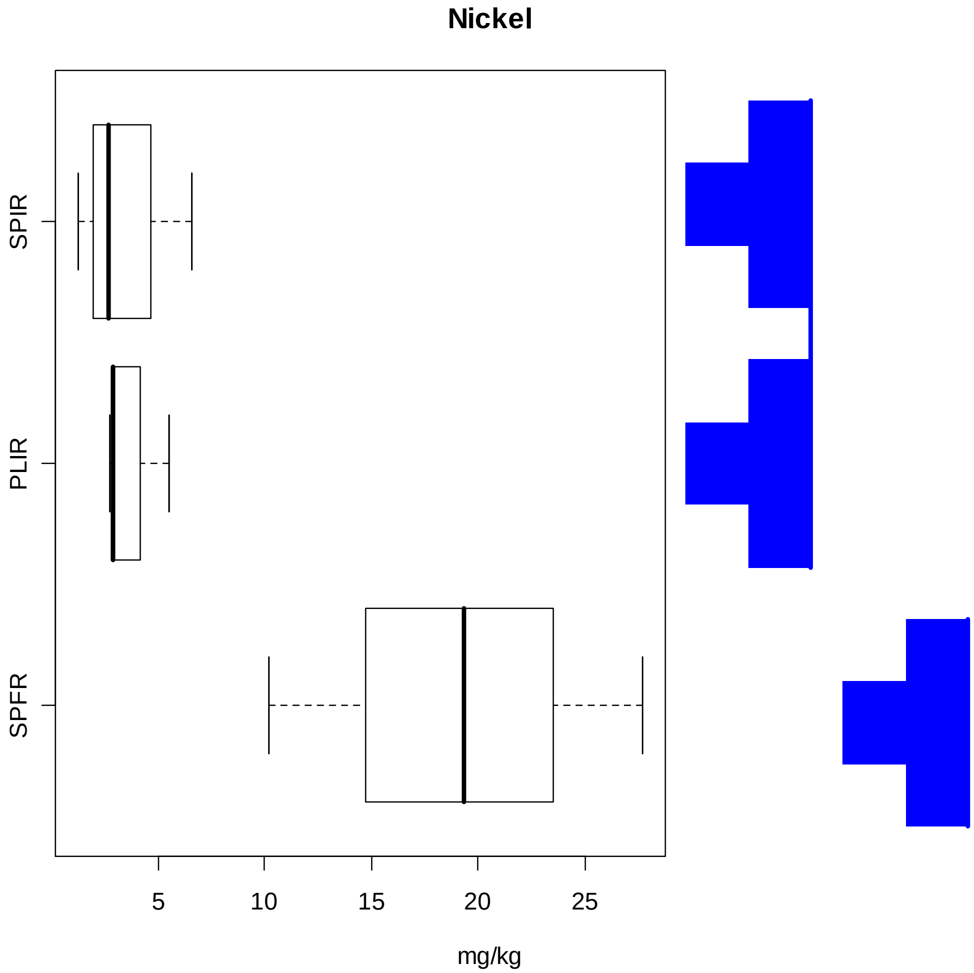


Figure 28. Boxplot of nickel concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

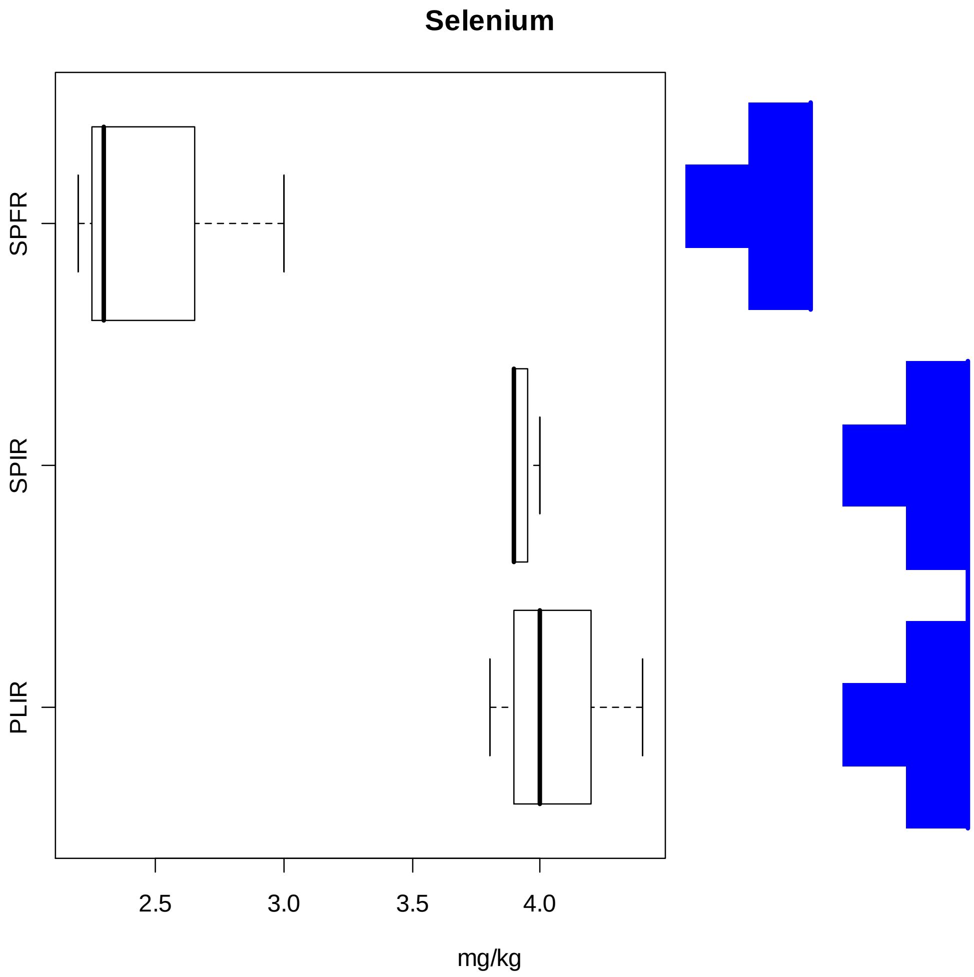


Figure 29. Boxplot of selenium concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant (p<0.05) groupings are indicated at right.

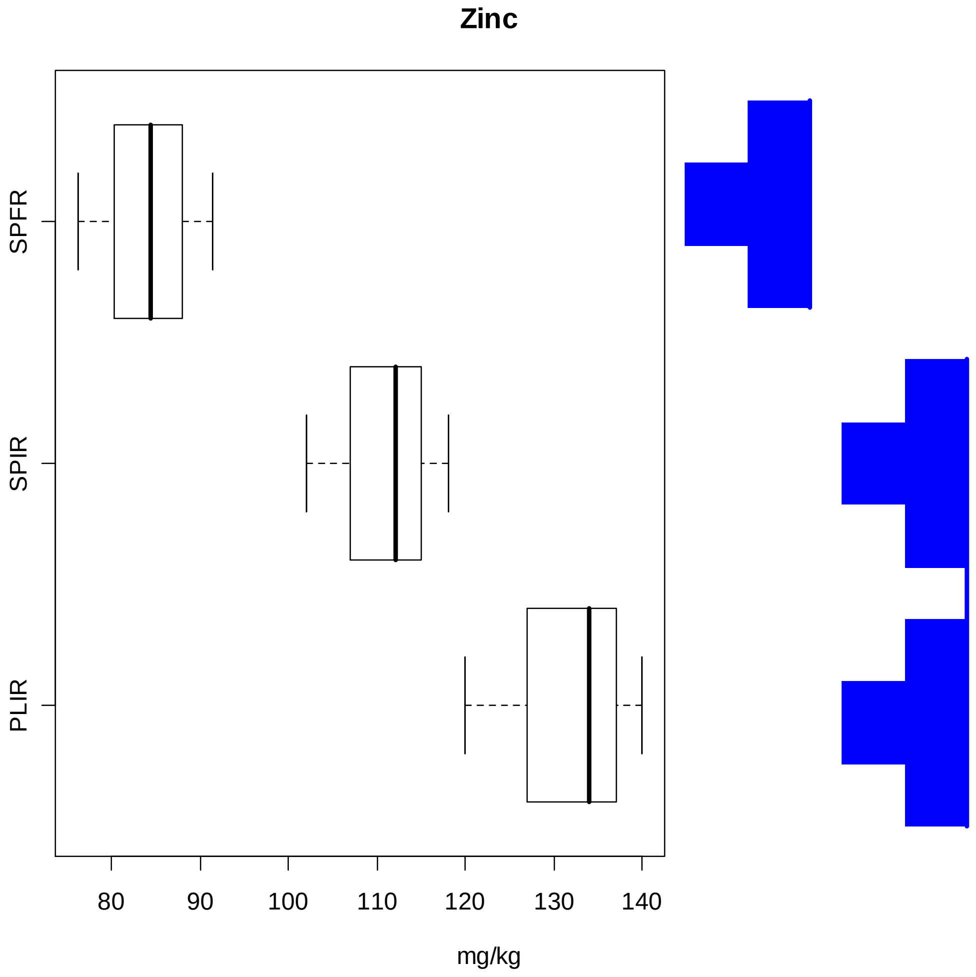


Figure 30. Boxplot of zinc concentration in mussel tissue at harvest sites (SPIR=Scripps Pier Initial Reference, SPFR=Scripps Pier Final Reference, PLIR=Point Loma Initial Reference). Significant ($p<0.05$) groupings are indicated at right.

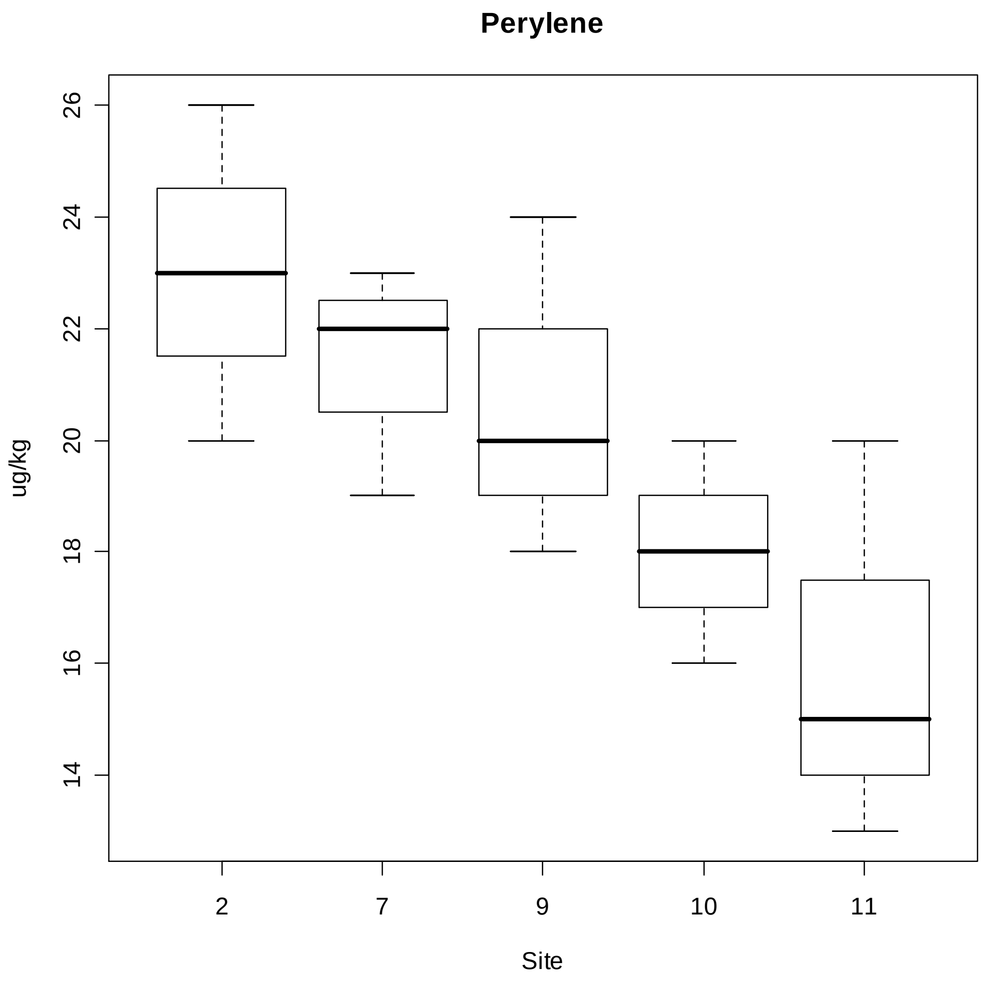


Figure 31. Boxplot of perylene concentration in mussel tissue among sites where it was detected. Concentrations were not significantly different among sites (Kruskal-Wallis test, p=0.143).

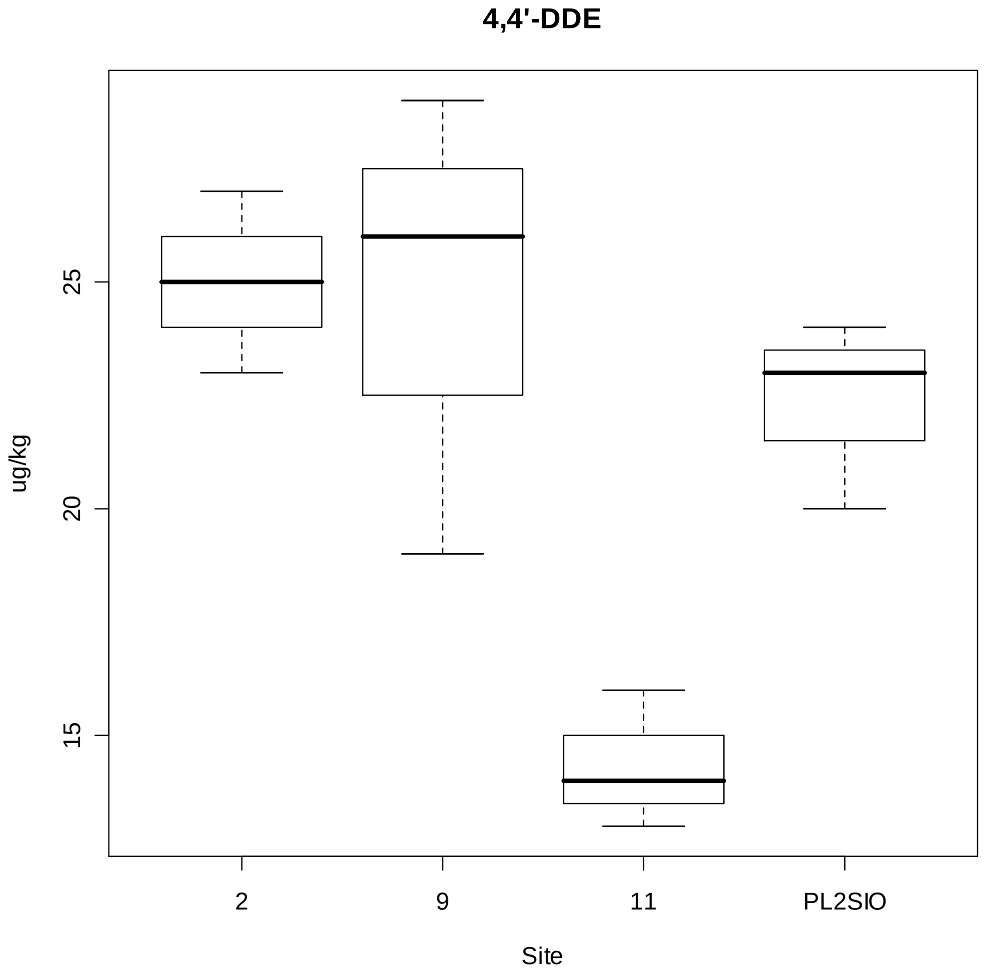


Figure 32. Boxplot of 4,4'-DDE concentrations in mussel tissue. Sites were not significantly different (Kruskal-Wallis test, p=0.071).

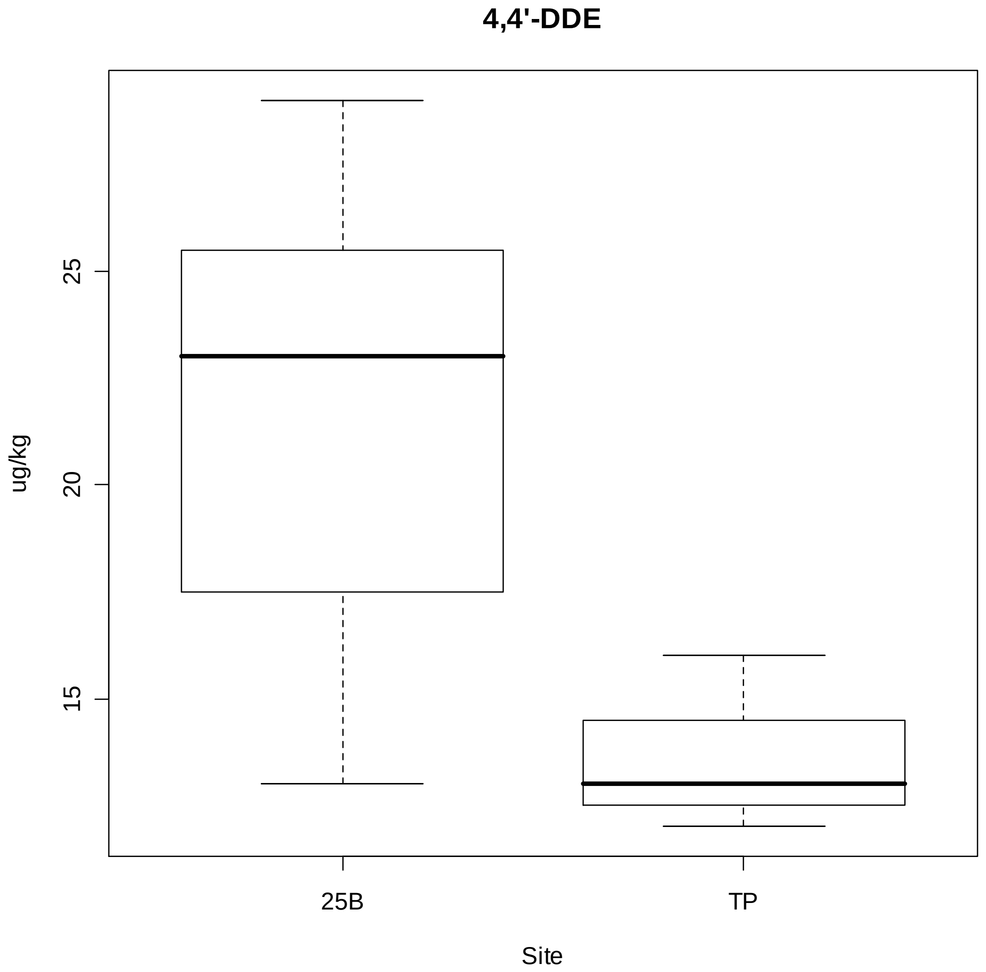


Figure 33. Boxplot of 4,4’-DDE concentrations in mussel tissue at 25B site and control site (TP=Torrey Pines). Concentrations were significantly different between control and 25B sites (Kruskal-Wallis test, p=0.030).

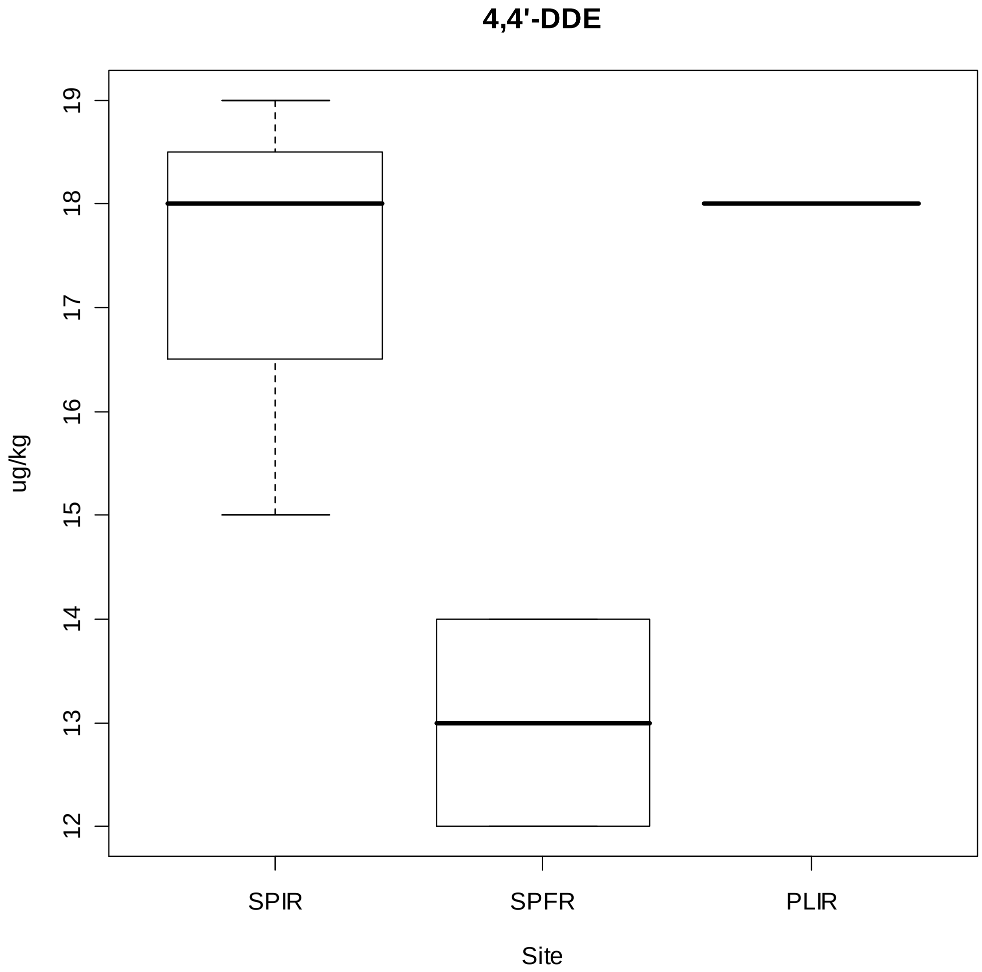


Figure 34. Boxplot of 4,4’-DDE concentration in mussel tissue from harvest sites (SPIR=SIO Pier initial reference, SPFR=SIO Pier final reference, PLIR=Pt. Loma initial reference). Concentrations were not significantly different among groups (Kruskal-Wallis test, p=0.103).

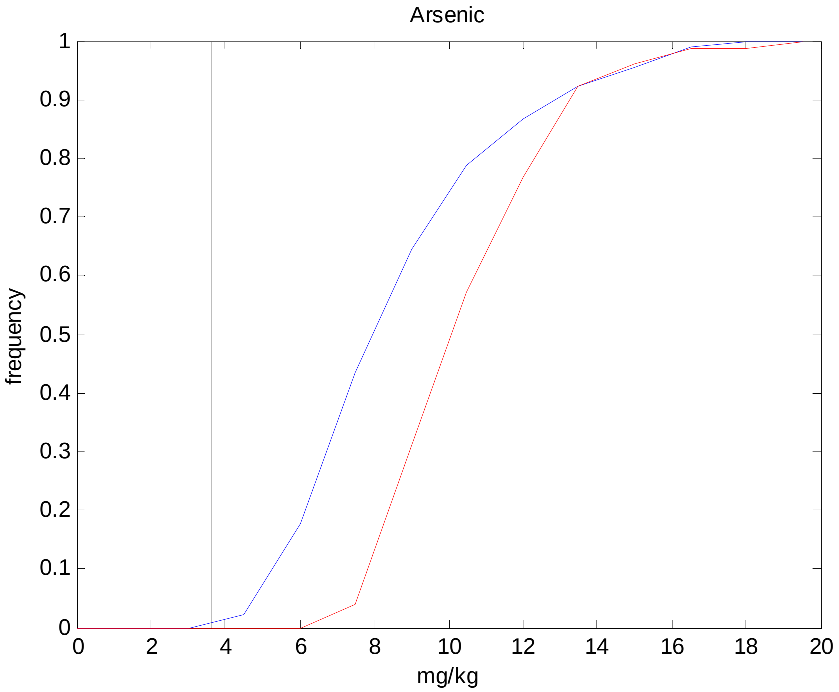


Figure 35. Cumulative frequency distributions of arsenic concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest observed concentration of arsenic along the west coast was ~18 mg/kg, sampled from Fraser Pt. on Santa Cruz Island in 2004 and was ~17 mg/kg near the lighthouse at Pt. Loma in 2003.

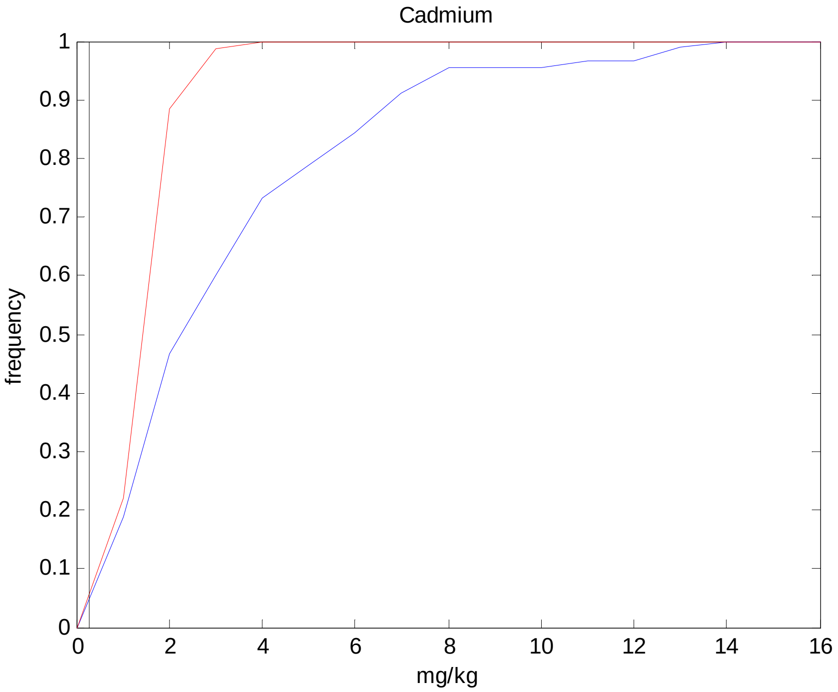


Figure 36. Cumulative frequency distributions of cadmium concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of cadmium observed along the west coast was ~14 mg/kg, sampled from Fraser Pt. on Santa Cruz Island in 2002.

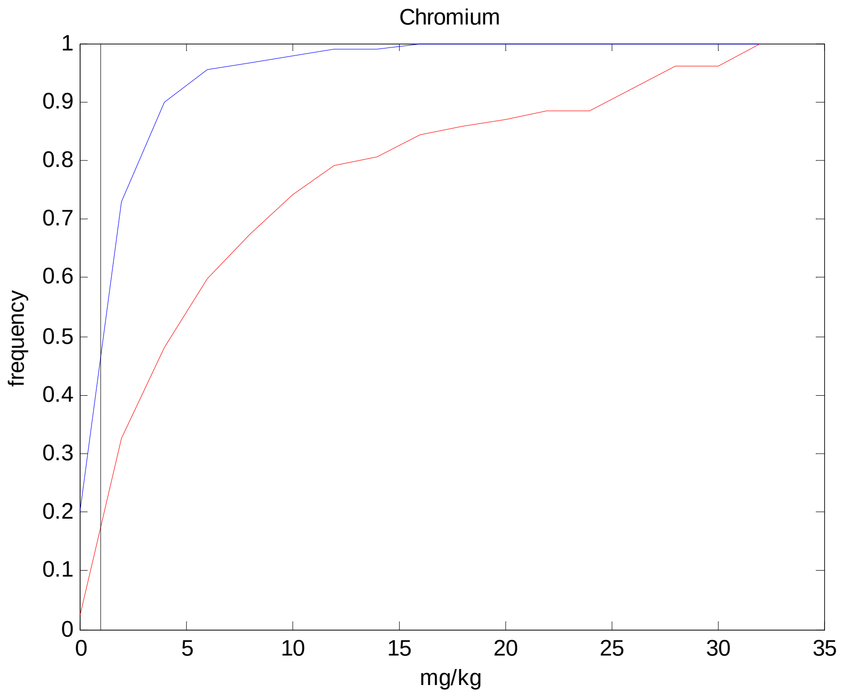


Figure 37. Cumulative frequency distributions of chromium concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of chromium observed in Mussel Watch was ~16 mg/kg, sampled from Pt. Roberts, WA in 2002. The greatest concentration of chromium in the present study was ~75 mg/kg, sampled from site 9. Relatively high concentrations of chromium were also observed at site SIO2PL (~29 mg/kg).

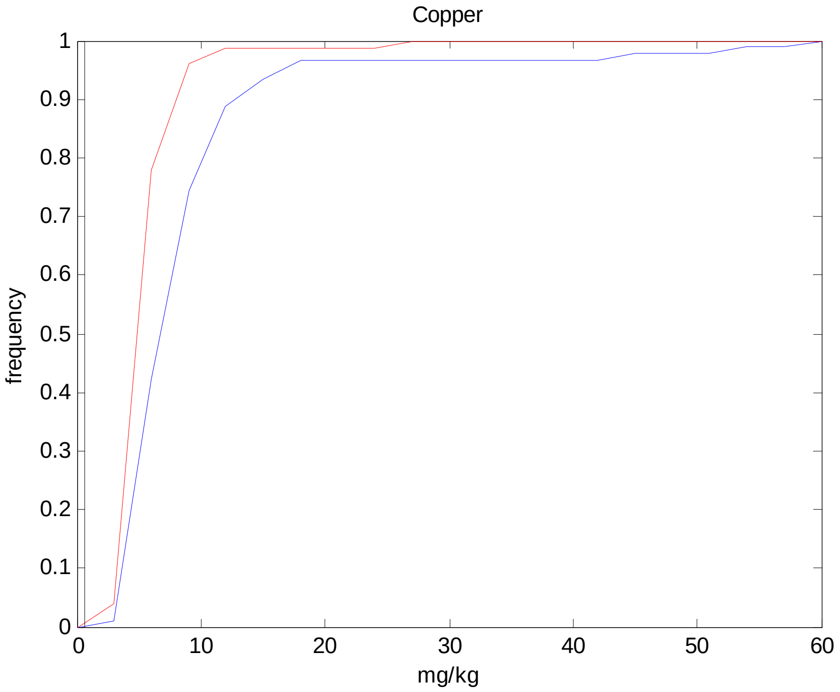


Figure 38. Cumulative frequency distributions of copper concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of copper observed along the west coast was ~139 mg/kg, sampled from Spenger's residence in Tomales Bay in 2003.

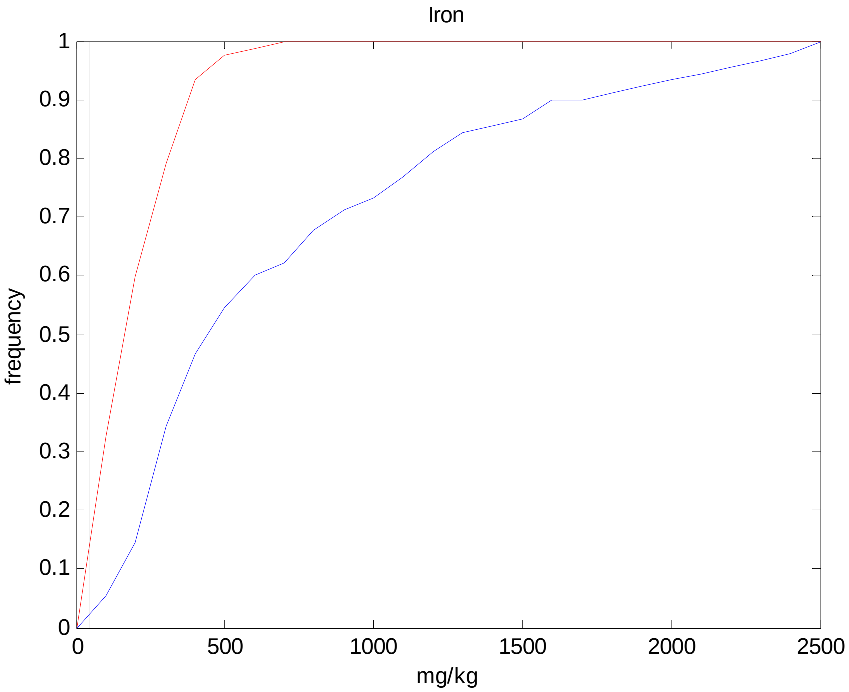


Figure 39. Cumulative frequency distributions of iron concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of iron observed along the west coast was ~2,640 mg/kg, sampled from Duwamish Head, Elliot Bay in 2002.

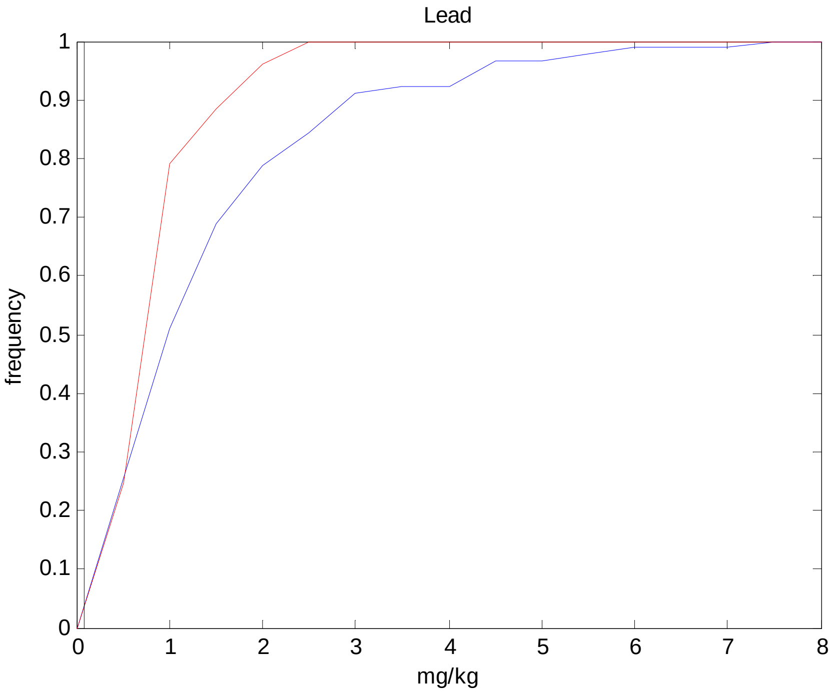


Figure 40. Cumulative frequency distributions of lead concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of lead observed along the west coast was ~7.6 mg/kg, sampled from Everett Harbor in Puget Sound in 2004.

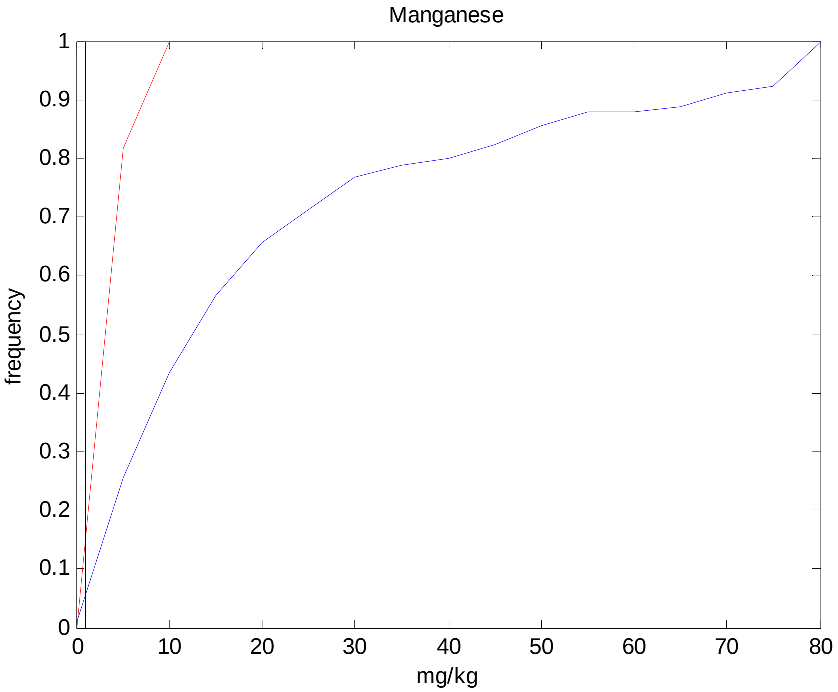


Figure 41. Cumulative frequency distributions of manganese in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of manganese observed along the west coast was ~405 mg/kg, sampled from Dumbarton Bridge in San Francisco Bay in 2003.

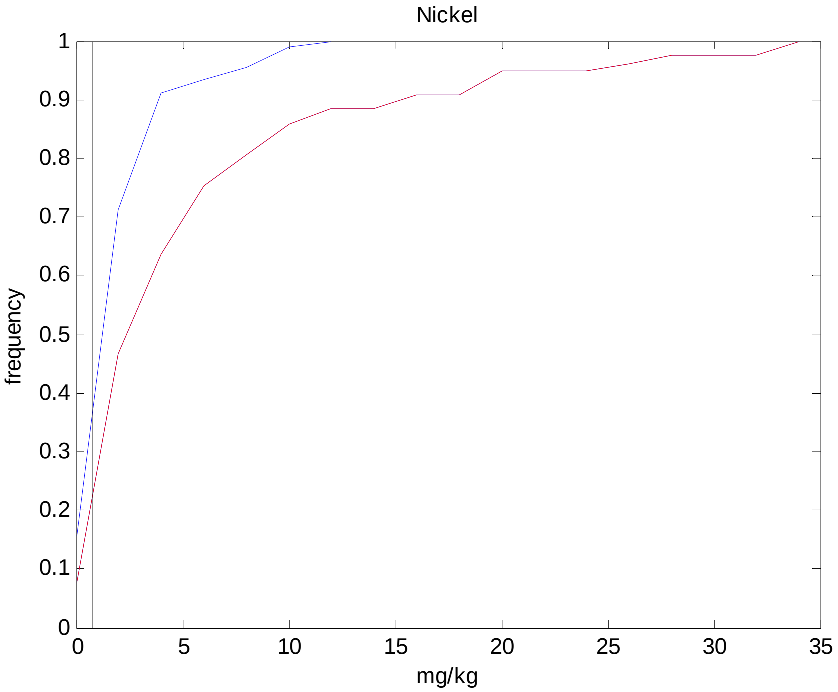


Figure 42. Cumulative frequency distributions of nickel concentration in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of nickel observed in the Mussel Watch program was ~11.7 mg/kg, sampled near the Pt. Arena Lighthouse in 2003. The greatest concentrations of nickel observed in this study were much greater ~51.8 mg/kg sampled from site 9. There were also high concentrations of nickel from site SIO2PL (25.1 mg/kg).

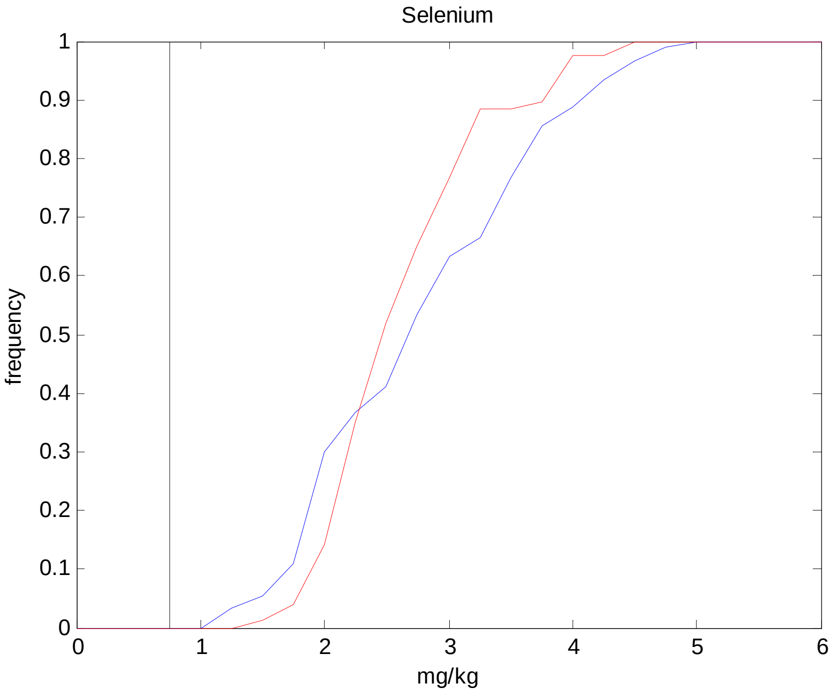


Figure 43. Cumulative frequency distributions of selenium concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of selenium observed along the west coast was ~5.1 mg/kg, sampled from the Westport Jetty, Gray's Harbor in 2002.

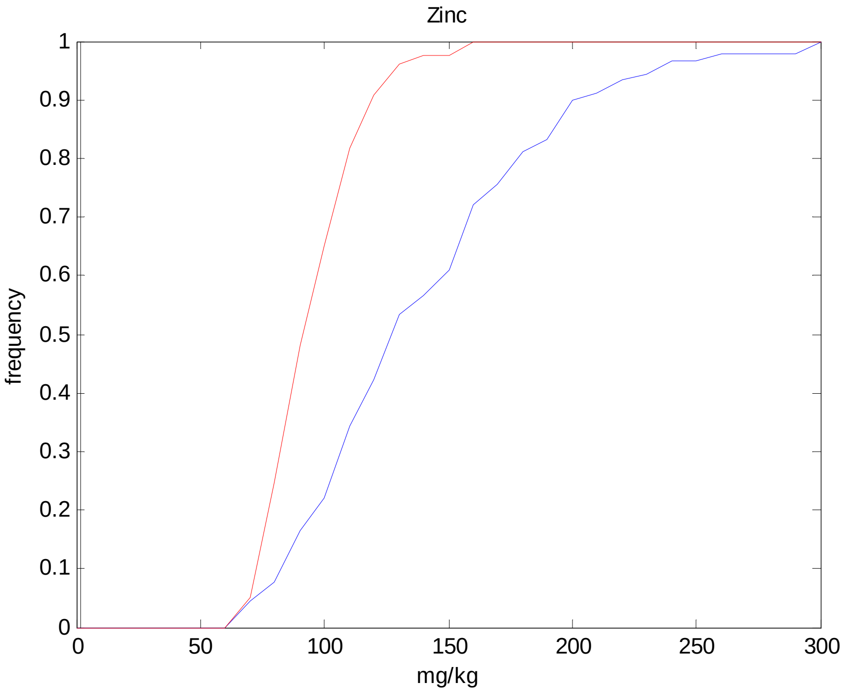


Figure 44. Cumulative frequency distributions of zinc concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of zinc observed along the west coast was ~3,750 mg/kg, sampled near Spenger's residence in Tomales Bay in 2003.

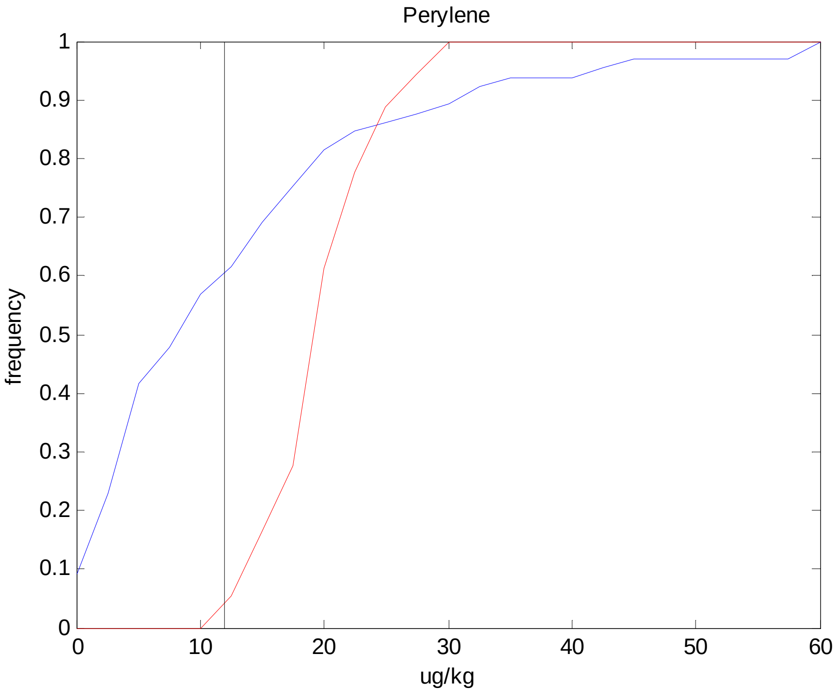


Figure 45. Cumulative frequency distributions of perylene concentrations in bivalves along the west coast (Mussel Watch, 2002-2004, blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The greatest concentration of perylene observed along the west coast was ~177 ug/kg, sampled from the fishing pier at San Pedro Harbor in 2004.

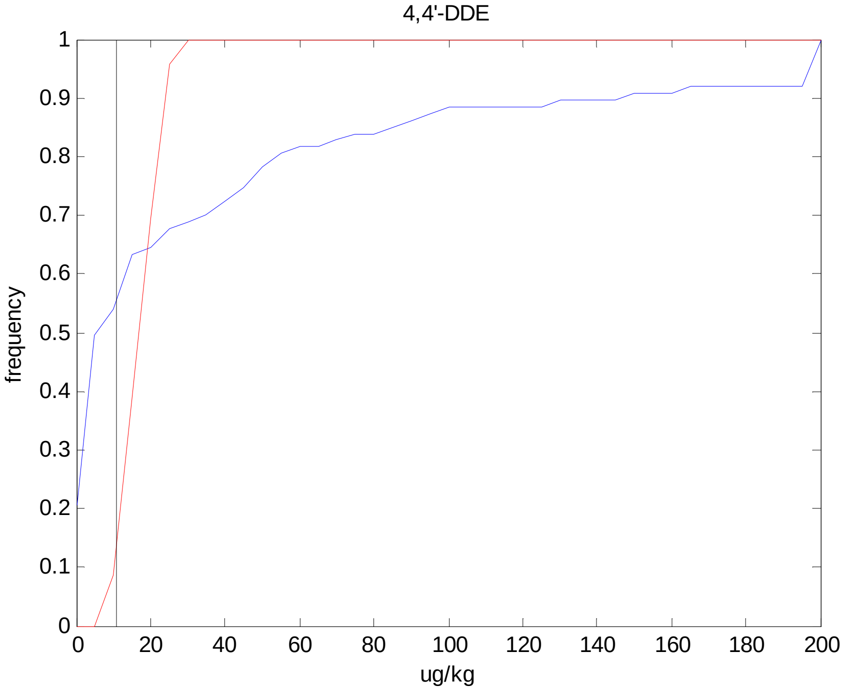


Figure 46. Cumulative frequency distributions of 4,4’-DDE concentrations in bivalves along the west coast (blue) and mussels in this study (red). Black line indicates reporting limit for samples from this study. The highest concentration of 4,4’-DDE observed along the west coast was ~642 ug/kg, sampled from the fishing pier at San Pedro Harbor in 2002.

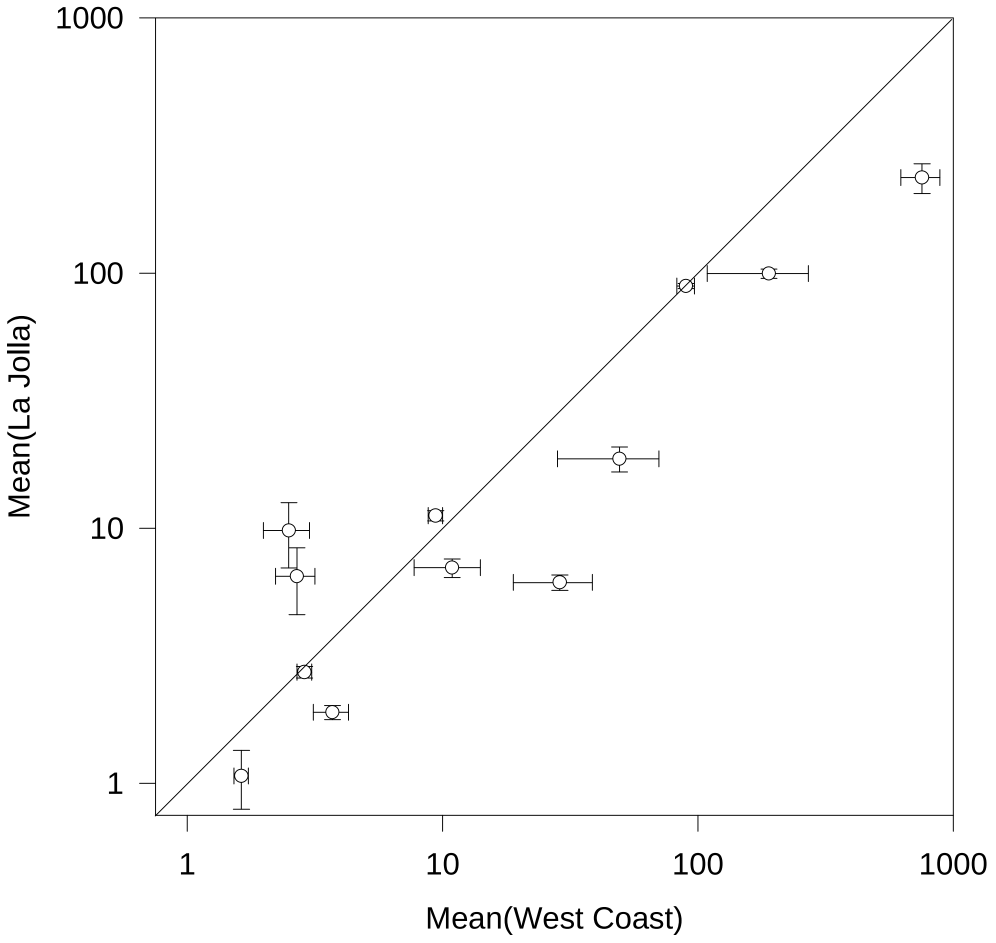


Figure 47. Plot of mean values of contaminants from Mussel Watch (2002-2004) and in mussels from this study. Contaminants are plotted by symbol in next figure. Error bars are 95% confidence limits. The line shows equivalence between Mussel Watch concentrations and concentrations in this study. Values falling above line indicate higher concentrations in present study.

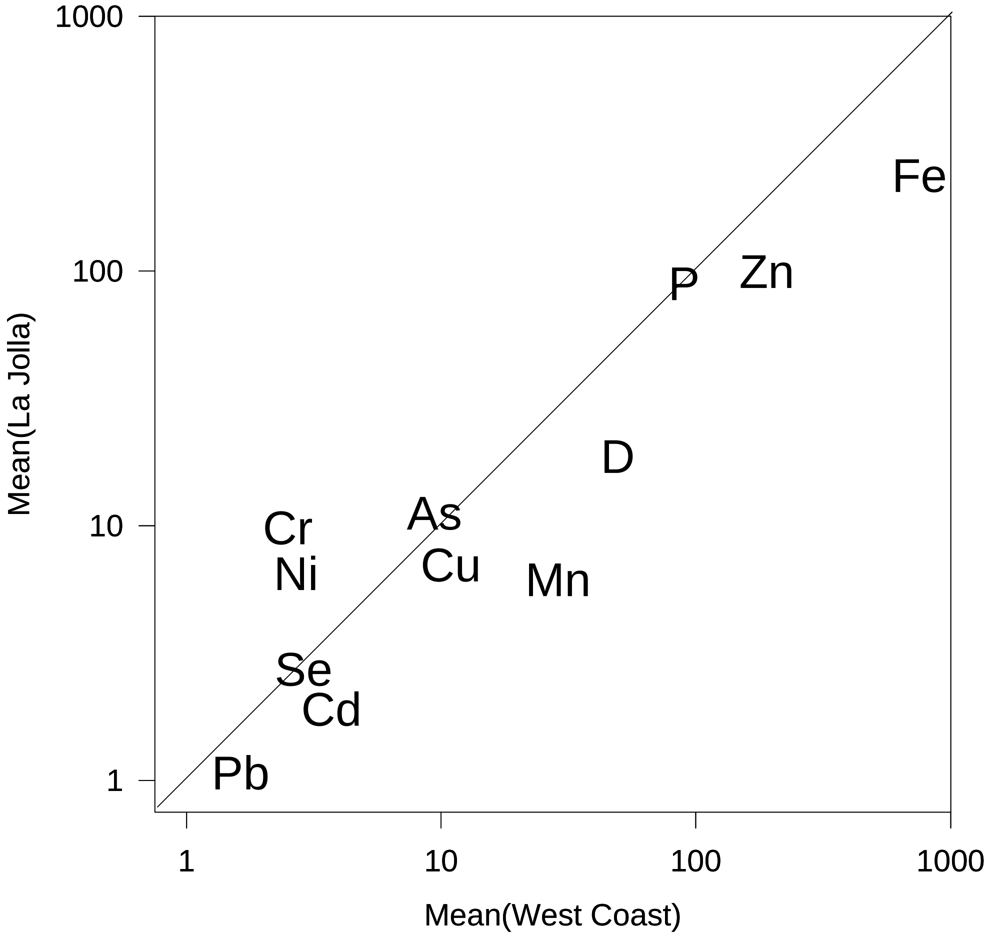


Figure 48. Plot of mean values of contaminants from Mussel Watch (2002-2004) and in mussels from this study. Contaminants are plotted by symbol (P=perylene, D=4,4'-DDE, A=arsenic, Ca=Cadmium, Ch=Chromium, Co=copper, I=Iron, L=lead, M=Manganese, N=nickel, S=Selenium, Z=zinc). Line indicates equivalence between Mussel Watch concentrations and concentrations in this study. Values falling above line indicate higher concentrations in present study. 95% confidence limits are shown in the preceding figure. Units for metals are mg/kg. Units for perylene and 4,4'-DDE are ug/kg.

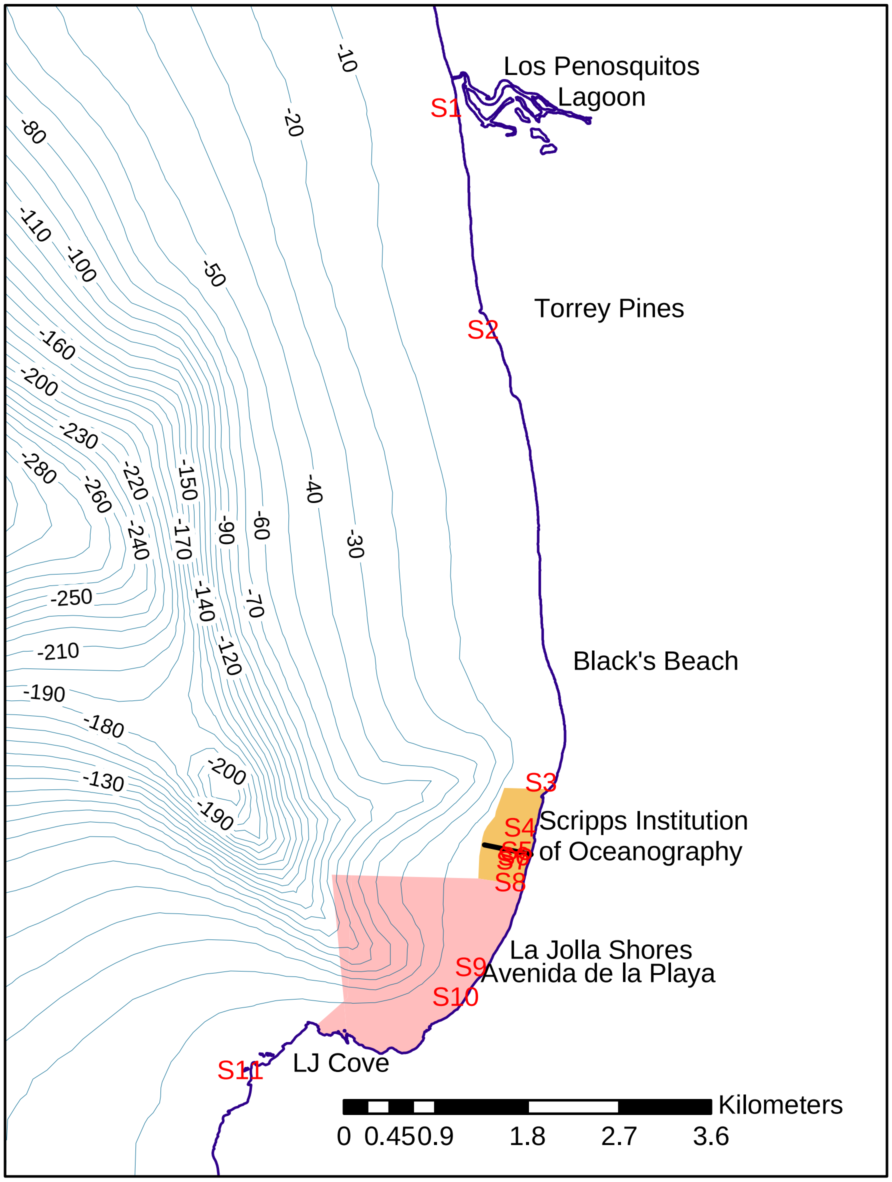


Figure 49. Map of sand crab sampling stations (station identifiers in red). The San Diego-Scripps MCA ASBS is shown in gold and the La Jolla MCA ASBS is shown in peach. Countour units are meters.

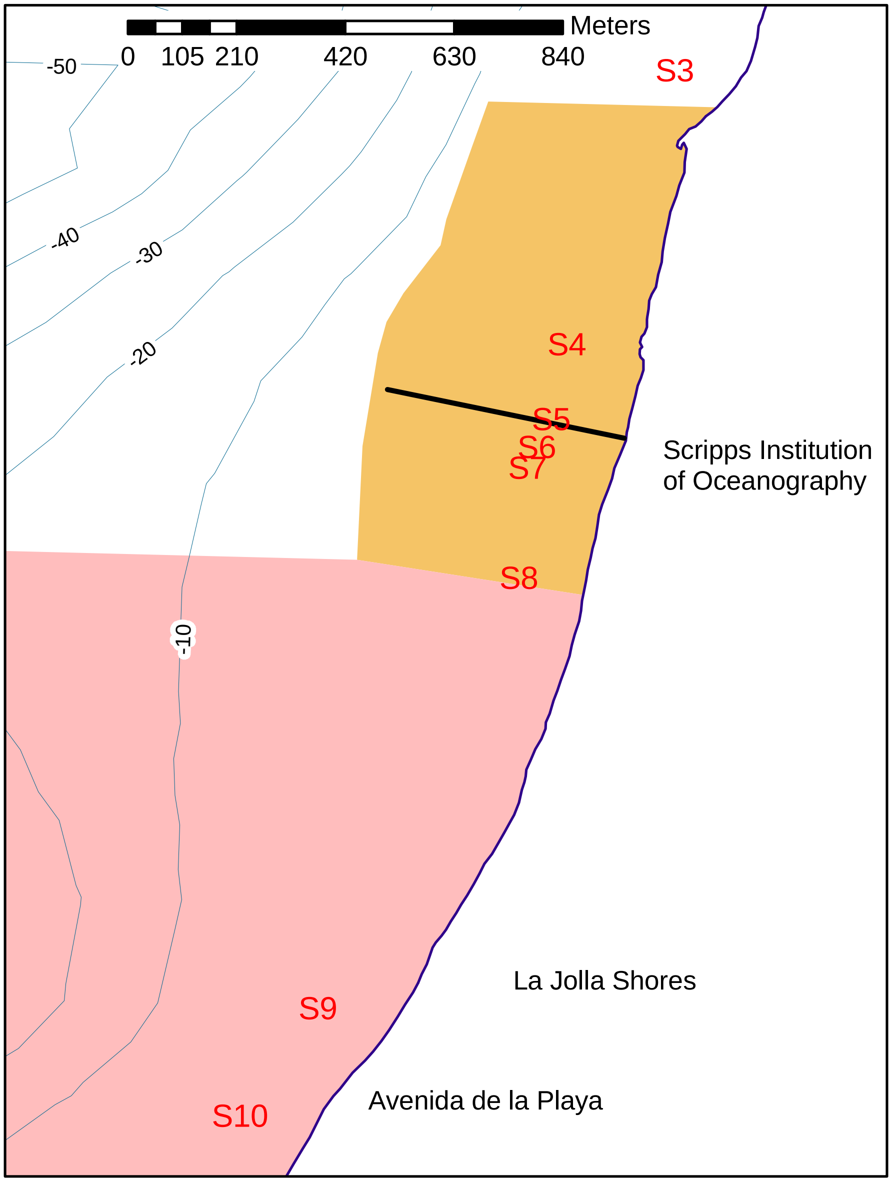


Figure 50. Close up of sand crab sampling stations within the ASBSs (station identifiers in red). The San Diego-Scripps MCA ASBS is shown in gold and the La Jolla MCA ASBS is shown in peach. Contour units are meters.

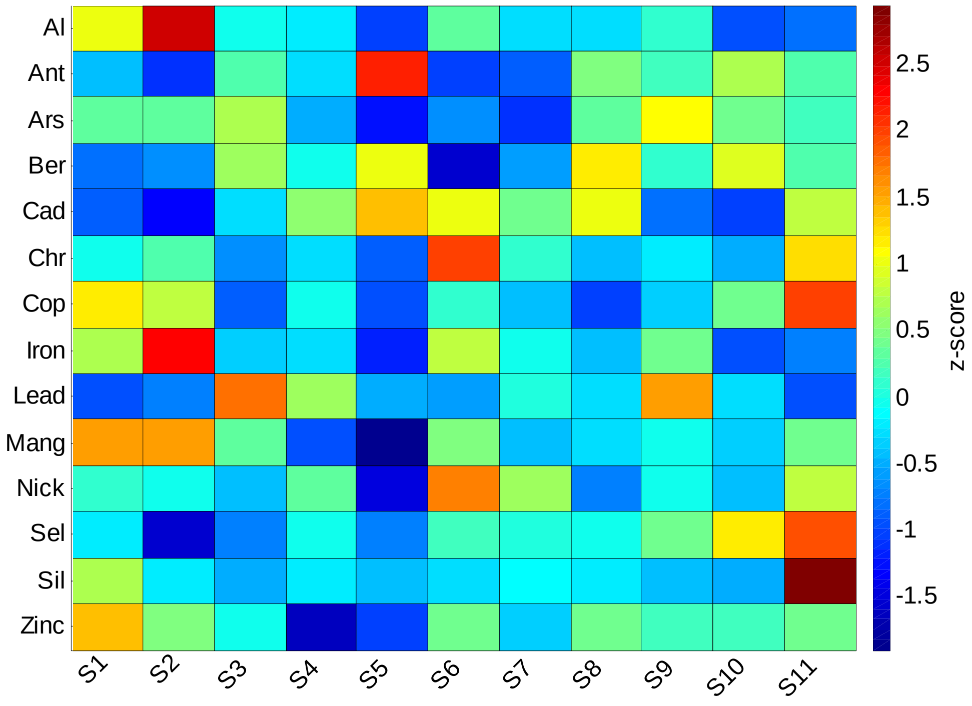


Figure 51. Z-scores of metal concentrations in sand crabs among stations.

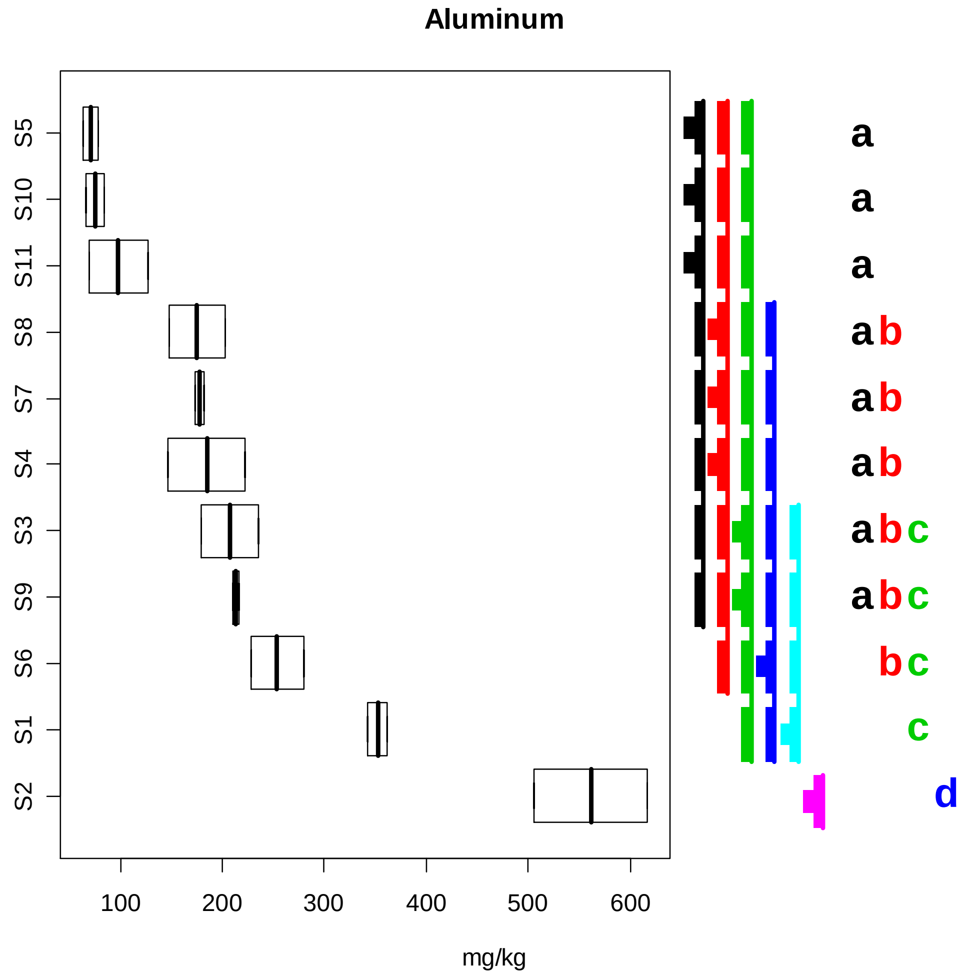


Figure 52. Multiple comparison boxplot of aluminum concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

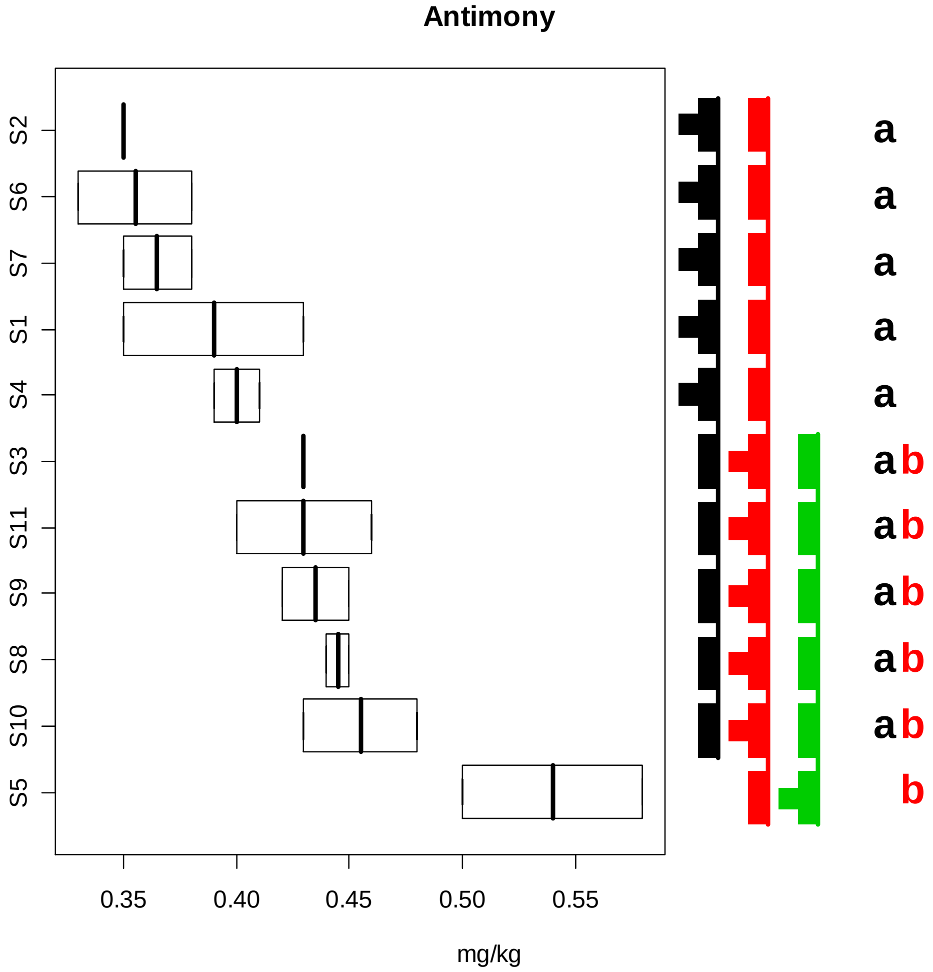


Figure 53. Multiple comparison boxplot of antimony concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

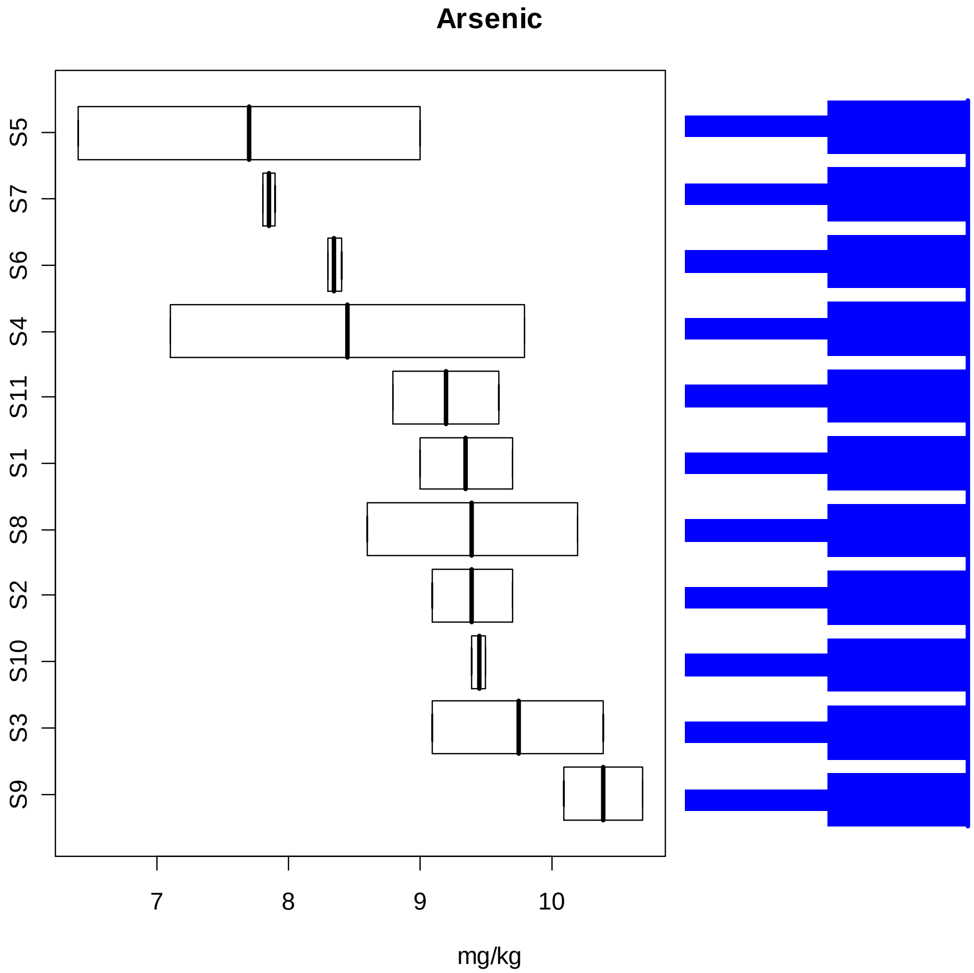


Figure 54. Multiple comparison boxplot of arsenic concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

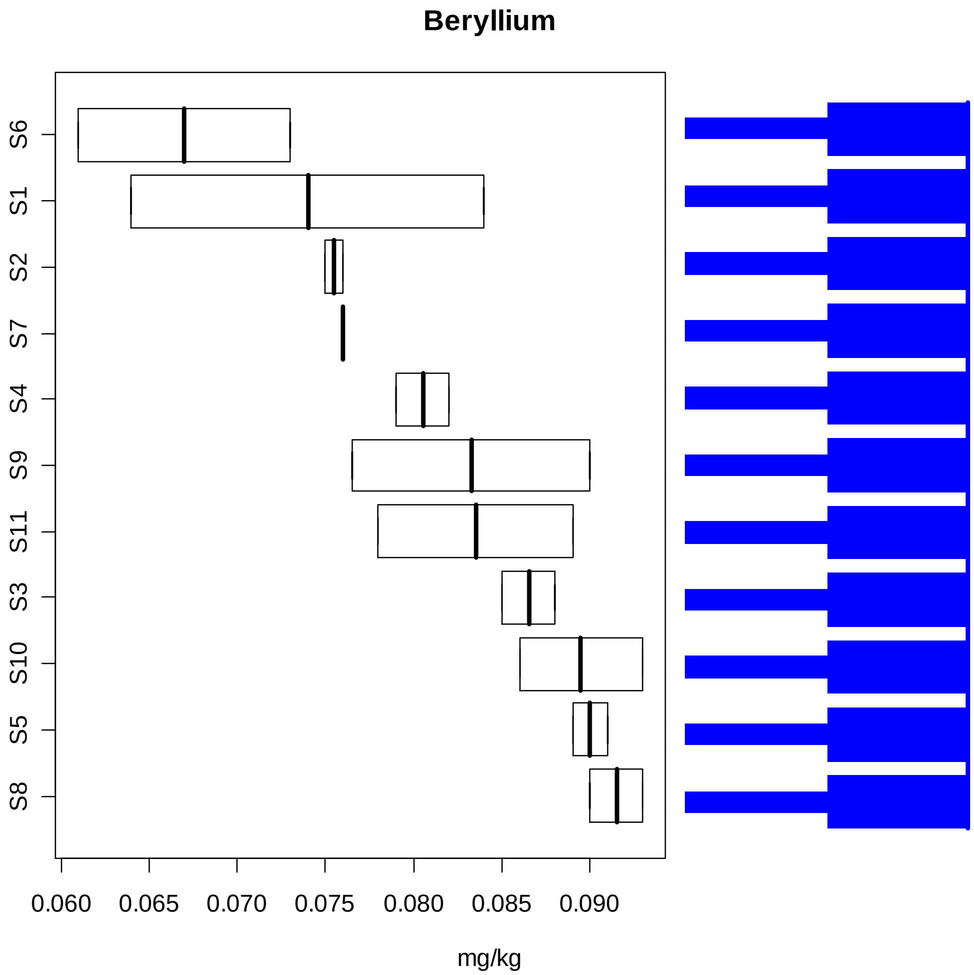


Figure 55. Multiple comparison boxplot of beryllium concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

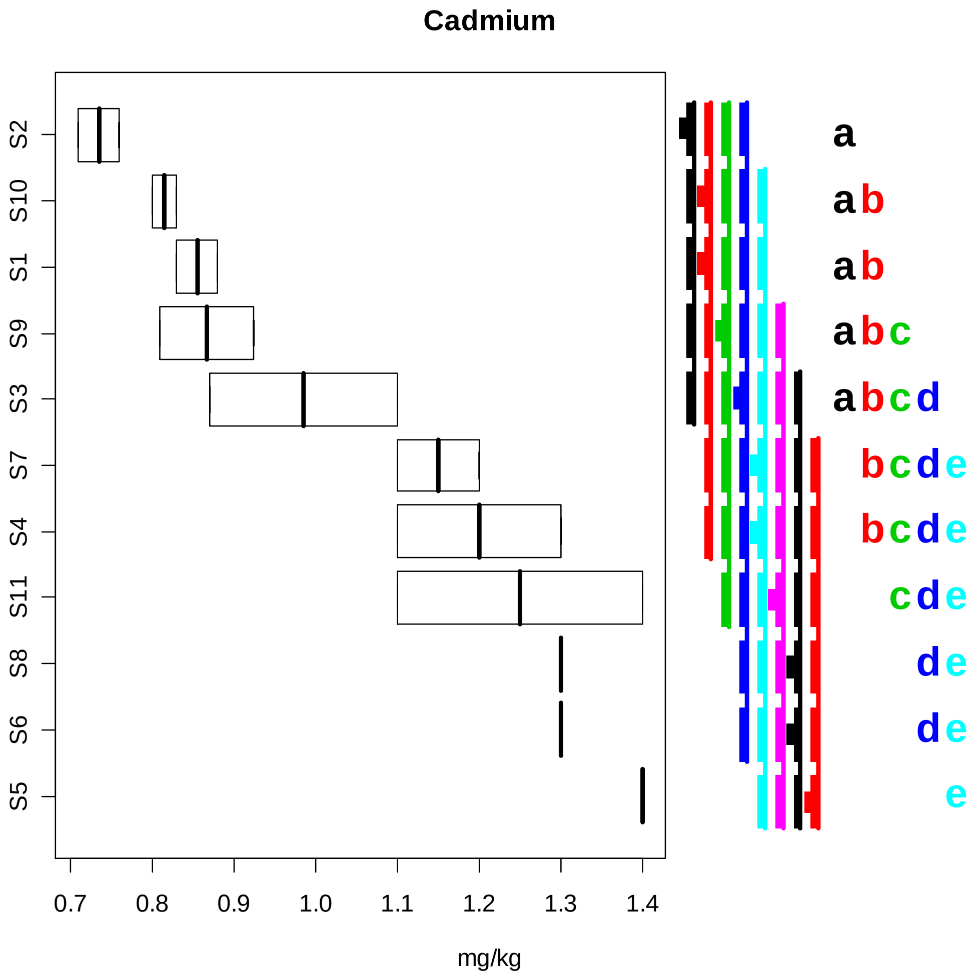


Figure 56. Multiple comparison boxplot of cadmium concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

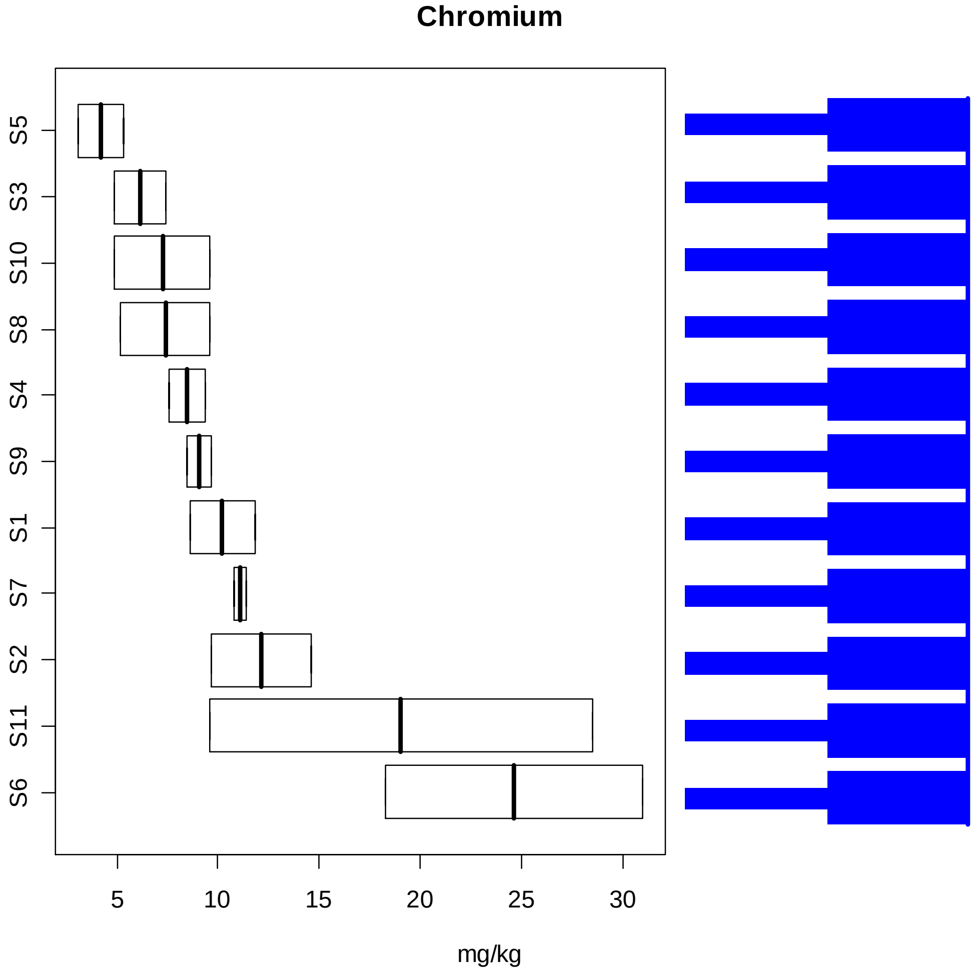


Figure 57. Multiple comparison boxplot of chromium concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

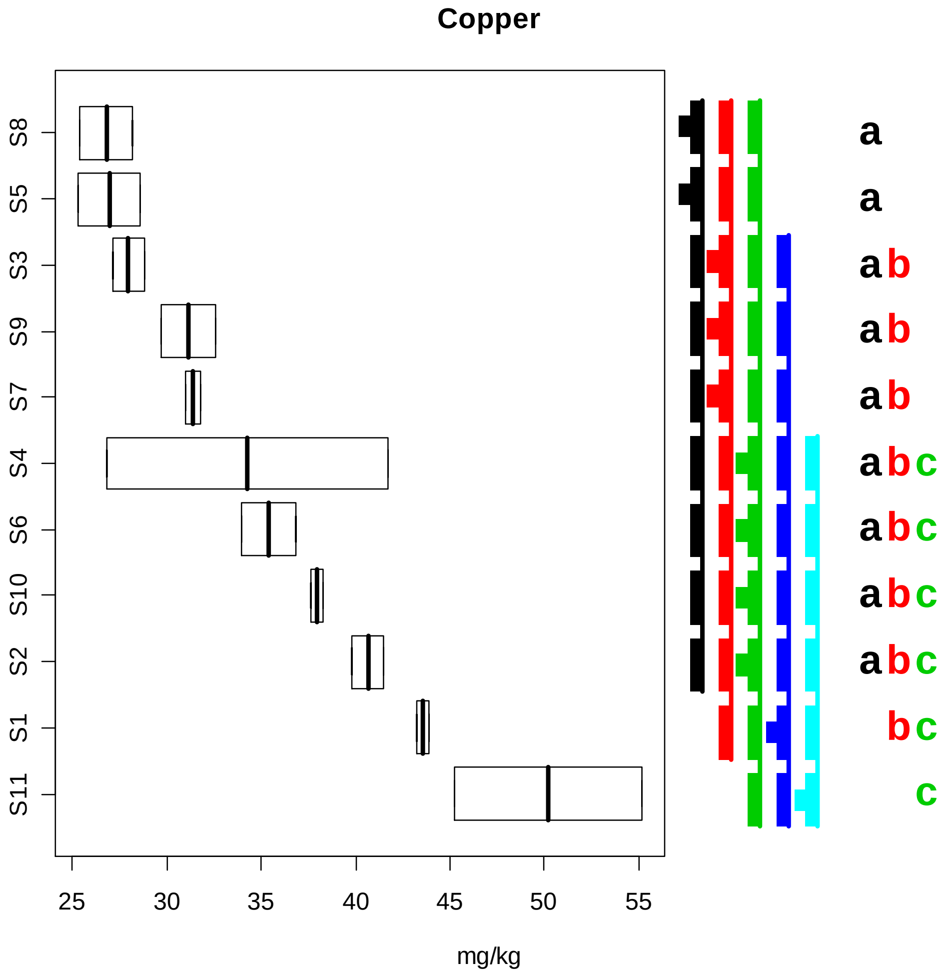


Figure 58. Multiple comparison boxplot of copper concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

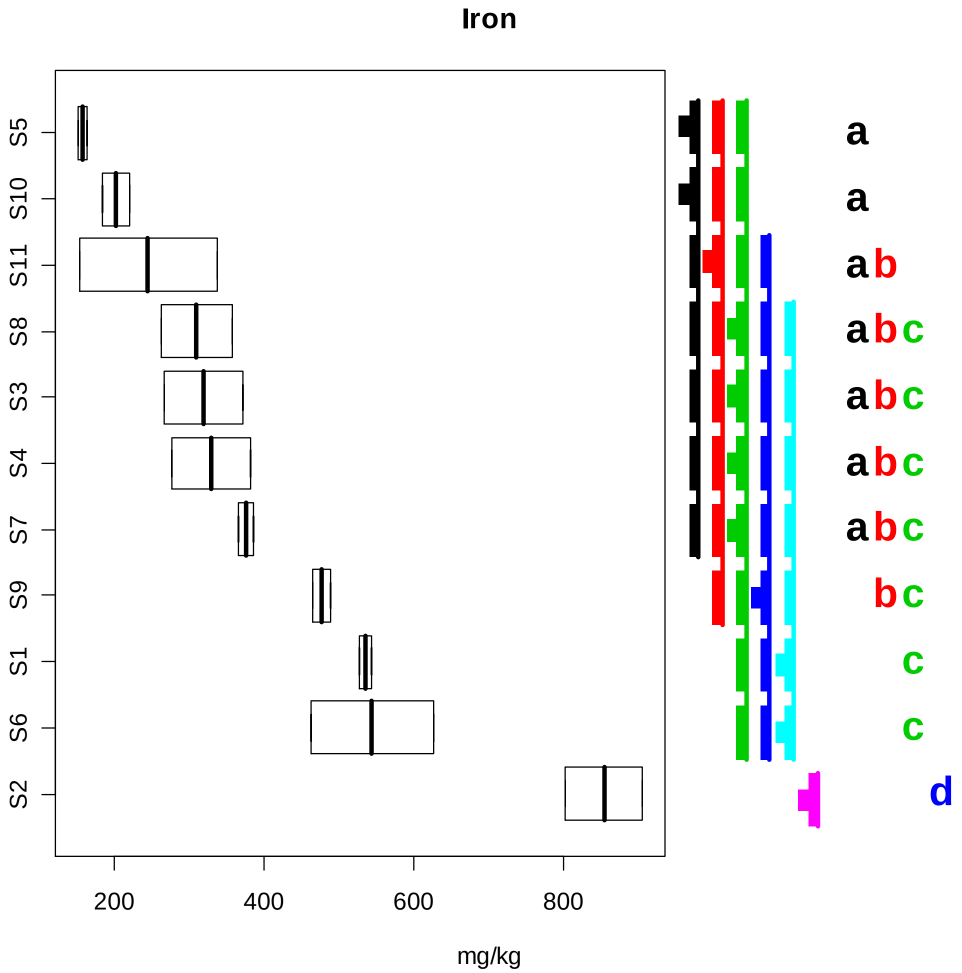


Figure 59. Multiple comparison boxplot of iron concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure x for an explanation of grouping boxes and letters on the right side.

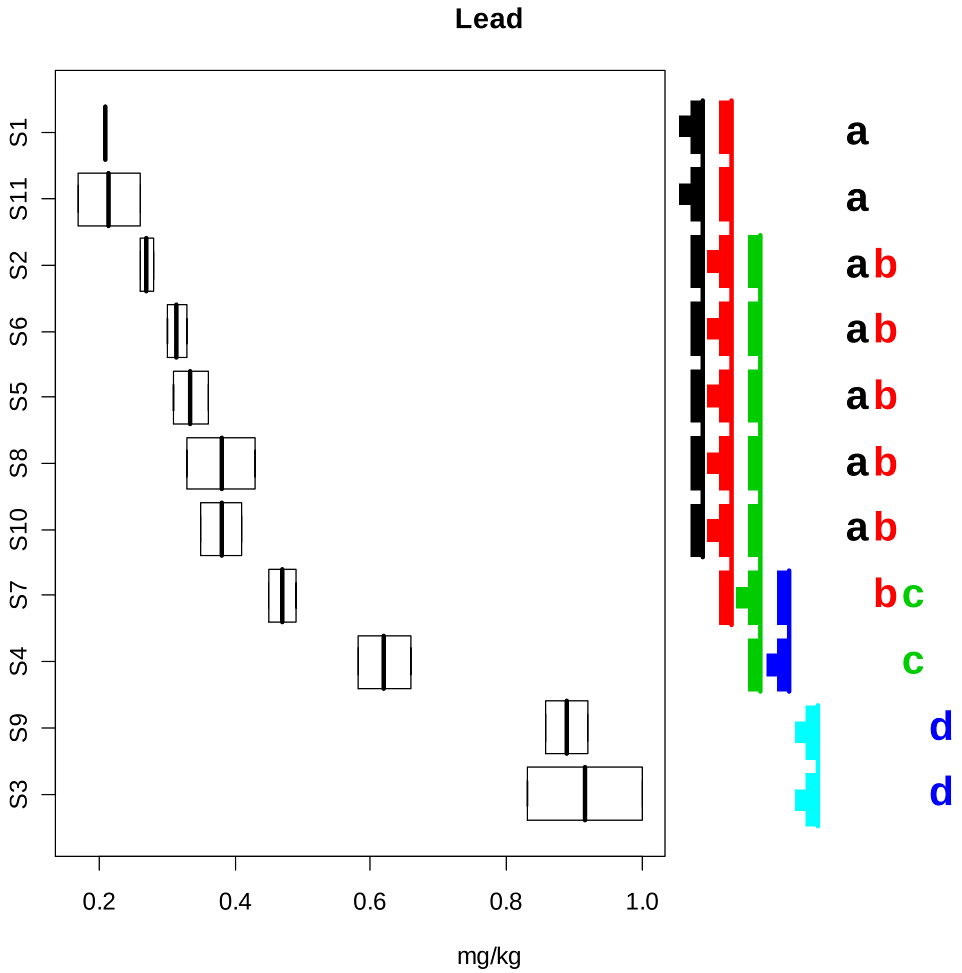


Figure 60. Multiple comparison boxplot of lead concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure x for an explanation of grouping boxes and letters on the right side.

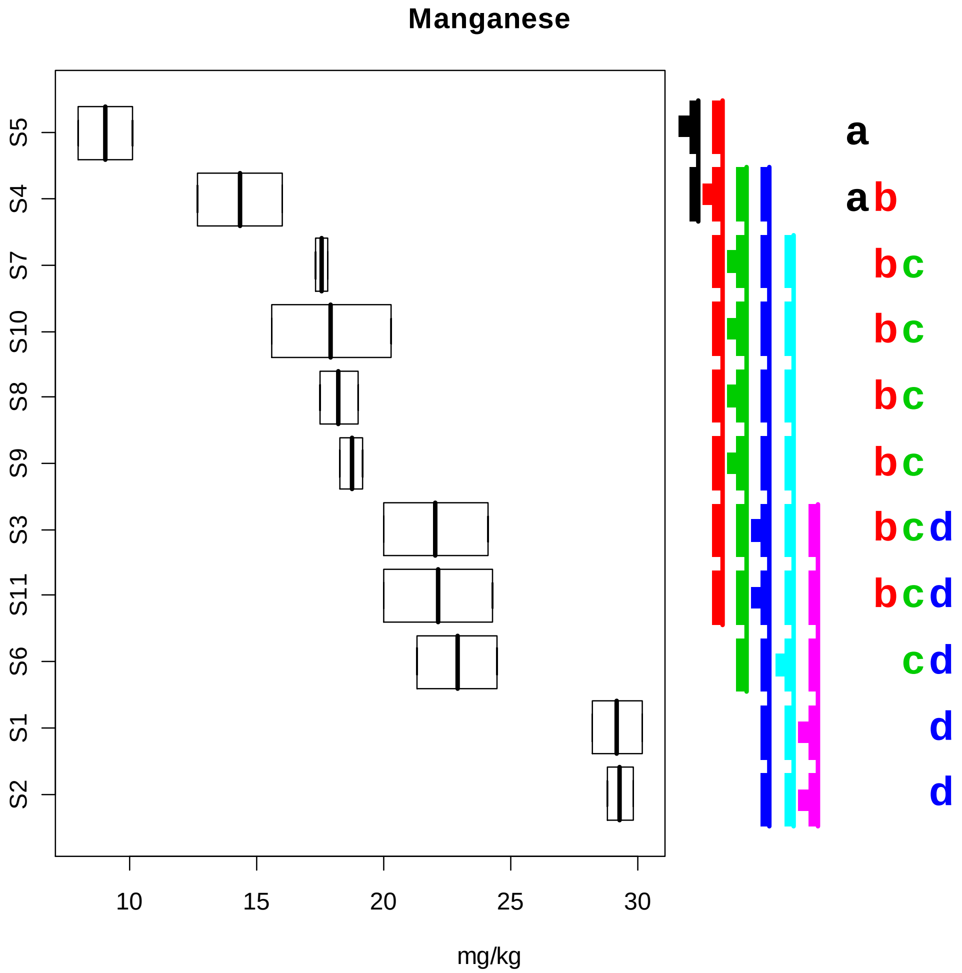


Figure 61. Multiple comparison boxplot of manganese concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

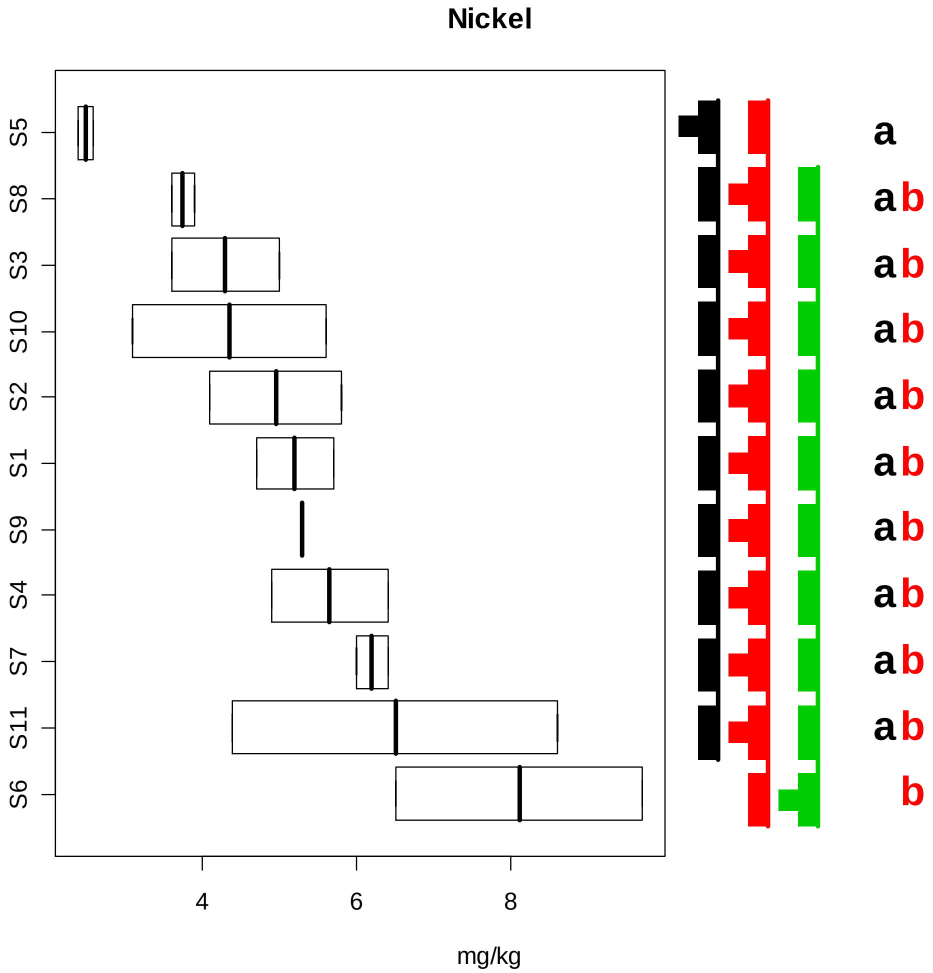


Figure 62. Multiple comparison boxplot of nickel concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

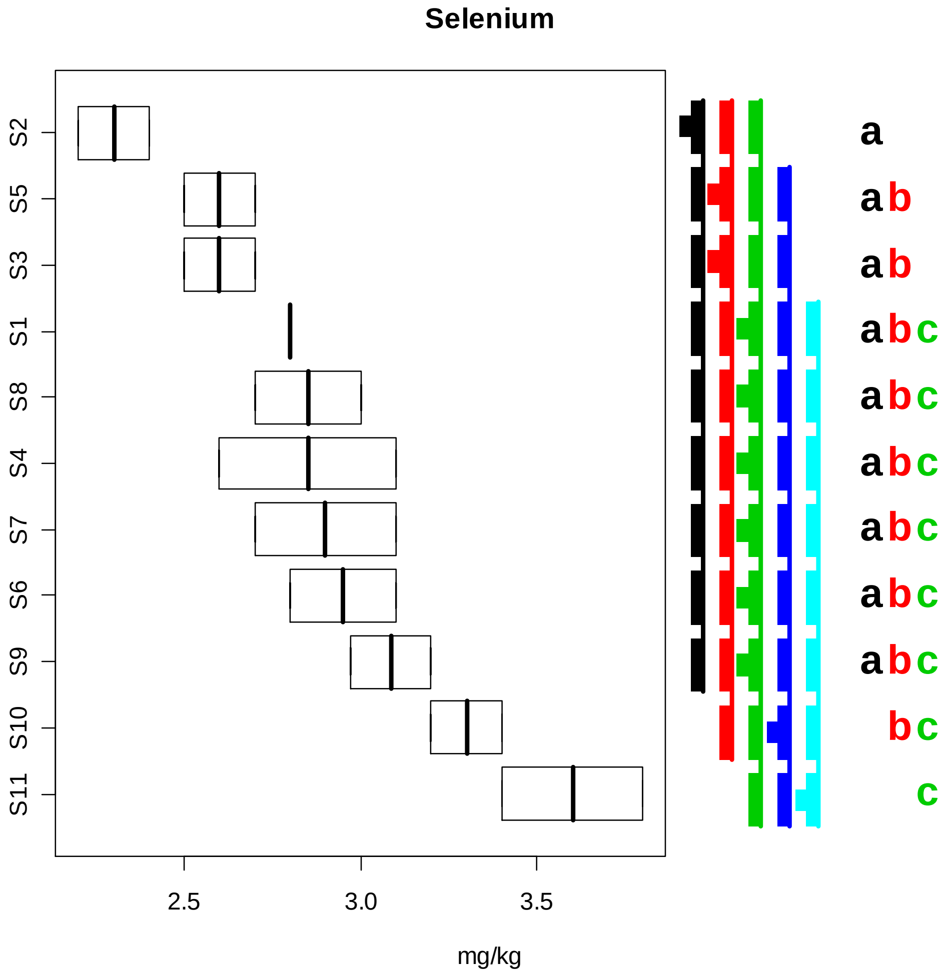


Figure 63. Multiple comparison boxplot of selenium concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

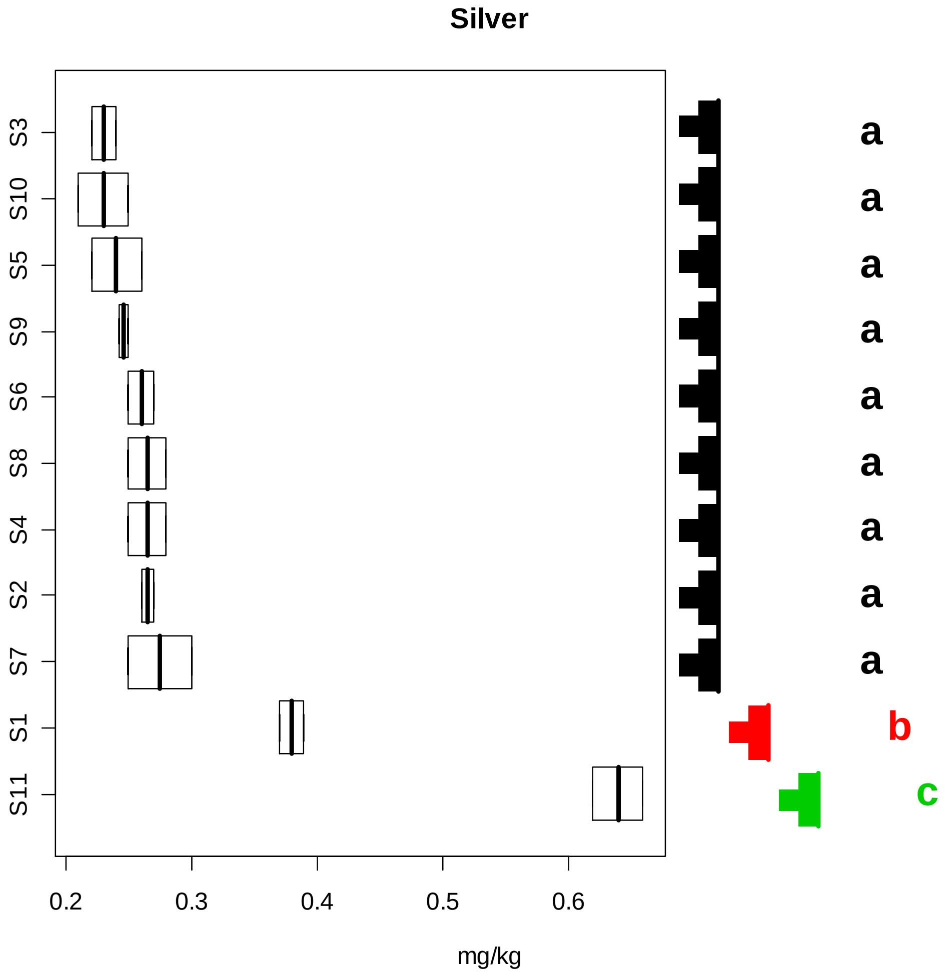


Figure 64. Multiple comparison boxplot of silver concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

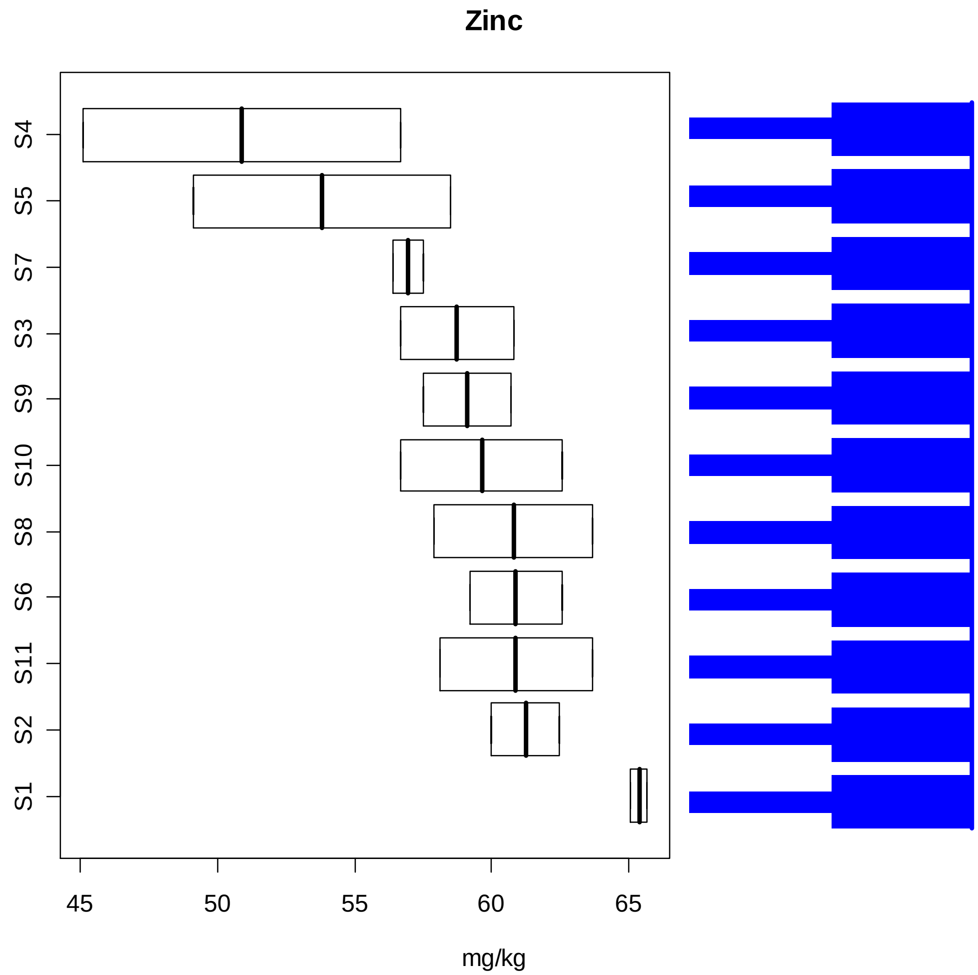


Figure 65. Multiple comparison boxplot of zinc concentrations in sand crabs by site. Boxes represent upper and lower quartiles and vertical line indicates median. Boxplots estimated using MLE. See Figure 5 for an explanation of grouping boxes and letters on the right side.

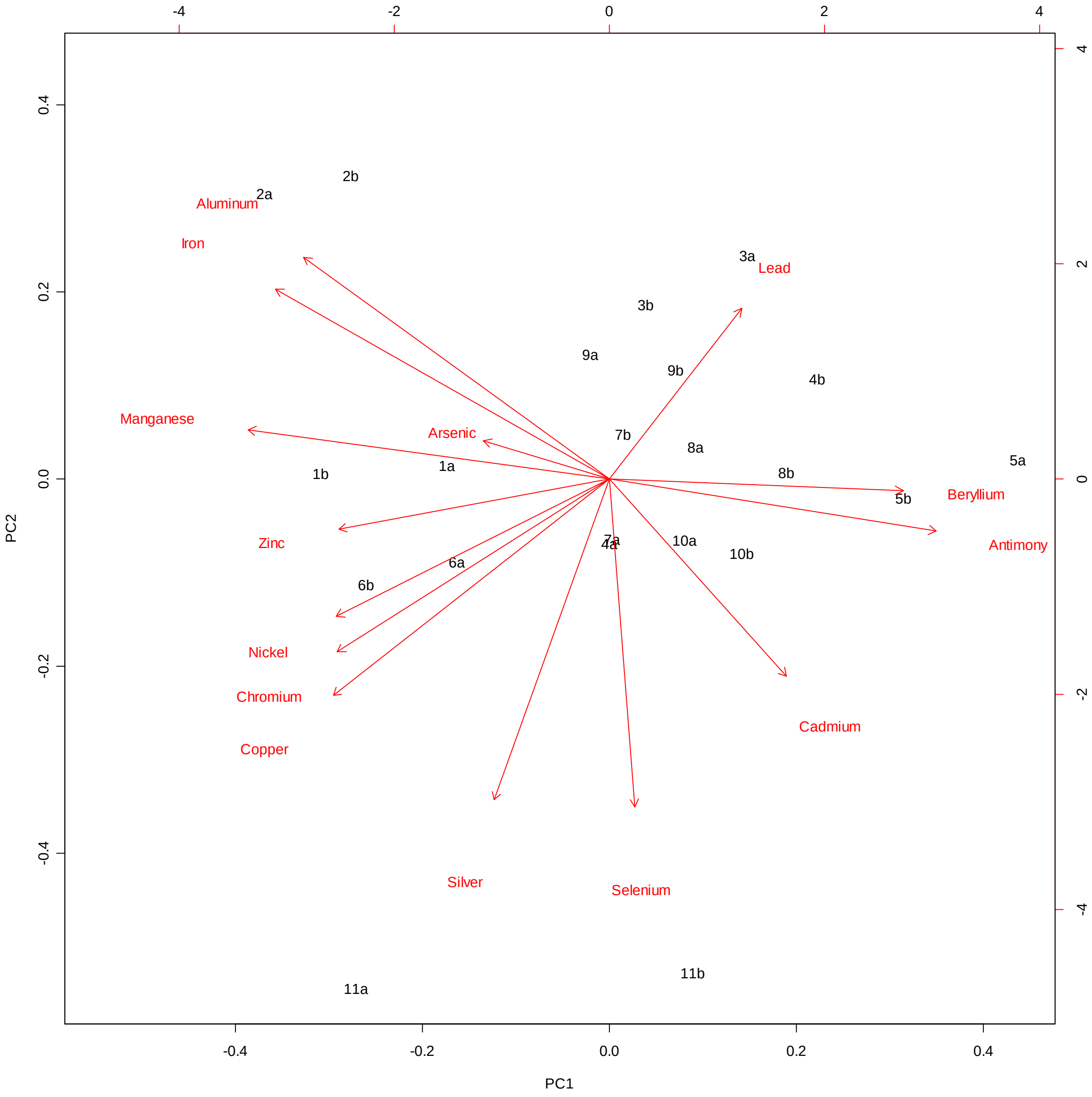


Figure 66. Plot of first two principal components of metal concentrations among sites (two replicate samples per site). The first two principal components accounted for ~61% of total variation.

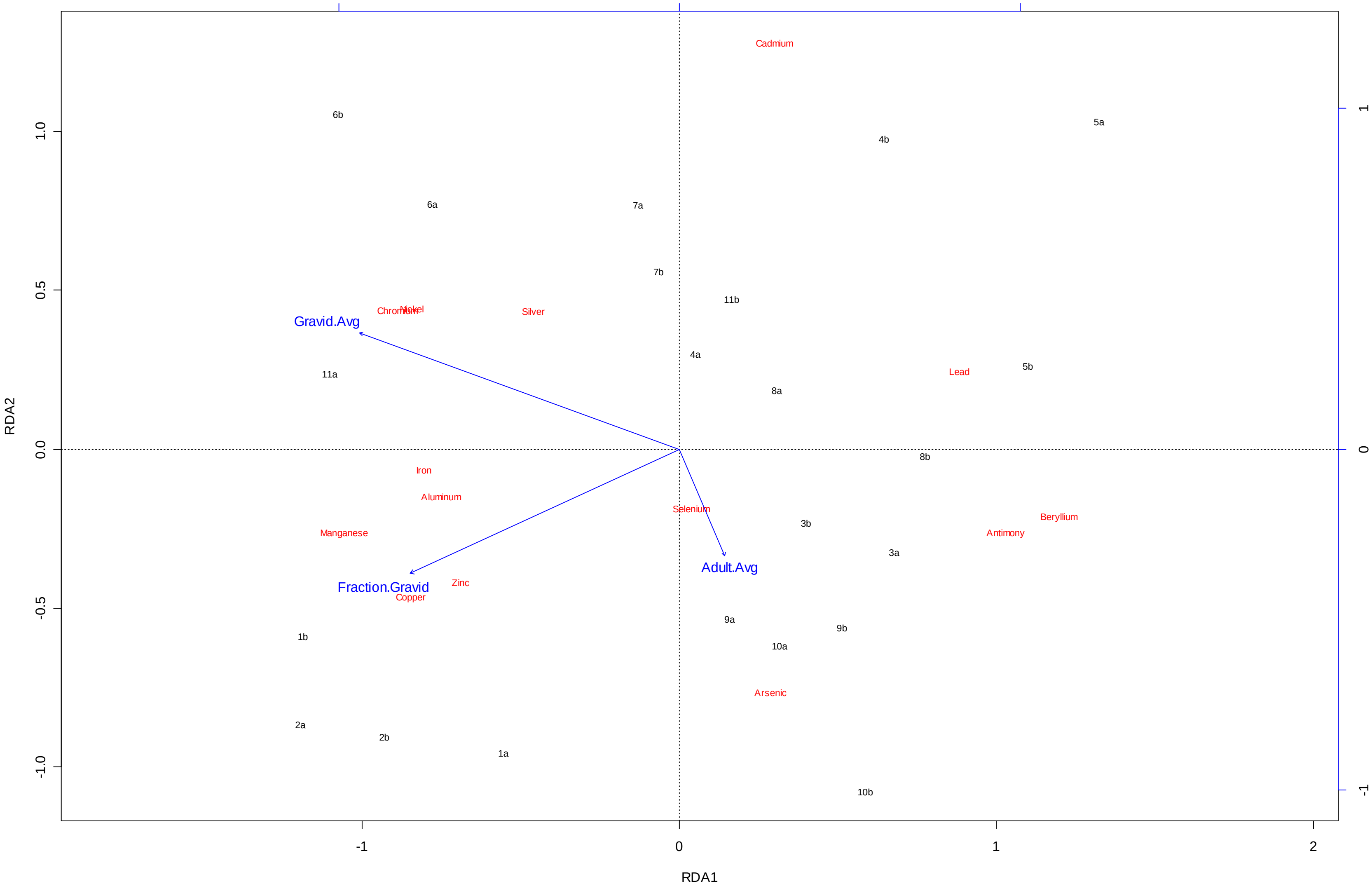


Figure 67. Plot of redundancy analysis (RDA) of sand crab data. See next page for a description of plot.

Figure 67 (cont.). Descriptor variables include the size and gravid compositions of the samples (Fraction.Gravid=fraction of animals gravid, Adult.Avg=average size of adult non-gravid sand crabs in sample, Gravid.Avg=average size of gravid sand crabs in sample). Reponse variables were metals (indicated in red). Samples from study sites are indicated by numbers with lowercase letters (2 samples per site, e.g., “1a” and “1b” indicate the two replicates sampled from site S1). The distances among sites represent euclidean distances among sites within the RDA ordination. The projection of sites onto descriptor vectors (blue arrows - size averages and fraction gravid) indicates relative sample compositions with regard to sizes and fraction gravid. The projection of sites onto imaginary lines drawn from the origin to each metal shows relative values of each metal for that site. Angles between imaginary lines drawn from the origin to each metal with descriptor vectors indicate the correlation between them. The first two RDA components accounted for ~55% of total variability, while all three of the total unconstrained eigenvalues accounted for 86% of the variance. See text for results of linear weighted regressions of size and gravid status.

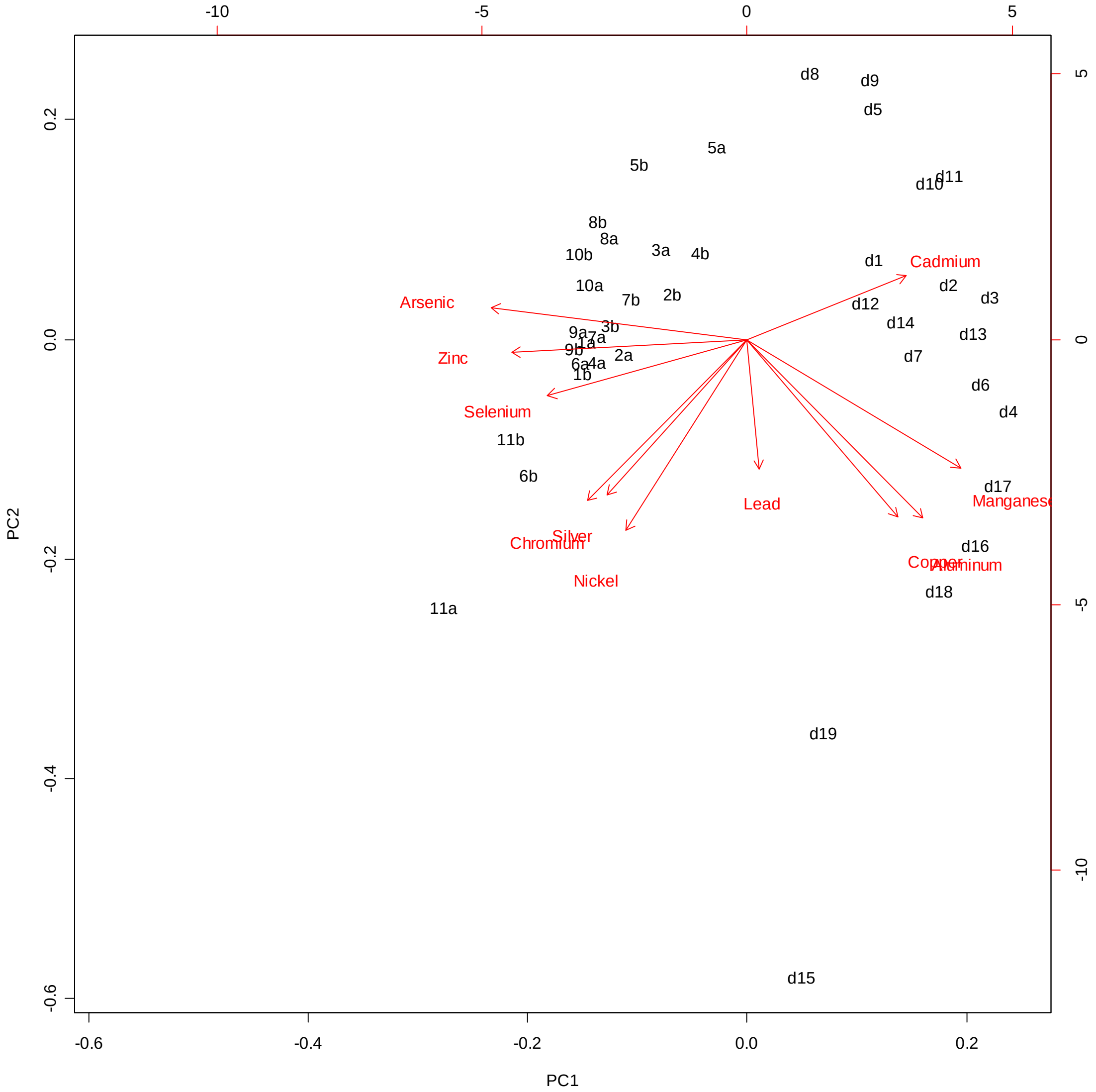


Figure 68. Principal component plot of metals in sand crabs from this study and Dugan et al. 2005 where sand crabs were sampled at 19 locations from north central California to Los Angeles (see text). See next page for more details. The first two principal components accounted for ~67% of the total variability. Samples from the present study are listed with numbers followed by an “a” or “b” indicating sampling location (e.g., “1a” and “1b” indicate the two replicate samples from site “S1”). Values from Dugan et al. 2005 represent 19 sampling locations, which are ordered from north to south with increasing numbers, each beginning with “d” (e.g., d1, d2, ..., d19 – north to south). Red arrows indicate metal concentrations for comparison among sampling locations. Relative concentrations can be estimated by orthogonally projecting sampling points onto metal axes.

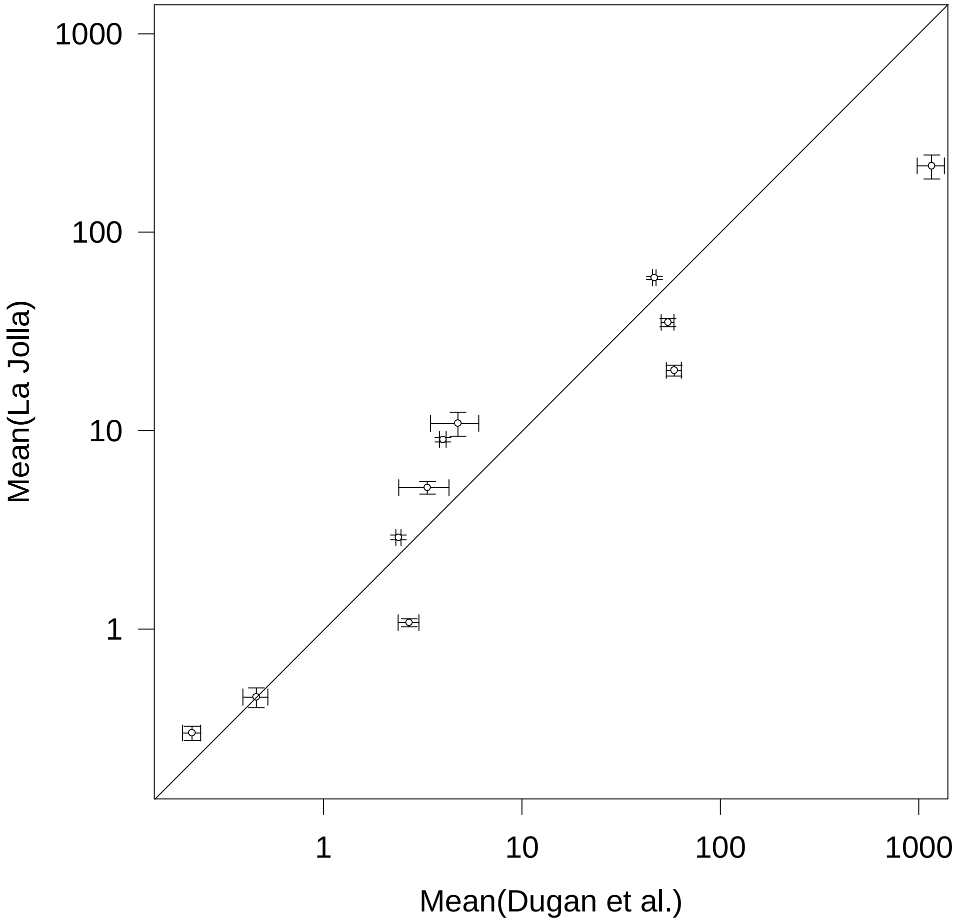


Figure 69. Average metal concentrations (aluminum, arsenic, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, and zinc in sand crabs in the present ASBS study plotted against concentrations from the Dugan et al. 2005 study. Diagonal indicates equivalence between the studies. See Figure x for mean metal symbols. Error bars are 95% confidence intervals.

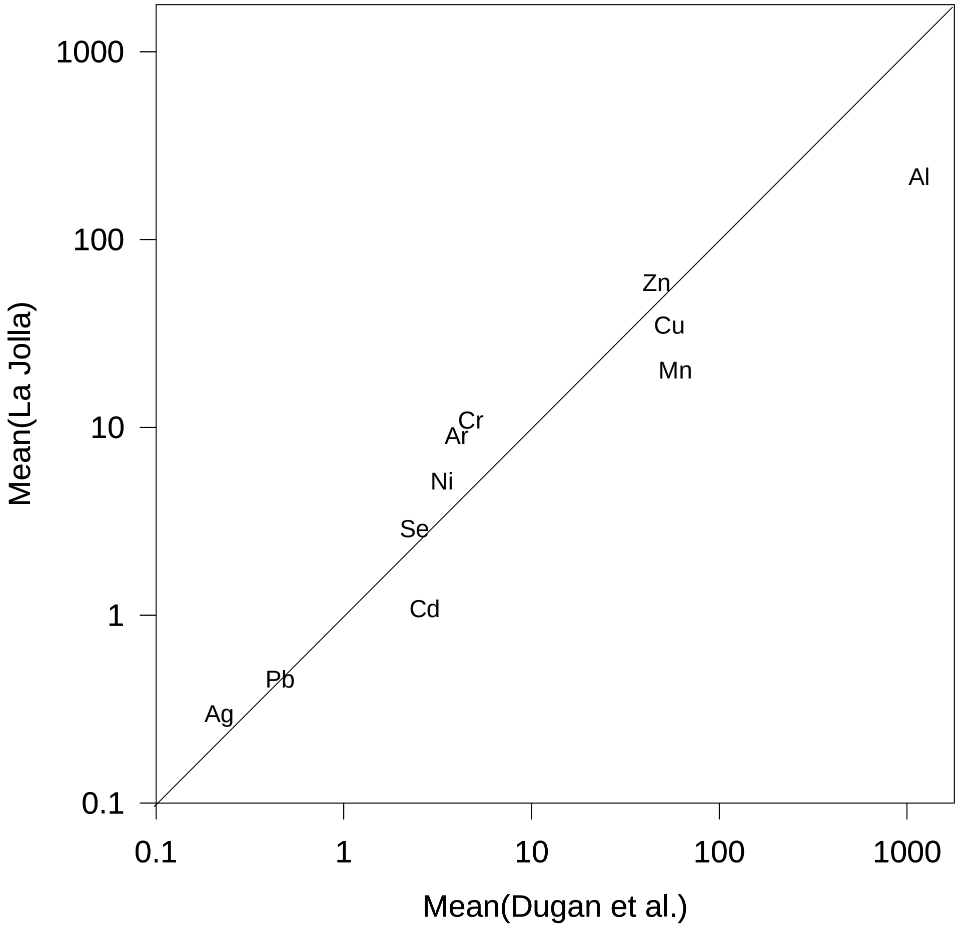


Figure 70. Average metal concentrations (aluminum, arsenic, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, and zinc in sand crabs in the present ASBS study plotted against concentrations from the Dugan et al. 2005 study. Diagonal indicates equivalence between the studies.

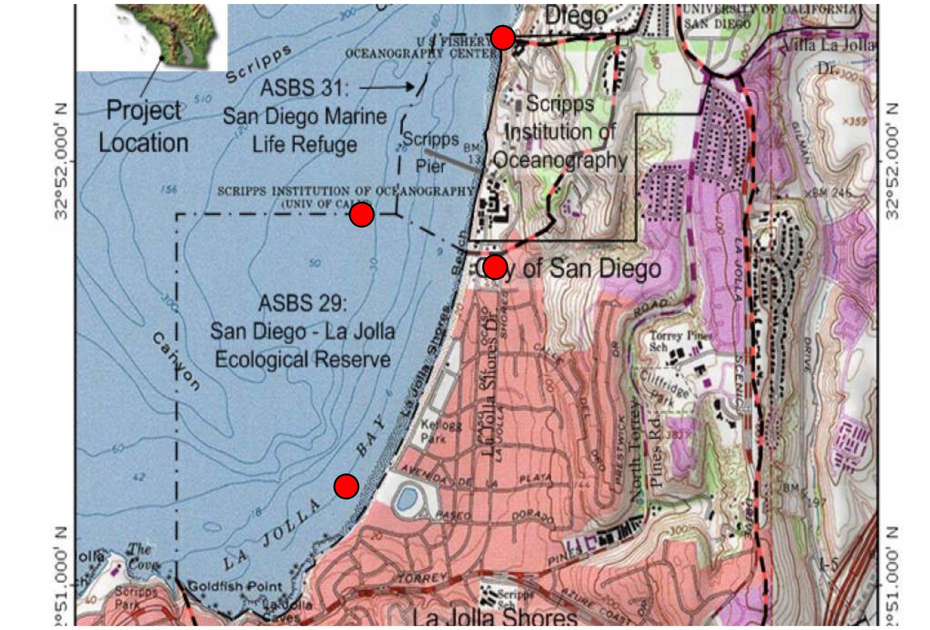


Figure 71.  ADCP Deployment Sites

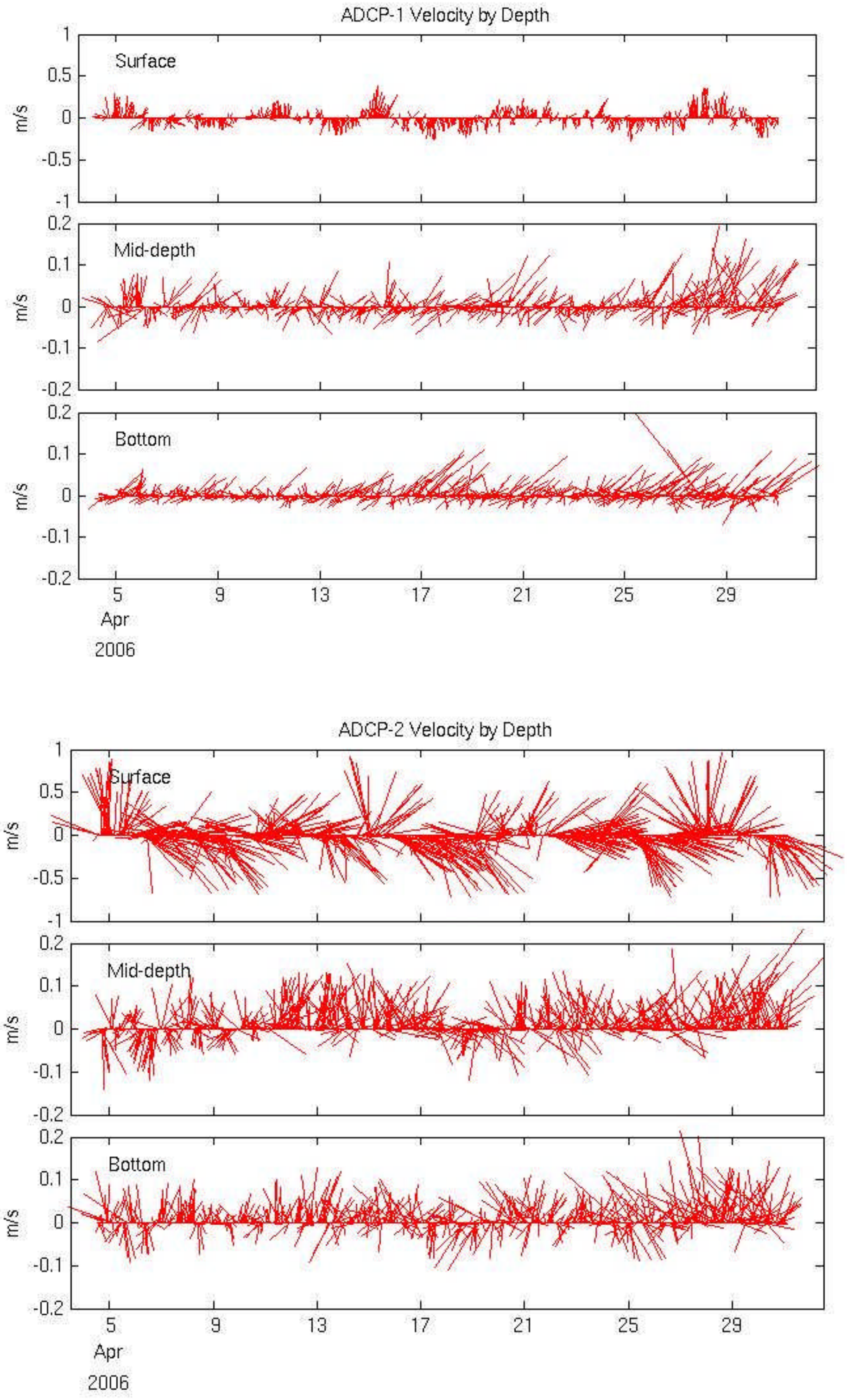
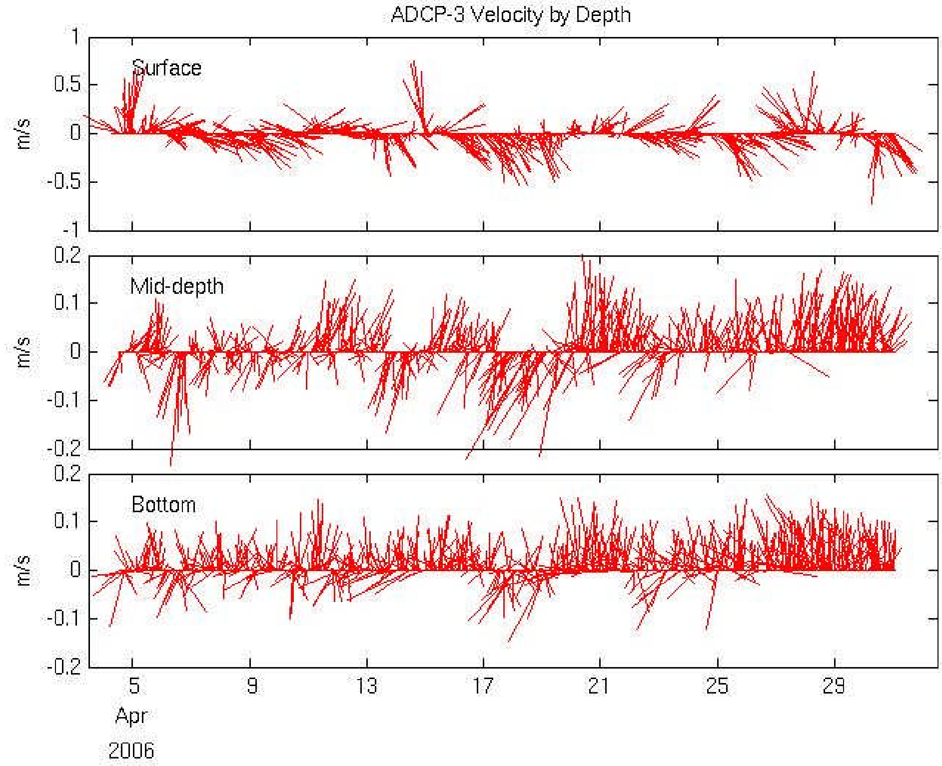


Figure 72(a,b). Surface, mid-depth and bottom velocities for ADCP-1 (top) and ADCP-2 (bottom). Direction of sticks is compass orientation, length is magnitude.



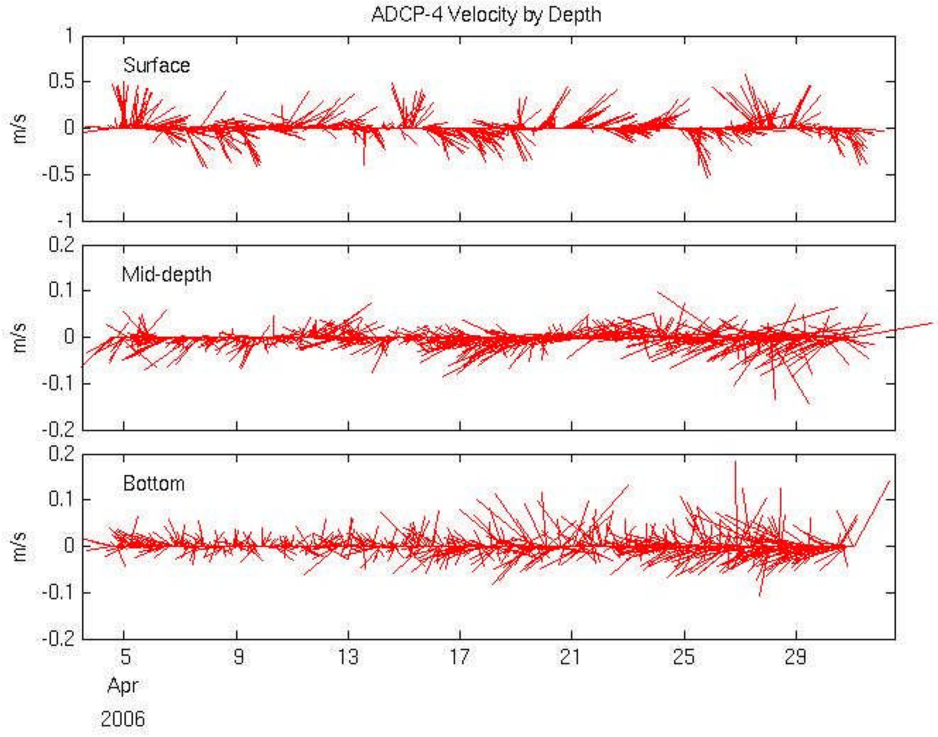


Figure 72 (c,d). Surface, mid-depth and bottom velocities for ADCP-3 (top) and ADCP-2 (bottom). Direction of sticks is compass orientation, length is magnitude.

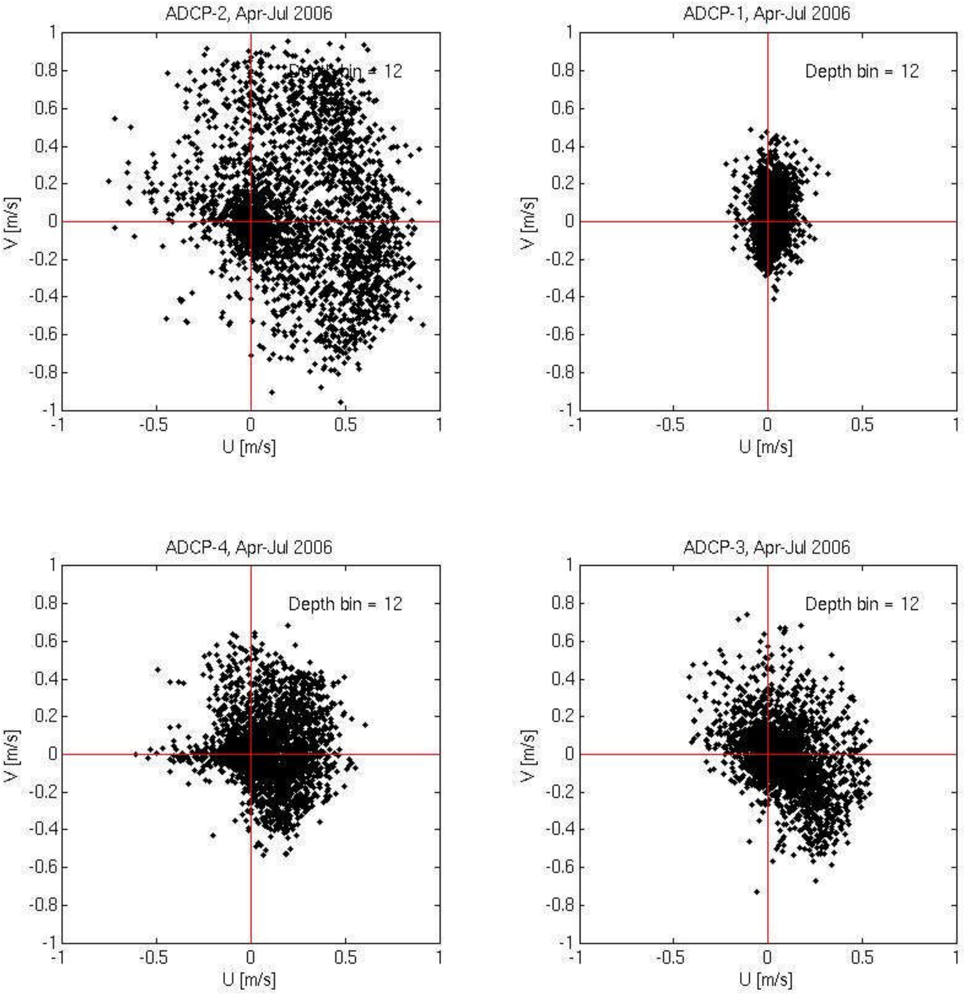


Figure 73(a). Surface Velocity April-July 2006 for all four sites. Vertical and horizontal axes indicate N-S and E-W compass directions. Velocity magnitude is represented by distance along the axes.

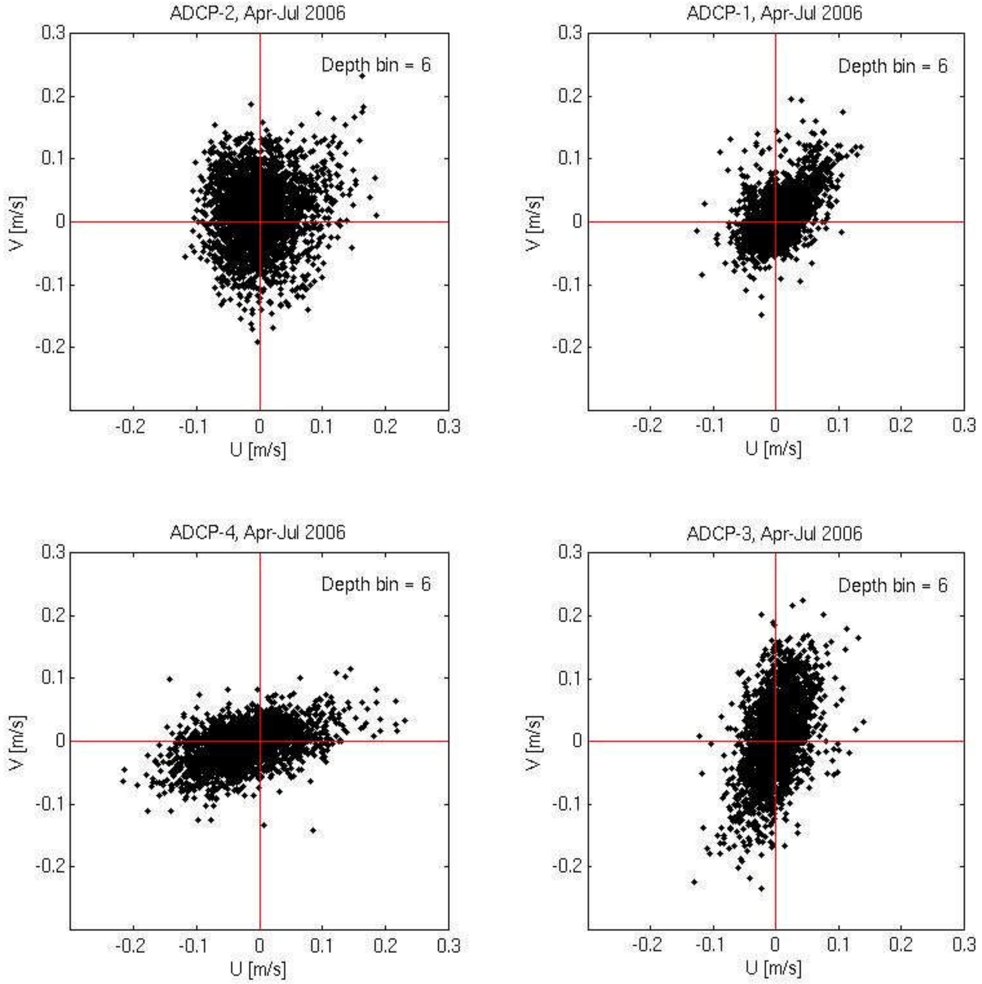


Figure 73(b). Mid-depth velocity, April-July 2006 for all four sites. Vertical and horizontal axes indicate N-S and E-W compass directions. Velocity magnitude is represented by distance along the axes.

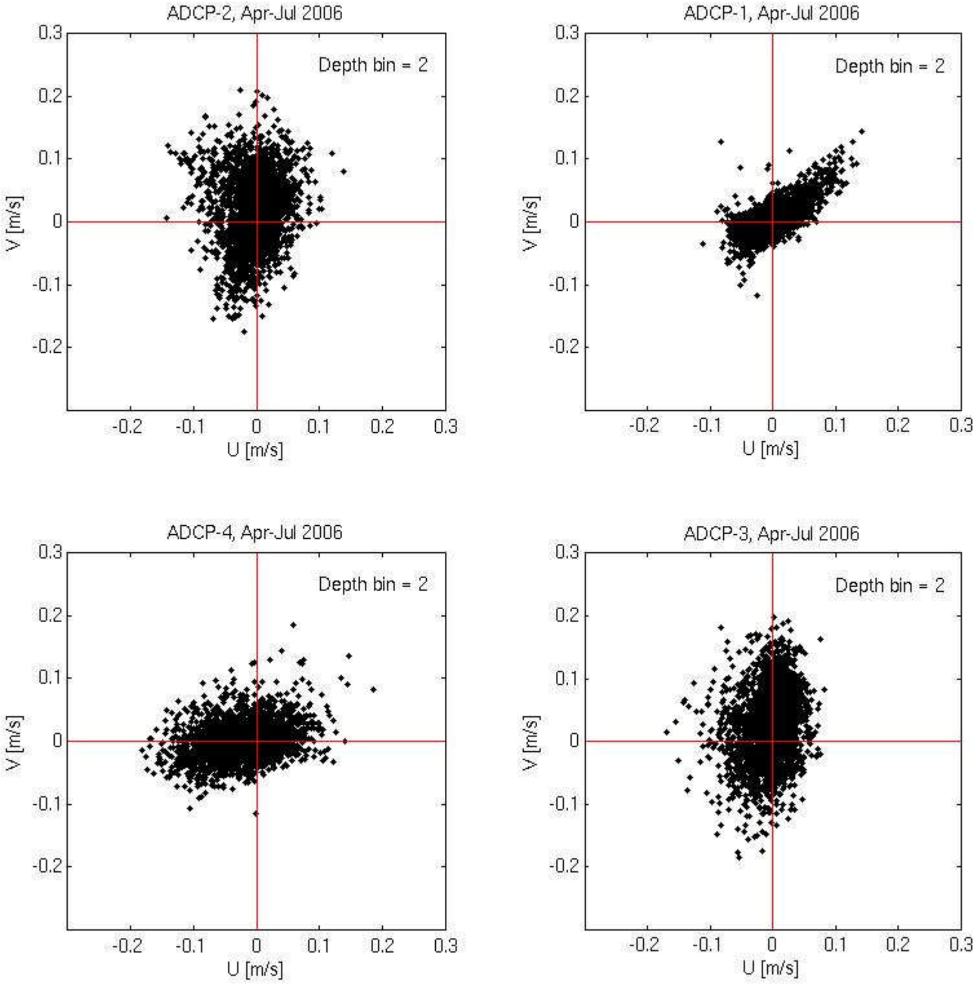


Figure 73(c). Bottom velocity, April-July 2006 for all four sites. Vertical and horizontal axes indicate N-S and E-W compass directions. Velocity magnitude is represented by distance along the axes.

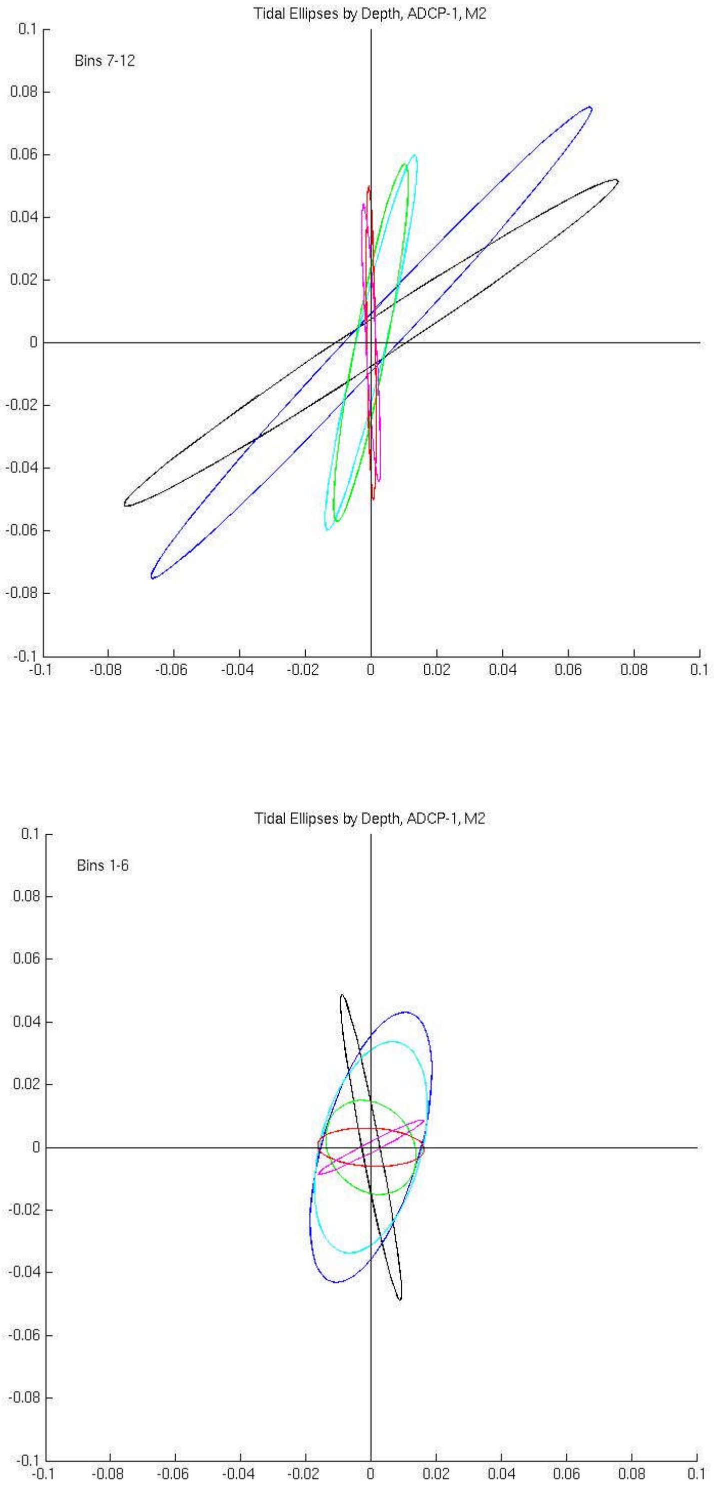


Figure 74(a,b). M2 tidal ellipses at ADCP-1. a) upper water column, b) lower water column. Blues are higher, reds are lower. (will get legend)

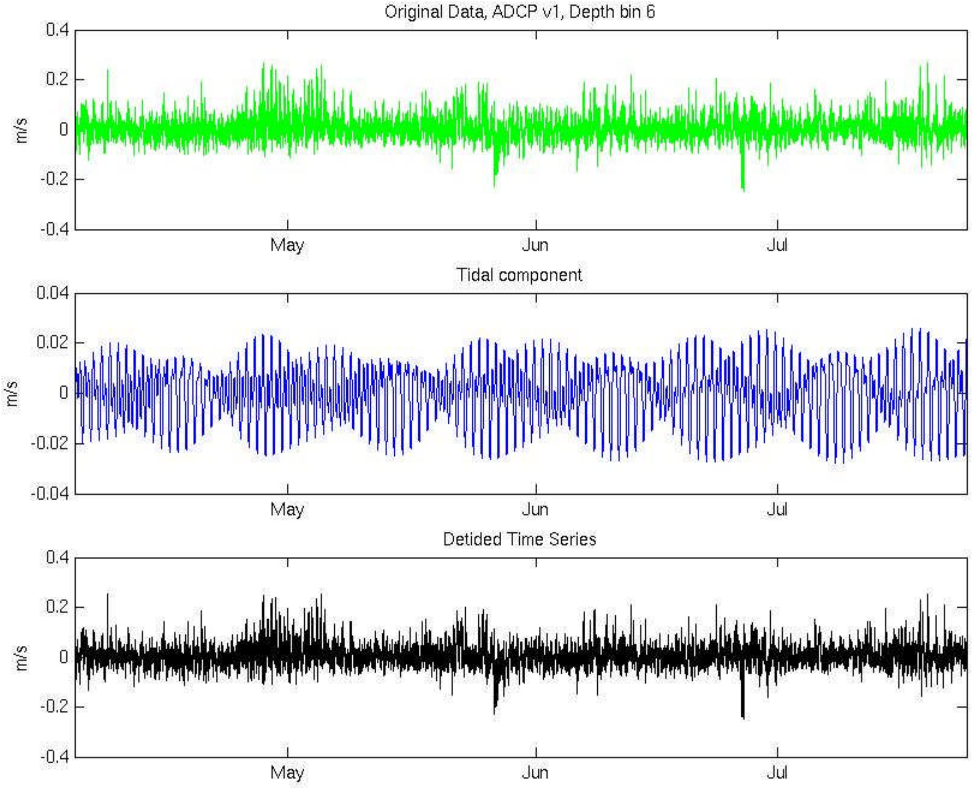
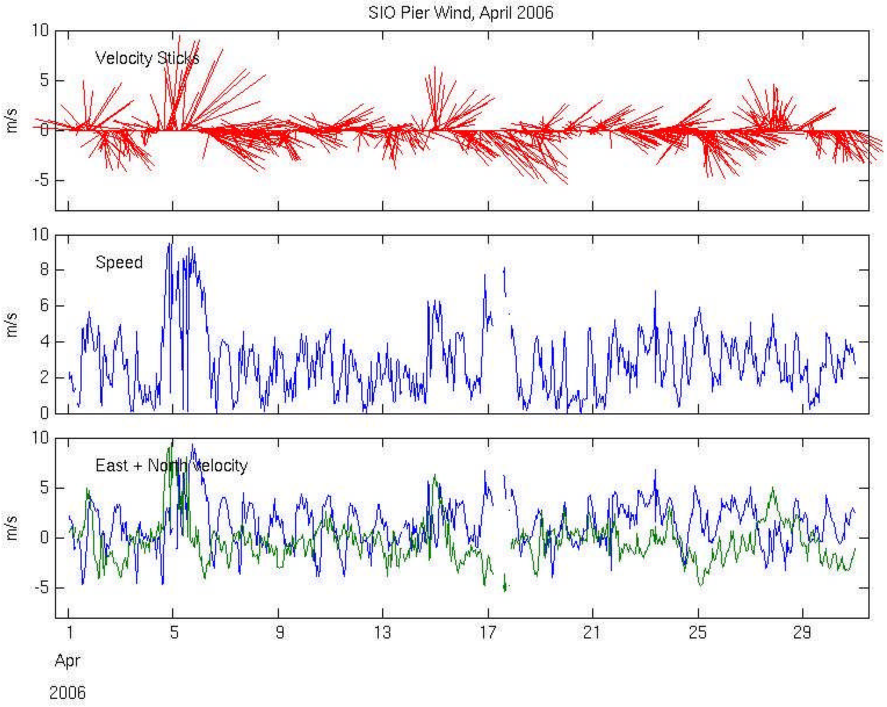


Figure 75. Northward velocity component at ADCP-1. Top: raw velocity data, Middle: Tidal components, Bottom: Detided velocity data. (Note: Scale on tidal component panel is 1/10 of the raw and detided panels).



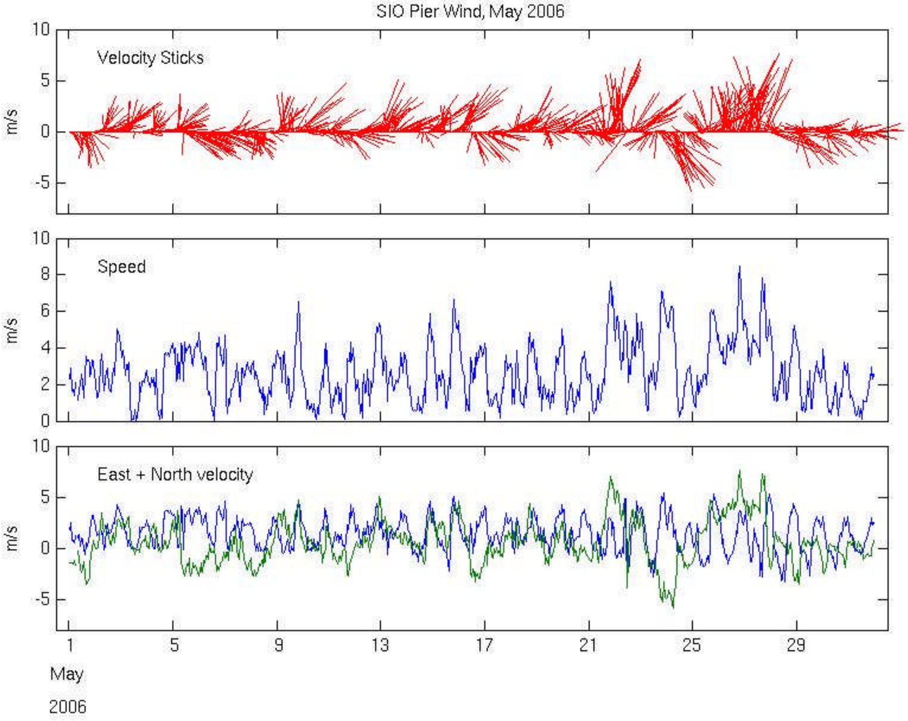
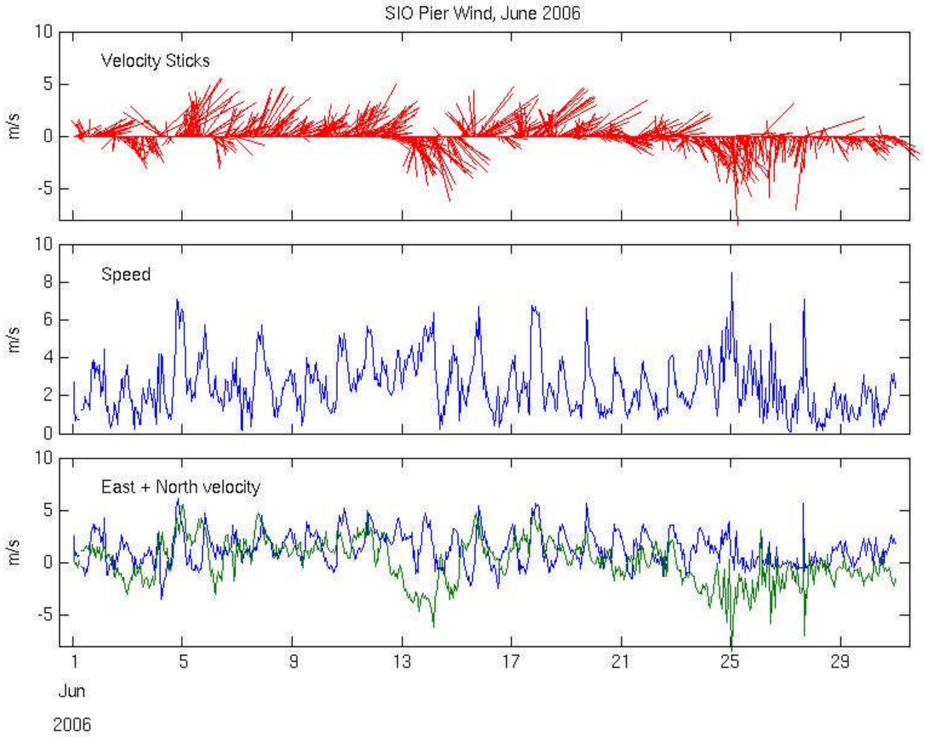


Figure 76(a,b). Wind measurements from Scripps Pier for April (top) and May (bottom) 2006. Velocity is shown using oceanographic conventions (positive northward and eastward).



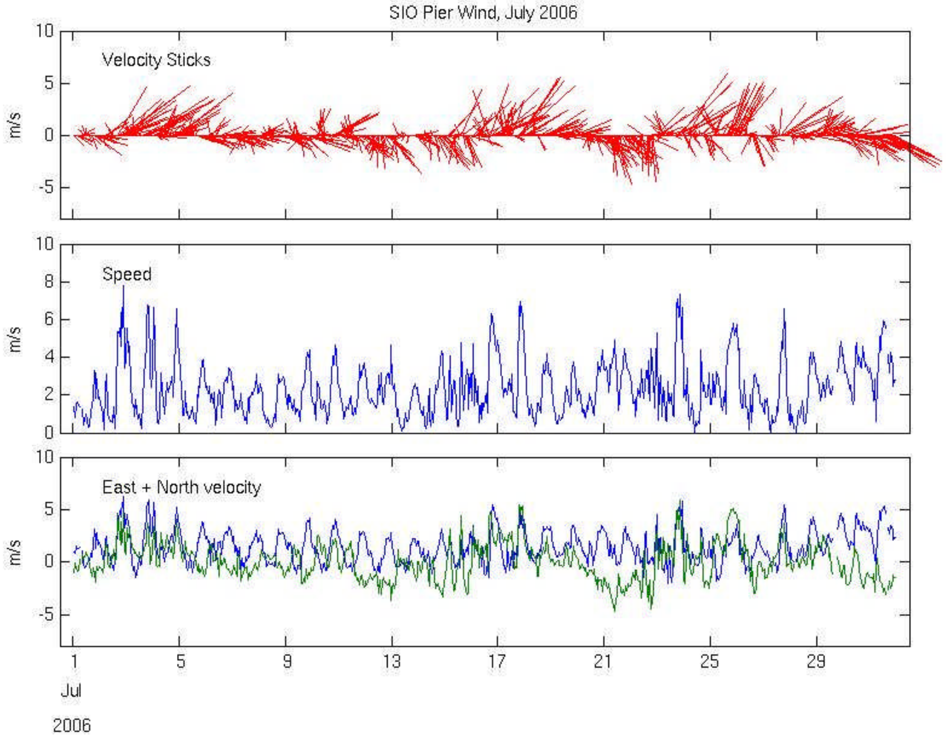


Figure 76(c,d). Wind measurements from Scripps Pier for June (top) and July (bottom) 2006. Velocity is shown using oceanographic conventions (positive northward and eastward).

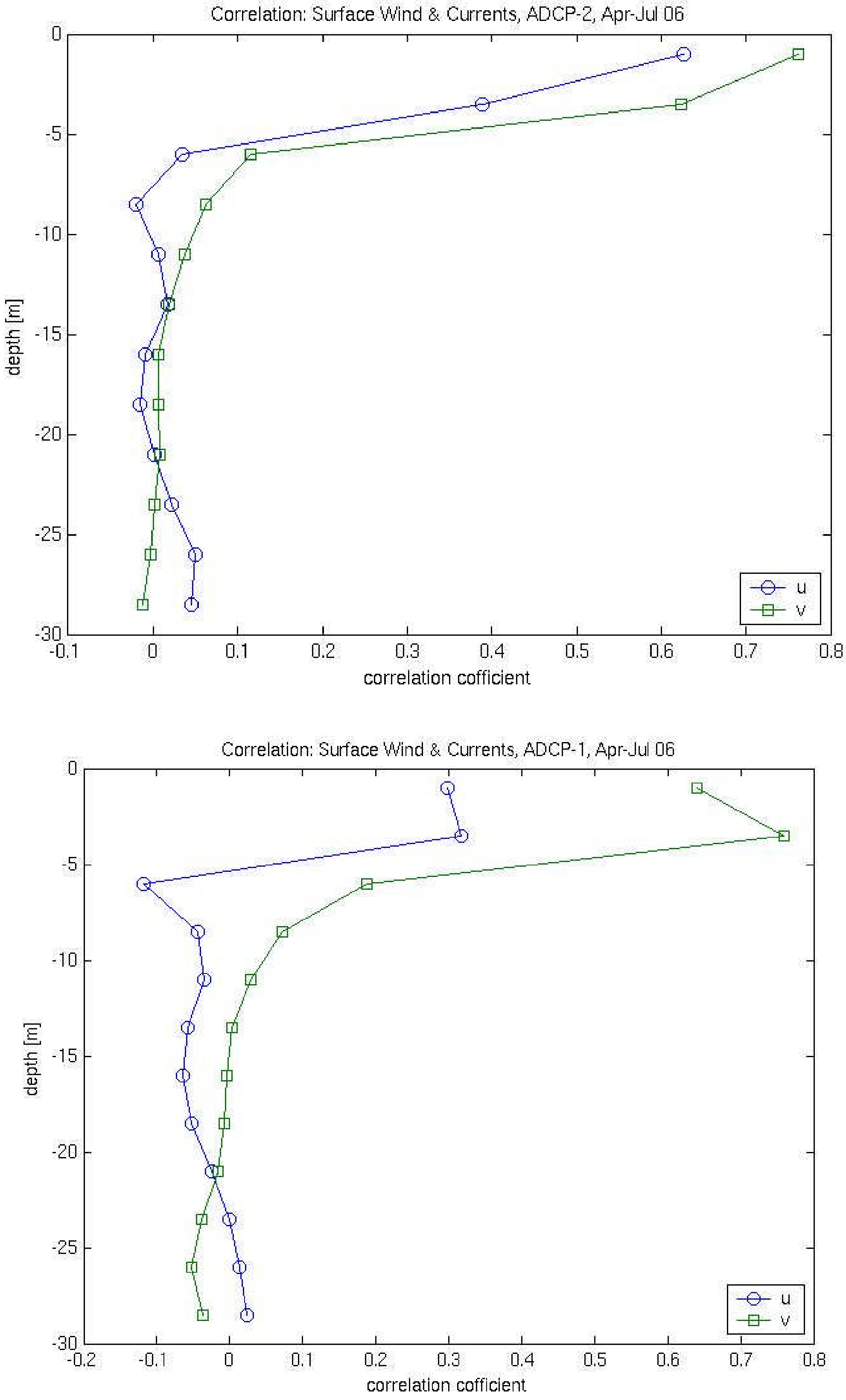


Figure 77(a,b). Correlation between surface wind direction and velocity and ADCP currents from surface to bottom for deep sites, (top) ADCP-1, (bottom) ADCP-2.

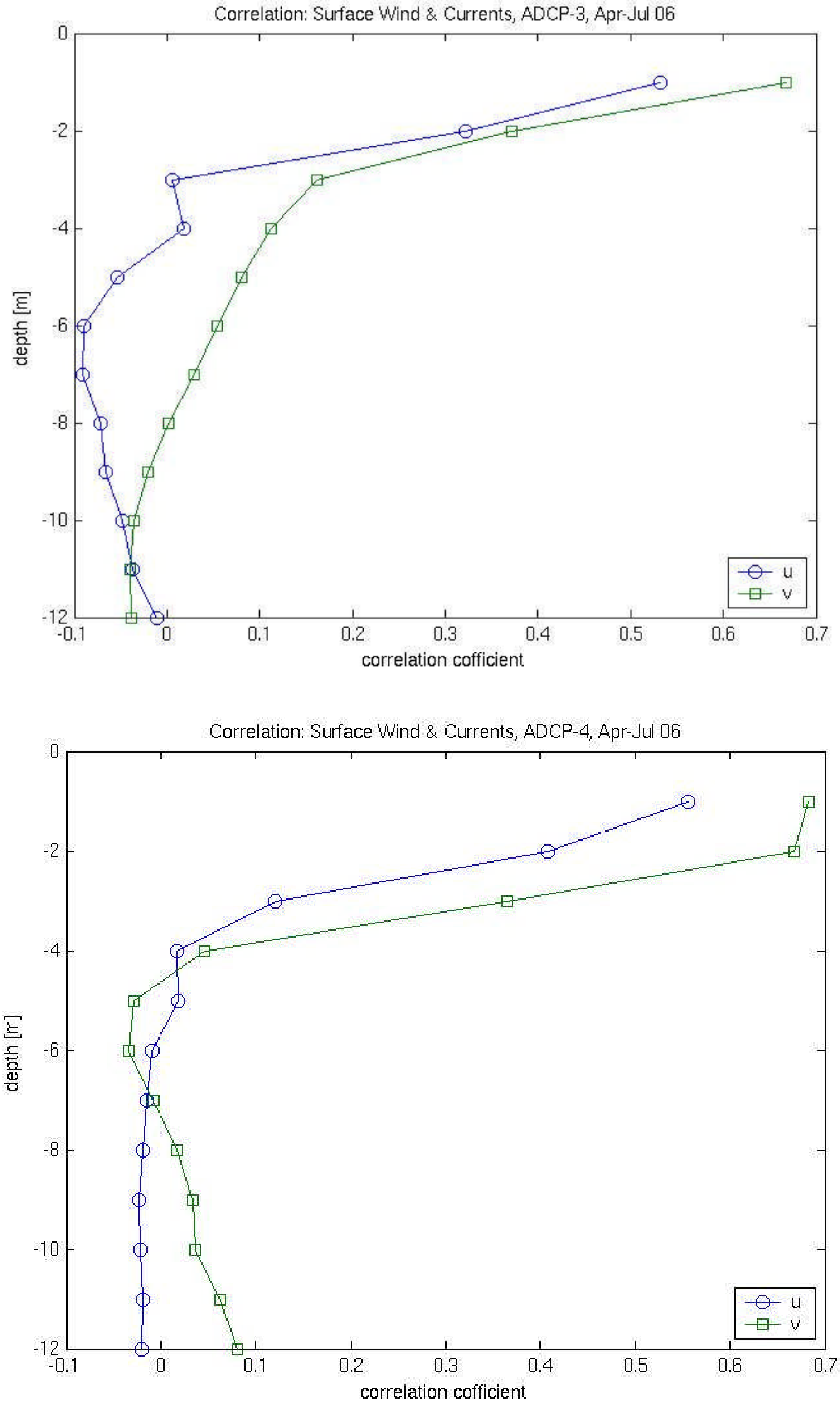


Figure 77(c,d). Correlation between surface wind direction and velocity and ADCP currents from surface to bottom for shallow sites, (top) ADCP-3, (bottom) ADCP-4.

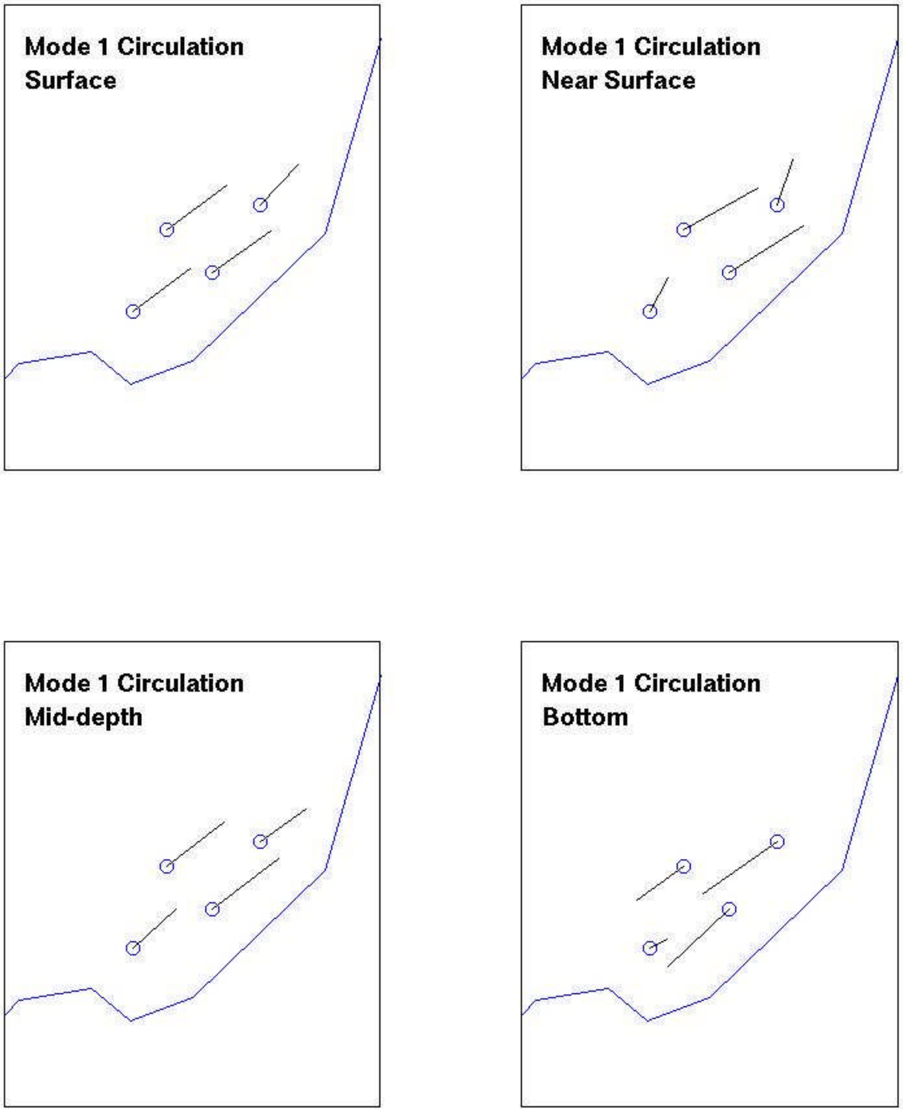


Figure 78.  Mode 1 Circulation at four depths.

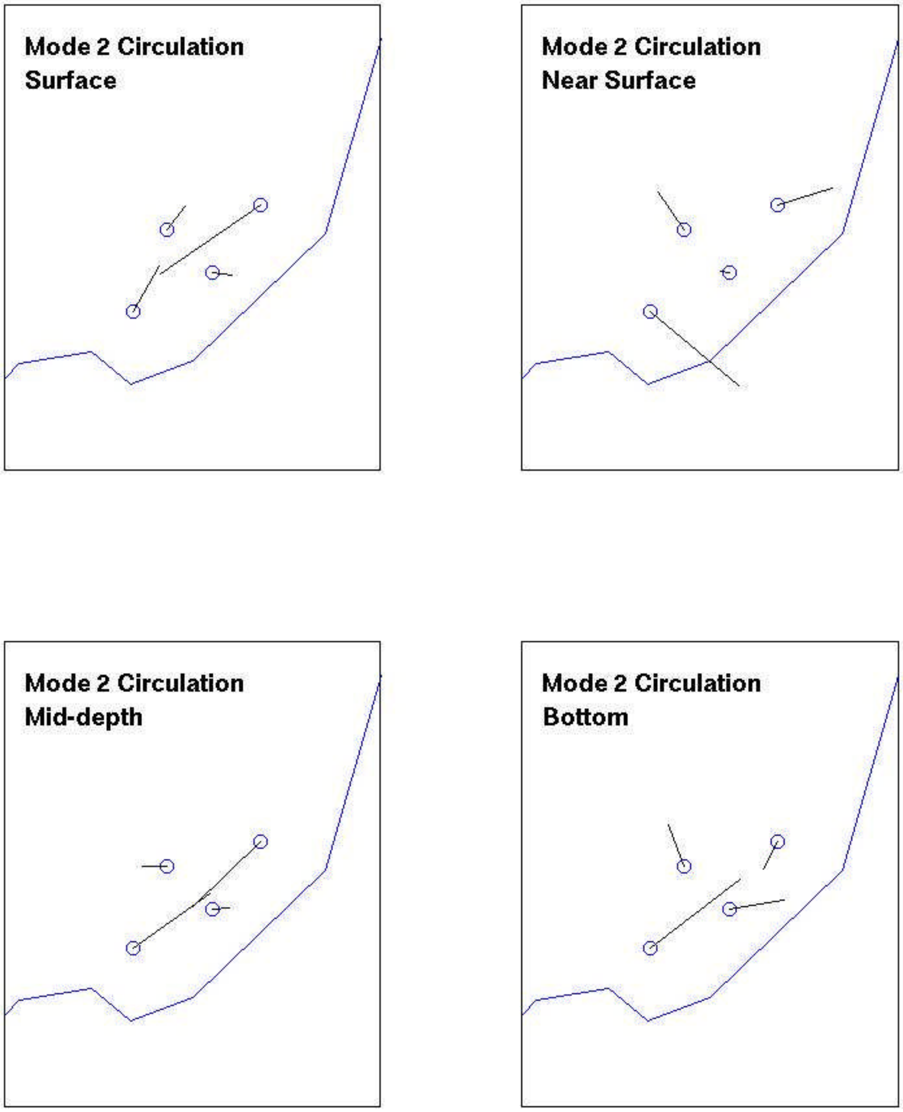


Figure 79. Mode 2 circulation at four depths.

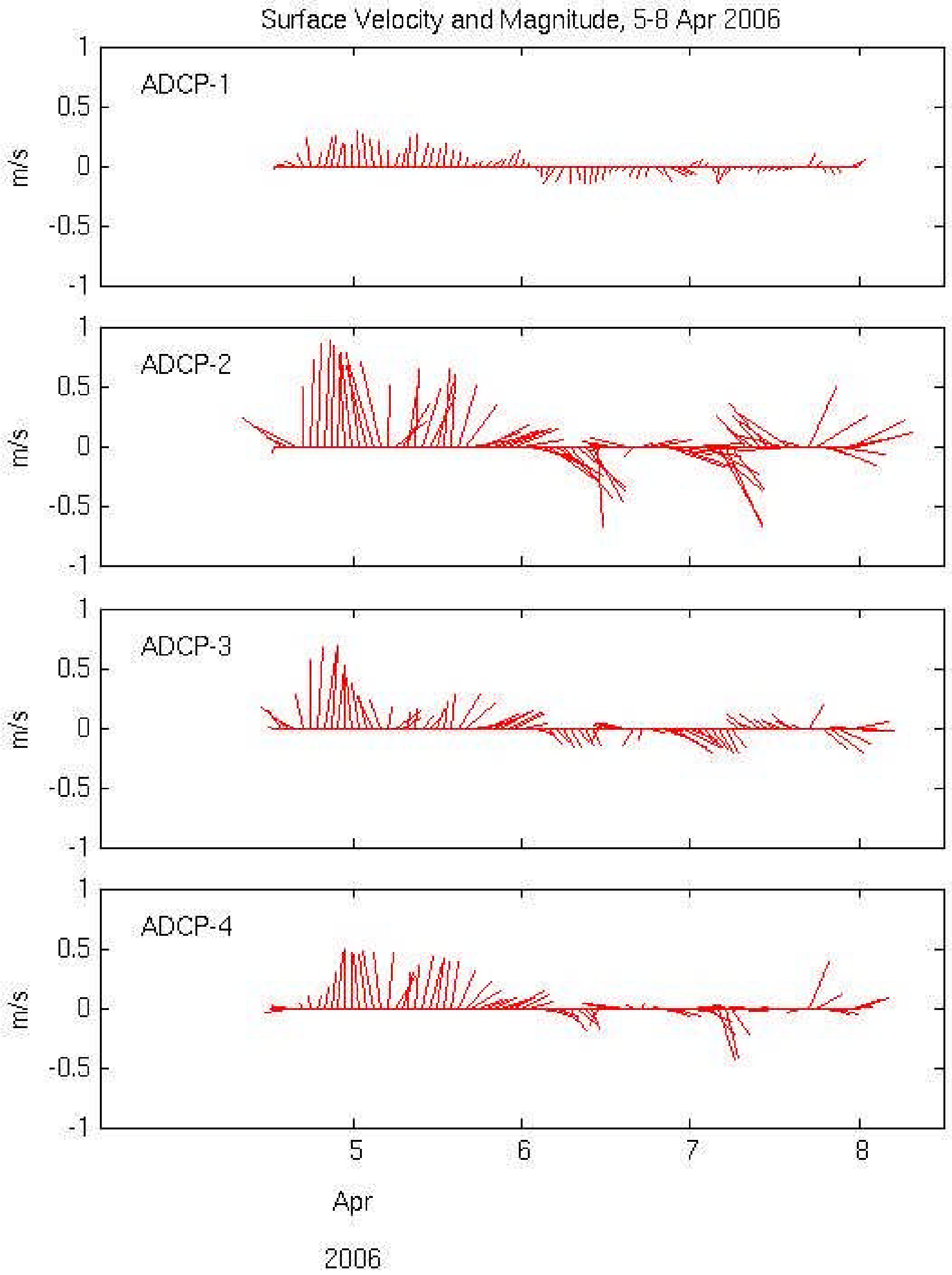


Figure 80(a). Surface velocity at the four sites during and following April 5 storm event.

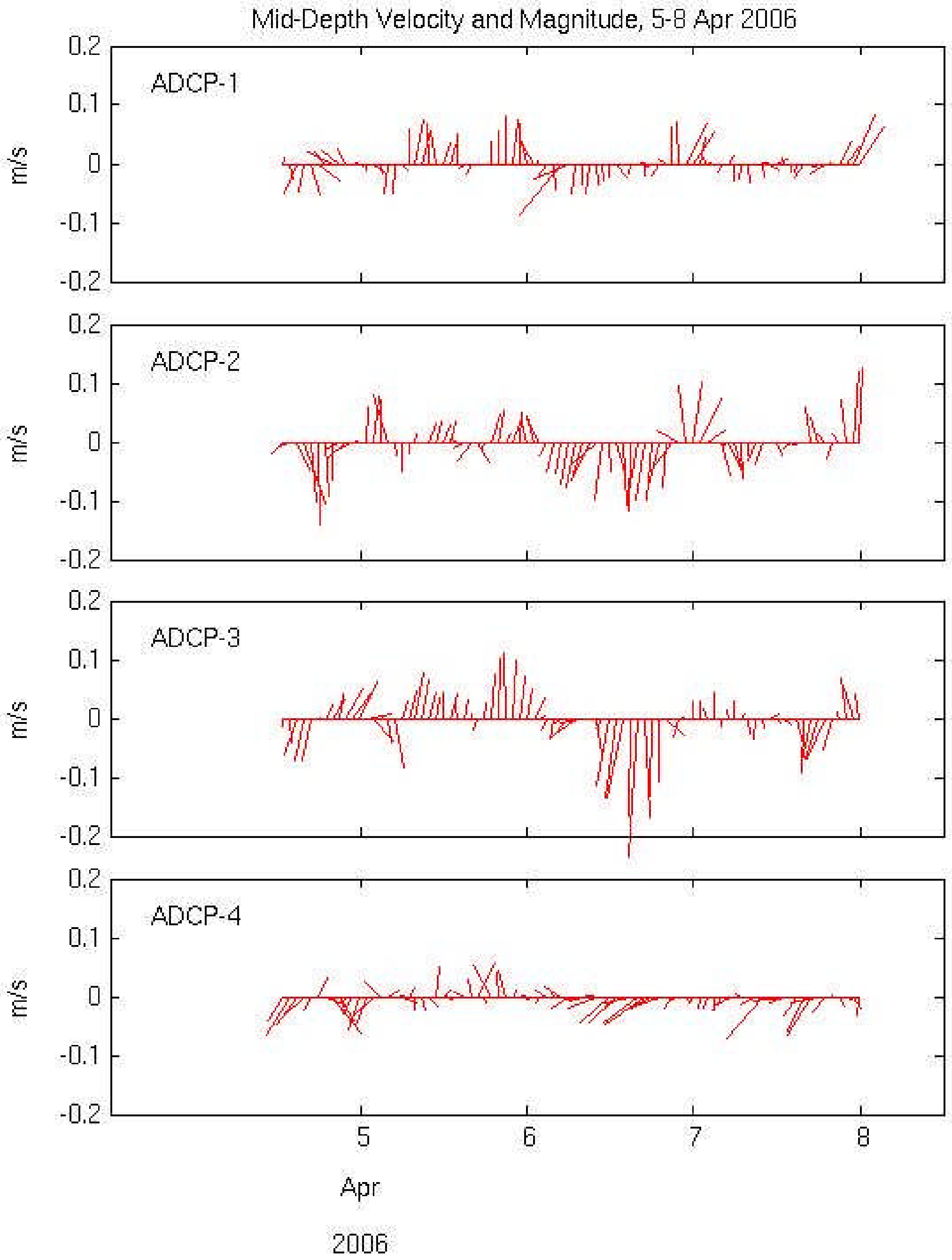


Figure 80(b). Mid-depth velocity at the four sites during and following April 5 storm event.

# APPENDIX B – LIST OF CONSTITUENTS

## Table B-1. California Mussel Constituents and Reporting Limit Ranges

| Parameter | Class | Minimum Reporting Limit | Maximum Reporting Limit |
|---|---|---|---|
| %Lipids Determination | Lipids | 0.1 | 0.1 |
| 1-Methylnaphthalene | PAH | 2 | 66 |
| 1-Methylphenanthrene | PAH | 2 | 66 |
| 2,3,5 Trimethylnaphthalene | PAH | 2 | 66 |
| 2,6 Dimethylnaphthalene | PAH | 2 | 66 |
| 2-Methylnaphthalene | PAH | 2 | 66 |
| 4,4'-DDD | ChlorPest | 2 | 22 |
| 4,4'-DDE | ChlorPest | 2 | 22 |
| 4,4'-DDT | ChlorPest | 2 | 22 |
| Acenaphthene | PAH | 2 | 66 |
| Acenaphthylene | PAH | 2 | 66 |
| Aldrin | ChlorPest | 1 | 11 |
| alpha-BHC | ChlorPest | 1 | 11 |
| alpha-Chlordane | ChlorPest | 1 | 11 |
| Aluminum | Metal | 5.9 | 89.3 |
| Anthracene | PAH | 2 | 66 |
| Arsenic | Metal | 0.47 | 4.1 |
| Azinphos-methyl (guthion) | OrgPhosPest | 50 | 500 |
| Barium | Metal | 0.09 | 2.3 |
| Benzo(a)anthracene | PAH | 2 | 66 |
| Benzo(a)pyrene | PAH | 2 | 66 |
| Benzo(b)fluoranthene | PAH | 2 | 66 |
| Benzo(e)pyrene | PAH | 2 | 66 |
| Benzo(g,h,i)perylene | PAH | 2 | 66 |
| Benzo(k)fluoranthene | PAH | 2 | 66 |
| Beryllium | Metal | 0 | 0.13 |
| beta-BHC | ChlorPest | 1 | 11 |
| Biphenyl | PAH | 2 | 66 |
| BZ#101 | PCB | 0.4 | 4.4 |
| BZ#105 | PCB | 0.4 | 4.4 |
| BZ#114 | PCB | 0.4 | 4.4 |
| BZ#118 | PCB | 0.4 | 4.4 |
| BZ#123 | PCB | 0.4 | 4.4 |
| BZ#126 | PCB | 0.4 | 4.4 |
| BZ#128 | PCB | 0.8 | 8.9 |
| BZ#138 | PCB | 0.4 | 4.4 |
| BZ#153 | PCB | 0.8 | 8.9 |

## Table B-1. California Mussel Constituents and Reporting Limit Ranges

| Parameter | Class | Minimum Reporting Limit | Maximum Reporting Limit |
|---|---|---|---|
| BZ#156 | PCB | 0.4 | 4.4 |
| BZ#157 | PCB | 0.4 | 4.4 |
| BZ#167 | PCB | 0.8 | 8.9 |
| BZ#169 | PCB | 0.4 | 4.4 |
| BZ#170 | PCB | 0.4 | 4.4 |
| BZ#18 | PCB | 0.4 | 4.4 |
| BZ#180 | PCB | 0.4 | 4.4 |
| BZ#183 | PCB | 0.4 | 4.4 |
| BZ#184 | PCB | 0.8 | 8.9 |
| BZ#187 | PCB | 0.4 | 4.4 |
| BZ#189 | PCB | 0.4 | 4.4 |
| BZ#195 | PCB | 0.4 | 4.4 |
| BZ#198 | PCB | 0.4 | 4.4 |
| BZ#206 | PCB | 0.4 | 4.4 |
| BZ#209 | PCB | 0.4 | 4.4 |
| BZ#28 | PCB | 0.4 | 4.4 |
| BZ#44 | PCB | 0.4 | 4.4 |
| BZ#49 | PCB | 0.4 | 4.4 |
| BZ#52 | PCB | 0.4 | 4.4 |
| BZ#66 | PCB | 0.4 | 4.4 |
| BZ#77 | PCB | 0.4 | 4.4 |
| BZ#8 | PCB | 0.4 | 4.4 |
| BZ#81 | PCB | 0.8 | 8.9 |
| BZ#87 | PCB | 0.8 | 8.9 |
| C1-Chrysenes | PAH | 2 | 66 |
| C1-Dibenzothiophenes | PAH | 2 | 66 |
| C1-Fluoran/Pyrenes | PAH | 2 | 66 |
| C1-Fluorenes | PAH | 2 | 66 |
| C1-Naphthalenes | PAH | 2 | 66 |
| C1-Phenan/Anthracenes | PAH | 2 | 66 |
| C2-Chrysenes | PAH | 2 | 66 |
| C2-Dibenzothiophenes | PAH | 2 | 66 |
| C2-Fluoran/Pyrenes | PAH | 2 | 66 |
| C2-Fluorenes | PAH | 2 | 66 |
| C2-Naphthalenes | PAH | 2 | 66 |
| C2-Phenan/Anthracenes | PAH | 2 | 66 |
| C3-Chrysenes | PAH | 2 | 66 |
| C3-Dibenzothiophenes | PAH | 2 | 66 |

## Table B-1. California Mussel Constituents and Reporting Limit Ranges

| Parameter | Class | Minimum Reporting Limit | Maximum Reporting Limit |
|---|---|---|---|
| C3-Fluoran/Pyrenes | PAH | 2 | 66 |
| C3-Fluorenes | PAH | 2 | 66 |
| C3-Naphthalenes | PAH | 2 | 66 |
| C3-Phenan/Anthracenes | PAH | 2 | 66 |
| C4-Chrysenes | PAH | 2 | 66 |
| C4-Naphthalenes | PAH | 2 | 66 |
| C4-Phenan/Anthracenes | PAH | 2 | 66 |
| Cadmium | Metal | 0 | 0.35 |
| Chlordane | ChlorPest | 10 | 110 |
| Chlorpyrifos | OrgPhosPest | 50 | 500 |
| Chromium | Metal | 0.1 | 0.98 |
| Chrysene | PAH | 2 | 66 |
| Copper | Metal | 0 | 0.87 |
| Decachlorobiphenyl | PCB | 1 | 11 |
| delta-BHC | ChlorPest | 1 | 11 |
| Demeton | OrgPhosPest | 50 | 500 |
| Dibenz(a,h)anthracene | PAH | 2 | 66 |
| Dibenzothiophene | PAH | 2 | 66 |
| Dieldrin | ChlorPest | 2 | 22 |
| Endosulfan I | ChlorPest | 1 | 11 |
| Endosulfan II | ChlorPest | 2 | 22 |
| Endosulfan sulfate | ChlorPest | 2 | 22 |
| Endrin | ChlorPest | 2 | 22 |
| Endrin aldehyde | ChlorPest | 2 | 22 |
| Endrin ketone | ChlorPest | 2 | 22 |
| Fluoranthene | PAH | 2 | 66 |
| Fluorene | PAH | 2 | 66 |
| gamma-BHC (Lindane) | ChlorPest | 1 | 11 |
| gamma-Chlordane | ChlorPest | 1 | 11 |
| Heptachlor | ChlorPest | 1 | 11 |
| Heptachlor epoxide | ChlorPest | 1 | 11 |
| Indeno(1,2,3-cd)pyrene | PAH | 2 | 66 |
| Iron | Metal | 3.5 | 45.7 |
| Lead | Metal | 0 | 0.087 |
| Malathion | OrgPhosPest | 50 | 500 |
| Manganese | Metal | 0 | 0.087 |
| Mercury | Metal | 0 | 0.16 |
| Methoxychlor | ChlorPest | 10 | 110 |

## Table B-1. California Mussel Constituents and Reporting Limit Ranges

| Parameter | Class | Minimum Reporting Limit | Maximum Reporting Limit |
|---|---|---|---|
| Naphthalene | PAH | 2 | 66 |
| Nickel | Metal | 0 | 0.87 |
| Parathion, ethyl | OrgPhosPest | 50 | 500 |
| Parathion, methyl | OrgPhosPest | 50 | 500 |
| Perylene | PAH | 2 | 66 |
| Phenanthrene | PAH | 2 | 66 |
| Pyrene | PAH | 2 | 66 |
| Selenium | Metal | 0.1 | 0.87 |
| Silver | Metal | 0 | 0.26 |
| Solids, Percent | Solids | | |
| Tetrachloro-meta-xylene | PAH | 0.4 | 4.4 |
| Tetrachloro-m-xylene | PAH | 1 | 11 |
| Tin | Metal | 0.2 | 4 |
| Toxaphene | ChlorPest | 100 | 1100 |
| TRIBUTYLPHOSPHATE | OtherOrgPhos | 50 | 500 |
| TRIPHENYLPHOSPHATE | OtherOrgPhos | 50 | 500 |
| Zinc | Metal | 0.1 | 1.4 |

### Table B-2. Sand Crab Constituents and Reporting Limit Ranges

| Analyte | Class | Minimum Reporting Limit | Maximum Reporting Limit |
|---|---|---|---|
| %Lipids Determination | Lipids | 0.1 | 0.1 |
| 1-Methylnaphthalene | PAH | 2 | 12 |
| 1-Methylphenanthrene | PAH | 2 | 12 |
| 2,3,5 Trimethylnaphthalene | PAH | 2 | 12 |
| 2,6 Dimethylnaphthalene | PAH | 2 | 12 |
| 2-Methylnaphthalene | PAH | 2 | 12 |
| Acenaphthene | PAH | 2 | 12 |
| Acenaphthylene | PAH | 2 | 12 |
| Aluminum | Metal | 5.9 | 26.8 |
| Anthracene | PAH | 2 | 12 |
| Antimony | Metal | 0.02 | 0.089 |
| Arsenic | Metal | 0.47 | 2.1 |
| Benzo(a)anthracene | PAH | 2 | 12 |
| Benzo(a)pyrene | PAH | 2 | 12 |
| Benzo(b)fluoranthene | PAH | 2 | 12 |
| Benzo(e)pyrene | PAH | 2 | 12 |
| Benzo(g,h,i)perylene | PAH | 2 | 12 |
| Benzo(k)fluoranthene | PAH | 2 | 12 |
| Beryllium | Metal | 0.01 | 0.045 |
| Biphenyl | PAH | 2 | 12 |
| C1-Chrysenes | PAH | 2 | 12 |
| C1-Dibenzothiophenes | PAH | 2 | 12 |
| C1-Fluoran/Pyrenes | PAH | 2 | 12 |
| C1-Fluorenes | PAH | 2 | 12 |
| C1-Naphthalenes | PAH | 2 | 12 |
| C1-Phenan/Anthracenes | PAH | 2 | 12 |
| C2-Chrysenes | PAH | 2 | 12 |
| C2-Dibenzothiophenes | PAH | 2 | 12 |
| C2-Fluoran/Pyrenes | PAH | 2 | 12 |
| C2-Fluorenes | PAH | 2 | 12 |
| C2-Naphthalenes | PAH | 2 | 12 |
| C2-Phenan/Anthracenes | PAH | 2 | 12 |
| C3-Chrysenes | PAH | 2 | 12 |
| C3-Dibenzothiophenes | PAH | 2 | 12 |
| C3-Fluoran/Pyrenes | PAH | 2 | 12 |
| C3-Fluorenes | PAH | 2 | 12 |
| C3-Naphthalenes | PAH | 2 | 12 |
| C3-Phenan/Anthracenes | PAH | 2 | 12 |

## Table B-2. Sand Crab Constituents and Reporting Limit Ranges

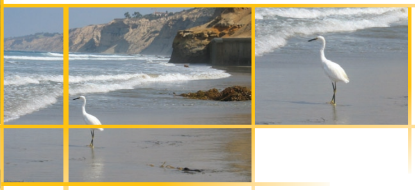
| Analyte | Class | Minimum Reporting Limit | Maximum Reporting Limit |
|---|---|---|---|
| C4-Chrysenes | PAH | 2 | 12 |
| C4-Naphthalenes | PAH | 2 | 12 |
| C4-Phenan/Anthracenes | PAH | 2 | 12 |
| Cadmium | Metal | 0.01 | 0.045 |
| Chromium | Metal | 0.13 | 0.59 |
| Chrysene | PAH | 2 | 12 |
| Copper | Metal | 0.22 | 1 |
| Dibenz(a,h)anthracene | PAH | 2 | 12 |
| Dibenzothiophene | PAH | 2 | 12 |
| Fluoranthene | PAH | 2 | 12 |
| Fluorene | PAH | 2 | 12 |
| Indeno(1,2,3-cd)pyrene | PAH | 2 | 12 |
| Iron | Metal | 6 | 27.4 |
| Lead | Metal | 0.01 | 0.045 |
| Manganese | Metal | 0.06 | 0.27 |
| Mercury | Metal | 0.016 | 0.091 |
| Naphthalene | PAH | 2 | 12 |
| Nickel | Metal | 0.02 | 0.089 |
| Perylene | PAH | 2 | 12 |
| Phenanthrene | PAH | 2 | 12 |
| Pyrene | PAH | 2 | 12 |
| Selenium | Metal | 0.02 | 0.089 |
| Silver | Metal | 0.03 | 0.13 |
| Solids, Percent | Solids | NA | NA |
| Thallium | Metal | 0.01 | 0.045 |
| Zinc | Metal | 0.19 | 0.86 |

# Appendix C –

Analytical description and hardcopy of mussel data from STL Burlington

# APPENDIX C

# ASBS Facts Sheets



# La Jolla

## Areas of Special Biological Significance (ASBS)

The California State Water Resources Control Board created Areas of Special Biological Significance (ASBS) to protect our oceans and prevent pollution within some of the most pristine and biologically diverse sections of California's coast. Today, there are 34 such areas in California, and La Jolla is home to ASBS numbers 29 and 31. These ASBS encompass a large portion of the La Jolla Shores marine environment, which includes the La Jolla State Marine Conservation Area and the adjoining San Diego-Scripps State Marine Conservation Area.

### ASBS Partnerships

To protect and improve water quality in these two ASBS, the City of San Diego has formed a partnership with San Diego Coastkeeper and Scripps Institution of Oceanography (SIO). This is a unique hands-on partnership to implement the La Jolla Shores Coastal Watershed Management Plan, which is intended to be the blueprint for actions that will be taken locally.

### Watershed Regulations

The water that drains into the ASBS comes from various "watersheds" in La Jolla. A "watershed" is defined as a geographical area that drains to a specified point on a water course (natural flow downhill based on topography). The La Jolla watersheds are located in a concentrated area which drains into the ocean, and therefore, the ASBS. By and large, pollution that impacts water quality is the result of land based activities such as driving, recreation, over-irrigation, landscaping, and pet waste.

Pollution and other waste discharges into the ASBS are prohibited by the California Ocean Plan. However, the Ocean Plan allows cities to apply to the State Water Board for exceptions to the prohibition if certain conditions are met. The State is currently working to identify the conditions for those exceptions. The Partnership is working towards the execution of a three-step program in this watershed to reduce pollution into the ASBS waters off of La Jolla.

The three steps are:

1. Forming a management plan
2. Execution of a water monitoring program
3. Implementation of BMPs (Best Management Practices)

### The La Jolla ASBS Watershed Plan

The La Jolla Shores Coastal Watershed Management Plan is intended to generate guidelines for actions that will be taken locally to protect and improve water quality in the two ASBS off the coast of La Jolla. The Plan addresses the urban runoff and stormwater that discharge from these watersheds. The La Jolla watersheds are roughly bounded by Mt. Soledad and La Jolla Scenic Drive. The Watershed Plan also develops frameworks for monitoring marine ecosystems for information management to better manage ASBS issues, and to protect La Jolla's coastal waters.

### The Watershed Plan Process

Thus far, the Partnership has successfully secured a planning grant in the amount of $500,000. This grant will fund the framework and planning process for the La Jolla ASBS. To fully realize The Watershed Management Plan, additional grant funding will be sought. To date, the Partnership has completed the evaluation and assessment phases, and is currently analyzing the water monitoring data. The partnership is in the process of developing the BMP's for the Plan, and sharing these preliminary ideas with the public.

<table>
<tr><th colspan="8">La Jolla Shores Coastal Watershed Management Plan</th></tr>
<tr><td colspan="5">2006</td><td colspan="2">2007</td><td>2008-2010</td></tr>
<tr><td>Situation Analysis</td><td colspan="2">Ocean Ecosystem Assessment</td><td>BMP Planning</td><td>Draft Plan & BMP's</td><td>Watershed Plan Adoption</td><td colspan="2">Begin Implementation</td></tr>
<tr><td>Evaluation</td><td>Watershed Monitoring</td><td>Data Analysis</td><td colspan="2">Public Workshops</td><td colspan="3"></td></tr>
<tr><td colspan="6">Planning Grant</td><td colspan="2">Construction Grant</td></tr>
</table>

## Next Steps

A preliminary list of recommended BMP's for the La Jolla Shores Area has been created.

***Recommendations include:***

- Enhance and convert existing streets into “Green Streets”. The “Greet Streets” model can be found in other areas of the country that are properly managing stormwater runoff, including Portland, Seattle, and Denver, among others.
- Placement of “Infiltration Landscaping” within the unpaved area of the La Jolla Shores Drive right-of-way for wet weather overflow. This will involve construction of aesthetic landscape strips that will serve as shallow infiltration areas along the traveled way.
- Replacement of asphalt concrete paving with pervious concrete in areas such as the parking lots for La Jolla Shores Beaches along Camino del Oro & El Paseo Grande which will allow stormwater to percolate through the ground rather than running directly into the ASBS.
- Replacement of the existing storm drain system within Avenida de la Playa with a new gasket system and new pump mechanism.
- Research the possibility of using portions of various other open spaces as additional landscape infiltration zones.
- Use of more effective street sweepers that incorporate vacuum capabilities.
- Washing down the streets by opening up fire hydrants at key locations throughout the watershed, with the wash water taken to the sanitary sewer by the existing and future dry weather diversion systems.

The City of San Diego

San Diego Coastkeeper

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This information is available in alternative formats upon request.

Printed on recycled paper.

# La Jolla
## Areas of Special Biological Significance (ASBS)

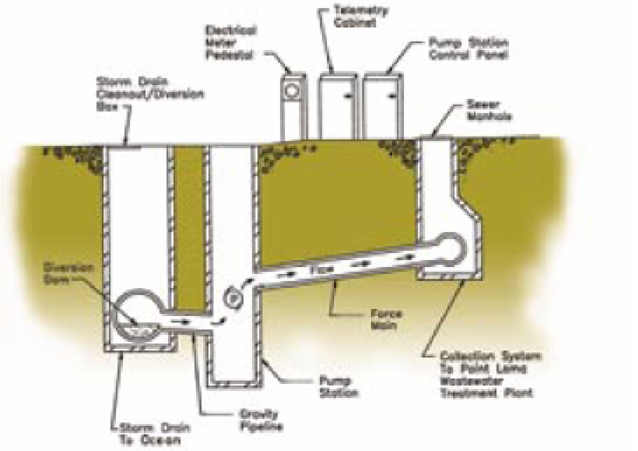
## Proposed Structural BMPs

### THE COASTAL LOW FLOW DIVERSION PROGRAM

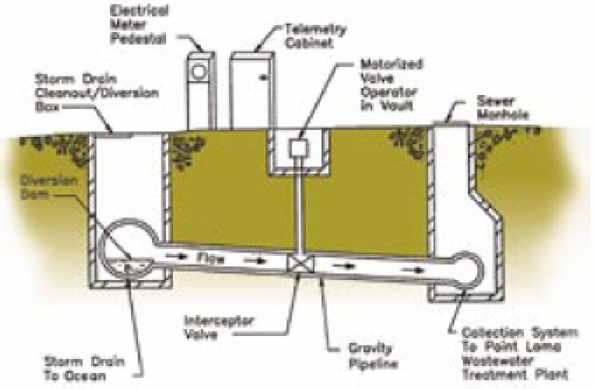
The Coastal Low Flow Diversion Program works on the principle that dry season storm drain flows (low flows) are often polluted. Normally, storm drains collect polluted flows year-around from sidewalks, curbs, gutters and inlets and carry them untreated to the nearest beach, creek, river or bay via a series of underground pipes

Coastal Low Flow Diversion facilities capture flows from urban runoff and sewage spills just upstream of the storm drain pipe terminus at the beach. Often these facilities are the last barrier protecting the beach from unhealthy flows.

Diversion facilities consist of a series of underground pipelines, valves and pumps. They tie into the storm drain system and divert “low flows” into the sewer system for treatment. “Low flows” are urban runoff and/or sewage overflows, or flows seen during dry weather periods as opposed to the “high flows” experienced during rainy periods. The Diversion facilities are equipped with sensors that trigger the facility to shut down and stop diversion when high flows are experienced.

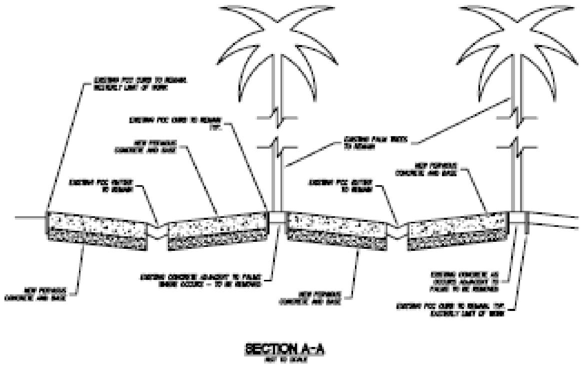


PUMPED LOW FLOW STORM DRAIN DIVERSION



GRAVITY LOW FLOW STORM DRAIN DIVERSION

## KELLOGG PARK PARKING LOT BMP RETROFIT – CONCEPTUAL DESIGN



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# APPENDIX D

# Framework Recommendations for a Statewide ASBS Information Management System

# Framework Recommendations for a Statewide ASBS Information Management System

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La Jolla, CA  92093-0213

## 1.0 Information Management Overview

In recent years there has been an awakening to the need for integrated information management systems to provide efficiency in assessing and managing regulatory programs.  The statewide network of Areas of Special Biological Significance (ASBS) is one example in which a robust and persistent data system is required.  A large amount and wide variety of data have been, and will be, collected in the watershed and ASBS through both regulatory permitting requirements and ancillary data collection efforts required to assess ASBS performance.  Currently, these datasets are relatively isolated and unavailable to a wide range of users.  Information management systems are needed for integration and public data dissemination so that interrelated biological-physical-chemical processes present in the watershed and marine environment can be assessed.  These data requirements span both regulatory and non-regulatory based data collection efforts.

The information management system developed for this Plan, and described below, was designed to meet the following project needs:

- Data collection and storage
- Analysis and evaluation by the professional, policy making and regulatory community to assess the performance of the ASBS
- Data availability to the general scientific community
- Dissemination to the public for outreach and stewardship

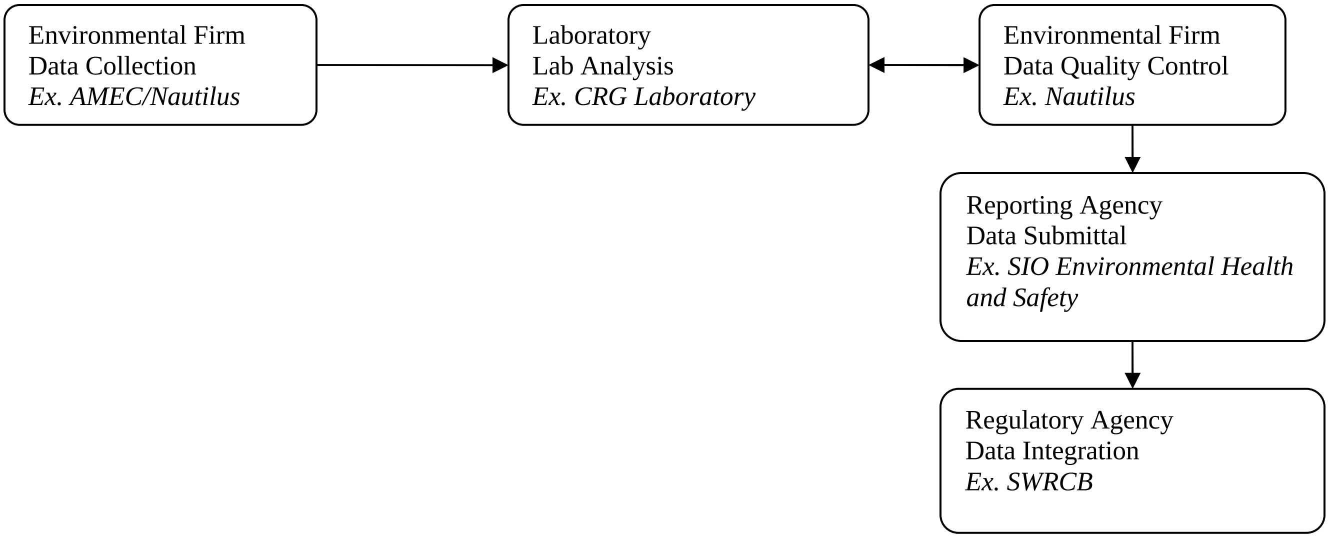
A distinction is made between *information management* and *data management*.  Data management consists primarily of the “back-end” system (or network of systems) for data collection, ingestion, storage, archival, and retrieval.  A robust data management system should consist of a tested and reliable method of acquiring data, a scalable and accessible method of storing and retrieving data, and a secure and replicated method of archiving data.  Information management is the process by which the data becomes useful to decision makers.  It includes the mechanisms for utilizing the data, optimized methods for disseminating the data, and the generation and presentation of useful products that can be used for research and decision making.  Information management facilitates the transition from content (data) to knowledge.

The goal of the ASBS information management system is to establish the infrastructure needs and generate a conceptual design required for long term assessment of ASBS performance and related management decisions.  The infrastructure needs to meet both the needs of the regulatory data collection as well as incorporate monitoring activities, scientific studies, and observations that are required for enhanced ecosystem assessment and ASBS management, yet may be outside of the present regulatory framework.

This document details recommendations created by the Coastal Observing R&D Center at Scripps Institution of Oceanography (SIO) to establish a comprehensive statewide framework of an ASBS informational management system, and pilot activities undertaken to implement a foundation for that system. The report is organized in the following manner. Section 2.0 reviews the existing data management systems that were identified as having relevance to the ASBS network. Section 3.0 Summarizes the ASBS functionality of the SWAMP data system. Section 4.0 Identifies and discusses those critical variables that are required to assess the processes which influence ASBS performance, yet are outside of the present regulatory framework. Section 5.0 Provides a discussion for requirements, limitations, and technical trade-offs of data display functions. Section 6.0 Provides recommendations for next steps.

## 2.0 Data Systems Relevant to an ASBS

An assessment of water quality data systems was conducted through a series of meetings with personnel involved in water quality data handing and through online research. To illustrate the complexities and challenges involved in managing these data, it is useful to summarize a typical chain of custody for sample data collected in the La Jolla ASBS. Sampling and analysis is contracted out by most agencies required to report on water quality. The samples are often collected by an environmental engineering firm then sent to a laboratory for analysis. The lab reports results back to the engineering firm for quality control, who in turn reports final results to the contracting agency. Agencies are responsible for reporting measurements to the State Water Resource Control Board (SWRCB). SIO Environmental Health and Safety (EH&S) utilize AMEC Consulting Firm for seawater sampling and MACTEC Engineering and Consulting, Inc. for storm water monitoring. The City of San Diego contracts to Weston Solutions, Inc. for all monitoring efforts. Reporting mechanisms and methods vary between all companies. The primary method of data storage is in spreadsheets (.xls, .csv) and primary method of data transfer is through email or paper reports. In terms of data scalability, query and web display, these practices are not sustainable. No standardization exists between the internal methods of data storage. Below is an example data flow chart, notice there is currently no public display or dissemination.



There have been several Regional and State efforts directed at establishing a standard protocol for water quality measurements. Relevant programs include CIWQS and SWAMP.

**California Integrated Water Quality System Project (CIWQS)**
This project is defined as:

> "a new computer system for the State and Regional Water Quality Control Boards to track information about places of environmental interest, manage permits and other orders, track inspections, and manage violations and enforcement activities. CIWQS also includes an electronic Self Monitoring Report (eSMR) tool for submission of monitoring reports via an internet web site. CIWQS is part of an overall effort to integrate several disparate legacy systems, compile water quality data, standardize permits, automate processes, and to make data more accessible to State Water Board staff, dischargers, the public, and the U.S. Environmental Protection Agency." (http://www.swrcb.ca.gov/ciwqs/index.html)

The electronic Self Monitoring Report (eSMR) is currently tailored for National Pollutant Discharge Elimination System (NPDES) Permit dischargers. The system is tuned for limited reporting requirements, and eventually plans to include Sanitary Sewer Overflow (SSO) and Storm Water Annual Reporting Module (SWARM) permitting. Because this system is streamlined for single sample type (water), it cannot currently accommodate other data types or batch sampling without significant modification and, therefore, can not be recommended as a comprehensive data management system. However, these specific applications do play an important role in data management and have been implemented within the Southern California Coastal Ocean Observing System (SCCOOS).

CIWQS summary: streamlined, parameter specific data system
Pros: efficient, simple, easily implemented
Cons: limited in scope, non scalable, not easily adapted for ASBS requirements

**The Southern California Coastal Ocean Observation System (SCCOOS)**
SCCOOS was established by a consortium of research organizations that extends from Northern Baja California in Mexico to Morro Bay at the southern edge of central California, and aims to streamline, coordinate, and further develop individual institutional efforts by creating an integrated, multidisciplinary coastal observatory in the Bight of Southern California to provide data and information primarily for the benefit of society.

SCCOOS aims to integrate a broad suite of observations to include but not limited to: surface currents, satellite imagery, wave conditions and forecasts, meteorological conditions and forecasts, water quality, ocean temperature, salinity, chlorophyll, and density in the form of products and raw data. The SCCOOS data management team has developed a number of innovative data interfaces and products, leveraging google maps to provide localized, zoomable, and navigable interactive display of data. This effort allows scientists, decision makers, and the public access to products that will provide a scientific basis for research, management, and improved uses of the ocean environment.

Targeted architectures are currently in use within the Southern California Coastal Observing System (SCCOOS) data management system. For example, SCCOOS ingests data from Environmental Health agencies throughout Southern California for public display of water quality data. The data are saved in a simple relational database. Although, the SCCOOS data management team did transform the excel files into a UNIX/LINUX-based MySQL database for measurement number scalability, the database is tuned specifically for water quality measurements alone and does not contain controlled vocabularies or outside observational fields. SCCOOS partnered with Southern California Coastal Water Research Project (SCCWRP) Information Systems Manager, Larry Cooper, to create a transfer mechanism and format based on the CIWQS NPDES data format for bacteria data from bight wide Environmental Health Agencies. These observations can be found online at: http://www.sccoos.org/data/waterquality/ Participating agencies include:

- Santa Barbara County; Environmental Health Services
- Ventura County, Department of Environmental Health
- Los Angeles County, Department of Public Health, Environmental Health
- City of Long Beach, Health & Human Services
- Orange County, Health Care Agency, Water Quality Department
- San Diego County, Department of Environmental Health.

Agencies are able to submit measurements to SCCOOS data managers located at Scripps through an enabled macro on their reporting spreadsheet. Data is emailed to a specified water quality address at SCCOOS where the attachment is then parsed into a database through an automated process. By simplifying the reporting process and automating data ingestion, SCCOOS data managers are able to maintain the data flow independent of user intervention. This system is sufficient for storing time series of water quality measurements of total coliforms, fecal coliforms, and enterococci at given station locations. However, as an ASBS data management system, this standalone water quality system is limited in scope and scalability, yet it demonstrates the capability for integrating spatially dispersed, mandated data sets into a unified system that has the potential for integration with other variables of interest.

SCCOOS summary: regional observational data system
Pros: includes non-regulatory observational parameters and limited regulatory data
Cons: not fully developed for integrated ASBS regulatory and non-regulatory parameters

**Surface Water Ambient Monitoring Program (SWAMP)**
SWAMP is defined as:

> "SWAMP is a statewide monitoring effort designed to assess the conditions of surface waters throughout the state of California. The program is administered by the State Water Board. Responsibility for implementation of monitoring activities resides with the nine Regional Water Quality Control Boards that have jurisdiction over their specific geographical areas of the state. Monitoring is conducted in SWAMP through the Department of Fish and Game and U.S. Geological Survey master contracts and local Regional Boards monitoring contracts. SWAMP also hopes to capture monitoring information collected under other State and Regional Board Programs such as the State's TMDL

> (Total Maximum Daily Load), Nonpoint Source, and Watershed Project Support programs. SWAMP does not conduct effluent or discharge monitoring, which is covered under National Pollutant Discharge Elimination System permits and Waste Discharge Requirements."
> (http://www.waterboards.ca.gov/swamp/index.html)

The SWAMP data management system is more comprehensive than CIWQS, including lookup tables for varying sample types, preparation methods, and collection methods. The SWAMP data structure also includes documented templates for lab entry and backend storage relationships. Due to the complexity of the SIO permit requirements, the limited scope of CIWQS, and the growing use of SWAMP throughout the state, data managers determined integration of the SWAMP structured system would be a preferred method for data storage, retrieval, and display of ASBS regulatory data.

SWAMP summary: comparatively matured water quality monitoring data system
Pros: comprehensive, collaborative, and becoming a standard
Cons: complex and still under development, developed for focused site

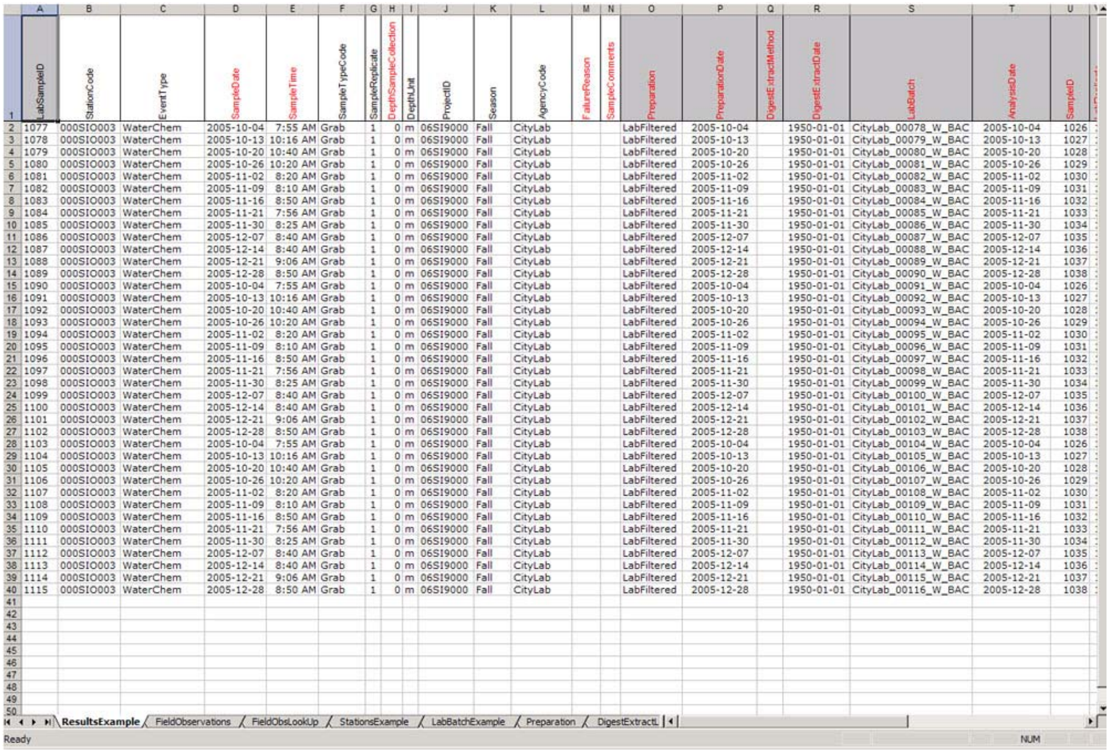
## 3.0 SWAMP Data System Details

The SWAMP data system is examined in more detail as it was identified to be the system which most closely matches the regulatory needs for the ASBS.

SWAMP is comprised of several modules. The backend or database contains approximately 38 tables each with dependencies or relationships with other tables. Lookup tables consist of static information which can relate to various measurements. Examples of such a table include agency information (name, address, contact, email, telephone, etc.); station information (name, address, latitude, longitude, county, water body type, etc.); and analyte description (name, number, group, description, etc.). Lookup tables do not always describe a physical location, contact, or parameter but could also reference units, qualifiers, or codes. Lookup tables limit field vocabulary avoiding data entry errors such as misspellings, capitalization differences, or invalid data types. They also optimize database functionality and size as each data result does not have to include full station, agency, sample type information reducing duplicity within the database. The backend contains the complete set of data with relationships between tables joining related information. For example, the results table would contain a station ID along with time of observation and observation value, the station ID field would be joined to the station ID field in the station ID lookup table. The station ID lookup table would contain information regarding that particular station as previously described. Entry into the data system requires input from data collectors taking measurements and field observations. Within the SWAMP system, data entry to the backend is facilitated through excel spreadsheets.

Because the SWAMP data system handles several different data types and is quite complex, data entry into the system is not trivial for an individual lab handling one data type. Templates have, therefore, been generated for simplification and ease of data entry. Templates for chemical, toxicity, and station entry are developed for data entry. Each template consists of a Results worksheet including all of the fields necessary to describe that particular parameter. Subsequent worksheets within the excel file consist of lookup tables with related ID's for field entry within the main Results tab. There are actually very few fields within the Results worksheet that are not correlated to a lookup table containing a controlled vocabulary. Again, this helps facilitate ambiguity and variability between data entry personnel. Consistency between observation reporting is essential for future analysis and comparison across parameters, time periods, analytes, etc. For a given data type, the templates contain full relationships and input fields. Completed templates must then be ingested into the backend database. Ingestion can be automated through programmed parsing scripts. The scripts will read template files, strip out values and load into the appropriate tables within the backend. Once new values are entered into the system, they will be queried and displayed on the website. The following is a graphical display of bacteriological data ingestion from lab submittal to web display presented in steps.

1.) Submit SWAMP compatible template to information management electronically



| LabSampleID | StationCode | EventType | SampleDate | SampleTime | SampleTypeCode | SampleReplicate | DepthSampleCollection | DepthUnit | ProjectID | Season | AgencyCode | FailureReason | SampleComments | Preparation | PreparationDate | DigestExtractMethod | DigestExtractDate | LabBatch | AnalysisDate | SampleID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 1108 | 000SIO003 | WaterChem | 2005-11-09 | 8:10 AM | Grab | 1 | 0 | m | 06SI9000 | Fall | CityLab | | | LabFiltered | 2005-11-09 | | 1950-01-01 | CityLab_00109_W_BAC | 2005-11-09 | 1031 |
| 1109 | 000SIO003 | WaterChem | 2005-11-16 | 8:50 AM | Grab | 1 | 0 | m | 06SI9000 | Fall | CityLab | | | LabFiltered | 2005-11-16 | | 1950-01-01 | CityLab_00110_W_BAC | 2005-11-16 | 1032 |
| 1110 | 000SIO003 | WaterChem | 2005-11-21 | 7:56 AM | Grab | 1 | 0 | m | 06SI9000 | Fall | CityLab | | | LabFiltered | 2005-11-21 | | 1950-01-01 | CityLab_00111_W_BAC | 2005-11-21 | 1033 |
| 1111 | 000SIO003 | WaterChem | 2005-11-30 | 8:25 AM | Grab | 1 | 0 | m | 06SI9000 | Fall | CityLab | | | LabFiltered | 2005-11-30 | | 1950-01-01 | CityLab_00112_W_BAC | 2005-11-30 | 1034 |
| 1112 | 000SIO003 | WaterChem | 2005-12-07 | 8:40 AM | Grab | 1 | 0 | m | 06SI9000 | Fall | CityLab | | | LabFiltered | 2005-12-07 | | 1950-01-01 | CityLab_00113_W_BAC | 2005-12-07 | 1035 |
| 1113 | 000SIO003 | WaterChem | 2005-12-14 | 8:40 AM | Grab | 1 | 0 | m | 06SI9000 | Fall | CityLab | | | LabFiltered | 2005-12-14 | | 1950-01-01 | CityLab_00114_W_BAC | 2005-12-14 | 1036 |
| 1114 | 000SIO003 | WaterChem | 2005-12-21 | 9:06 AM | Grab | 1 | 0 | m | 06SI9000 | Fall | CityLab | | | LabFiltered | 2005-12-21 | | 1950-01-01 | CityLab_00115_W_BAC | 2005-12-21 | 1037 |
| 1115 | 000SIO003 | WaterChem | 2005-12-28 | 8:50 AM | Grab | 1 | 0 | m | 06SI9000 | Fall | CityLab | | | LabFiltered | 2005-12-28 | | 1950-01-01 | CityLab_00116_W_BAC | 2005-12-28 | 1038 |

*Figure 1. Results table from SWAMP compatible template*

2.) Template is parsed and ingested into backend relational database

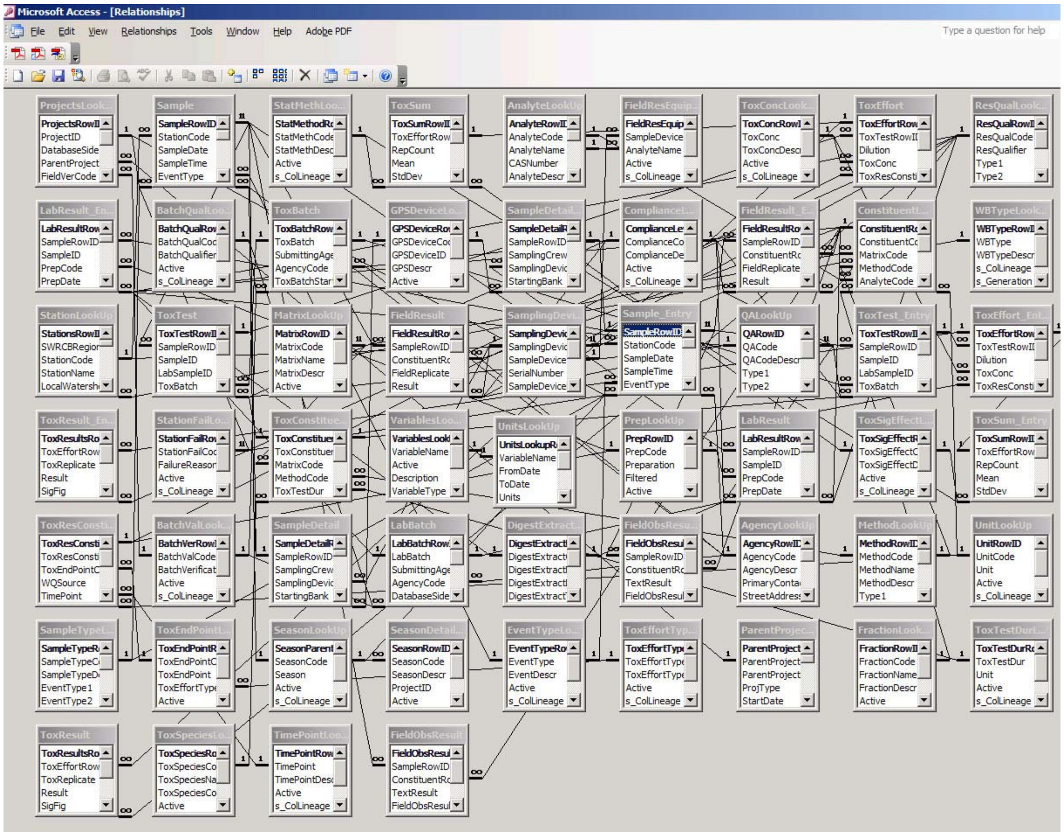
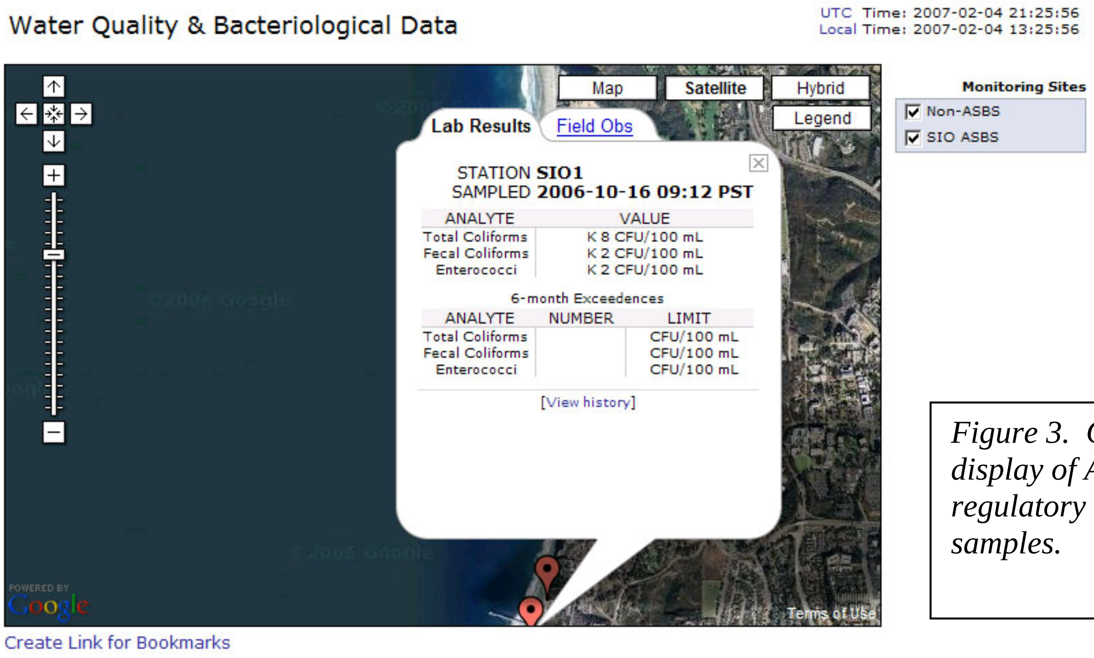


*Figure 2. Relationship view of database taken from Access (operational database is in MySQL)*

3.) Query database and Display to Web



STATION **SIO1**
SAMPLED **2006-10-16 09:12 PST**

| ANALYTE | VALUE |
|---|---|
| Total Coliforms | K 8 CFU/100 mL |
| Fecal Coliforms | K 2 CFU/100 mL |
| Enterococci | K 2 CFU/100 mL |

6-month Exceedences

| ANALYTE | NUMBER | LIMIT |
|---|---|---|
| Total Coliforms | | CFU/100 mL |
| Fecal Coliforms | | CFU/100 mL |
| Enterococci | | CFU/100 mL |

*Figure 3. Online display of ASBS regulatory bacteria samples.*

## 4.0 Non-regulatory data required to assess ASBS performance

There are several different types of data that must be collected to thoroughly and effectively manage the ASBS. These types include regulatory ecosystem management data, and supplemental environmental data. The data management team recommends adoption and modification of the SWAMP (Surface Water Ambient Monitoring Program) backend for regulatory ASBS data. Ecosystem and an expanded environmental data set will require a separate data system. Following ecosystem management and supplemental environmental data recommendations, those data systems will require design and development within the Implementation Grant. Background on recommended SWAMP configuration system details can be found at http://www.cordc.ucsd.edu/projects/asbs/

Designated Areas of Special Biological Significance (ASBS) along the coast of California exist in a complex coastal regime subject to ever-changing land-sea-atmospheric interactions. As a result, when evaluating the performance and behavior of an ASBS, it will be important to understand the physical environment both within and surrounding its environs. This regional description of the time-varying coastal environmental processes relevant to the ASBS will be critical to understanding ecosystem changes within the ASBS. A critical assessment question coastal zone managers face will be:

1. How to link trends and changes in the monitoring data to the management decisions made within the ASBS.
2. Assessing whether the observed changes are a result of climate/natural variability, or if external, anthropogenic influences are impacting the ASBS.

Attributes and processes deemed relevant to assessing the ASBS include:

- Local meteorological conditions including regional precipitation which influence the watershed bordering the ASBS.
- Location and size of nearby wetlands, the state of the wetland (entrance open/closed) and volumes of freshwater exchange with the coast.
- Time records of the flow of freshwater from streams, and rivers nearby the ASBS. The mouths of many of these sources may be lagoons and wetlands, or discharges outside of the ASBS.
- The ocean circulation both within and surround the ASBS. Observations of the circulation will allow estimates of the residence time of discharges within the ASBS, as well as provide insight on how non-ASBS discharges may influence the ASBS. Regional observations of the physical circulation can be used for tracking the fate and transport of both pollutants within the ASBS, but also provide data to assist with understanding biological connectivity within and across the ASBS boundaries. Coastal circulation will also influence the flux of nutrients into the ASBS through internal tidal surges and regional upwelling events.
- Sediment composition and transport processes within the ASBS are needed both for understanding transport of pollutants with the ASBS, and for assessing changes in migrating sediment levels which can influence the biota.
- Coastal ecosystems are sensitive to the temperature of the ocean. In addition, changes in temperature can also co-vary with nutrient levels. Ocean temperatures and stratification should be monitored continuously to assess changes on both tidal, daily, seasonal, and climate scales.

- The optical properties of water within and surrounding the ASBS should be monitored as underwater ecosystems depend on sunlight. The optical properties may covary with both biological productivity and concentrations of fine sediments.

A draft list of variables relevant to understanding these processes are provided below. Specifics related to the density of observations at individual ASBS sights must be determined after an appropriate assessment has been conducted. It is recommended that these observations be made near-continuously when technically feasible.

- Ocean stratification measurements (temperature and salinity)
- Ocean surface current maps both internal and external to the ASBS boundary
- Ocean current profiles (observations at depth)
- Ocean salinity
- Wave height and direction, modeled surfzone currents
- Bathymetry maps (repeated observation to document changes)
- Bottom type, grain size and substrate
- Local meteorology to describe local precipitation and upwelling favorable winds
- Flow rates for local estuaries and freshwater discharges (natural or otherwise) nearby the ASBS
- Time records of nutrients (nitrates, phosphates, silicates) within the ASBS

The SWAMP data system is designed and tuned for ASBS regulatory water quality data. Ecosystem and supporting environmental data necessary for full ASBS assessment must be integrated with the regulatory water quality, chemistry, toxicity, and field observations. SWAMP, however, is not the complete storage mechanism for these other data types. Each data type may require its own database or be saved as a series of time series files with supporting metadata. The joining components for integrating and comparing across multiple variables and/or data sets are location (latitude and longitude), elevation, and time. Those variables allow cross referencing in space and time. A complete ASBS data system must include both regulatory and non-regulatory data including biological, chemical, and physical attributes. The closest data system that meets the data management needs for these essential variables is within the ocean observing framework provided by SCCOOS.

## 5.0 Information Presentation

While backend data collection, storage, archival, and integration are the foundation of a data system; data display and dissemination also play an integral role in the full information management system. Data transforms to information when it is appropriately processed and presented in a clear, comprehensible manner. Data collected over long time series can show trends and highlight anomalies. Point measurements such as bacteriological samples collected at a given location can be displayed on a timeline putting recent observations into a longer time period perspective. Gridded data such as surface currents are better displayed on a map putting the vectors into context of the region. Data sets such as satellite ocean color and surface currents can be overlaid to help examine a relationship or correlation. In designing integrated products for web display user needs must be addressed.

Visualization tools for ecosystem assessment must be developed further in order to comprehensively analyze the ASBS in context with surrounding areas. The data management community is struggling with those visualization tools. Often times, a GIS tool is used for layering environmental data. Unfortunately, those tools prove to be sluggish and burdensome due to the shear volume of data processing required. Most servers either take a significant amount of time to display the data or cause an error upon retrieval of multiple layers. They also can not display time series of events such as a developing current field or bacteria results over the latest wet period. Standalone software programs such as google earth and fleudermaus provide an excellent visualization tool, but require local access to data sets. Serving capabilities have not yet been fully developed. Solutions to this problem include automated processing of established data products, database indexing for faster data retrieval, multiple processors within data servers, and increasing internet bandwidth. Developmental and technological advancements on these fronts require planning, engineering, and resources.

SCCOOS has developed a number of innovative data interfaces and products, leveraging google maps to provide localized, zoomable, and navigable interactive display of data. Providing data visually online is a powerful tool, enabling academics, decision makers, and the public easy access to public data. Users are able to download data values as well in an ascii tabular format. With manageable data sets, ascii download is often times the preferred method. It's easily understood and ingestible into an alternate analysis software package. Most spatial or Geographic Information System (GIS) data is less suited for such transfer methods and requires alternate formatting for data download. These types of data are far too voluminous for tab or common delimited files. The SIO data management team plans to display regulatory bacteria, toxicity, and chemical analysis data in a similar format to the tiled google display. The data management team has implemented improved data dissemination utilities through the use of recent web based technologies and mapping capabilities. Future data products can be integrated and designed based on user needs assessment and utility.

## 6.0 Recommendations

Recommendations for future data system development and management include defining changes within, adoption, and implementation of the SWAMP structure; development and design of a data system for ecosystem management; integration of environmental observational data; needs assessment with ASBS science and management community to define optimal data distribution, presentation, and analysis tools; and prototyping implementation of an end-end system in an ASBS to serve as a model for a statewide system.

Although SWAMP in its current form does not fulfill the entire suite of regulations, the system can serve as a building block for a comprehensive and transferable relational data management system for ASBS regulatory data. The SWAMP data management system was chosen over other data management systems because it is more comprehensive, including lookup tables for laboratory contacts, station ID, units, analytes, methods, etc. and the need for statewide compliance and compatibility. The SWAMP system is not a single solution data system for all required ASBS assessment measurement parameters. A fully functional information management system can be considered a system of systems. Much of the ecosystem management and environmental observational data will also need to be saved in formats which give the flexibility needed for examining multidisciplinary processes. Required spatial and temporal cross referencing attributes include latitude, longitude, elevation, and time. These attributes enable efficient data integration, analysis, and visualization.

Future efforts should involve expertise found at Moss Landing Marine Laboratory who are currently expanding the SWAMP data system. The system should consist of a relational database within a unix/linux operating system environment (e.g. mysql, postgres, oracle). For security purposes data management best practices should be stored on a system with backup capabilities. Ideal programming would include some sort of redundant array of independent disks (RAID) and offsite backup utility. Finally, reasonable products and public display is an essential component of the information management system. Management and assessment of the ASBS extends far beyond collection, ingestion, and display of regulatory data. Integration of physical and biological data is necessary for full ecosystem analysis. Web based data presentation and dissemination will allow the interrelationships of these datasets to be examined over space and time. Visualization methods should be leveraged from the SCCOOS information management system for dissemination and display. The future of the ASBS information management system should include an iterative implementation method whereas the system is designed, tested, and then improved based on performance, reliability, and comprehensiveness.

Implementation Goals and Objectives

- Design and implement a robust and scalable data management system for storage, archival, retrieval, dissemination, and display of regulatory data leveraging from the SWAMP data system.
- Determine undefined attributes necessary for realizable ecosystem assessment of ASBS.
- Begin integration and aggregation of biological and physical data based on location (latitude, longitude), time, and elevation leveraging existing data sets within SCCOOS.
- Following needs assessment with ASBS science and management community, display ASBS data in an organized and digestible format easily accessible to scientists, decision makers, and the general public.
- Create an iterative management process for continued improvement and regional integration.

# APPENDIX E

# Best Management Practices Technology Effectiveness

| Applicable BMP Technologies - Description | Removal Efficiency Rating for Total Metals (1) | Performance Data Indicating CTR Concentrations Will be Achieved | Removal Efficiency Rating for Bacteria (1) | Removal Efficiency Rating for Sediment (1) | Watershed Characterization Implementation Issues | Relative Capital Costs | Relative O&M Costs | Retain BMP for Watershed Implementation Plan |
|---|---|---|---|---|---|---|---|---|
| 1. **Adsorption/Ion Exchange – Granular Activated Carbon – Treatment Train** – Equalization Basin to a Screen or Filter Bag to a Granular Activated Carbon (GAC) column fed by gravity | High | Data on the effectiveness of this technology for storm water applications is limited. Due to potential clogging and interferences from organic material, the efficiency of the GAC column may be reduced and outflow concentration may not meet CTR. | Medium<br>GAC may promote consider-able microbial growth on carbon surface | Medium | Highly developed setting reduces lower cost opportunities to install this technology. Sufficient Public lands that are close to discharge points are only available in upper watersheds. Limited installation possibilities between the outfall and the Receiving waters. Remaining options are to locate systems within residential and commercial areas requiring buy-out of private property. | High<br>Rated high compared to Retention Basin but provides greater benefit in reducing pollutants | High<br>Spent GAC media may be considered hazardous waste | Yes<br>Treatment system requires pretreatment and equalization through a retention-sedimentation basin. A smaller "package" treatment system may be applicable for small (<10acres) drainage area and design storm of 0.5 in. Larger drainage areas and storm events will require large areas for equalization and pretreatment. Regulatory issues will restrict placement of these systems above the outfalls on private lands or available public lands to which the storm flows will need to be conveyed, and potentially pumped.<br>Reduction of flows through Low Impact Development has limited application due to built-out status of the watershed. |
| 2. **Equalization, Chemical Precipitation Treatment (Sodium Sulfide) and Sand Filter** – This is a chemical treatment process that includes equalization in a basin or vault followed by a treatment process of pH adjustment, precipitation, clarifier, and removal of fine particles using a sand filter prior to discharge into the receiving waters. | High | Data on the effectiveness of this technology for storm water applications is currently not available. This is an effective chemical treatment process that can meet the CTR concentrations for constant flows with consistent characteristics. The high variability of storm water flows and constituent concentrations may limit the effectiveness of this treatment system. | Medium | Medium | Same issues of developed setting as Technology No. 1. | High<br>Not rated in Caltrans Guidance document – Treatment system will be high capital cost | High<br>Sludge may be considered hazardous waste | Yes<br>Treatment system has not been applied to storm water applications which are infrequent and highly variable. System will require trained operator, although some of the system can be automated. Effectiveness of this process requires continuous operation, which is not the case for periodic and variable storm flows.<br>See Technology No. 1 regarding space constraint issues for equalization and pretreatment. |
| 3. **Adsorption/Ion Exchange – Granular Activated Carbon (GAC) or Ion Exchange (IX) Media w/ Detention Sedimentation BMPs** – Treatment Train – Storm water enters mixing chamber with GAC or IX media and then flows to sedimentation basin and finally filtration chamber | High | The effectiveness of this technology on storm water applications is dependent on volume of flows that are required for treatment. In order to allow sufficient mixing/ contact with GAC or IX, the flow needs to be controlled. This BMP may not meet CTR at higher flows where less contact would occur. | Medium | Medium | Same issues of developed setting as Technology No. 1. | High<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants | High | Yes<br>See Technology No. 1 regarding space constraint issues for equalization and pretreatment. |
| 4. **Adsorption/Ion Exchange – GAC Sandwich Filter and Blanket w/ Pretreatment Detention Sedimentation BMPs or Chemically Enhanced Detention Basin (CEDBs)**– Storm water flows to Equalization / Detention Basin then to Filter Chamber/ Bed composed of GAC or IX underlain by a Sand Filter separated by Geotextile – discharge from Underdrains below Sand Filter. This system can be modified to incorporate these two steps into one CEDB if sufficient larger sediment is removed prior to entering CEDB to reduce clogging of the filter and treatment media. | High | The effectiveness of this BMP on storm water flows is in the pilot testing stage. Results reported by Caltrans and the Navy on pilot projects using activated alumina indicate technologies is effective in significantly reducing dissolved metals. The effectiveness of the BMP in meeting the CTR concentration will depend on the level of maintenance of the filter system which would be prone to clogging. Use of geotextiles can reduce clogging and O&M but relative O&M costs will be high. | Medium<br>GAC may promote microbial growth | Medium | Same issues of developed setting as Technology No. 1. | High<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants | High<br>Frequent clogging and short bedlife require high O&M<br>Spent GAC / IX may be hazardous waste | Yes<br>See Technology No. 1 regarding space constraint issues for equalization and pretreatment. |

| Applicable BMP Technologies - Description | Removal Efficiency Rating for Total Metals (1) | Performance Data Indicating CTR Concentrations Will be Achieved | Removal Efficiency Rating for Bacteria (1) | Removal Efficiency Rating for Sediment (1) | Watershed Characterization Implementation Issues | Relative Capital Costs | Relative O&M Costs | Retain BMP for Watershed Implementation Plan |
|---|---|---|---|---|---|---|---|---|
| 5. **Adsorption/GAC or IX Sandwich Filter and Blanket w/ Pretreatment Detention Sedimentation using Plate and Tube Settlers** - Similar technology to Item #3, but retention/sediment basin can be a vault or chamber that uses parallel plates or inclined tube to can increase sedimentation in smaller space | High | Same as Item #3. | Medium | Medium | Similar implementation issues to Technology # 3, however depending on the amount of storm flow to be treated, the pre-treatment step space requirements are reduced by the use of parallel plates or inclined tubes within the vault or chamber since these reduce velocity and increase retention time using a smaller volume to be retained. | High<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants | High | Yes<br>See Technology No. 1 regarding space constraint issues for equalization and pretreatment.<br>For smaller drainage area, use of an underground vault and treatment/filtration chamber may be possible where sufficient public space is available near the MS4 system. |
| 6. **Adsorption/Ion Exchange – Ion Exchange Column – Treatment Train** – Equalization Basin to a Screen or Filter Bag to a ion exchange (IX) column fed by gravity. IX resin could either be placed in pressure vessels or in a canister at the pond outlet | High | Data on the effectiveness of this technology for storm water applications is limited. Due to potential clogging if pretreatment does not remove enough sediment, and need to re-generate the IX resins, the efficiency of the GAC column may be reduced and outflow concentration may not meet CTR. | Medium | Medium | Same issues of developed setting as Technology No. 1. | High<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants | High<br>Spent IX media can be considered hazardous waste | Yes<br>See Technology No. 1 regarding space constraint issues for equalization and pretreatment. |
| 7. **Modified Austin Sand Filter** – This technology is modeled after partial sedimentation type Austin-style sand filters, but with 12-24 inches of IX media overlain by sand rather than typical 18 inches of sand. Media can be activated iron coated alumina or other IX media. | High | The effectiveness of this BMP on storm water flows is in the pilot testing stage. Results reported by Caltrans on pilot projects using activated alumina indicate technologies is effective in significantly reducing dissolved metals. The effectiveness of the BMP in meeting the CTR concentration will depend on the level of maintenance of the filter system which would be prone to clogging. | Medium | Medium | Technology is applicable to developed watersheds as it can be installed as a retrofit of existing storm drain channels system. *This BMP is undergoing pilot testing by Caltrans, and is limited in its treatment capacity.* | Medium | Medium | Yes<br>This technology has limited treatment capacity because it is contained within a treatment chamber that is generally installed below ground. Therefore, this technology may have only select application to smaller drainage areas and portions of storm flows that through studies have identified a design storm or flow that should be treated to meet the objectives. Furthermore, this technology is in a testing stage. The effectiveness of this option to meeting the CTR and other constituent limits is not known. |
| 8. **Bioretention** – This is manufactured modular bioretention system that is used in urban setting as an alternative to traditional curbside landscaping. There are also non-proprietary systems. Storm water enters curb inlet and infiltrates through soil and engineered media. Infiltration seeps into perforated pipe that flows into storm drain system. Plantings use root system to reduce pollutants and uptake pore water. *This technology is limited to first flush treatment.* | High | Pollutant removal efficiency high for limited flow that the system can treat. Capacity of the system is dependent on soil and engineered media permeability and storage capacity. Data on removal of dissolved metals is limited. System is effective in removal of total metals and particulates that may be a source of dissolved metals in the receiving waters. Technology can not treat full storm flows. | High | High | Technology is applicable to developed watersheds as it can be installed as a retrofit of existing storm drain system. There are high space requirements within the right of way to install the system. This includes the plantings, soil and engineering media within the right of way.<br>Implementation near coastal areas must consider potential groundwater/tidal influence issues. Implementation in the upper watershed must consider slope stability issues. | High<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants<br>The cost will be high if implemented on a wide scale since the system capacity is relatively small. Construction in right of way may require traffic control. | Medium – Low<br>Planting will require watering during dry season | Yes<br>The technology is best applicable only to treatment of a small portion of storm events and therefore provides a “first flush” treatment option that can reduce particulates and total metals which may reduce dissolved metals concentrations at the storm drain outlets.<br>BMP has limited applications where sufficient right of way is available to retrofit existing storm sewer and curb side plantings. |

| Applicable BMP Technologies - Description | Removal Efficiency Rating for Total Metals (1) | Performance Data Indicating CTR Concentrations Will be Achieved | Removal Efficiency Rating for Bacteria (1) | Removal Efficiency Rating for Sediment (1) | Watershed Characterization Implementation Issues | Relative Capital Costs | Relative O&M Costs | Retain BMP for Watershed Implementation Plan |
|---|---|---|---|---|---|---|---|---|
| 9. **Chemical Treatment-Alum – Treatment Train** – Alum is added through a chemical feed system to the storm water and then discharged to sedimentation basin where floc is settled out prior to discharge to receiving waters. A minimum of 1 minute retention time required after alum added before discharge to watershed. | High | Technology has been successfully used for phosphorus and suspended solids removal, less application for dissolved metals. CTR likely not to be achieved with this technology, although total metals concentrations will be significantly reduced | Medium | High | Highly developed setting significantly reduces opportunities to install this technology. Sufficient Public lands close to discharge points only available in upper watersheds, limited installation above outfalls in residential and commercial areas | High<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants. | High<br>Management and disposal costs of sludge<br>Optimization of alum addition will vary with storm – high technical operational needs | No<br>This treatment technology has relatively high costs and is rated as medium for all the constituents of concern. Application in developed setting also limited. Other technologies already listed provided greater efficiencies and greater chance of meeting treatment goals. |
| 10. **Linear Bioretention Trenches** – This is similar to Item #6, but is not a manufactured modular bioretention system rather a French drain type system into which sheet flow enters and infiltrates into a plant/filter medium underlain by a gravel and drain pipe system. The filter media is separated from the drain layer by a geotextile. *This BMP is more of a runoff and treatment volume reduction BMP as it is limited in its capacity.* | Medium | Pollutant removal efficiency high for limited flow that the system can treat. Capacity of the system is dependent on soil and engineered media permeability and storage capacity. Data on removal of dissolved metals is limited. System is effective in removal of total metals and particulates that may be a source of dissolved metals in the receiving waters. Technology can not treat full storm flows. *This BMP is more of a runoff and treatment volume reduction BMP as it is limited in its capacity unless additional storage is provided through installation of larger below ground drainage layers.* | High | Medium | Technology is applicable to developed watersheds as it can be installed as a retrofit of existing storm drain channels system. *This BMP is more of a runoff and treatment volume reduction BMP as it is limited in its capacity unless additional storage is provided through installation of larger below ground drainage layers.*<br>Implementation near coastal areas must consider potential groundwater/tidal influence issues. Implementation in the upper watershed must consider slope stability issues. | Medium -Low<br>The cost will be high if implemented on a wide scale since the system capacity is relatively small. Construction in right of way may require traffic control. | Medium – Low<br>Planting will require watering during dry season | Yes<br>BMP has limited applications where sufficient right of way is available to retrofit existing storm channels. The technology also is applicable only for *runoff and treatment volume reduction* of a small portion of storm events and therefore provides a “first flush” treatment option that can reduce particulates and total metals which may reduce dissolved metals concentrations at the storm drain outlets. |
| 11. **Below Grade Infiltration Chambers** – There are numerous available manufactured systems (Cultec Contractor, Recharger, Matrix, Rainstore, Stormcell, Stormchamber, Stormtech, & VersiCell) that provide temporary storage of storm water flows within sub-surface vaults or chamber that then allow for direct infiltration into the subsoils or first distribute the stored storm water through a seepage drainage bed that is then infiltrated into the sub-soils. | High | This technology has been proven to meet required concentrations since the storm water is completely infiltrated into the sub-soils rather than discharged to the receiving waters. | High | High | The Watershed is characterized by poorly draining soils except in the lower watershed. The application of BMPs that use infiltration may be limited within the watershed. Site specific geotechnical investigations are needed to determine if subsurface soils provide adequate infiltration rates.<br>Implementation near coastal areas must consider potential groundwater/tidal influence issues. Implementation in the upper watershed must consider slope stability issues. | High-Medium<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants | Medium-Low | Not for Widescale Implementation – May be applicable where site specific geotechnical investigations indicate subsurface soils have adequate infiltration rates to accommodate repeated storm events without resulting in flooding.<br>Due to the low permeability of the soils within the upper portions of the watershed, the application of BMPs that use infiltration to treat full design flows is limited to a small percentage of watershed area. |

| Applicable BMP Technologies - Description | Removal Efficiency Rating for Total Metals (1) | Performance Data Indicating CTR Concentrations Will be Achieved | Removal Efficiency Rating for Bacteria (1) | Removal Efficiency Rating for Sediment (1) | Watershed Characterization Implementation Issues | Relative Capital Costs | Relative O&M Costs | Retain BMP for Watershed Implementation Plan |
|---|---|---|---|---|---|---|---|---|
| 12. **Porous Pavement** – Allows storm water to infiltrate through the pavement section to a stone "reservoir course" that stores the storm water until it infiltrates into the underlying soils. | High | This technology has been proven to meet required concentrations since the storm water is completely infiltrated into the sub-soils rather than discharged to the receiving waters. | High | High | The Watershed is characterized by poorly draining soils. The application of BMPs that use infiltration is limited within the watershed unless additional storage is provided through engineered below ground drainage layers. Underdrain systems will also be required to prevent built-up of head and potential structural damage. Site specific geotechnical investigations are needed to determine if subsurface soils provide adequate infiltration rates. | High<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants | Medium-Low | Yes – Limited Applications Where Engineered Drainage Layers and Under drain systems provided.<br>Due to the low permeability of the soils within the upper portions of the watershed, the application of BMPs that use infiltration is limited to a small percentage of watershed area.<br>Technologies that rely on infiltration can be engineered for low permeability soils if sufficient storage is provided through underground drainage layers and under drain systems. These engineered systems will still have finite storage capacity to treat large storm flows requiring by-pass systems to address flooding. |
| 13. **Infiltration Basins** – Basin are installed as an "off line" system that collected and stores a design storm volume and allows the storm water to infiltrate into the sub-soils | High | This technology has been proven to meet required concentrations since the storm water is completely infiltrated into the sub-soils rather than discharged to the receiving waters. | High | High | The Watershed is characterized by poorly draining soils. The application of BMPs that use infiltration is limited within the watershed.<br>Site specific geotechnical investigations are needed to determine if subsurface soils provide adequate infiltration rates.<br>Implementation near coastal areas must consider potential groundwater/tidal influence issues. Implementation in the upper watershed must consider slope stability issues. | Lower<br>Rated lower compared to retention basin but provides greater benefit in reducing pollutants | Medium-Low | Not for Widescale Implementation – May be applicable where site specific geotechnical investigations indicate subsurface soils have adequate infiltration rates to accommodate repeated storm events without resulting in flooding.<br>Due to the low permeability of the soils within the upper portions of the watershed, the application of these BMPs that uses infiltration is limited to a small percentage of watershed area.<br>Although technologies that rely on infiltration can be engineered for low permeability soils if sufficient storage is provided through underground drainage layers, infiltration basins will require these systems across the basin and therefore function as a sand filter system with under drains. A sand filter alone will not meet the objectives. Therefore, this technology does not provide a cost effective alternative. |
| 14. **Bio-swale with Infiltration** – BMP uses vegetation to reduce transport of sediment and infiltration to treat the remaining flow – Application is limited to pre-treatment or to limited storm water flow or design flow. | High | This technology has been proven to meet required concentrations since the storm water is completely infiltrated into the sub-soils rather than discharged to the receiving waters. This BMP has limited applications due to the limited capacity. | High | High | The Watershed is characterized by poorly draining soils within the upper portions of the watershed. The application of BMPs that use infiltration is limited within the watershed.<br>Site specific geotechnical investigations are needed to determine if subsurface soils provide adequate infiltration rates.<br>Implementation near coastal areas must consider potential groundwater/tidal influence issues. Implementation in the upper watershed must consider slope stability issues. | High-Medium<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants | Medium-Low | Yes – As a runoff and treatment volume reduction technique<br>Due to the low permeability of the soils within the upper portions of the watershed, the application of BMPs that use infiltration is limited to a small percentage of watershed area.<br>Technologies that rely on infiltration can be engineered for low permeability soils if sufficient storage is provided through underground drainage layers and under drain systems. These engineered systems will still have finite storage capacity to treat large storm flows requiring by-pass systems to address flooding. |

| Applicable BMP Technologies - Description | Removal Efficiency Rating for Total Metals (1) | Performance Data Indicating CTR Concentrations Will be Achieved | Removal Efficiency Rating for Bacteria (1) | Removal Efficiency Rating for Sediment (1) | Watershed Characterization Implementation Issues | Relative Capital Costs | Relative O&M Costs | Retain BMP for Watershed Implementation Plan |
|---|---|---|---|---|---|---|---|---|
| 15. **Low Impact Site Design (LID) Techniques** – This includes collection, storage and reuse of runoff from roof drains. LID techniques also include porous pavement (#12), bioswales (#13), and bioretention (#8) technologies that use infiltration to reduce runoff flows and thus reduce pollutant loads | High | LID techniques have the potential to meet the CTR concentrations if applied throughout the drainage area resulting in the significant reductions in runoff volumes and thus concentrations at the storm drain outlets. The performance of this technology will therefore depend on the level of implementation, and for infiltration techniques, the capacity of the soils to infiltrate and store runoff volumes. This BMP has limitations to full scale implementation in the Chollas Creek watershed which is built-out and has predominantly low permeability soils. These systems can include modification of existing subgrade soils and replacement of poorly draining soils with sand layers. | High | Medium | The Watershed is characterized by poorly draining soils within the upper portions of the watershed. The application of BMPs that use infiltration is very limited within the watershed unless additional storage is provided through engineered below ground drainage layers. Underdrain systems will also be required to prevent built-up of head and potential structural damage. | Medium | Medium | Yes – As a runoff and treatment volume reduction technique<br>Due to the low permeability of the soils within the upper portions of the watershed, the application of BMPs that use infiltration is limited to a small percentage of watershed area.<br>Technologies that rely on infiltration can be engineered for low permeability soils if sufficient storage is provided through underground drainage layers and underdrain systems. These engineered systems will still have finite storage capacity to treat large storm flows requiring by-pass systems to address flooding.<br>LID for new construction can reduce future potential increases in runoff volume and peak flows.<br>This technology will be retained for use as a runoff and treatment volume reduction technique of storm water up to the capacity of the system. |
| 16. **Dry Weather and First Flush Diversion Structures** –This technology would divert dry weather flows from selected storm drain outlets that are observed to pool nuisance flows at the discharge, and convey these flows to the existing sanitary sewer. These diversion structures can also divert a portion of the first flush of a storm event until a design flow is reached and is then bypassed. | High | Metals exceedances are not an issue in dry weather flows, but may be accumulated in pools at some outlet structures that then are washed into the channel as part of the first flush. Pollutograph data is needed to assess if metals are a first flush issue that if diverted would reduce the flow weighted concentrations down to CTR values. | High<br>Same issue as metals removal with regard to whether the bacteria levels are highest in the first flush and can be reduced to meet regulatory objectives | High<br>Same issue as metals removal with regard to whether pesticides levels are highest in the first flush and can be reduced to meet regulatory objectives | Highly developed nature of the watershed will impact implementation of this BMP that will require retro-fitting existing storm drain outlets and construction of conveyance lines to connect with the sanitary sewer. | Medium | Medium | Yes<br>This BMP is applicable only to those outlets where a connection to the sanitary sewer is feasible and where dry weather flows are sufficient and contain constituent concentrations in exceedances of the water quality objectives. The Watershed is generally dry during the dry weather period, but outlets are observed to pool nuisance flows near the discharge point. Pollutograph data is needed to assess whether dry weather and first flush diversions would be effective in reducing concentrations in flow weighted storm water samples to below the objectives for all the constituents under current and proposed TMDLs. The capacity of the existing sewer lines and the treatment plant also needs to be verified. |
| 17. **UV/Ozone – Treatment Train –** This technology would treat discharge flows from selected storm drain outlets as the final stage in a treatment train to reduce bacterial loads through exposure to UV/Ozone energy sources. A treatment train is required to remove gross solids and particulates prior to treatment. | Low | Metals exceedances are not treated by UV/Ozone treatment systems. | High<br>UV/Ozone techniques have the potential to meet bacteria reduction goals if applied throughout the drainage area as the last step in treatment train BMPs. The performance of this technology will therefore depend on the level of implementation, and the capacity of the pre-treatment steps to reduce solids in the runoff. | Low | Highly developed setting significantly reduces opportunities to install this technology. Sufficient Public lands close to discharge points only available in upper watersheds, limited installation above outfalls in residential and commercial areas | High.<br>Rated high compared to retention basin but provides greater benefit in reducing pollutants. | High | Yes<br>Treatment system requires pretreatment and equalization through a retention-sedimentation basin. A smaller “package” treatment system may be applicable for small (<10acres) drainage area and design storm of 0.5 in. Larger drainage areas and storm events will require large areas for equalization and pretreatment. Regulatory issues will restrict placement of these systems above the outfalls on private lands or available public lands to which the storm flows will need to be conveyed, and potentially pumped. |

# APPENDIX F

# La Jolla Shores Coastal Watershed BMP Project List

## La Jolla Shores Coastal Watershed BMP Project List

The development of best management practices (BMPs) to address the protection goals of the La Jolla Shores Coastal Watershed Management Plan and reduce the identified impacts to the ASBS is based on an integrated and tiered approach. The integrated approach addresses all priority constituents in the BMP development. A tiered prioritization process then addresses constituents with the greatest biological impacts through the effective use of resources and is then used to rank potential BMPs. In the integrated and tiered process, each BMP is then classified according to the relative efficiency of constituent removal from the system, level of infrastructure required for implementation, and cost.

Three tiers of BMP classifications are defined. Tier I BMPs focus on non-structural source control and pollution prevention measures that are designed to reduce the amount and understand the effect of pollutants entering runoff though education, enforcement and behavioral modification programs.

Tier I – Non-structural BMPs and Activities
- Source Control Measures and Pollution Prevention BMPs
- ASBS Ecosystem Assessment Studies to Determine Biological Impacts
- Effectiveness Monitoring of BMPs
- Integrate Efforts through Information Management
- Public Participation and Community Involvement through Ocean Stewardship

Tier II includes structural BMPs such as infiltration basins, bioretention and LID techniques to reduce wet and dry weather runoff volumes and further reduce pollutant entry into the ASBS. Additionally, Tier II includes source and design studies that will aid in the further identification of pollutant sources and provide design parameters for construction of effective in-line treatment systems as part of Tier III.

Tier II – Structural BMPs and Activities
- Soil and Hydrologic Studies, Source Studies and Determination of Design Storm
- Aggressive Pollutant Source Control in Targeted Areas (e.g. Street Sweeping)
- Implementation of Urban Runoff Reduction LID Techniques
- Dry weather Flow Diversions
- Effectiveness Monitoring of BMPs

Tier III BMPs are infrastructure-intensive structural pollution reduction treatment measures that typically require significant capital investment and/or have impacts on surrounding communities.

Tier III – Treatment BMPs and Activities
- Property Acquisition and Easements (where necessary)
- Implementation of Treatment BMPs in Targeted Areas where Tier I and Tier II BMPs have been shown not to meet full reduction goals
- Effectiveness Monitoring of BMPs

Effectiveness assessment, monitoring, and data incorporation into the overall information management program are components common to all three tiers. Within each tier, the effectiveness of each BMP program must be monitored in order to assess whether the program is meeting pollution reduction goals. A secondary benefit of effectiveness monitoring is that oftentimes BMP techniques can be modified or pollutant sources can be identified in order to further reduce pollutant loads as time series data becomes available.

The development of the implementation strategy for BMPs to reduce pollution within the La Jolla Shores Coastal Watershed and impacts to the ASBS requires that potential management measures be prioritized. Criteria for the prioritization process include:

- Consistent with ASBS Protection Model
- Meets the Plan objectives
- Meets multiple regulatory objectives
- Reduces priority COC inputs to ASBS
- Follows the tiered approach to urban runoff management
- Leads to understanding of ASBS ecosystem impacts
- Fills critical data gaps
- Contributes to ASBS information management
- Increases ASBS stewardship within the watershed
- Implements the most feasible and cost effective measures first
- Assesses management measure effectiveness

A three-phased implementation approach is then developed based on the prioritization criteria listed above. Central to the prioritization process is the iterative nature of the ASBS Protection Model where priority management actions concurrently address identified project goals, priority pollutants and identify emergent issues. Phase I of this approach consists of implementing a range of Tier I and II, and pilot Tier III, pollution prevention and source control measures to address high priority pollutant and loading areas identified in the ASBS Triad Assessment. Phase II will consist of continued implementation of a range of Tier I and II, and some pilot Tier III, pollution prevention and source control measures to address high priority pollutant and loading areas originally identified in the Triad Assessment and modified as a result of effectiveness and ecosystem assessments conducted in Phase I. Information gathered during Phases I and II will then used to prioritize management measures in Phase III. Similar to Phase II, Phase III will incorporate data and knowledge acquired as part of previous phases to prioritize specific pollutant reduction BMPs, characterize design parameters for structural BMPs, and identify emergent constituents of concern and data gaps. This process occurs in parallel with ongoing ASBS ecosystem assessment projects and the development of an overall information management strategy that integrates specific pollutant reductions with identifiable ecological effects. The overall goal of the phased and integrated approach is to address individual constituents of concern and meet pollution reduction goals in a prioritized cost-efficient manner.

The following table presents the specific projects identified for the La Jolla Shores Coastal Watershed through the application of the ASBS Protection Model.

| Phase | BMP Level | WMP Goal | Project | Project Description | Location | Property Owner | Funding Source |
|---|---|---|---|---|---|---|---|
| PHASE I - 3-5 YEARS | Tier I | **ASBS Ecosystem Assessment** | Water Circulation, Dispersion and Physical Processes Assessment | Investigation of water circulation and dispersion patterns from sources within and adjacent to ASBS. | ASBS near and off-shore waters | State | *Not funded.* |
| | | **ASBS Ecosystem Assessment** | Sediment Transport/ Benthic Habitat Assessment | Survey of benthic habitats and sediment properties for understanding of ecosystem structure and movement of sediment-bound COCs. | ASBS near and off-shore waters | State | Partial- UCSD. |
| | | **ASBS Ecosystem Assessment** | Prioritized Community Assessments | Assessment activities involving habitat characteristics and requirements of the following ASBS communities: Subtidal and Intertidal Algal Turf Community, Subtidal and Intertidal Soft-Bottom Community; Microbial Sediment Community; Shallow Boulder Reef Community; Submarine Canyon Community; Kelp Forest Community. | ASBS near and off-shore waters | State | *Not funded.* |
| | | **ASBS Ecosystem Assessment** | Supplementation of Planning Grant Ecosystem Assessments | Assessment would involve additional data collection of bioaccumulation investigation to confirm findings; sediment contamination study if bioaccumulation findings are confirmed; Study of heat shock proteins and metalothioniens in mussels. | ASBS nearshore waters | State | *Not funded.* |
| | | **Information Management** | Information and Data Infrastructure Development | Assess interrelated biological-physical-chemical processes present in the watershed and marine environment through information integration and public data dissemination. | Regional | N/A | *Not funded.* |
| | | **Public Participation** | Speakers Bureau/Information Dissemination/Pollution Prevention Curriculum | Public education campaign aimed at public and policy decision makers in the La Jolla area using email updates and quarterly newsletter mailings to interested community members, informational brochures to schools, volunteers, and community groups and a local media campaign to ASBS users and visitors.<br>Also a school education campaign (K-12) through Project SWELL curricula that promotes science-based, comprehensive and hands-on water quality and pollution prevention. | Regional | Mixed/City | *Not funded.* |
| | | **Public Participation** | Outreach | Educational exhibit that shows the linkages between watersheds and the ocean, highlighting research at SIO as well as interpreting UCSD's "best practices". Program will raise awareness of watershed protection and the factors that impact the ASBS and encourage behavior changes that reduce pollutant discharges. | Regional | UCSD | *Not funded.* |
| | | **Public Participation** | Outreach | Public educational tool highlighting ecological, cultural and conservation aspects of the area in a concrete/lithocrete map to encourage stewardship for recreational visitors to Kellogg Park. | Regional | City | *Watershed Stakeholders* |
| | | **Public Participation/ Urban Runoff** | Pollution Prevention/Source Control | Partnership to implement BMPs throughout the La Jolla Shores watershed. Program will train Urban Corps members in storm water management skills including source control BMP implementation, pollutant load reduction assessments, and sediment/erosion control implementation. | Regional | UCSD | *Not funded.* |
| | | **Urban Runoff** | Community Based Social Marketing<br>Baseline Residential Survey | Assess priority pollution prevention/runoff reduction strategies to reduce pollutant loads. | Regional | Private | Consolidated Grant/City |
| | | **Urban Runoff** | Commercial Inspection | Reduce pollutant loading through increased inspection of targeted priority pollutant sources. | Eating/Drinking Establishments<br>Auto-Related Facilities | Private | City |
| | | **Urban Runoff** | Pollution Prevention/Source Control | Reduce pollutant loads by covering trash enclosures, stormwater diversion to prevent pollutant exposures and, material storage to contain and prevent the exposure of significant materials and equipment during storm events. | UCSD/Scripps Institute of Oceanography (SIO) | UCSD | Consolidated Grant |
| | | **Urban Runoff** | Restoration and Erosion Control | Use of retaining structures, native vegetation to restore eroding areas, and sedimentation controls to reduce sediment loading into storm drain inlets. | UCSD/SIO | UCSD | Consolidated Grant<br>*Additional Areas Not Funded.* |
| | | **Urban Runoff** | Runoff Reduction (Irrigation) | Irrigation runoff reduction from the western portion of the UCSD campus. The irrigation water distribution system will be improved to reduce water use and prevent irrigation water from discharging into the storm water conveyance system. | UCSD/SIO | UCSD | *Not funded.* |
| | | **Urban Runoff** | Pilot Air Deposition Study | Assess pollutant load contribution from aerial deposition. | Regional | City | City |
| | Tier II | **Urban Runoff** | Pilot Sediment Loading and Design Storm Study | Assess pollutant load contribution from residential and open space areas in watershed. | Regional | City | City |
| | | **Urban Runoff** | Runoff Reduction (Green Lot) | Use of porous pavement to increase infiltration and reduce stormwater volume. | Kellogg Parking Lot (1/2) | City | City |
| | | | | | Kellogg Parking Lot (1/2) | City | *Not funded.* |
| | | **Urban Runoff** | Runoff Reduction (Green Street) | Reduce runoff and pollutant loading by use of porous pavement and infiltration basins to decreasing stormwater volume. | La Jolla Shores/Torrey Pines | City | *Not funded.* |
| | | | | | La Jolla Shores - North | City | Grant/City |
| | | **Urban Runoff** | Dry Weather Flow Diversion | Reduce runoff and pollutant loads by diverting non-storm water discharges to the sanitary sewer system and/or vegetated areas for infiltration. | 1624 Torrey Pines Rd<br>Torrey Pines Rd & Charlotte St<br>Camino Del Oro<br>Avenida De La Playa (Upgrade)<br>UCSD/SIO Parking Lots P002 & P007<br>SIO-Wash Racks<br>SIO Wash Areas | City & UCSD | Consolidated Grant/<br>Clean Beaches Initiative (CBI) |

| Phase | BMP Level | WMP Goal | Project | Project Description | Location | Property Owner | Funding Source |
|---|---|---|---|---|---|---|---|
| **PHASE I - Continued** | **Tier II Cont.** | **Urban Runoff** | Bioretention BMP | Reduce runoff and pollutant loading by installation of retention basins designed to allow runoff to collect and infiltrate in a vegetated swale. | City property | City | *Not funded.* |
| | | **Urban Runoff** | Trash Segregation | Reduce pollutant loads by installation of trash segregation device. | Avenida De La Playa | City | City |
| | | **Urban Runoff** | Street Sweeping (Vacuum-Assisted truck) | Targeted street sweeping in high-traffic corridors and braking areas to reduce pollutant loading. | Regional | City & UCSD | City - Funded<br>*UCSD-Not Funded.* |
| | | **Urban Runoff** | Low Impact Development Parking Lot | Use of biofiltration/bioretention systems to attenuate peak flows and reduce the concentration of COCs in wet weather flows. | UCSD/SIO Lots P002, P003, P014 | State | Consolidated Grant<br>*Additional Areas Not Funded.* |
| | **Tier III** | **Urban Runoff** | Pilot Diversion/Media Filter | Reduce stormwater pollutant loads through media filter and divert dry weather flows to the sanitary sewer system. | SIO Outfall 2 | State | Consolidated Grant |
| | | **Urban Runoff** | Pilot Treatment System on SIO Property | Reduce pollutant loads and non-indigenous species from seawater return discharges. | Birch Aquarium | State | Consolidated Grant |
| **PHASE II - 5-10 YEARS** | **Tier I** | **Information Management** | Information and Data Infrastructure Development | Assess interrelated biological-physical-chemical processes present in the watershed and marine environment through information integration and public data dissemination. | Regional | N/A | *Not funded.* |
| | | **Public Participation** | Outreach for Runoff Reduction (Green Lot) | Promote pollution prevention practices that will result in the reduction of non-point source pollution into the ASBS through public education campaign. | Regional | City | City |
| | | **Urban Runoff** | Commercial Inspection/Enforcement | Increased inspection of targeted priority pollutant sources to reduce pollutant loading. | Eating/Drinking Establishments<br>Auto-Related Facilities | Private | City |
| | **Tier II** | **Urban Runoff** | Runoff Reduction Project | Reduce pollutant loads by providing incentives to promote the use of smart irrigation systems and better management of water use practices. | Regional | Mixed | Grant/City |
| | | **Urban Runoff** | LID/Dry Weather Flow Diversion | Reduce runoff and pollutant loads by diverting non-storm water discharges to the sanitary sewer system and/or vegetated areas for infiltration. | Locations TBD | City & UCSD | *Not funded.* |
| | | **Urban Runoff/ ASBS Ecosystem Assessment** | Restoration and Erosion Control | Reduce runoff and pollutant loads by improving storm water inlets and outlets, relining concrete channels, re-vegetating grass swales, increase vegetative cover to increase infiltration, in non-storm water and storm water runoff. | UCSD/SIO | State | *Not funded.* |
| | | **Urban Runoff** | Trash Segregation | Reduce pollutant loads by installation of trash segregation device. | Cliffridge<br>TBD | City | City |
| | | **Urban Runoff** | Low Impact Development Parking Lot | Storm water treatment system to reduce the concentration of COCs in wet weather flows. | UCSD Parking lot P102 | State | *Not funded.* |
| | **Tier III** | **Urban Runoff** | Pilot E&S Control (Sediment) | Reduce pollutant loads by installation of sediment reduction device. | TBD | City | TBD |
| | | **Urban Runoff** | Pilot Stormwater Treatment System on University Property | Use of pretreatment vegetative swales and a bioretention cell systems to attenuate peak flows and reduce the concentration of COCs in wet weather flows. | SIO Outfall 003 | State | *Not funded.* |
| **PHASE III - 10+YEARS** | **Tier I** | **Information Management** | Information and Data Infrastructure Development | Assess interrelated biological-physical-chemical processes present in the watershed and marine environment through information integration and public data dissemination. | Regional | N/A | *Not funded.* |
| | | **Public Participation** | Continual Pollution Prevention/Source Control | Prevent runoff using "smart" irrigation controls to prevent over watering, eliminate dry weather flows, and assist with water conservation efforts. | UCSD/SIO Water Delivery System | State | *Not funded.* |
| | | **Public Participation** | Continual Outreach for:<br>Pollution Prevention<br>Runoff Reduction | Promote pollution prevention practices that will result in the reduction of non-point source pollution into the ASBS through public education campaign. | Regional | City | *Not funded.* |
| | **Tier II** | **Urban Runoff** | LID/Dry Weather Flow Diversion | Reduce runoff and pollutant loads by diverting non-storm water discharges to the sanitary sewer system and/or vegetated areas for infiltration. | Locations TBD | City & UCSD | *Not funded.* |
| | **Tier III** | **Urban Runoff** | Treatment System for Priority COCs on State Property | A system to collect wet weather flows from the SIO pier and divert those flows to a treatment system to reduce the concentration of COCs in wet weather flows will be installed. | SIO Outfall 1 | State | *Not funded.* |
| | | **Urban Runoff** | Treatment System for Priority COCs on City Property | Runoff reduction of wet weather flows and divert those flows to a treatment system to reduce the concentration of COCs in wet weather flows will be installed. | City | State | *Not funded.* |
| | | **Urban Runoff** | Run-off Storage and Treatment System for Designated drainage areas | Reduce and treat runoff for designated drainage areas | SIO Pier | State | *Not funded.* |

# APPENDIX G

# La Jolla Shores Coastal Watershed BMP Project List Strategy Evaluation

| | | | ICWMP OBJECTIVES | | | | IRWM STRATEGIES | | | | | | | | | | STATE OBJECTIVES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | OCEAN PROTECTION COUNCIL | | | | | | | | |
| PHASE | TIER | TYPE OF PROJECT | Develop a science-based ecosystems approach to ASBS/ocean protection | Protect and improve water quality and reduce ecosystem impacts | Facilitate ASBS Data Storage and Knowledge Transfer | Encourage Community involvement and ocean stewardship | Environmental/habitat protection and improvement | Recreation and public access | Stormwater capture and management | Water conservation | Water quality protection and improvement | NPS pollution control | Watershed planning | Runoff reduction | Ocean ecosystem protection | Ocean Stewardship | Enchance the capacity and perfomance of agency programs | Improve understanding of ocean and coastal ecosystems | Improve ocean and coastal water quality | Improve quantity and quality of ocean and coastal habitat | Increase healthy ocean and coastal wildlife populations | Promote ocean and coastal awareness and stewardship | Ocean Plan | Basin Plan | TMDL |
| I | I | Water Circulation, Dispersion and Physical Processes Assessment | ■ | ● | ● | ● | ● | . | ● | . | ■ | ● | ■ | . | ■ | ● | ■ | ■ | ■ | ● | ● | ● | ● | ● | ● |
| I | I | Sediment Transport/ Benthic Habitat Study | ■ | ● | ● | ● | ● | . | ● | . | ■ | ● | ■ | . | ■ | ● | ■ | ■ | ■ | ● | ● | ● | ● | ● | ● |
| I | I | Prioritized Community Assessments | ■ | ● | ● | ● | ● | . | ● | . | ■ | ● | ■ | . | ■ | ● | ■ | ■ | ■ | ● | ● | ● | ● | ● | ● |
| I | I | Supplementation of Planning Grant Studies- Bioaccumulation and Sediment | ■ | ● | ● | ● | ● | . | ● | . | ■ | ■ | ■ | . | ■ | ● | ■ | ■ | ■ | ● | ● | ● | ● | ● | ● |
| I | I | Information and Data Infrastructure Development | ■ | ● | ■ | ■ | ● | . | ● | ● | ■ | ● | ■ | . | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| I | I | Public Participation- Speakers Bureau, Information Dissemination, Pollution Prevention Curriculum | ● | ● | ● | ■ | ● | ● | . | ● | ■ | ● | ● | . | ■ | ■ | ● | ● | ● | ● | ● | ■ | ● | ● | ● |
| I | I | Outreach- Educational Exhibit | ● | ● | ■ | ■ | ● | . | . | . | ● | ● | ● | ● | ● | ● | ● | . | ● | ● | ● | ■ | ● | ● | ● |
| I | I | Outreach- Educational Tool | ● | ● | ■ | ■ | ● | . | . | . | ● | ● | ● | ● | ● | ● | ● | . | ● | ● | ● | ■ | ● | ● | ● |
| I | I | Public Participation/Pollution Prevention/Source Control | ■ | ■ | ● | ■ | ■ | . | ■ | ● | ■ | ■ | ● | ● | ■ | ● | ● | . | ■ | ● | ● | ■ | ● | ● | ● |
| I | I | Community Based Social Marketing- Baseline Residential Survey | ● | ■ | ● | ■ | ● | . | ● | . | ● | ● | ■ | ● | ● | ● | ● | . | ● | ● | ● | ■ | ● | ● | ● |
| I | I | Commercial Inspection | ● | ● | ● | ■ | ● | . | . | . | ■ | ● | ● | . | ● | . | ● | . | ● | ● | ● | ■ | ● | ● | ● |
| I | I | Pollution Prevention/Source Control | ■ | ■ | ● | ■ | ■ | . | ■ | ● | ■ | ■ | ● | ● | ■ | ● | ● | . | ■ | ● | ● | ■ | ● | ● | ● |
| I | I | Restoration and Erosion Control- Retaining Structures | ■ | ■ | ● | ■ | ■ | ● | ■ | ● | ■ | ● | ● | ■ | ■ | ● | ● | . | ■ | ■ | ■ | ● | ● | ● | ● |
| I | I | Pilot Air Deposition Study | ■ | ● | ● | . | ● | . | ● | . | ● | ● | ■ | . | ● | . | ● | ■ | ● | ● | ● | . | ● | ● | ● |
| I | II | Pilot Sediment Loading and Design Storm Study | ■ | ● | ● | . | ● | . | ■ | . | ● | ● | ■ | ● | ● | . | ● | ■ | ● | ● | ● | . | ● | ● | ● |
| I | II | Runoff Reduction (Green Lot) | ■ | ■ | ● | ● | ■ | . | ■ | ● | ■ | ■ | ● | ■ | ■ | . | . | . | ■ | ● | ● | . | ● | ● | ● |
| I | II | Runoff Reduction (Green Street) | ■ | ■ | ● | ● | ■ | . | ■ | ● | ■ | ■ | ● | ■ | ■ | . | . | . | ■ | ● | ● | . | ● | ● | ● |
| I | II | Dry Weather Flow Diversions | ■ | ■ | ● | . | ■ | . | ■ | . | ■ | ■ | ● | ■ | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| I | II | Bioretention BMP | ● | ■ | ● | . | ■ | . | ■ | . | ■ | ■ | ● | ■ | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| I | II | Pilot Trash Segregation | ■ | ■ | ● | . | ● | . | ■ | . | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| I | II | Street Sweeping (Vacuum-Assisted Truck) | ■ | ■ | ● | ● | ■ | . | ● | . | ■ | ● | ● | . | ■ | ● | ■ | . | ■ | ● | ● | . | ● | ● | ● |
| I | II | Low Impact Development Parking Lot | ■ | ■ | ● | ● | ■ | . | ■ | ● | ■ | ■ | ● | ■ | ■ | ● | . | . | ■ | ● | ● | ■ | ● | ● | ● |
| I | III | Diversion/Media Filter | ■ | ■ | ● | . | ● | . | ■ | . | ■ | ■ | ● | . | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| I | III | Pilot Treatment System on SIO Property | ■ | ■ | ● | . | ■ | . | ■ | . | ■ | ■ | ● | . | ■ | ● | ● | . | ■ | ● | ● | ■ | ■ | ■ | ■ |
| II | I | Information and Data Infrastructure Development | ■ | ● | ■ | ■ | ● | . | ● | ● | ■ | ● | ■ | . | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| II | I | Outreach for Runoff Reduction (Green Lot) | ● | ● | ■ | ■ | ■ | . | ● | ● | ● | ● | ● | . | ● | ● | ● | . | ● | ● | ● | ■ | ● | ● | ● |
| II | I | Commercial Inspection/Enforcement | ● | ● | ● | ■ | ● | . | ● | ● | ■ | ● | ● | ● | ● | ● | ● | . | ● | ● | ● | ■ | ● | ● | ● |
| II | II | Runoff Reduction Project- SMART Irrigation Systems | ● | ■ | ● | . | ■ | . | ■ | . | ■ | ■ | ● | ■ | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| II | II | LID/Dry Weather Flow Diversions | ■ | ■ | ● | . | ■ | . | ■ | . | ■ | ■ | ● | ■ | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| II | II | Restoration and Erosion Control- Stormwater System Upgrades | ● | ■ | ● | ■ | ■ | ● | ■ | ● | ■ | ■ | ● | . | ■ | ● | ● | ■ | ■ | ● | ● | ■ | ● | ● | ● |
| II | II | Low Impact Development Parking Lot | ■ | ■ | ● | ● | ■ | . | ■ | ● | ■ | ■ | ● | ● | ■ | ● | . | . | ■ | ● | ● | ■ | ● | ● | ● |
| II | II | Pilot Trash Segregation | ■ | ■ | ● | . | ● | . | ■ | . | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| II | III | Pilot E&S Control (Sediment) | ■ | ■ | ● | . | ● | . | ■ | . | ■ | ● | ● | . | ● | . | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| II | III | Pilot Stormwater Treatment System on State Property- Vegetative Swales | ■ | ■ | ● | . | ● | . | ■ | . | ■ | ■ | ● | . | ■ | ● | ● | . | ■ | ● | ● | ● | ■ | ■ | ■ |
| III | I | Information and Data Infrastructure Development | ■ | ● | ■ | ■ | ● | . | ● | ● | ■ | ● | ■ | . | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| III | I | Continual Pollution Prevention/Source Control | ■ | ■ | ● | ■ | ● | . | ■ | ■ | ■ | ■ | ● | ■ | ■ | ● | ● | . | ■ | ■ | ■ | ● | ● | ● | ● |
| III | I | Continual Outreach Pollution Prevention/Source Control | ■ | ■ | ● | ■ | ● | . | ■ | ■ | ■ | ■ | ● | ■ | ■ | ● | ● | . | ■ | ■ | ■ | ● | ● | ● | ● |
| III | II | LID/Dry Weather Flow Diversions | ■ | ■ | ● | . | ■ | . | ■ | . | ■ | ■ | ● | ■ | ■ | ● | ● | . | ■ | ● | ● | . | ■ | ■ | ■ |
| III | III | Treatment System on State Property | ■ | ■ | . | . | ● | . | ■ | . | ■ | ■ | ● | . | ■ | ● | ● | . | ■ | ● | ● | ● | ■ | ■ | ■ |
| III | III | Treatment System on City Property | ■ | ■ | . | . | ● | . | ■ | . | ■ | ■ | ● | . | ■ | ● | ● | . | ■ | ● | ● | ● | ■ | ■ | ■ |
| III | III | Run-off Collection and Treatment System | ■ | ■ | . | ● | ● | . | ■ | ● | ■ | ■ | ● | ● | ■ | ● | ● | . | ■ | ● | ● | ● | ■ | ■ | ■ |

■ - Direct Benefit
● - Indirect Benefit

# APPENDIX H

# La Jolla Shores ICWMP Public Review Draft Comments

# APPENDIX H
# La Jolla Shores ICWM Plan Comments on July 27th, 2007 Public Review Draft

| No. | Commenter | Comment | Response |
|---|---|---|---|
| 1 | Isabelle Kaye, UCSD Natural Reserve System (NRS) Manager | Page 16: Think about including the Scripps Coastal Reserve in description of the resource management entities and jurisdictional responsibilities. See http://nrs.ucop.edu > San Diego > Scripps.<br>As manager of the reserve, I am particularly interested in how this plan integrates/informs our management planning. | Added section 2.9 to describe reserve. Also see comment No. 4, 8, 9. |
| 2 | Anonymous | • LJ more trash receptacles, cigarette butt receptacles disbursed throughout the beach.<br>• Seagull covers (on trash bins)<br>• Enforcement of litter laws on beach<br>• Erosion from rodents & squirrels (they eat all of the greenery & burrow) | Added project to Plan. |
| 3 | Jenn Leuaine | What I have been able to learn thus far regarding the Coastkeeper plan it appears it is all 100% vital to the sustainability to marine life and the protection of the beach in an effort to create a long-term plan that will provide systems that <u>prevent</u> pollution. I think a campaign throughout the city that is catchy and memorable will ensure people to participate and operate! Thanks! | Public outreach has been included throughout the planning horizon. One project already started in the watershed is Community Based Social Marketing (CBSM), a new way to address pollution prevention and environmental damaging behaviors – one with proven results in communities where projects are implemented. |
| 4 | Isabelle Kaye, UCSD NRS Manager | There is no mention of the Scripps Coastal Reserve or the Natural Reserve System in the La Jolla Shores Coastal Watershed Management Plan. | See comment No. 1 above. |
| 5 | Isabelle Kaye, UCSD NRS Manager | The plan suffers from the perspective that the only land area responsible for the water quality in the ASBS is the watershed defined by the overland and piped flows of water that enter coastal waters from immediately landward of the ASBS. A more realistic and useful approach would have been to have considered a larger terrestrial and marine zone with significant influence on the ASBS. | Plan has been expanded to better describe area around the watershed and their potential influence on the ASBS. However, the focus of this Plan was the ASBS so only local management measures in the direct watershed are considered. |
| 6 | Isabelle Kaye, UCSD NRS Manager | 4.1.4 Toxicity testing: Is there a reason why there are no organisms that are naturally predominant in the shallow coastal waters used in the testing. Could some be included? | Organisms were selected based on State Water Resources Control Board requirements. Kelp is a local species. |
| 7 | Isabelle Kaye, UCSD NRS Manager | 4.1.5.2 Key Drainage Infrastructure: It is unlikely that any of the “natural drainages” in the watershed do not carry year-round nuisance flows | Comment noted. |

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| 8 | Isabelle Kaye, UCSD NRS Manager | 4.1.5.2 Key Drainage Infrastructure: Sumner and Blacks Canyons drain to the ocean immediately north of the ASBS, and under the usual pattern of coastal long-shore flow, they are obvious contributors to the water quality in the ASBS. There is an obvious opportunity to control polluting flows into the ASBS by controlling flows (from UCSD and La Jolla Farms) through these two canyons. | See comment No. 1 above. |
| 9 | Isabelle Kaye, UCSD NRS Manager | 4.1.5.2 Key Drainage Infrastructure: Portions of the UCSD campus drain to Sumner Canyon and thus to the immediate vicinity of the northern edge of the ASBS. Releases from this area contribute to dry weather nuisance flows or “urban drool” and to eroding flows following storm events. | See comment No. 1 above. |
| 10 | Isabelle Kaye, UCSD NRS Manager | 4.1.5.2 Key Drainage Infrastructure: The almost pristine hydrology and geomorphology of the Knoll invite scientific comparisons with the developed adjacent areas to the south that directly drains to the ASBS. There is an opportunity for establishing reference sites and baselines in this portion of the reserve, in terms of background pollutant levels and physical processes. | Sand Crabs were collected and Mussels were outplanted in the nearshore adjacent to the Knoll for comparison purposes. They were also collected and outplanted as far north as Los Peñasquitos lagoon and as far south as Point Loma. See Figure ES of Appendix B. |
| 11 | Isabelle Kaye, UCSD NRS Manager | 4.1.6 Land Use: The omission of the university as a land use distinct from “commercial” is very misleading; it should be called out separately, especially since different SWRCB rules have applied. | The text, Figure F-14 and F-15, and Table 5 have been modified to reflect more accurate Land Use description. |
| 12 | Isabelle Kaye, UCSD NRS Manager | 4.1.6 Land Use: The watershed is called “built out”, yet there are plans for additional building on campus open space, including the Venter Institute, parking structures at SIO, re-construction of the Southwest Fisheries Science Center, etc. etc. | The Regional Description does address the potential for construction projects on campus. |
| 13 | Isabelle Kaye, UCSD NRS Manager | 4.1.6 Land Use: Figure 14 should show the UC properties separate from commercial. | See comment No. 11 above. |
| 14 | Isabelle Kaye, UCSD NRS Manager | 4.1.6 Land Use:. Figure 15 shows a nursery in the single-family residential area in the northern part of the watershed, and it is called out repeatedly as a potential source of pollutants. Both its location and its significance seem highly unlikely. This and the previous figure do not adequately depict the parking lots that constitute a large part of the SIO campus and elsewhere in La Jolla Shores. | Repetition related to nursery has been removed to de-emphasize its potential impact. |
| 15 | Isabelle Kaye, UCSD NRS Manager | 4.1.7 Potential COC sources: Construction is not adequately identified as a potential source of sediment in the watershed. The University has been a significant source of sediment over the years (recently with regard to site now occupied by the Rady School of Management.) | Section 4.1.7 has been modified to identify construction on campus as a potential source of sediment. |

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| 16 | Isabelle Kaye, UCSD NRS Manager | 4.1.7 Potential COC sources: The University is also not adequately identified as a likely source of pesticides, herbicides, and invasive species. It is also a huge source of nuisance flows as a result of over irrigation of lawns. | University activities have been added as a potential source of pesticides. The University does employ an Integrated Pest Management (IPM) program and tests in the watershed do not show pesticides as a concern at this time. |
| 17 | Isabelle Kaye, UCSD NRS Manager | 4.4.1 Stakeholders; The Natural Reserve System is not listed in this section and should be called out separately here. | Natural Reserve System has been added as a stakeholder. |
| 18 | Isabelle Kaye, UCSD NRS Manager | 4.4.1 Stakeholders; The NRS would greatly appreciate collaborative support in raising public and institutional awareness of the presence and natural history of the Scripps Coastal Reserve, the educational opportunities it affords, as well as responsibilities of visitors. | Comment noted. |
| 19 | Isabelle Kaye, UCSD NRS Manager | Goals and Objectives (Section 5):<br>5.1 Methodology;<br>• The NRS could be involved in items 4 and 5.<br>• Data and metadata generated by permitted projects could be made available through the database, and NRS users could be made aware of the information available that might enhance their research and teaching projects.<br>• The NRS has a long history of encouraging stewardship of the area through educational outreach and restoration activities, albeit on a less-than-grandiose scale. | Comment noted. NRS plan is included in Table 10. Monitoring data is available on the project information management system at http://cordc.ucsd.edu/projects/asbs/ |
| 20 | Isabelle Kaye, UCSD NRS Manager | Goals and Objectives (Section 5)<br>5.2 Management Issues/5.2.1 Key Issues:<br>• Ecosystem assessment – ecosystem data have been collected by researchers using the SCR over the past four decades; some of these studies have been long-term, e.g. Engle, et al. from UC Santa Barbara<br>• Information Management – Users of the SCR would likely be interested in accessing data acquired as part of the LJSCWMP, as well as contributing<br>• Public involvement – The NRS has initiated docent programs for the terrestrial and shoreline portions of the SCR, largely focused on protecting the cultural and natural resources of the Reserve; these programs could be expanded to include water quality and watershed monitoring | Comment noted. The website in Comment 19 could be added to the SCR website as a link. |
| 21 | Courtney Ann Coyle, (paraphrased) | **Larger Watershed** – While we understand the practical need to establish boundaries, the Plan and its implementation would benefit from more description of the larger watershed which the Plan states extends up to the | The Regional Description has been broadened. See also Comment No. 1, 4, 8 and 9 above. |

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| | | northerly parts of Torrey Pines State Reserve. Because of the nature of the ocean and its ecology, urban and other runoff from canyons and bluffs may directly and cumulatively adversely impact the study area. Expanded discussion in the draft Plan, in addition to that state below, would help achieve the goals and objectives of the Plan. (Section 3.0-3.1, page 14, Figure ES Site Map, and Appendix F La Jolla Shores Coastal Watershed BMP Project List.) | |
| 22 | Courtney Ann Coyle, Attorney at Law | **Tribal Participation** – While we note from the Plan that a certain level of outreach was performed, we also note that the Plan itself observed that participation at public forms was below expectations. In the future, we would recommend that a special effort be made to involve local tribal governments and entities to participate in the Plan and its implementation. As you know, local tribes continue to have strong connections to the shore, ocean and lands within the study are. Their interest in the care and protection of these places is evidenced by their recent efforts to monitor and influence coastal land use issues and support "The Map" project within the study area. Bothe the City of San Diego and the State Native American Heritage Commission maintain consultation lists with tribal contacts information. Tribal view could also be incorporated into the draft Plan (Section 2.3.2 Cultural and Social Values, page 9 and Section 4.4 Public Participation page 48). | The Regional Description has been modified to recognize the history of Native Americans in the watershed. Also the project partners have been working with Native American tribes on The Map project (included in the Plan) to recognize their influence in the area. |