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**City of San Diego**
**Public Utilities Department**

**March 2022**

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# APPENDIX C

# OCEAN BENTHIC CONDITIONS

City of San Diego
Public Utilities Department

March 2022

# APPENDIX C

# Summary of Findings

The City of San Diego (City) conducts an extensive Ocean Monitoring Program to evaluate potential environmental effects associated with the discharge of treated wastewater to the Pacific Ocean via the Point Loma Ocean Outfall (PLOO). Data collected are used to determine compliance with receiving water quality requirements, as specified in National Pollutant Discharge Elimination System (NPDES) permits, and associated orders; these permits and orders are issued by the San Diego Regional Water Quality Control Board (SDRWQCB) and the U.S. Environmental Protection Agency (USEPA) for the City's Point Loma Wastewater Treatment Plant (PLWTP). The principal objectives of the ocean monitoring efforts for the PLOO region include: (1) measure and document compliance with NPDES permit requirements and California Ocean Plan (Ocean Plan) water quality objectives and standards; (2) assess any impact of wastewater discharge, or other anthropogenic inputs, on the local marine ecosystem, including effects on coastal water quality, seafloor sediments, and marine life; (3) monitor natural spatial and temporal fluctuations of key oceanographic parameters, and evaluate the overall health and status of the San Diego marine environment.

Results of receiving waters monitoring activities conducted for the PLOO region between July 1, 1991 through December 31, 2020, are presented in the various appendices of this application, and in various previous receiving waters monitoring reports available via the City's webpages. Appendices C1-C5 include results of the primary monitoring components related to ocean benthic conditions at core and regional stations. Assessments of benthic conditions, including benthic sediment quality (physical properties, sediment chemistry, and sediment toxicity), and the status of benthic invertebrate communities, are presented in Appendices C1, C2, C3, and C4. Appendix C1 also presents the results of trawling activities designed to monitor communities of bottom dwelling demersal fishes and megabenthic invertebrates. Bioaccumulation assessments to measure contaminants in marine fishes are presented in Appendix C5. Measurements of fecal indicator bacteria and oceanographic data to evaluate potential movement and dispersal of the PLOO waste fields (plumes), and to assess compliance with water contact standards defined in the Ocean Plan are available elsewhere in this application (e.g., Appendix D). Summaries of the main findings for each of the core ocean monitoring components conducted by the City and presented in Appendices C1-C5 are included below.

### APPENDIX C1 | BENTHIC SEDIMENTS, INVERTEBRATES AND FISHES

The City's discharge of municipal wastewater into offshore marine waters maintains natural conditions in sediments and biota beyond the wastewater zone of initial dilution

(ZID). Monitoring and assessment of benthic sediment conditions and the status of marine invertebrate and fish communities are conducted to assess outfall related impacts and are described in this Appendix. The City's offshore monitoring program has collected more than 4,800 benthic samples (sediments and infauna) from different monitoring stations surrounding the PLOO from mid-1991 through 2020. In addition, over 700 otter trawls have been performed during this time to monitor demersal fish and megabenthic invertebrate communities in the region, while additional trawls and rig fishing activities have been conducted to monitor the bioaccumulation of contaminants in fish tissues.

After 27 years of wastewater discharge from the extended PLOO, monitoring results show only minor changes beyond the ZID boundary off Point Loma. Chemical and biological conditions of the sediments indicate no environmentally significant changes associated with the discharge. The only evidence of organic or contaminant loading of the sediments are slightly higher sulfide and Biochemical Oxygen Demand (BOD) levels at a few sites located within about 300 meters (m) of the discharge zone. Although some changes have occurred that correspond to the initiation of discharge, benthic habitats outside the ZID boundary are characterized by infaunal communities composed of indigenous populations representative of natural conditions. Key parameters such as infaunal abundance, species diversity, Benthic Response Index (BRI), and patterns of key "indicator" species, are being maintained within the limits of variability that typify natural benthic communities of the Southern California Bight (SCB) continental shelf. Finally, analysis of trawl-caught fish and invertebrate communities show no evidence of outfall effects.

## Sediments

Sediment conditions off Point Loma were analyzed based on a total of 708 samples collected from the 12 primary core stations located at outfall depths during winter and summer surveys from 1991 through 2020. Of the 708 samples analyzed herein, 60 were collected prior to discharge and 648 were collected during the post-discharge period. The latter includes 312 samples for the period covered in the City's 2007 PLWTP modified permit application (i.e., 1994-2006), 168 samples for the period covered in the City's 2015 PLWTP modified permit application (i.e., 2007-2013), and 168 additional samples for the period from 2014 through 2020.

Wastewater discharge did not significantly affect sediment quality in the vicinity of the PLOO. Since the outfall began operation, there has been little evidence of organic or contaminant loading in the area. Most measured parameters continue to exist at levels within the range of natural variability for the San Diego region and other SCB reference areas, and below available contaminant thresholds. Although there were increases in levels of a few trace metals in 1994 shortly after discharge began, these increases were only temporary. The only sustained effects were mostly restricted to a few sites located within about 120-300 m of the outfall discharge zone (i.e., within 200 m of the ZID). These three near-ZID sites include station E14 located near the ZID boundary just west of the center of the outfall wye, and stations E11 and E17 located off the ends of the southern and northern diffuser legs, respectively. Station E11 is located about 149 m from the southern ZID boundary, while E17 is located about 197 m from the northern ZID boundary. These effects included an increase in the percentage of coarse sediments (i.e., decrease in percent fines), measurable increases in sulfide concentrations in near-outfall sediments, as well as smaller increases in sediment BOD levels. Consequently, the PLOO discharge is not affecting sediment quality to the point that it would degrade the resident marine biota.

## Benthic Infauna

The benthic infauna communities off Point Loma were analyzed based on 707 0.1-$m^2$ grab samples collected from the 12 primary core stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Of the 707 samples analyzed herein, 60 were collected prior to discharge (1991-1993) and 647 afterwards (1994-2020).

Benthic infauna communities around the PLOO continue to be dominated by ophiuroid-polychaete based assemblages and have mirrored changes that have occurred throughout the SCB since monitoring began. For example, the brittle star *Amphiodia urtica* and several species of polychaetes (e.g., *Proclea* sp A, *Spiophanes duplex, Phisidia sanctamariae)* were dominant species during both the pre- and post-discharge periods. Polychaetes continue to account for the greatest number of species and individuals overall. Similar assemblages dominate much of the southern California mid-shelf benthos, including the San Diego region, although patches of other benthic assemblages occur in areas of different sediment types. The shifts in community composition that have occurred over time off Point Loma probably represent variation in southern California assemblages related to large-scale oceanographic events (e.g., El Niño), natural population fluctuations, and habitat heterogeneity.

Although variable over the past 30 years, infaunal communities off Point Loma have generally remained characteristic of undisturbed habitats. Despite this overall stability, comparisons of data from the pre- and post-discharge periods indicate a few trends. For example, there was a general increase in the total abundance and number of species of benthic infauna in the years after wastewater discharge began, although a similar pattern was already present prior to discharge. The increase in species richness was initially more pronounced nearest the outfall, but in recent years has been similar at all stations. Increases in infaunal abundance were also generally accompanied by decreases in dominance, another pattern contrary to known pollution effects. Considering the nature of the above changes, benthic communities around the PLOO are not dominated by pollution tolerant species at this time.

Other changes in the benthos near the outfall also suggest minor effects coincident with anthropogenic activities. For example, the increased variability in number of species and infaunal abundance at near-ZID station E14 since discharge began may be indicative of minor community destabilization or continuing disturbance. A similar increase in the BRI at this station during the post discharge period may also be indicative of enrichment or disturbance events. However, BRI values at all other stations are still considered characteristic of undisturbed benthic habitats. Finally, the patchiness of sediments near the outfall and the corresponding shifts in assemblage structure suggest that changes at this station may be related to localized physical disturbance (e.g., shifting sediment types or freshwater input) as well as to organic enrichment.

Populations of some indicator organisms revealed changes that correspond to minor organic enrichment or other physical changes near the outfall, while populations of others revealed no evidence of impact. For example, there was a significant change in the difference between ophiuroid populations, such as members of the genus *Amphiodia*, that occur near the outfall (i.e., station E14) and those present at reference stations. Although *Amphiodia* populations have fallen most sharply near the outfall, their numbers have been declining region-wide in both the San Diego area and the SCB. These declines may be due to large scale phenomena such as global warming or ocean acidification. Although changes in *Amphiodia* populations at station E14 may also be related to organic enrichment, other factors such as increased predation pressure near the outfall pipe or coarser sediments from the outfall pipe's ballast rock may be important. Whether or not these changes are related to organic enrichment, predation, or some other factor, abundances of *Amphiodia* off Point Loma are still within the range of those occurring naturally in the SCB. Patterns of change in populations of the polychaete *Capitella teleta* (formerly referred to as *C. capitata* species complex off San Diego), the bivalve *Parvilucina tenuiscuplta*, and ostracods of the genus *Euphilomedes* also suggest a subtle enrichment effect near the outfall; however, densities of these organisms remain low compared to what may be expected within a significantly disturbed habitat and are within the range of natural variation for the SCB. Other benthic invertebrates that have been suggested as bioindicators, such as several polychaete species in the genus *Mediomastus* and amphipods in the genera *Rhepoxynius* and *Ampelisca*, also revealed few changes that would indicate habitat degradation near the outfall.

Although some changes in benthic assemblages have appeared off Point Loma, these assemblages are still similar to those present prior to discharge and to natural indigenous communities of the southern California continental mid-shelf. Thus, after 27 years of outfall operation, the discharge of wastewater through the PLOO has not caused any significant biological changes in benthic community structure that may be interpreted as degradation.

## Demersal Fishes & Megabenthic Invertebrates

Demersal fish and megabenthic invertebrate communities were analyzed based on a total of 321 trawls conducted at six stations off Point Loma during winter and summer surveys from 1991 through 2020. Of these trawls, 30 were performed prior to discharge (1991-1993) and 291 afterwards (1994-2020).

Overall, there was no evidence that wastewater discharged through the PLOO affected demersal fish or megabenthic invertebrate communities, as the abundance and distribution of species generally varied similarly at nearfield and farfield stations, and the high degree of variability in these assemblages was consistent across all surveys, including before wastewater discharge began. This conclusion was supported by multivariate analyses presented in the most recent biennial receiving waters monitoring and assessment report, which were used to evaluate changes in trawled fish and invertebrate community structure within the PLOO region without *a priori* assignment of nearfield versus farfield location, or pre- and post-discharge time periods. This type of variability is consistent with what has been observed in similar habitats elsewhere off the coast of southern California. Consequently, changes in local populations of demersal fish and megabenthic invertebrate communities are more likely due to natural factors, such as changes in ocean temperatures associated with El Niño, or other large-scale oceanographic events. Finally, the lack of physical abnormalities or indicators of disease such as fin rot, lesions, or tumors suggest that fish populations have remained healthy off Point Loma since monitoring began.

## APPENDIX C2 | SAN DIEGO BENTHIC TOLERANCE INTERVALS

Multivariate analyses were performed on 1,027 0.1-$m^2$ benthic infauna grab samples collected from 1994 through 2017 during various regional surveys and special studies to identify benthic sites or communities likely to provide the most appropriate reference values for environmental indicators within the PLOO region, and to quantify their tolerance intervals. For environmental data, the tolerance interval is a statistical tool used to define the putative natural range of values for reference variables. Tolerance intervals were calculated for 27 sediment parameters and 15 biological indicators, selected to match parameters assessed in Appendix C1. These tolerance intervals were then compared to data from the 12 primary core PLOO benthic stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020 (n=707 0.1-$m^2$ benthic infauna grab samples).

Overall, 85% of the sediment particle size, sediment chemistry, and biological indicator values from PLOO benthic stations located at outfall depths were found to be within tolerance intervals calculated using reference data. For most parameters, upper tolerance interval bounds represent thresholds for the direction of response predicted from environmental impact. These were exceeded at PLOO near-ZID stations for 5% of sulfide values, 3% of BOD values, 7% of BRI values, 5% of *Solemya pervernicosa* values, and 1% of *Capitella teleta* values. The threshold for BOD was also exceeded for 5% of samples from farfield stations. Several other parameters that also exceeded upper bound thresholds at farfield and/or near-ZID stations relatively frequently (≤12%) included total organic carbon, cadmium, *Euphilomedes* spp, and *Mediomastus* spp. These findings demonstrate that all stations within the sampling program are largely indicative of background conditions and support the overall conclusion that local benthic infauna communities remain relatively unaffected by the effluent discharge.

## APPENDIX C3 | SAN DIEGO SEDIMENT QUALITY ASSESSMENT

Sediment quality on the continental shelf off San Diego, along with associated benthic infauna communities, was assessed using the State of California's sediment quality assessment framework. This framework integrates indices of benthic infaunal community structure, sediment chemistry exposure, and sediment toxicity as multiple lines of evidence (LOE) used to classify each site into one of five potential categories: (1) unimpacted; (2) likely unimpacted; (3) possibly impacted; (4) likely impacted; (5) clearly impacted. For this study, a total of 65 sediment samples from 53 different stations were collected during the summers of 2016 through 2020, including 16 samples from near-ZID stations E11, E14, E15, and E17, and 49 samples from randomly selected regional stations. Modifications of the standardized framework typically applied to embayments comprised the application of the 10-day amphipod sediment toxicity test, and the application of the BRI, both of which were developed for evaluation of sediments and infauna in offshore waters.

Based on the State of California's sediment quality assessment framework, 98% of the 58 samples that had all lines of evidence available (i.e., not too shallow or deep for the BRI and at least 96% of chemistry parameters analyzed) were deemed unimpacted. The single exception was collected from near-ZID station E14 during summer 2017. Despite having a BRI value indicative of moderate disturbance (37), sediments from this sample were deemed likely unimpacted, as they were found to be nontoxic with minimal exposure to pollutants. California's State Water Resource Control Board (SWRCB) considers both unimpacted and likely unimpacted categories as healthy, or representative of conditions undisturbed by pollutants in sediment. These findings support previous conclusions that changes in benthic infauna communities at station E14 may reflect a habitat with coarser sediment particle size composition rather than by wastewater contamination. These findings also support the overall conclusion that local benthic infauna communities remain relatively unaffected by the effluent discharge.

## APPENDIX C4 | ASSESSMENT OF MACROBENTHIC COMMUNITIES OFF POINT LOMA

Multivariate analyses were performed on 695 sediment particle size and 707 0.1-$m^2$ benthic macrofauna (i.e., infauna) grab samples from the 12 primary core PLOO benthic stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Multivariate techniques, such as ordination and cluster analyses, were used to evaluate changes in benthic community structure within the PLOO region without *a priori* assignment of near-ZID versus farfield location, or pre- and post-discharge time periods.

Ordination and cluster analyses of 29 years of sediment particle size data resulted in five cluster groups that were primarily distinguished by differing proportions of very fine sand and fine particles (silt and clay subfractions combined). The largest cluster encompassed 93% of all samples and had the highest proportion of fine particles compared to the other groups. It is likely that this sediment cluster group represents background conditions in the Point Loma region (also referred to as "mud-belt" shelf habitats) that correspond to the *Amphiodia* "mega-community" which is known to be common off San Diego, as well as other parts of the southern California mainland shelf. The remaining clusters all had coarser sediments to varying degrees, and largely represented sediment composition often found at northern reference station B12, southern farfield station E2, and near-ZID station E14.

Ordination and cluster analyses of 30 years of macrofaunal data resulted in 15 cluster groups that primarily reflected changes in the abundances of ~65 species over time, as well as particle size composition (e.g., presence of coarse particles, medium sand, fine sand, or very fine sand) to a lesser degree. The three largest clusters together encompassed 96% of samples collected from 11 of 12 PLOO stations sampled 1991-2020. As with the largest particle size cluster group, it is likely that assemblages represented by these three groups denote background "mud-belt" shelf habitat conditions in the Point Loma region that correspond to the *Amphiodia* "mega-community," divided into three different time periods. Another three cluster groups represented assemblages found at northern farfield station B12, associated with sandier sediments (more medium and coarse sand, less fine sand and fine particles), also broken up over three time periods. The remaining nine groups represented smaller "outlier" assemblages most often associated with distinct particle size composition (e.g., presence of very coarse or very fine particles).

Overall, these findings support the conclusion presented in the various appendices of this application that wastewater discharged through the PLOO over the past 27 years has not affected benthic macrofaunal (i.e., infaunal) communities in the region. For example, patterns related to pre- versus post-discharge periods were not apparent in the distribution of macrofauna cluster groups, and near-ZID vs farfield station differences were minimal. Instead, sediments from 93% of the samples collected from 1992 through 2020, and assemblages from 88% of macrofaunal grabs (96% with northern reference station B12 excluded) collected from 1991 through 2020 were representative of background conditions typical for this portion of the southern California coast and consistent with results of regional surveys off San Diego and other areas of the SCB.

## APPENDIX C5 | BIOACCUMULATION ASSESSMENT

Demersal fishes can accumulate chemical contaminants from the environment, including surrounding waters, benthic sediments, and from the food they consume. The City currently monitors the bioaccumulation of contaminants in fishes inhabiting areas surrounding the PLOO by analyzing liver tissues of species collected from four trawl zones (six stations) and muscle tissues of species collected from two rig fishing stations. These stations are located along the mainland shelf at depth ranges similar to where wastewater is discharged. Specific species are targeted for analysis based on their ecological or commercial importance.

Results are presented for contaminant levels of 11 metals, dichloro-diphenyl-trichloroethane (DDT) and other chlorinated pesticides, and polychlorinated biphenyl compounds (PCBs) measured in more than 20 species of fish collected from surveys conducted between October 1995 and October 2020. Six trace metals (arsenic, cadmium, copper, mercury, selenium, zinc), DDT, and PCBs were detected in ≥85% of all liver tissue samples from trawl-caught fishes, while chromium, lead, nickel, silver, tin, chlordane, dieldrin, hexachlorobenzene (HCB), and hexachlorocyclohexane (HCH) were found in 2% to 59% of the liver tissue samples. Five metals (arsenic, copper, mercury, selenium, zinc) and DDT also occurred frequently (≥61%) in the muscle tissue samples from fishes collected at rig fishing stations, while cadmium, chromium, lead, nickel, silver, tin, chlordane, HCB, HCH, and PCBs were found in 1% to 50% of the muscle samples.

Overall, there was no evidence that the discharge of wastewater via the Point Loma outfall has caused abnormal body burdens of any toxic pollutants known to have adverse effects on marine fishes or their consumers. Tissue contaminant concentrations varied substantially among different species, across stations, and over time, although none showed patterns relative to proximity to the PLOO. Contaminant concentrations were considerably less in the muscle tissues of fishes than in liver tissues, and contaminant loads were generally within the range of those reported previously for other SCB fish assemblages. Concentrations of mercury, chlordane, and total DDT in muscle tissues from sport fish reported herein were below United States Food and Drug Administration (USFDA) action limits. However, some tissue samples composed of various rockfish species and California Scorpionfish had mercury, total DDT, and total PCB concentrations above the California Office of Environmental Health Hazard Assessment (OEHHA) fish contaminant goals, and arsenic, chromium, and selenium concentrations above median international standards. Elevated levels of these contaminants are not uncommon in sport fish from the greater San Diego region, including the Coronado Islands which are used by the City as a reference area for the South Bay Ocean Outfall.

# APPENDIX C1

# BENTHIC SEDIMENTS, INVERTEBRATES AND FISHES

March 2022

# APPENDIX C1

# Benthic Sediments, Invertebrates, and Fishes

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C1-B Summary of Benthic Macrofauna Invertebrate Species Collected from Outfall Discharge Depths Near the Point Loma Ocean Outfall from 1991 through 2020

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C1-D Summary of Megabenthic Invertebrate Species Captured at Six Trawl Stations Around the PLOO, 1991 through 2020.

# APPENDIX C1

# Benthic Sediments, Invertebrates, and Fishes

## SECTION C1-1 | INTRODUCTION

The City of San Diego (City) conducts an extensive Ocean Monitoring Program to evaluate potential environmental effects, such as degraded seafloor habitats, associated with the discharge of treated wastewater to the Pacific Ocean via the Point Loma Ocean Outfall (PLOO). To determine the condition of seafloor habitats, ongoing ocean monitoring efforts include analyses of various sediment particle size and chemistry parameters, along with assessments of benthic invertebrate and demersal fish communities. Analyses of sediments are important, as anthropogenic inputs to the marine ecosystem, including municipal wastewater, can lead to increased concentrations of pollutants within the local environment. The relative proportions of sand, silt, clay, and other particle size parameters are also examined, as concentrations of some compounds are known to be directly linked to sediment composition (Emery 1960, Eganhouse and Venkatesan 1993). Additionally, physical and chemical sediment characteristics help to define the primary microhabitats for benthic macroinvertebrates (infauna, or macrofauna) that live within or on the seafloor, and many demersal fish species are known to be associated with specific sediment types that reflect the habitats of their preferred invertebrate prey (Cross and Allen 1993). As many benthic infauna species (e.g., worms, crabs, clams, brittle stars) live relatively long and stationary lives, they may respond to the effects of pollution, or other disturbances, over time (Hartley 1982, Bilyard 1987). The response of many of these species to environmental stressors is also well documented, and thus monitoring changes in discrete populations, or more complex communities, can help identify areas impacted by anthropogenic inputs (Pearson and Rosenberg 1978, Bilyard 1987, Warwick 1993, Smith et al. 2001). Finally, because trawled fish and megabenthic invertebrate species also live on or near the seafloor, they too are exposed to sediment conditions, and may exhibit the effects of pollution, or other disturbances, over time.

The City of San Diego began pre-discharge monitoring for the extended deepwater PLOO in July 1991. The design of the monitoring program was determined by members of the City's Ocean Monitoring Program through consultation with the United States Environmental Protection Agency (USEPA) and the San Diego Regional Water Quality Control Board (SDRWQCB). The aim of the program was to establish fixed stations at various distances and depths from the diffuser pipe, which would be monitored to evaluate the quality of sediments and their associated invertebrate and fish communities in order to determine whether or not changes in these communities might be attributed to discharge from the outfall. Construction of the Point Loma outfall extension was completed in November 1993 at which time wastewater discharge was initiated at the deepwater location at depths of approximately 100 meters (m).

Overall, a total of 83 quarterly or semiannual benthic or trawl surveys were conducted off Point Loma from 1991 through 2020, including 2.5 years monitoring pre-discharge conditions (1991-1993), and 27 years monitoring post-discharge conditions (1994-2020).

This appendix includes analyses of sediment, invertebrate and fish monitoring data collected from the Point Loma outfall region over the past 30 years (1991-2020), thus providing an update of the assessment presented in the City's previous 301(h) modified permit application in 2015, which addressed monitoring data collected from 1991 through 2013 (City of San Diego 2015). The primary goals of this appendix are to document levels of contaminant loading in local seafloor sediments, identify the overall condition of benthic habitats in the PLOO region, and determine if any habitat degradation may be related to wastewater discharge via the PLOO. Discharge-related effects were evaluated in terms of (1) the range of natural variability under reference conditions, (2) the magnitude and spatial extent of any changes, and (3) an assessment of the potential for adverse effects. Estimates of natural variability for benthic sediment, infauna, and trawl community parameters in the Southern California Bight (SCB) have been extracted from various regional and bight-wide surveys (i.e., Bight surveys) conducted since 1994. These studies include the 1994 SCB Pilot Project (Allen et al. 1998, Bergen et al. 1998, 2001, Schiff and Gossett 1998), and subsequent Bight'98, Bight'03, Bight'08, Bight'13, and Bight'18 programs (Allen et al. 2002, 2007, 2011, Noblet et al. 2002, Ranasinghe et al. 2003, 2007, 2012, Schiff et al. 2006, 2011, Dodder et al. 2016, Gillett et al. 2017, BSQPC 2018, SCCWRP 2018). For sediments and infauna, comparisons were also made to annual region-wide surveys of the San Diego mainland shelf conducted as part of regular monitoring requirements (San Diego "mini" regional surveys), and tolerance intervals calculated from all regional and bight-wide surveys (see Appendix C2 in this application).

## SECTION C1-2 | GENERAL METHODOLOGY

All sampling and analytical methodologies follow guidelines established by the Environmental Protection Agency (USEPA 1987a, 1987b) and as defined in a series of four Monitoring and Reporting Programs (MRPs) for National Pollutant Discharge Elimination System (NPDES) Permit CA0107409. These include the MRPs in Order No. 95-106 adopted in 1995, Order No. R9-2002-0025 adopted in 2002, Addendum No. 1 to Order No. R9-2002-0025 adopted in 2003, Order No. R9-2009-0001 adopted in 2009, and current Order No. R9-2017-0007 adopted in 2017. The geographic coordinates and depths of the benthic and trawl monitoring stations for the PLOO region, along with details of changes or corrections, are also included in these MRPs. Significant changes to the MRP requirements for the Point Loma region adopted in 2003 as part of Addendum No. 1 to Order No. R9-2002-0025 that affect comparisons between pre- and post-discharge periods were described in detail in City of San Diego (2007c). However, all data have been completely reanalyzed for this application to account for such factors (see sections on sediment, infauna, and trawl datasets, below).

Additional details regarding PLOO monitoring are available in the City of San Diego's Quality Assurance Plan (City of San Diego 2020c) and receiving waters reports, most of which are available online (City of San Diego 2021b). Careful sample logging and chain of custody procedures are followed throughout the program so that all samples and data are readily tracked and inventoried from the collection process through laboratory analysis and data reporting.

Samples for benthic analyses were collected using a single or double 0.1-$m^2$ Van Veen grab, with one grab used for sediment quality analysis and one grab used for benthic community analysis. This type of grab is highly regarded for its sampling capabilities, including depth of penetration, lack of pressure wave upon impact, and ease of use. Criteria established by the USEPA to ensure consistency of grab samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987a). Sub-samples for particle size analyses were taken from the top 2 centimeters (cm) of the sediment surface and handled according to standard guidelines (USEPA 1987a, SCCWRP 2018). Samples for infauna analysis were transferred to a wash table aboard ship, rinsed with seawater, and then sieved through a 1.0-milimeter (mm) mesh screen in order to remove as much sediment as possible.

Demersal fish and megabenthic invertebrate communities were sampled using a 7.6 m Marinovich otter trawl net fitted with a 1.3 cm cod-end mesh (see Mearns and Allen 1978). Standard sampling procedures require towing the net for a total of 10 minutes bottom time per trawl, at a speed of around 2 knots, along a predetermined heading. Analyses of these trawl surveys are currently based on a single successful trawl per station during each sampling period.

## Sediment & Infauna Datasets

Previous analyses of benthic sediments and macrofaunal communities in the vicinity of the Point Loma deepwater outfall have been based on the results of replicate grabs from all stations sampled during all surveys conducted from 1991 through 2020. These included a total of 10 pre-discharge surveys (July 1991-October 1993) and 73 post-discharge surveys (January 1994-July 2020). The subsequent sediment quality dataset comprised results from a total of 1,772 successful 0.1-$m^2$ grab samples, while the biological (infauna) dataset comprised results from 3,117 successful 0.1-$m^2$ grab samples (Table C1-1). These datasets represent about 177 $m^2$ and 312 $m^2$ of seafloor sediments, respectively, and previous assessments utilizing these data have shown no significant evidence of habitat degradation due to wastewater discharge (City of San Diego 1995a, b, 1996, 1997a, 1998a, 1999a, 2000b, 2001, 2002a, 2003a, 2004b, 2005a, 2006a, 2007a, c, 2008a, 2009a, 2010a, 2011a, 2012a, 2013a, 2014b, 2015a, b, 2016a, 2018, 2020b, 2021a).

However, for the sake of continuity across all years, benthic sediment and infaunal analyses for PLOO stations presented in this application were limited as follows: (1) included only winter and summer surveys (typically conducted during January and July); (2) included only the 12 primary core stations located along the 98-m (320 feet) outfall discharge depth contour (from north to south: B12, B9, E26, E25, E23, E20, E17, E14, E11, E8, E5, E2) (Figure C1-1); (3) included just the first infauna grab per station to align most closely with corresponding sediment samples. These limitations have resulted in an analytical benthic database for this appendix that includes results from 708 sediment grabs and 707 infauna grabs collected at the primary core stations during winter and summer surveys from 1991 through 2020 (Table C1-1).

## Trawl-Caught Fish & Invertebrate Datasets

As with sediments and infauna, previous analyses of demersal fish and megabenthic invertebrate communities in the vicinity of the Point Loma deepwater outfall have been based on the results of all trawls from all stations sampled during all surveys conducted from 1991 through 2020. These included a total of 10 pre-discharge surveys (July 1991–October 1993) and 73 post-discharge surveys (January 1994–July 2020). The subsequent database comprised results from a total of 705 trawls surrounding the deepwater discharge site (Table C1-1). Earlier assessments utilizing these data have shown no significant evidence of habitat degradation due to wastewater discharge (City of San Diego 1995a, b, 1996, 1997a, 1998a, 1999a, 2000b, 2001, 2002a, 2003a, 2004b, 2005a, 2006a, 2007a, c, 2008a, 2009a, 2010a, 2011a, 2012a, 2013a, 2014b, 2015a, b, 2016a, 2018, 2020b, 2021a).

However, for the sake of continuity across all years, analyses of demersal fish and megabenthic invertebrate communities presented in this application for PLOO stations were limited as follows: (1) included only winter and summer surveys (typically conducted during January and July); (2) excluded data from stations SD9 and SD11, where sampling was discontinued in July 2003; (3) excluded data from replicate trawls taken at each station through 1995; (4) excluded analysis of invertebrate biomass that was no longer recorded after July 2003; (5) included only trawls that were of approximately 10 minutes in duration (i.e., excluded short trawls due to massive red crab hauls, see City of San Diego 2020b). These limitations have resulted in analytical datasets for this appendix that includes results from 321 trawls conducted during winter and summer surveys from 1991 through 2020 (Table C1-1).

**TABLE C1-1**
Total number of benthic grab samples (sediments and infauna) and community trawls (demersal fishes and megabenthic invertebrates) for the PLOO monitoring program from 1991 through 2020. Pre-discharge period = 1991-1993; Post-discharge period = 1994−2020. Data include: (a) total number of grabs and trawls over all surveys (2 or 4) per year for all benthic (n=23 max) and trawl (n=8 max) sites; and (b) number of grabs and trawls analyzed in this application for just the winter and summer surveys each year from the 12 primary core benthic stations and six current trawl stations.

| Year | Sediment Grabs[a] | | Infauna Grabs[ab] | | Community Trawls[ac] | |
|---|---|---|---|---|---|---|
| | Total | Analyzed | Total | Analyzed | Total | Analyzed |
| 1991 | 46 | 12 | 84 | 12 | 32 | 6 |
| 1992 | 92 | 24 | 168 | 24 | 64 | 12 |
| 1993 | 92 | 24 | 168 | 24 | 64 | 12 |
| 1994 | 92 | 24 | 168 | 24 | 64 | 12 |
| 1995 | 92 | 24 | 167 | 24 | 64 | 12 |
| 1996 | 92 | 24 | 168 | 24 | 32 | 12 |
| 1997 | 69 | 24 | 168 | 24 | 32 | 12 |
| 1998 | 92 | 24 | 168 | 24 | 32 | 12 |
| 1999 | 92 | 24 | 165 | 23 | 32 | 12 |
| 2000 | 92 | 24 | 168 | 24 | 32 | 12 |
| 2001 | 92 | 24 | 168 | 24 | 32 | 12 |
| 2002 | 92 | 24 | 167 | 24 | 32 | 12 |
| 2003 | 58 | 24 | 107 | 24 | 22 | 12 |
| 2004 | 34 | 24 | 70 | 24 | 12 | 12 |
| 2005 | 34 | 24 | 68 | 24 | 12 | 12 |
| 2006 | 44 | 24 | 88 | 24 | 12 | 12 |
| 2007 | 44 | 24 | 88 | 24 | 12 | 12 |
| 2008 | 34 | 24 | 68 | 24 | 8 | 8 |
| 2009 | 34 | 24 | 68 | 24 | 8 | 8 |
| 2010 | 44 | 24 | 88 | 24 | 12 | 12 |
| 2011 | 44 | 24 | 88 | 24 | 12 | 12 |
| 2012 | 34 | 24 | 68 | 24 | 12 | 12 |
| 2013 | 34 | 24 | 46 | 24 | 12 | 12 |
| 2014 | 44 | 24 | 44 | 24 | 12 | 12 |
| 2015 | 44 | 24 | 88 | 24 | 12 | 12 |
| 2016 | 44 | 24 | 44 | 24 | 3 | 3 |
| 2017 | 44 | 24 | 44 | 24 | 2 | 2 |
| 2018 | 35 | 24 | 35 | 24 | 6 | 6 |
| 2019 | 44 | 24 | 44 | 24 | 12 | 12 |
| 2020 | 44 | 24 | 44 | 24 | 12 | 12 |
| **Total** | **1,772** | **708** | **3,117** | **707** | **705** | **321** |
| Pre-discharge | 230 | 60 | 420 | 60 | 160 | 30 |
| Post-discharge | 1,542 | 648 | 2,697 | 647 | 545 | 291 |

[a] Reduced # of grabs and trawls in some years due to resource exchange agreements approved by SDRWQCB / USEPA.
[b] Six infauna grabs not analyzed due to poor preservation: (1) Stn. E23, Rep 2, Oct 1995; (2) Stn. B11, Rep 1, Jan 1999; (3) Stn. E7, Rep 2, Apr 1999; (4) Stn. E8, Rep 1, Jul 1999; (5) Stn. E20, Rep1, Oct 2002; (6) Stn. B9, Rep 2, Jan 2003.
[c] Trawls = 2 trawls/station 1991-1995 and 1 trawl/station 1996-2020; total of 19 trawls were not analyzed in 2016-2017 due to <10 minute duration.

# SECTION C1-3 | SEDIMENT CONDITIONS

The City has been monitoring marine sediment conditions in areas surrounding the extended PLOO since 1991. Benthic surveys were conducted quarterly from July 1991 through July 2003, after which sampling was modified to semiannual surveys during winter (typically January) and summer (typically July) of each year. Locations for all benthic stations sampled during these periods are shown in Figure C1-1. This section focuses on sediment particle size characteristics and the accumulation of organic solids and toxic contaminants during the pre- and post-discharge monitoring periods in order to evaluate the possible effects of wastewater discharge.

## Analyses

Sediment analyses included herein are based on data from winter and summer surveys conducted from 1991 through 2020 at the 12 primary core stations located at outfall depths (see Section C1-2 for a complete description of dataset reduction). This dataset includes 60 samples collected during the five pre-discharge surveys (summer 1991–summer 1993), and 648 samples collected during the 54 post-discharge surveys (winter 1994–summer 2020). Of the 708 total sediment samples included in this assessment, 168 have not been analyzed as part of previous Point Loma Wastewater Treatment Plant (PLWTP) modified permit applications (City of San Diego 2007c, 2015a).

The primary core stations E14, E11 and E17 are located within about 100–300 m of the outfall diffuser legs (i.e., within 200 m of the zone of initial dilution, or ZID) and are considered nearfield or near-ZID sites (Figure C1-1). Station E14 is nearest the outfall, located adjacent to the ZID boundary about 103 m west of the center of the outfall wye. This station is the site most likely to be impacted by wastewater discharge. Stations E11 and E17 are located a little farther away off the ends of the southern and northern diffuser legs, respectively. Station E11 is located about 149 m from the southern ZID boundary, while E17 is located about 197 m from the northern ZID boundary. The remaining seven "E" stations are considered farfield sites. The two "B" stations are located more than 11 km north of the discharge area and were originally selected to represent reference or control sites. However, benthic communities differed between the "B" and "E" stations prior to operation of the outfall (Smith and Riege 1994; City of San Diego 1995a). Thus, farfield station E26 was selected to represent an additional reference site. This station is located approximately 8 km north of the outfall and is considered the least likely "E" station to be impacted by wastewater discharge.

A detailed description of the analytical protocols may be obtained from the City's Environmental Chemistry Services Laboratory. Briefly, sediments were analyzed on a dry weight basis for trace metals, chlorinated pesticides, polychlorinated biphenyl compounds (PCBs), and polycyclic aromatic hydrocarbons (PAHs). Data presented in this report were primarily summarized using detected values only, with no substitutions made for analyte concentrations that fall below method detection limits (MDLs) for each parameter (Attachment C1-A). Limiting analyses to detected values (i.e., excluding non-detects) is considered a conservative way of handling contaminant concentrations as it creates a strong upward bias in the data and respective summary statistics, and therefore

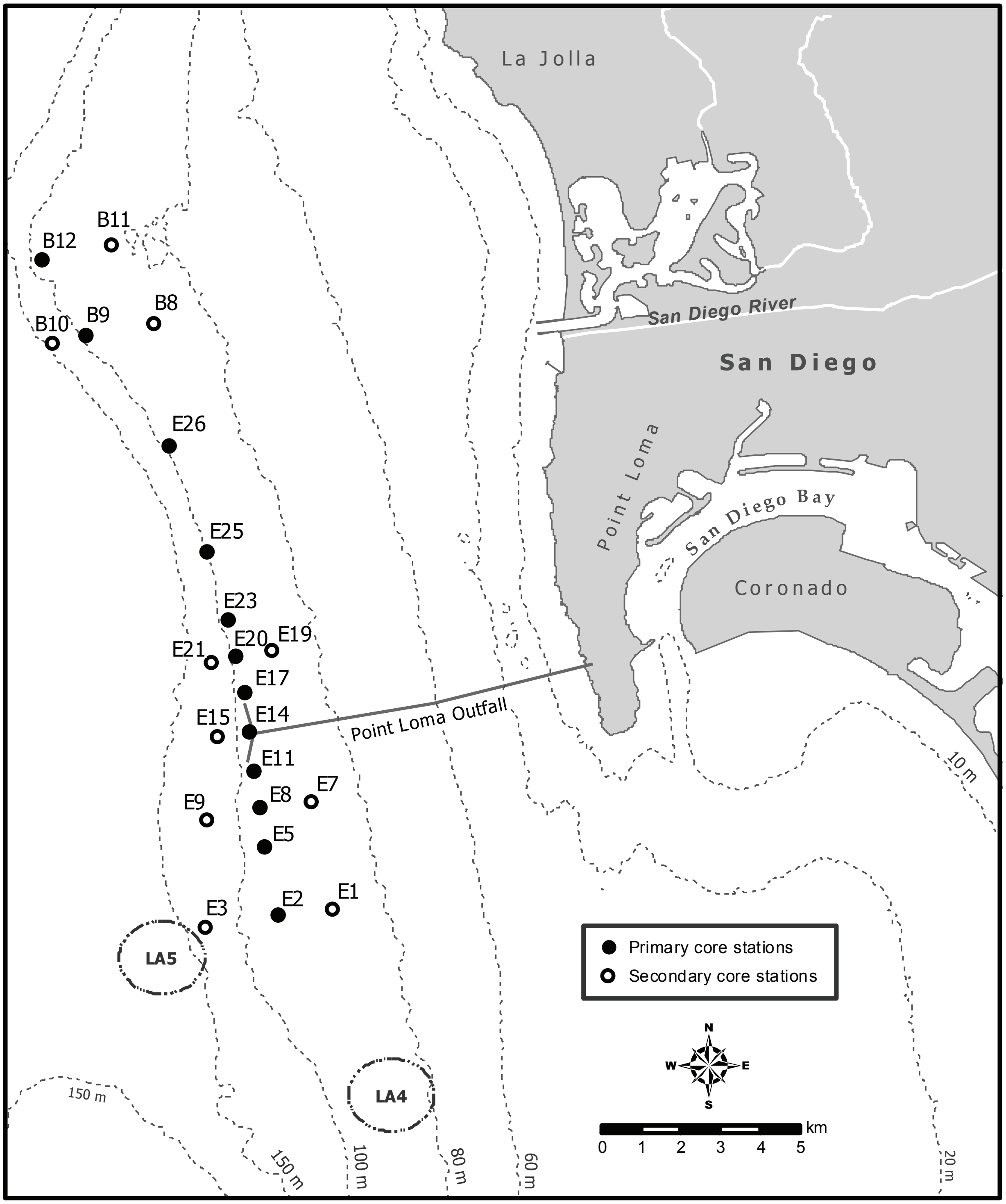


**FIGURE C1-1**

Benthic station locations sampled around the PLOO as part of the City of San Diego's Ocean Monitoring Program. Primary core stations (●) = 12 monitoring sites located along the 98-m outfall discharge depth contour that are the focus of the analyses presented in this 301(h) modified permit application. Secondary core stations (**o**) = five sites along the 88-m depth contour and five sites along the 116-m depth contour. LA-4 and LA-5 = USEPA designated dredged materials disposal sites.

may represent a worst-case scenario (e.g., see Helsel 2005a, b, 2006 for discussions of non-detect data). An exception was made for comparisons of City data to Bight survey results, as zeros were substituted for non-detects in those reports. For the sake of continuity between the various permit periods, estimated values that fell below MDLs, but confirmed by mass-spectrometry, were treated as non-detects. The exclusion of non-detects, including estimated values, represents a change from previous PLWTP modified permit applications (e.g., City of San Diego 2007c, 2015a).

Over the years, sediment particle size analyses were performed using various models of Horiba laser scattering particle analyzers, or a set of nested sieves. The Horiba measures particles ranging in size from 0.5 to 2000 micrometer (µm). Coarser sediments were removed and quantified prior to laser analysis by screening samples through a 2000 µm mesh sieve. These data were later combined with the Horiba results to obtain a complete distribution of particle sizes totaling 100%, and then classified into 11 sub-fractions and four main size fractions, based on the Wentworth scale (Folk 1980) (see Appendix C4, Attachment C4-A, in this application). When a sample contained substantial amounts of coarse sand, gravel, or shell hash that could damage the Horiba analyzer, and/or where the general distribution of sediments would be poorly represented by laser analysis, a set of nested sieves with mesh sizes of 2000 µm, 1000 µm, 500 µm, 250 µm, 125 µm, 75 µm, and 63 µm was used to divide the samples into seven sub-fractions.

The following parameters were evaluated to assess impacts on the sediments. Particle size parameters included fine particles (silt and clay subfractions combined), fine sands (very fine sand and fine sand subfractions combined), med-coarse sands (medium sand and coarse sand subfractions combined), and coarse particles (materials >1.0 mm in diameter) (see Attachment C4-A). Measures of organic loading included total organic carbon (TOC), total volatile solids (TVS), total nitrogen (TN), biochemical oxygen demand (BOD), and sulfides. Trace metals examined and summarized herein include aluminum, arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. In addition, sediment concentrations of the pesticide dichloro-diphenyl-trichloroethane (DDT), PCBs, and PAHs were evaluated. Continuity issues for summed parameters, like changes in the constituents analyzed, were addressed as follows: (1) total DDT was calculated without 2,2-bis(4-chlorophenyl)-1-chloroethylene (p,p-DDMU) (detected in <5% of samples at concentrations less than 58 ppt); (2) total PCB was calculated two ways, summed for all congeners detected in each sample (see Attachment C1-A), and summed for just the congeners that were analyzed across all years (i.e., excluding PCB 8, PCB 52, PCB 195, PCB 200, PCB 206); (3) total PAH was also calculated two ways, summed for all constituents detected in each sample (see Attachment C1-A), and summed for just the constituents that were analyzed across all years (i.e., excluding biphenyl, perylene, 2,3,5-trimethylnaphthalene, benzo[e]pyrene, 1-methylnaphthalene, 1-methylphenanthrene, 2,6-dimethylnaphthalene, 2-methylnaphthalene). Total DDT, PCB and PAH values that were missing constituents due to non-reportable results were also excluded from analyses (see City of San Diego 2018, 2020b, 2021a). Data for additional metals such as antimony, barium, thallium and tin, and chlorinated pesticides such as hexachlorobenzene, that occur sporadically off Point Loma and are generally present in very low concentrations are available in the City's annual monitoring reports (e.g., City of San Diego 2020b, 2021a).

The focus of most comparisons in this appendix is between conditions present during the 2.5-year pre-discharge period (July 1991-1993) and the entire 27-year post-discharge period (1994-2020). Exceptions are noted when data were not available for part of the pre-discharge period for specific parameters. Additionally, the post-discharge period is broken down into three periods (1994-2008, 2009-2013, 2013-2020) in some tables and figures to emphasize any patterns or trends during the period since the last PLWTP modified permit application. Finally, presentations of results over time at each primary core station are limited to data collected only during the summer (typically July) surveys to minimize differences due to natural seasonal fluctuations.

## Results

### *Particle Size Distribution*

Measurement of sediment particle size allows for a better interpretation of the interaction of benthic animals with the environment. For example, differences in sediment composition (e.g., fine vs. coarse particles) and associated levels of organic loading can affect the burrowing, tube building and feeding preferences of infaunal invertebrates, thus leading to changes in benthic community structure. Parameters such as particle size and the proportion of silt and clay combined (i.e., fine particles or percent fines), sand, and coarser particles (e.g., pebbles, gravel, shell hash) can be indicative of the hydrodynamic regime in the benthos, while physical properties of the sediments (i.e., size, shape, density, mineralogy) interact with deposited organic particles to create altered conditions in sediment carbon coupling at the boundary layer.

Particle size characteristics of sediments around the Point Loma outfall are summarized in Tables C1-2, C1-3 and C1-4 as fine particles (percent fines), fine sands, medium-coarse sands, and coarse particles, while trends for percent fines and percent coarse particles are presented in Figures C1-2 and C1-3, respectively. Overall, sediment composition has changed very little across the region during the past 29 years. For example, the percentage of fine particles averaged 40% at the primary core stations during the pre-discharge period and 41% during the post-discharge period, and were generally within the tolerance interval bounds of 24-66% for the San Diego mainland shelf (see Appendix C2, this application). However, the percentage of fine particles was higher region-wide in 2019-2020 than in previous years. This increase was also observed within the South Bay Ocean Outfall monitoring area (City of San Diego 2020b). Since it is unlikely that fine sediment would suddenly appear across such a large segment of the coastal shelf all at once (Dr. P. E. Parnell, Scripps Institution of Oceanography, personal communication, May 2020), further investigation is underway to determine the origins of this dramatic change.

Temporal variability of sediment composition at individual sites has been primarily in the sand and coarse fractions. For example, sediments at near-ZID station E14 have become slightly coarser since discharge began, averaging about 39% fines overall in 1991-1993 and only 32% fines since that time (Table C1-4). This change is likely related to the movement of ballast materials used to support the outfall pipe and the presence of patchy sediments in the area. The latter is evident in Figure C1-3 that shows the sporadic occurrence of very coarse sediments at this near-ZID site. Relic reef sediments at northern reference station B12 have also frequently been characterized by the presence of very coarse materials such as shell hash and gravel that

**TABLE C1-2**

Comparison of select sediment particle size and chemistry data for the PLOO benthic stations with data from the Southern California Bight (SCB) 1994, 1998, 2003, 2008, 2013, and 2018 regional surveys and annual San Diego regional surveys (1995−2020). PLOO data are presented for 98-m outfall depth stations sampled during winter and summer surveys with data expressed as means for all 12 stations combined during the pre-discharge (Pre-Dis; 1991−1993) and post-discharge (Post-Dis; 1994−2020) periods. For comparison to Bight values, zeros have been substituted for non-detects. SCB and San Diego regional survey data are expressed as mean values for the “mid-shelf” strata. Med = medium.

| | Southern California Bight Regional Surveys | | | | | | San Diego Regional Surveys | PLOO Surveys (1991−2020) | |
|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 1998 | 2003 | 2008 | 2013 | 2018 | | Pre-Dis | Post-Dis |
| **Particle Size (%)**[a] | | | | | | | | | |
| Fine Particles | 43 | 32 | 45 | 47 | 48 | 35 | 39 | 40 | 41 |
| Fine Sands | — | — | — | — | — | — | 46 | 57 | 55 |
| Med-Coarse Sands | — | — | — | — | — | — | 14 | 3 | 3 |
| Coarse Particles | — | — | — | — | — | — | 2 | 0 | 1 |
| **Organic Indicators**[c] | | | | | | | | | |
| TOC (%) | 0.7 | 0.9 | 0.8 | 1.0 | 0.7 | 0.7 | 0.6 | 0.5 | 0.7 |
| TVS (%) | — | — | — | — | — | — | 2.37 | 2.15 | 2.31 |
| TN (%) | 0.05 | 0.09 | 0.05 | 0.07 | 0.07 | 0.06 | 0.05 | 0.04 | 0.05 |
| BOD (ppm) | — | — | — | — | — | — | 319 | 270 | 303 |
| Sulfides (ppm) | — | — | — | — | — | — | 5.8 | 1.2 | 6.0 |
| **Metals (ppm)** | | | | | | | | | |
| Aluminum[b] | 10,500 | — | 13,165 | 10,035 | 13,000 | 9,600 | 9,932 | — | 9,121 |
| Arsenic | 5.1 | 5.6 | 4.1 | 6.1 | 2.7 | 4.4 | 3.5 | 2.4 | 3.1 |
| Beryllium | 0.2 | — | 0.6 | 0.3 | 0.2 | 0.4 | 0.1 | 0.4 | 0.2 |
| Cadmium | 0.3 | 0.4 | 0.4 | 0.3 | 0.7 | 0.6 | 0.1 | 1.3 | 0.2 |
| Chromium | 39 | 30 | 36 | 31 | 30 | 28 | 18 | 17 | 17 |
| Copper | 15 | 13 | 12 | 11 | 8 | 7 | 8 | 7 | 7 |
| Iron[b] | 18,600 | — | 19,511 | 20,724 | 18,000 | 19,000 | 13,137 | 12,408 | 12,665 |
| Lead | 11 | 12 | 7 | 8 | 7 | 6 | 5 | 2 | 3 |
| Manganese[b] | — | — | — | — | — | — | 113.2 | — | 99.7 |
| Mercury | 0.05 | 0.04 | 0.10 | 0.05 | 0.05 | 0.05 | 0.02 | 0.01 | 0.02 |
| Nickel | 18 | 23 | 14 | 12 | 15 | 12 | 7 | 7 | 7 |
| Selenium | 0.3 | 0.8 | 1.2 | 0.7 | 0.1 | 0.8 | 0.1 | 0.2 | 0.1 |
| Silver | 0.3 | 0.5 | 0.1 | 0.2 | 0.3 | 0.1 | 0.2 | 0.1 | 0.3 |
| Zinc | 59 | 58 | 47 | 46 | 48 | 45 | 31 | 28 | 28 |
| **Total DDT (ppt)** | 40,800 | 53,830 | 36,000 | 16,000 | 18,000 | 13,000 | 1,069 | 1,247 | 579 |
| **Total PCB (ppt)** | Aro[d] | 6,460 | 2,400 | 13,000 | 2,700 | 4,300 | 1,195 | Aro[d] | 147[d] |
| **Total PAH (ppb)** | <330.0 | 67.3 | 60.3 | 17.9 | 55.0 | 67.0 | 27.5 | 0.0 | 20 |

[a] Particle size not available before 1992 for PLOO surveys (i.e., 1991 data not comparable).
[b] TOC, TN, iron not measured before 1993, aluminum not measured before 1994, manganese not measured before 1996 for PLOO surveys.
[c] TVS, BOD and sulfides missing Bight values; BOD, sulfides also missing SCCWRP Reference Survey values.
[d] PCBs neasured as Aroclors (Aro) through April 1998, so values are limited to PCB congeners measured afterwards.

**TABLE C1-3**
Summary of sediment particle size and chemistry detection rates for PLOO primary core stations located at outfall depths (n=12). Data are for winter and summer surveys only from 1991–2020; pre-discharge surveys = 1991–1993 (n=5); post-discharge surveys = 1994–2020 (n=54). See text for details of data reductions. N = total number of samples; Detect = number of samples with detected results; Freq = detection rate (Detect/N); Med = medium.

| | Pre-Discharge 1991–1993 | | | 1994–2008 Post-Discharge | | | 2009–2013 Post-Discharge | | | 2014–2020 Post-Discharge | | | All Post-Discharge | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Detect | Freq | N | Detect | Freq | N | Detect | Freq | N | Detect | Freq | N | Detect | Freq |
| **Partice Size (%)**[a] | | | | | | | | | | | | | | | |
| Fine Particles | 48 | 48 | 100 | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 648 | 100 |
| Fine Sands | 48 | 48 | 100 | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 648 | 100 |
| Med-Coarse Sands | 48 | 48 | 100 | 360 | 333 | 93 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 621 | 96 |
| Coarse Particles | 48 | 9 | 19 | 360 | 105 | 29 | 120 | 14 | 12 | 168 | 26 | 15 | 648 | 145 | 22 |
| **Organic Indicators** | | | | | | | | | | | | | | | |
| TOC (%)[b] | 24 | 24 | 100 | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 648 | 100 |
| TVS (%) | 60 | 60 | 100 | 359 | 359 | 100 | 120 | 120 | 100 | 166 | 166 | 100 | 645 | 645 | 100 |
| TN (%)[b] | 24 | 24 | 100 | 359 | 351 | 98 | 120 | 120 | 100 | 168 | 168 | 100 | 647 | 639 | 99 |
| BOD (ppm) | 58 | 58 | 100 | 318 | 318 | 100 | 108 | 107 | 99 | 142 | 142 | 100 | 568 | 567 | 100 |
| Sulfides (ppm) | 60 | 45 | 75 | 360 | 352 | 98 | 118 | 118 | 100 | 167 | 161 | 96 | 645 | 631 | 98 |
| **Metals (ppm)** | | | | | | | | | | | | | | | |
| Aluminum[b] | — | — | — | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 648 | 100 |
| Arsenic | 60 | 60 | 100 | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 648 | 100 |
| Beryllium | 60 | 27 | 45 | 360 | 134 | 37 | 120 | 96 | 80 | 168 | 86 | 51 | 648 | 316 | 49 |
| Cadmium | 60 | 29 | 48 | 360 | 156 | 43 | 120 | 104 | 87 | 168 | 64 | 38 | 648 | 324 | 50 |
| Chromium | 60 | 60 | 100 | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 648 | 100 |
| Copper | 60 | 60 | 100 | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 165 | 98 | 648 | 645 | 100 |
| Iron[b] | 24 | 24 | 100 | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 648 | 100 |
| Lead | 60 | 16 | 27 | 360 | 175 | 49 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 463 | 71 |
| Manganese[b] | — | — | — | 312 | 312 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 600 | 600 | 100 |
| Mercury | 60 | 17 | 28 | 359 | 189 | 53 | 120 | 120 | 100 | 160 | 148 | 93 | 639 | 457 | 72 |
| Nickel | 60 | 58 | 97 | 360 | 337 | 94 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 625 | 96 |
| Selenium | 60 | 34 | 57 | 360 | 206 | 57 | 120 | 31 | 26 | 168 | 53 | 32 | 648 | 290 | 45 |
| Silver | 60 | 2 | 3 | 360 | 78 | 22 | 120 | 16 | 13 | 168 | 2 | 1 | 648 | 96 | 15 |
| Zinc | 60 | 60 | 100 | 360 | 360 | 100 | 120 | 120 | 100 | 168 | 168 | 100 | 648 | 648 | 100 |
| **Pesticides, PCBs, PAHs** | | | | | | | | | | | | | | | |
| Total DDT (ppt) | 60 | 37 | 62 | 360 | 102 | 28 | 120 | 52 | 43 | 148 | 147 | 99 | 628 | 301 | 48 |
| Total PCB (ppt)[c] | — | — | — | 252 | 2 | 1 | 120 | 7 | 6 | 154 | 75 | 49 | 526 | 84 | 16 |
| Total PCB Lim (ppt)[c] | — | — | — | 252 | 1 | 0 | 120 | 7 | 6 | 154 | 75 | 49 | 526 | 83 | 16 |
| Total PAH (ppb)[d] | 60 | 0 | 0 | 342 | 89 | 26 | 120 | 7 | 6 | 159 | 38 | 24 | 621 | 134 | 22 |
| Total PAH Lim (ppb)[d] | 60 | 0 | 0 | 342 | 87 | 25 | 120 | 7 | 6 | 159 | 25 | 16 | 621 | 119 | 19 |

[a] Particle size not available before 1992.
[b] TOC, TN, iron not measured before 1993, aluminum not measured before 1994, manganese not measured before 1996
[c] PCBs measured as Aroclors prior to April 1998 and as congeners thereafter; therefore PCB data reported herein are limited to congeners only for 1998-2020.
[d] Total PAH calculated two ways: with all detected constituents, and limited to constituents analyzed across all years.

**TABLE C1-4**

Summary of sediment particle size and chemistry data for PLOO primary core stations located at outfall depths (n=12). Data are for winter and summer surveys only from 1991−2020; pre-discharge surveys = 1991−1993 (n=5); post-discharge surveys = 1994−2020 (n=54). Med = medium. See text for details of data reductions.

| | Pre-Disharge (1991−1993) | | | | | 1994−2008 Post-Disharge | | | 2009−2013 Post-Disharge | | | 2014−2020 Post-Disharge | | | All Post-Disharge | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Sites | | | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | | | Outfall Stn. E14 | Ref. Stn. B9 |
| | Mean | Min | Max | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Min | Max | Mean | Mean |
| **Partice Size (%)**[a] | | | | | | | | | | | | | | | | | | | |
| Fine Particles | 40 | 28 | 52 | 39 | 42 | 39 | 31 | 43 | 44 | 34 | 50 | 43 | 31 | 52 | 41 | 11 | 74 | 32 | 47 |
| Fine Sands | 57 | 46 | 69 | 60 | 55 | 56 | 62 | 53 | 53 | 56 | 49 | 53 | 62 | 47 | 55 | 12 | 86 | 61 | 50 |
| Med-Coarse Sands | 3 | 0 | 20 | 1 | 2 | 4 | 2 | 4 | 2 | 3 | 1 | 3 | 3 | 1 | 3 | 0 | 65 | 2 | 3 |
| Coarse Particles | 1 | 0 | 2 | 1 | 1 | 4 | 11 | 3 | 8 | 17 | 1 | 5 | 19 | 0 | 5 | 0 | 64 | 13 | 3 |
| **Organic Indicators** | | | | | | | | | | | | | | | | | | | |
| TOC (%)[b] | 0.53 | 0.41 | 1.04 | 0.47 | 0.58 | 0.65 | 0.45 | 0.67 | 0.83 | 0.54 | 0.82 | 0.57 | 0.35 | 0.66 | 0.66 | 0.13 | 4.85 | 0.44 | 0.69 |
| TVS (%) | 2.15 | 1.00 | 3.30 | 2.07 | 2.37 | 2.46 | 1.94 | 3.01 | 2.29 | 1.73 | 3.12 | 2.03 | 1.52 | 2.59 | 2.31 | 1.02 | 5.42 | 1.79 | 2.92 |
| TN (%)[b] | 0.04 | 0.02 | 0.06 | 0.03 | 0.05 | 0.05 | 0.04 | 0.06 | 0.05 | 0.05 | 0.07 | 0.05 | 0.04 | 0.06 | 0.05 | 0.01 | 0.19 | 0.04 | 0.06 |
| BOD (ppm) | 270 | 95 | 501 | 254 | 301 | 310 | 417 | 311 | 306 | 356 | 341 | 287 | 416 | 276 | 304 | 121 | 980 | 405 | 309 |
| Sulfides (ppm) | 1.6 | 0.5 | 5.4 | 2.1 | 0.9 | 5.0 | 18.2 | 1.5 | 6.9 | 29.1 | 4.9 | 8.2 | 30.7 | 5.4 | 6.2 | 0.1 | 108.0 | 23.5 | 3.1 |
| **Metals (ppm)** | | | | | | | | | | | | | | | | | | | |
| Aluminum[a] | — | — | — | — | — | 10,160 | 7,982 | 10,747 | 8,412 | 7,207 | 9,434 | 7,400 | 5,499 | 8,381 | 9,121 | 3,130 | 22,800 | 7,195 | 9,891 |
| Arsenic | 2.4 | 1.4 | 4.0 | 2.2 | 2.1 | 3.3 | 3.6 | 3.5 | 3.0 | 3.2 | 3.6 | 2.6 | 2.0 | 2.9 | 3.1 | 1.2 | 7.8 | 3.1 | 3.3 |
| Beryllium | 0.8 | 0.2 | 2.0 | 1.0 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 | 0.2 | 0.3 | 0.2 | 0.1 | 0.2 | 0.4 | 0.0 | 3.1 | 0.3 | 0.3 |
| Cadmium | 2.6 | 0.5 | 5.7 | 1.9 | 3.3 | 0.6 | 0.5 | 0.6 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.3 | 0.0 | 5.7 | 0.3 | 0.4 |
| Chromium | 17.3 | 9.0 | 32.4 | 15.8 | 21.8 | 17.5 | 15.1 | 22.5 | 15.9 | 13.3 | 21.3 | 16.3 | 12.2 | 21.9 | 16.9 | 7.0 | 40.6 | 14.0 | 22.1 |
| Copper | 7.4 | 4.0 | 16.0 | 6.7 | 6.8 | 8.3 | 7.4 | 10.2 | 7.2 | 7.1 | 7.7 | 4.9 | 4.4 | 5.1 | 7.2 | 0.9 | 82.4 | 6.6 | 8.4 |
| Iron[a] | 12,408 | 9,700 | 20,300 | 10,250 | 14,450 | 13,731 | 10,840 | 17,760 | 11,542 | 9,081 | 15,570 | 11,181 | 7,534 | 15,043 | 12,665 | 4,840 | 27,200 | 9,657 | 16,650 |
| Lead | 6.9 | 5.0 | 12.0 | 5.1 | 5.8 | 5.5 | 3.7 | 6.5 | 5.5 | 5.0 | 6.6 | 3.3 | 2.3 | 4.2 | 4.7 | 1.2 | 15.5 | 3.5 | 5.6 |
| Manganese[a] | — | — | — | — | — | 109.4 | 95.5 | 120.6 | 96.8 | 90.6 | 106.4 | 83.8 | 69.7 | 96.6 | 99.7 | 31.5 | 317.0 | 87.3 | 111.0 |
| Mercury | 0.034 | 0.011 | 0.093 | 0.015 | 0.011 | 0.033 | 0.026 | 0.031 | 0.026 | 0.019 | 0.027 | 0.020 | 0.014 | 0.026 | 0.027 | 0.004 | 0.089 | 0.020 | 0.028 |
| Nickel | 6.9 | 3.0 | 10.0 | 7.2 | 7.3 | 7.6 | 8.1 | 8.3 | 7.2 | 6.9 | 8.6 | 6.0 | 5.3 | 7.1 | 7.1 | 2.5 | 29.0 | 7.1 | 8.0 |
| Selenium | 0.3 | 0.1 | 0.9 | 0.4 | 0.4 | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | 0.6 | 0.3 | 0.3 | 0.4 | 0.3 | 0.1 | 0.8 | 0.3 | 0.3 |
| Silver | 3.5 | 3.0 | 4.0 | nd | 3.0 | 1.0 | 0.4 | 1.1 | 1.7 | 1.2 | 0.5 | 35.3 | nd | nd | 1.8 | 0.0 | 67.4 | 0.5 | 0.9 |
| Zinc | 28.0 | 18.0 | 47.0 | 25.2 | 31.6 | 29.3 | 24.5 | 39.6 | 28.3 | 24.9 | 36.0 | 25.9 | 20.0 | 33.4 | 28.2 | 12.4 | 176.0 | 23.4 | 37.3 |
| **Pesticides, PCBs, PAHs** | | | | | | | | | | | | | | | | | | | |
| Total DDT (ppt) | 2,022 | 1,000 | 7,300 | 1,617 | 1,640 | 2,254 | 1,149 | 7,905 | 975 | 1,405 | 2,965 | 564 | 243 | 1,939 | 1,208 | 88 | 44,830 | 656 | 4,002 |
| Total PCB (ppt)[c] | — | — | — | — | — | 2,460 | nd | nd | 1,360 | nd | nd | 836 | 92 | 250 | 919 | 30 | 22,690 | 92 | 250 |
| Total PCB Lim (ppt)[c] | — | — | — | — | — | 1,720 | nd | nd | 1,227 | nd | nd | 794 | 92 | 250 | 842 | 21 | 21,090 | 92 | 250 |
| TotalPAH (ppb)[d] | nd | nd | nd | nd | nd | 116 | 74 | 144 | 121 | nd | nd | 33 | 8 | 11 | 93 | 4 | 3,024 | 58 | 91 |
| TotalPAH Lim (ppb)[d] | nd | nd | nd | nd | nd | 82 | 29 | 89 | 121 | nd | nd | 38 | nd | 7 | 75 | 4 | 2,680 | 29 | 69 |

[a] Grain size not available before 1992.
[b] TOC, TN, iron not measured before 1993, aluminum not measured before 1994, manganese not measured before 1996
[c] PCBs measured as Aroclors prior to April 1998 and as congeners thereafter; therefore PCB data reported herein are limited to congeners only for 1998-2020.
[d] Total PAH calculated two ways: with all detected constituents, and limited to constituents analyzed across all years.

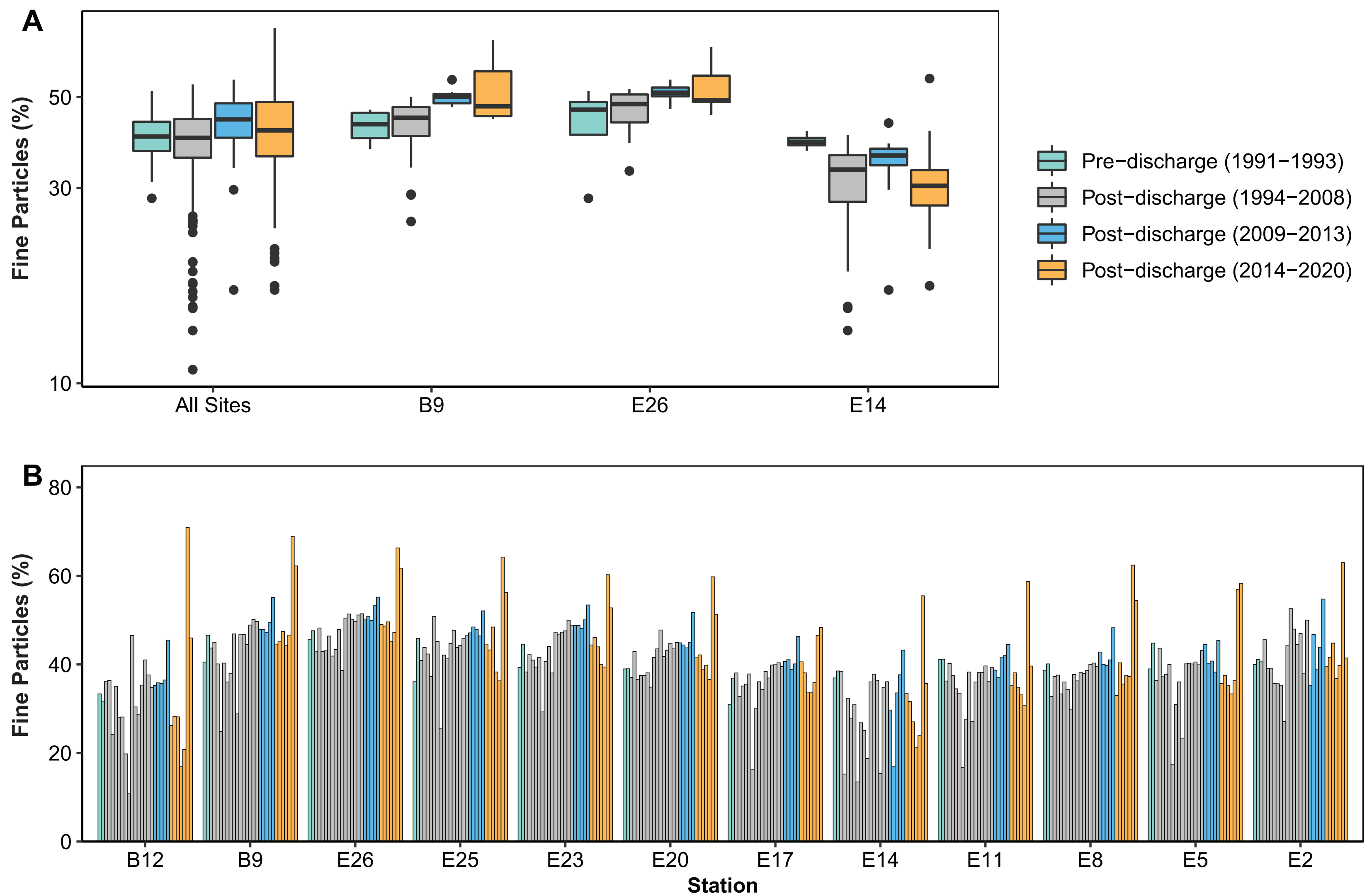


**FIGURE C1-2**

Percent fine particles (silt and clay) in sediments at outfall discharge depths near the PLOO from 1992 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

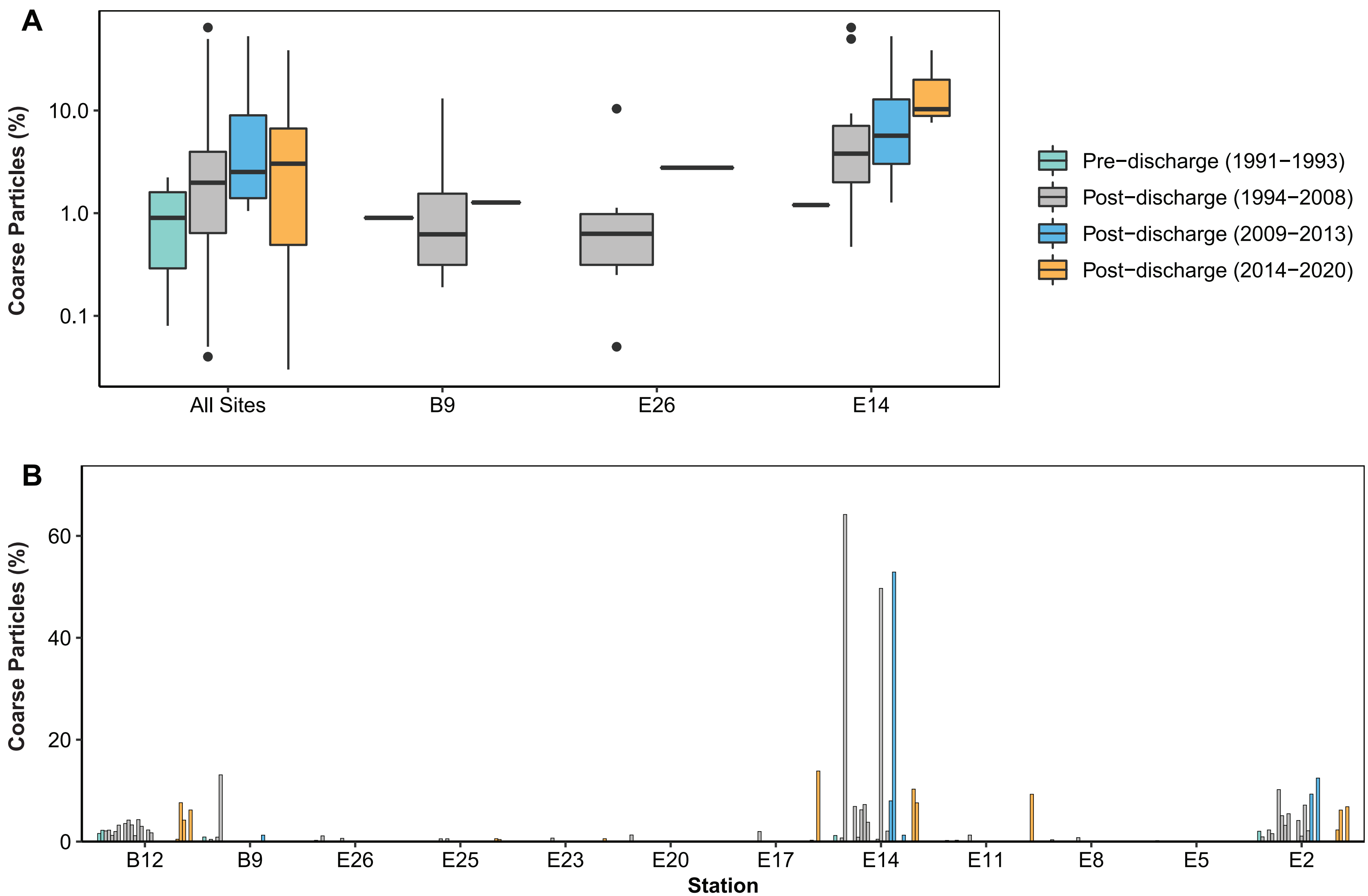


**FIGURE C1-3**
Percent coarse particles in sediments at outfall discharge depths near the PLOO from 1992 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

distinguish this station from most other sites along the outfall discharge depth contour. Relatively coarse materials have also been characteristic of the southernmost station E2, located on the way to LA-5 dredge materials disposal site where contaminated sediments dredged from San Diego Bay were deposited, and possibly impacted by "short dumps" (SAIC 1990, Anderson et al. 1993, Gardner et al. 1998, Steinberger et al. 2003). Overall, there appear to be no consistent changes over time that might correspond to effects caused by the discharge of wastewater, and even with the changes reported at station E14, more than 98% of samples had coarse particles within the tolerance interval bounds of 0-9% for the San Diego mainland shelf (see Appendix C2).

*Organic Loading Indicators*

Indicators of organic loading (enrichment) in benthic sediments, including TOC, TVS, TN, BOD, and sulfides were detected in almost all of the sediment samples collected at the primary core stations during pre-discharge surveys (75-100%) as well as during post-discharge surveys (98-100%) (Table C1-3). Of these, TOC and TVS represent the more direct measurements of carbon imported as fine particulate matter.

**Total Organic Carbon (TOC)**: TOC is a direct measurement of carbon derived from organic matter. It was not analyzed for sediments prior to October 1992, and therefore pre-discharge values represent data for only the winter and summer 1993 surveys. TOC values off Point Loma were generally similar to, or slightly less than, those from reference areas in the SCB as well as for other regional stations monitored off San Diego each year (Table C1-2). For example, all near-ZID stations, and more than 95% of the farfield stations, had TOC values below the upper tolerance interval bound (i.e., the threshold for the direction of response predicted from environmental impact) of 1.50% for the San Diego mainland shelf (see Appendix C2).

Operation of the Point Loma outfall has had no significant effect on TOC concentrations in local sediments, with TOC averaging 0.53% at all sites during the pre-discharge period and 0.66% during the post-discharge period (Table C1-4). There was little difference in concentrations recorded near the outfall (e.g., station E14) and at reference sites farther away (e.g., station B9). Although TOC concentrations at northern station B12 have been highly variable, comparisons to summer survey data from the other outfall depth sites revealed no discharge related spatial or temporal patterns (Figure C1-4). The absence of TOC accumulation in the area indicates that sediment microbes and organisms off Point Loma can maintain oxidative metabolism at a rate exceeding carbon input.

**Total Volatile Solids (TVS)**: TVS is a measure of organic carbon and nitrogenous material that can be metabolized and solubilized in both receiving waters and sediments. TVS levels averaged 2.15% at all sites prior to discharge and 2.31% afterwards (Table C1-4). These levels are typical of background conditions that occur in sediments up to 200 m depth in the SCB (see Bascom et al. 1979), which indicate that wastewater discharge via the outfall has not had any impact in terms of TVS. In fact, average TVS concentrations have decreased slightly nearest the outfall since discharge began, with values at near-ZID station E14 remaining lower or similar to sites located farther away since that time (Figure C1-5B). For example, 3% of samples from near-ZID stations were below the lower tolerance interval bound for the San Diego region of 1.6%, versus 2% of samples from farfield stations. Less than 1% of samples from near-ZID and farfield sites were above the upper tolerance interval bound of 4.2% for the San Diego mainland shelf (see Appendix C2).

**Total Nitrogen (TN)**: TN is a direct measure of nitrogenous material. It was not analyzed for sediments prior to October 1992, and therefore pre-discharge values represent data for only the winter and summer 1993 surveys. Sediment nitrogen concentrations averaged 0.04% at all sites during the pre-discharge period and 0.05% during the post-discharge period (Table C1-4). TN values off Point Loma were generally similar to or slightly less than those from reference areas in the SCB as well as for other regional stations monitored off San Diego (Table C1-2). For example, all near-ZID stations, and more than 99% of farfield stations, had TN values below the upper tolerance interval bound of 0.10% for the San Diego mainland shelf (see Appendix C2). No apparent outfall effects were evident, although nitrogen levels appear slightly higher at almost all sites during the 1994-2013 post-discharge years compared to values in 1993, as well as during the post-discharge period of 2009-2013) (Figure C1-6A). Comparison of data for the summer surveys indicated no pattern consistent with an outfall effect (Figure C1-6B).

**Biochemical Oxygen Demand (BOD)**: BOD is a measure of the level of oxidative metabolism of discharged organic material by bacteria. There was a slight increase in BOD concentrations in sediments at sites off Point Loma between the pre- and post-discharge periods (Figure C1-7). The greatest increase in BOD since wastewater discharge began occurred at near-ZID station E14. The pattern of slightly higher BOD at station E14 is consistent with predictions that a light sprinkling of organic material from the outfall might occur within or near the ZID. Overall, BOD averaged 270 parts per million (ppm) at outfall depths during the pre-discharge surveys and 304 ppm afterwards (Table C1-4). These values were well within the range of typical background concentrations of 250-1,000 ppm that have been reported for SCB sediments (e.g., Bascom 1979, Word and Mearns 1979), and were similar to mean values reported for regional stations sampled at mid-shelf depths off San Diego (Table C1-2). For example, only 3% of samples from near-ZID stations had BOD values above the upper tolerance interval bound for the San Diego mainland shelf of 440 ppm, versus 5% of samples from farfield stations (see Appendix C2). However, the analysis of BOD for determining tolerance intervals was limited to four regional surveys (1995, 1996, 1997, 1999).

**Sulfides**: The concentration of various dissolved sulfide forms, reported as total sulfides, is measured in sediments as an indicator of hypoxic/anoxic conditions created by the decomposition of organic matter that are averse to benthic organisms. Sulfide concentrations reported from primary core stations showed a distinct outfall related pattern near the PLOO. Concentrations increased sharply immediately after discharge began at near-ZID station E14 located about 103 m west of the outfall wye at the edge of the ZID, and to a lesser extent at stations E11 and E17 located approximately 150-200 m from the edges of the southern and northern ZID boundaries, respectively (Figure C1-8B). Detected concentrations of sulfides at E14 increased from an average of 2.1 ppm prior to discharge to 23.5 ppm afterwards (Table C1-4). Although sediment sulfides were not measured in the SCB reference surveys by means similar to the City's ocean monitoring program, comparable measurements have detected sulfide levels exceeding 50 ppm off Newport Beach (e.g., CSDOC 1993) and greater than 500 ppm near the terminated 7-mile sludge outfall in Santa Monica Bay (City of Los Angeles 1990). Results from PLOO primary core stations were

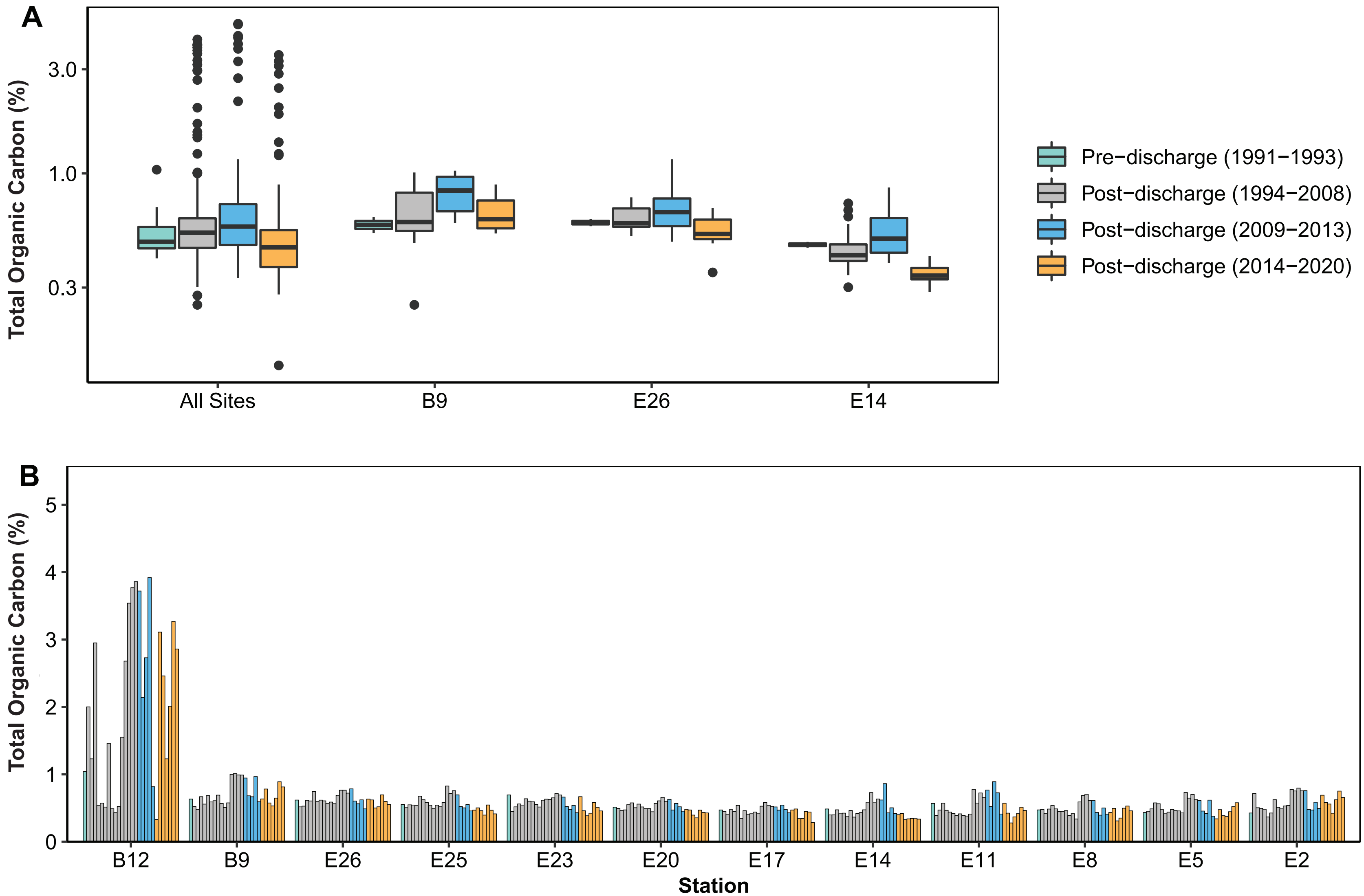


**FIGURE C1-4**

Total organic carbon in sediments at outfall discharge depths near the PLOO from 1993 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

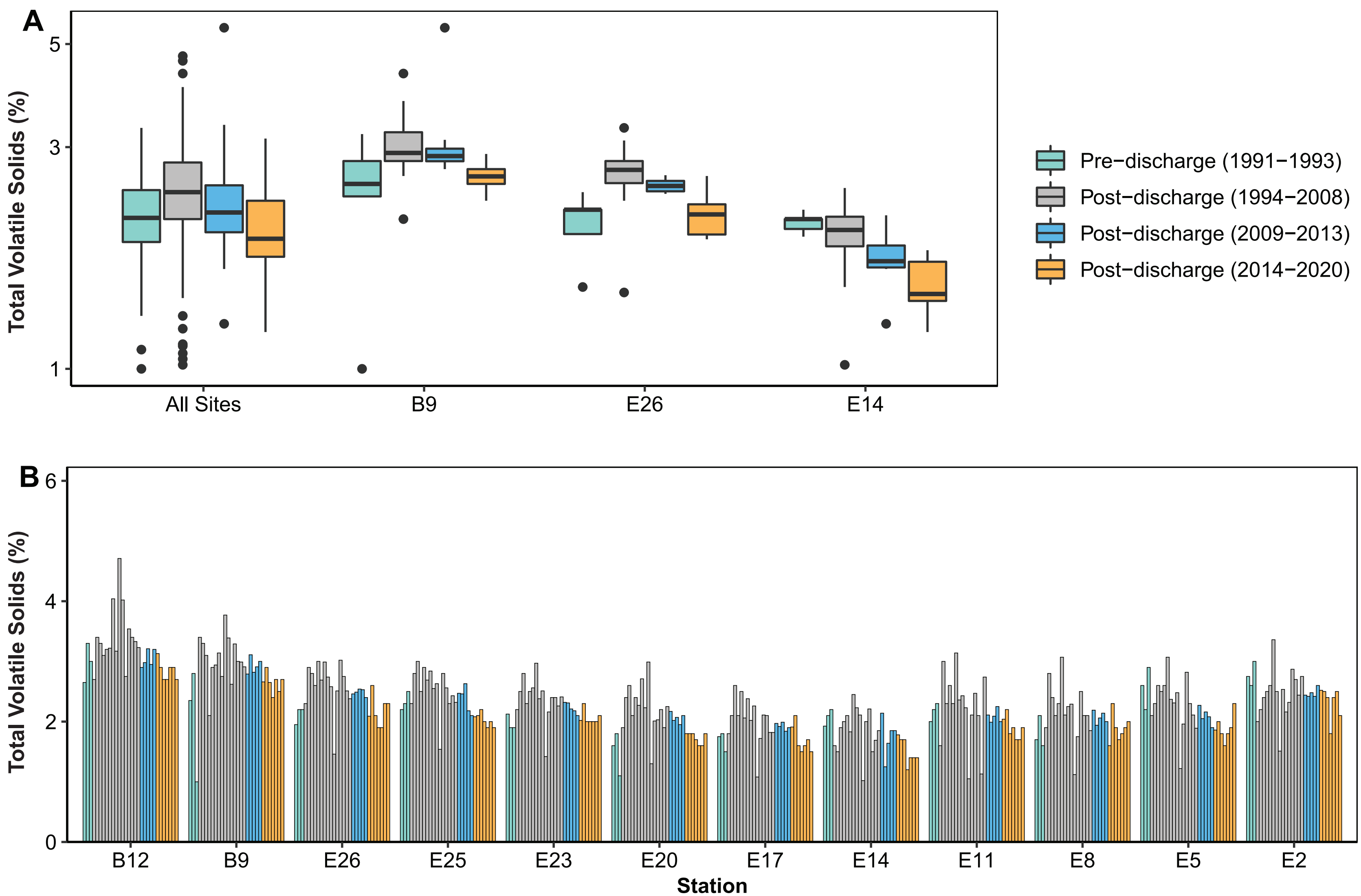


**FIGURE C1-5**
Total volatile solids in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

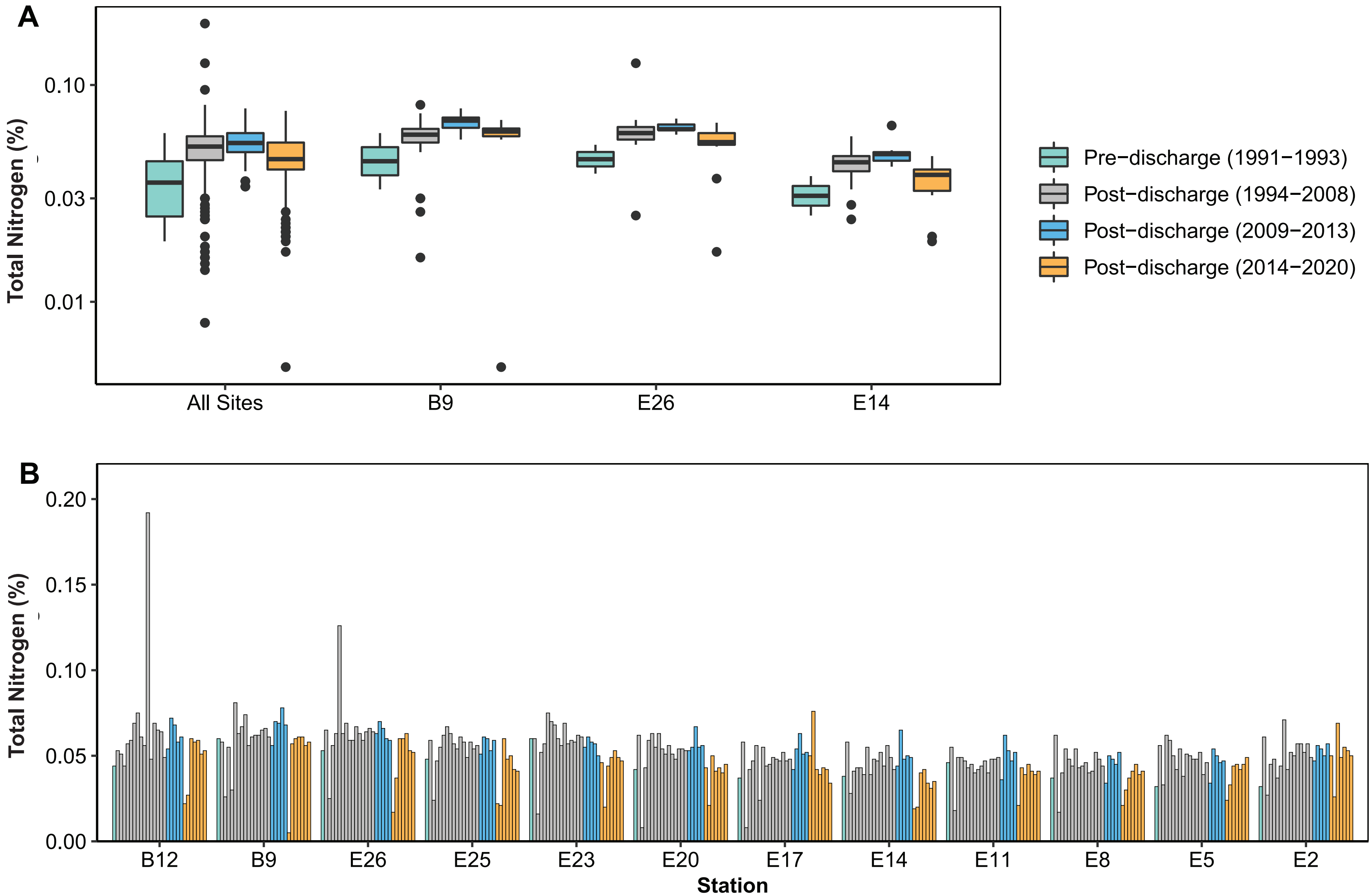


**FIGURE C1-6**
Total nitrogen in sediments at outfall discharge depths near the PLOO from 1993 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

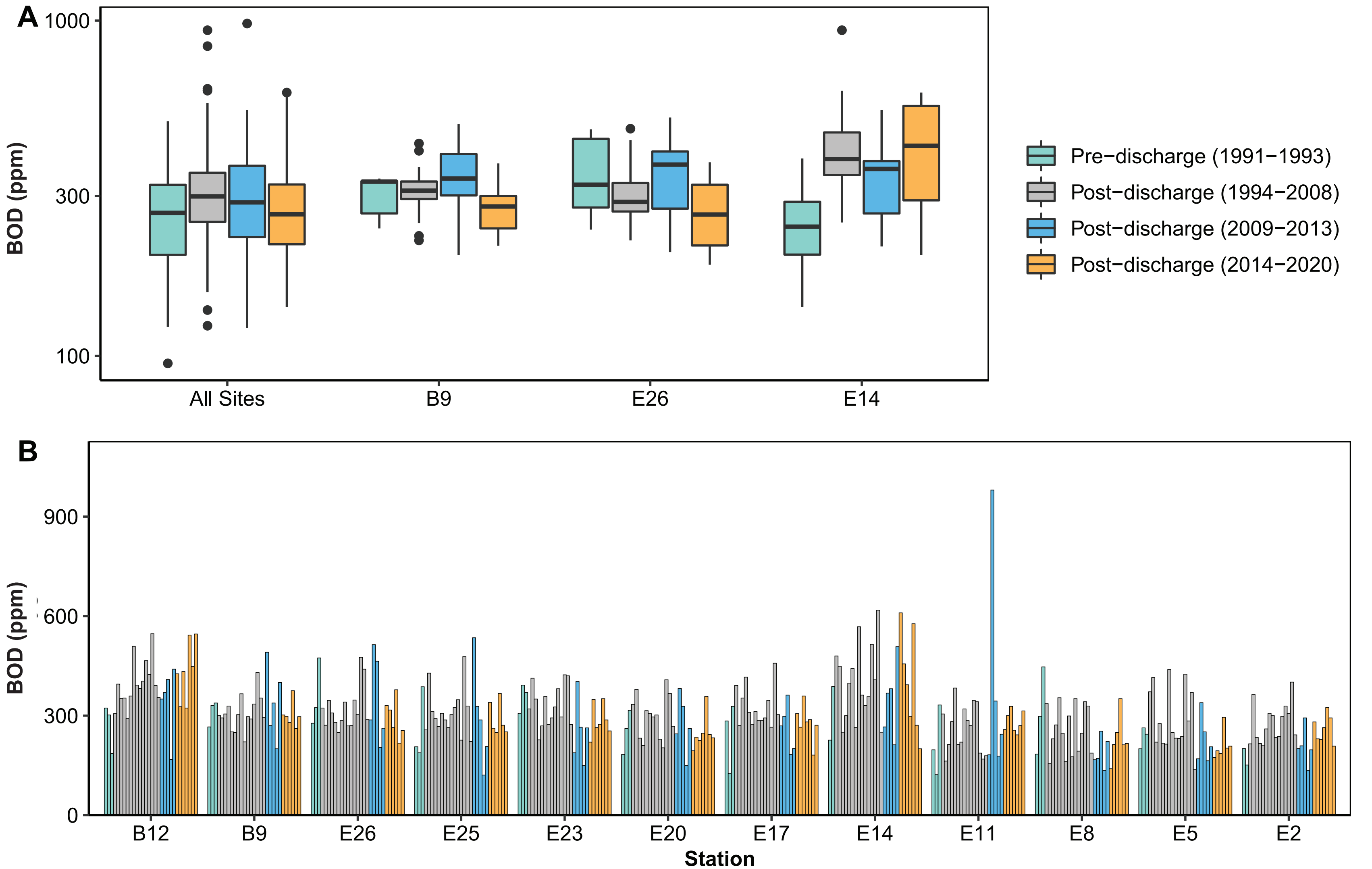


**FIGURE C1-7**
Biochemical oxygen demand (BOD) in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

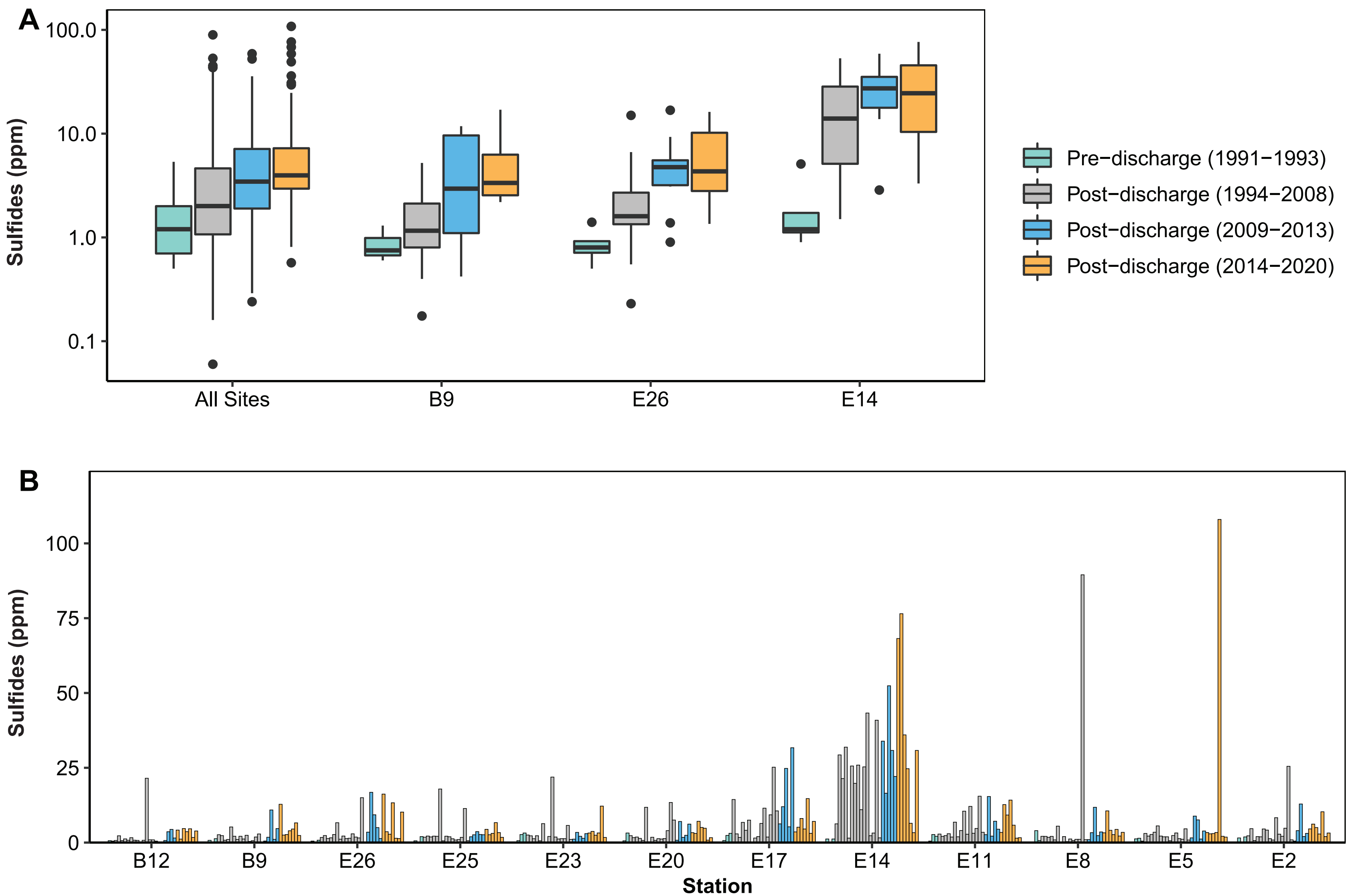


**FIGURE C1-8**

Sulfides in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

also similar to average values reported for regional stations sampled at mid-shelf depths off San Diego (Table C1-2), with 95% of samples falling below the upper tolerance interval bound of 18.1 ppm for the San Diego mainland shelf (see Appendix C2). There is no evidence that the relatively small increase in sulfide concentrations near the PLOO discharge site is affecting sediment quality to the point that it will degrade the resident marine biota.

*Trace Metals*

Detection rates have been relatively high for several different metals since pre-discharge monitoring began at PLOO stations in 1991 (Table C1-3, City of San Diego 2020b). Examination of spatial patterns utilizing San Diego regional surveys revealed no evidence of sediment contamination that could be attributed to local wastewater discharges via the PLOO. The broad distribution of various contaminants in sediments throughout the PLOO region is likely derived from several sources. Many trace metals are naturally derived from hydrothermal vents or the weathering of rocks and soils that become deposited on the coastal shelf via river flows, or terrestrial runoff associated with rain events. Additionally, Mearns et al. (1991) described the distribution of several contaminants as being ubiquitous in the SCB. Over the course of the 20th century, southern California became one of the largest commercial centers on the eastern Pacific for manufacturing, and aerospace and petrochemical industries. During this period there were numerous opportunities for pollutants to be transported to marine waters through spills, sewage discharges, power plant cooling water discharges, industrial discharges, atmospheric fallout, and run-off. In past decades (1950-1970s), sewage outfalls were considered the principal sources of contaminants to the SCB. However, contaminant inputs from sewage discharges have subsequently decreased by as much as an order of magnitude and as a result, other sources like dredge material disposal, aerial fallout, and run-off are being recognized as of equal or greater importance. For example, historical assessments of benthic sediments off the coast of Los Angeles have shown that as wastewater treatment improved, sediment conditions were more likely affected by other factors (Stein and Cadien 2009). Such factors may include bioturbative re-exposure of buried legacy sediments (Niedoroda et al. 1996, Stull et al. 1996), large storms that assist redistribution of legacy contaminants (Sherwood et al. 2002), and stormwater discharges (Schiff et al. 2006, Nezlin et al. 2007). Possible non-outfall sources and pathways of contaminant dispersal off San Diego include transport of contaminated sediments from San Diego Bay via tidal exchange, offshore disposal of dredged sediments, nearshore turbidity plumes emanating from the Tijuana River, and surface runoff from local watersheds (Parnell et al. 2008).

**Aluminum**: Sources of aluminum to ocean sediments include atmospheric deposition, hydrothermal venting, sediment resuspension, and continental drainage (e.g., fluvial) (Barraqueta et al. 2020). It also plays a role in wastewater treatment process as an additive to flocculants.

Aluminum concentrations were not analyzed for Point Loma sediments prior to 1994, and therefore pre-discharge vs. post-discharge comparisons cannot be made for this trace metal. Aluminum was detected in all sediment samples collected from 1994-2020 (Table C-3). Concentrations of aluminum off Point Loma were generally similar to or slightly less than those from reference areas in the SCB as well as for other regional stations monitored off San

Diego each year (Table C1-2). For example, all near-ZID and farfield stations had aluminum concentrations below the upper tolerance interval bound 23,600 ppm for the San Diego mainland shelf (see Appendix C2).

There was little difference in aluminum levels between the near-ZID and farfield stations during post-discharge years that could be attributed to wastewater discharge (Table C1-4, Figure C1-9A). Concentrations found in sediments declined regionally, with mean values dropping from 10,160 ppm in 1994-2008 to 8,412 ppm in 2009-2013, to 7,400 ppm in 2014-2020 (Table C1-4). Additionally, aluminum concentrations in sediments near the discharge zone were generally lower than at the more distant reference sites. For example, sediments at near-ZID station E14 averaged 7,195 ppm aluminum over all surveys, while northern reference site B9 averaged 9,891 ppm over the same period.

**Arsenic**: Arsenic is a common trace element that occurs naturally in seawater. It has also been used in herbicides, insecticides, wood preservatives, and in a variety of industrial applications (Mearns et al. 1991). Southern California marine coastal waters have a significant natural source of arsenic originating from the Punta Banda submarine hot springs in Baja California. These hot springs discharge water containing up to 420,500 ppb arsenic compared to 3 ppb that naturally occur in seawater.

Arsenic was detected in all sediment samples collected from 1991-2020 (Table C1-3), at concentrations below the sediment quality guidelines of Long et al. (1995), including the Effects Range Low (ERL) of 8.2 ppm and Effects Range Median (ERM) of 70.7 ppm. Mean detected values were 2.4 ppm over all sites during the pre-discharge period and 3.1 ppm afterwards (Tables C1-3 and C1-4). Although arsenic increased during the 1994-2013 post-discharge years across all sites, it was most pronounced at northern reference station B12 and secondarily at near-ZID station E14 (Figure C1-10B). The lack of any clear spatial pattern makes it unlikely that changes in arsenic concentrations were related to wastewater discharge. Furthermore, arsenic levels at the outfall discharge depth stations were relatively low overall, averaging a little less than regional survey values off San Diego or the rest of the SCB (Table C1-2). More than 99% of samples from near-ZID stations, and more than 97% of samples from farfield stations, had arsenic concentrations below the upper tolerance interval bound of 5.7 ppm for the San Diego mainland shelf (see Appendix C2). Additionally, all arsenic concentrations were below typical background levels of up to 10 ppm reported for Southern California by Mearns et al. (1991), thus supporting the conclusion that there has not been any significant accumulation of arsenic in the vicinity of the PLOO.

**Beryllium**: Beryllium is an element that occurs naturally (ATSDR 2021). It is present in a variety of materials, such as rocks, coal and oil, soil, and volcanic dust. Beryllium alloys (mixtures of metals) are also used in making electrical and electronic parts or as construction materials for machinery and molds for plastics in automobiles, computers, sports equipment (such as golf clubs and bicycle frames), and dental bridges. Pure beryllium metal is used in nuclear weapons and reactors, aircraft and space vehicle structures, instruments, x-ray machines, and mirrors. Beryllium oxide is also made from beryllium ores and is used to make specialty ceramics for electrical and high-technology applications.

Beryllium was detected in 45% of sediment samples collected during the pre-discharge period, and 49% of samples collected during the post-discharge period (Table C1-3). Concentrations of beryllium in sediments from PLOO stations have been variable throughout the region, ranging from below detection limits to a maximum of 3.1 ppm (Table C1-4), and revealed no patterns consistent with an outfall related effect (Figure C1-11). Levels of beryllium within the PLOO region remain consistent with values recorded during regional surveys off San Diego and the rest of the SCB (Table C1-2). For example, more than 99% of samples from near-ZID stations, and more than 94% of samples from farfield stations, had beryllium concentrations below the upper tolerance interval bound of 1.54 ppm for the San Diego mainland shelf (see Appendix C2).

**Cadmium**: Cadmium is widely used in electroplating, as a pigment in paints, in batteries, and as a plastic stabilizer (Mearns et al. 1991). It has been one of the metals targeted for source control in the San Diego pretreatment program resulting in a significant decline in effluent concentrations over time.

Cadmium was detected in 48% of sediment samples during the pre-discharge period, with mean concentrations of 2.6 ppm, and was detected in 50% of sediment samples at mean concentrations of 0.3 ppm afterwards (Tables C1-3 and C1-4). Cadmium values never exceeded the ERM of 9.6 ppm, and rarely exceeded the ERL of 1.2 ppm (see City of San Diego 2020b; Long et al. 1995). It is unclear what is responsible for the general decrease in cadmium after wastewater discharge began since variation was very high at all sites (Figure C1-12). Review of the data from the summer surveys provided no additional clarification, with concentrations of cadmium being relatively high (2.0–5.7 ppm) at all sites in 1993 and near or below detection limits at most other times (Table C1-4, Figure C1-12B). Post-discharge levels of cadmium within the PLOO region remain consistent with values recorded during regional surveys off San Diego and the rest of the SCB (Table C1-2). Additionally, more than 96% of samples from near-ZID stations, and more than 89% of samples from farfield stations, had cadmium values below the upper tolerance interval bound of 0.9 ppm for the San Diego mainland shelf (see Appendix C2).

**Chromium**: Chromium is a natural element, for example as a significant component of sedimentary rocks, and is therefore common at low levels in the environment, making sediment deposition from river flows or terrestrial runoff potential sources of chromium to ocean sediments. It is also used in a number of industrial applications, chiefly metallurgical and chemical. It is an important component of stainless steel and is used in the production of pigments, tanned leather, wood preservatives and anti-corrosives (Goyer 1986).

Chromium was detected in all sediment samples collected from 1991-2020, with concentrations averaging 17.3 ppm over all sites during the pre-discharge period and 16.9 ppm afterwards (Tables C1-3 and C1-4). Chromium values never exceeded the ERL of 81 ppm (Long et al. 1995). Levels of chromium found at PLOO primary core stations were similar to San Diego regional survey values but generally lower than typical background conditions in the SCB (Table C1-2). For example, more than 99% of samples from near-ZID and farfield stations had chromium values below the upper the tolerance interval bound of 31.6 ppm for the San Diego mainland shelf (see Appendix C2). In addition, although temporal changes were similar across the region, chromium levels were generally higher at northern reference stations B9 and B12 than at the other 10 primary core stations (Figure C1-13).

**Copper**: Copper is another trace metal that occurs naturally in the environment at low levels. Other possible sources of copper to ocean sediments include the burning of coal, copper mining, copper-based algicides, fungicides, and antifouling paints (Mearns et al. 1991). It also has widespread use in use in industrial commercial and household products and applications. For example, copper is leached from many materials that are part of the sewage flow entering the treatment plant, and it also originates from copper water pipes. Dredged sediments from San Diego Bay deposited at the LA-5 disposal site may also be a source of copper to the Point Loma region, due to high levels of copper in Bay sediments resulting from the common use of antifouling paints, as well as from a bulk ore-loading operation for copper concentrate (Young et al. 1979).

Copper was detected in >99% of sediment samples collected from 1991-2020, with concentrations averaging 7.4 ppm over all sites during the pre-discharge period and 7.2 ppm afterwards (Tables C1-3 and C1-4). Copper values never exceeded the ERM of 270 ppm, and rarely exceeded the ERL of 34 ppm (see City of San Diego 2020b; Long et al. 1995). Overall, values off Point Loma were within regional values of 7-15 ppm observed throughout the SCB and off San Diego (see Table C1-2), and all samples from near-ZID stations, and more than 99% of samples from farfield stations, had copper values below the upper tolerance interval bound of 25.8 ppm for the San Diego mainland shelf (see Appendix C2). Copper levels in sediments from around the PLOO have generally been highest at southern station E2 located near the LA-5 dredged materials disposal site, although there was a single anomalous spike during the summer of 1997 at reference station B9 (see Figure C1-14B). There does not appear to be any outfall-related trend in sediment copper concentrations off Point Loma.

**Iron**: Possible sources of iron include terrestrial runoff, settling of detritus from plankton blooms, dust storms, and hyrothermal vents. As with aluminum, iron also plays a role in wastewater treatment process as an additive to flocculants.

Iron concentrations were not measured in 1991 or 1992, therefore pre-discharge values are for 1993 only. While iron has been detected in all sediment samples (Table C1-3), no outfall effects have been evident among PLOO primary core stations, with there being little difference between pre- and post-discharge iron concentrations (12,408 and 12,665 ppm, respectively) (Table C1-¬4, Figure C1-15). In fact, the highest iron concentrations generally occurred in sediments at northern reference stations B12 and B9, as well as southernmost station E2 (Figure C1-15b). Overall, iron concentrations in sediments off Point Loma were generally lower than found elsewhere throughout the SCB (see Table C1-2). All samples from near-ZID stations, and more than 99% of samples from farfield stations, had iron values below the upper tolerance interval bound of 24,800 ppm for the San Diego mainland shelf (see Appendix C2).

**Lead**: Lead has become widely distributed in the environment as a result of its prior use in gasoline and paints (Mearns et al. 1991). Lead in wastewater may be derived from various industrial uses and lead solder in water piping systems, however levels in wastewater have been declining over the years and are now below detection levels in Point Loma effluent (see Appendix C5, this application). Detection rates for lead increased from 27% pre-discharge to 71% post-discharge (Table C1-3). As with some other metals, this change was most likely due to increased sensitivity of instrumentation over the years (see Figure 4.6 with lead MDLs plotted over time, City of San Diego 2020b). Despite the higher frequency of detection, concentrations of lead in sediments from PLOO primary core stations remained well below the ERL of 46.7 ppm (Long et al. 1995), with a maximum recorded value of 15.5 ppm (Table C1-4). There were no clear patterns relative to the outfall. Instead, lead levels within the PLOO monitoring region have generally been highest at southern station E2 located near the LA-5 dredge materials disposal site (Figure C1-16B). Overall, lead values at PLOO stations were lower than background concentrations in the San Diego region and for the entire SCB (Table C1-2). All samples from near-ZID stations, and more than 99% of samples from farfield stations, had lead values below the upper tolerance interval bound of 13.2 ppm for the San Diego mainland shelf (see Appendix C2).

**Manganese**: Manganese is another trace metal that occurs naturally in the environment at low levels. Possible sources of manganese to ocean sediments include river flows and terrestrial runoff, hydrothermal vents, atmospheric fallout due to the use of manganese compounds generated as combustion products from motor vehicles and coal-burning industrial plants, as well as the production of steel, batteries, ceramics, and dietary supplements. Manganese is also used in some pesticides, fertilizers and as a gasoline additives.

Manganese was not analyzed during the pre-discharge period, and therefore comparisons are limited to the post-discharge surveys. This metal was detected in all sediment samples collected. Overall, manganese levels were similar across the outfall depth stations with no patterns indicative of a discharge effect (Table C1-4, Figure C1-17). For example, manganese averaged 99.7 ppm over all sites during the entire post-discharge period, with values being a little lower at near-ZID station E14 (mean=87.3 ppm) than at reference station B9 (mean=111.0 ppm) and at San Diego regional stations (mean=113.2 ppm). Causes for the sporadic spikes in manganese across the region over the years remain unknown. Manganese was not measured during the SCB surveys, but all samples from near-ZID and farfield stations had values that fell below the upper tolerance interval bound of 336 ppm for the San Diego mainland shelf (see Appendix C2).

**Mercury**: Mercury is a common trace element in ocean waters and sediments and has a wide variety of natural and anthropogenic sources (Mearns et al. 1991). It may be injected into the atmosphere by volcanism, transported into coastal waters by rain and runoff, or released directly into the ocean through geothermal springs. Man-made sources include the use of mercury in fungicides, plastics, medical preparations, and in smelting and mining processes, while electrochemical industries also generate mercury waste.

Detection rates for mercury increased from 28% during the pre-discharge period, to 93% during the most recent post-discharge period (Table C1-3). As with some other metals, this change is most likely due to increased sensitivity of instrumentation over the years (see Figure 4.6 with mercury MDLs plotted over time, City of San Diego 2020b). Detected values from all sites were less than 0.089 ppm (Table C1-4), never exceeded the ERL of 0.15 ppm (Long et al. 1995), and were well within the range reported regionally for San Diego and the rest of the SCB (Table C1-2). For example, all samples from near-ZID and farfield stations had mercury values below the upper tolerance interval bound of 0.107 ppm for the San Diego mainland shelf (see Appendix C2). While concentrations have been variable during the post-discharge years, median values have declined at both near-ZID and farfield stations, with no outfall-related patterns indicated. Instead, the highest mercury concentrations typically occurred at station E2 near the LA-5 dredged materials disposal site (Figure C1-18).

**Nickel**: Nickel has broad industrial applications and has become widespread in the environment (Mearns et al. 1991).

Nickel was detected in 97% of sediment samples collected during the pre-discharge period, and 96% of samples collected afterwards (Table C1-3). Concentrations of this metal ranged from below detection limits to a maximum of 29.0 ppm in Point Loma sediments (Table C1-4), never exceeding the ERM of 51.6 ppm and rarely exceeding the ERL of 20.9 ppm (see City of San Diego 2020b; Long et al. 1995). Additionally, all reported values were well below average background concentrations for the SCB (Table C1-2). More than 99% of samples from near-ZID and farfield stations had nickel values below the upper tolerance interval bound of 12.3 ppm for the San Diego mainland shelf (see Appendix C2), and there is no evidence that discharge from the PLOO is resulting in any sustained accumulation of nickel in local sediments (see Figure C1-19).

**Selenium**: Selenium is another trace metal that occurs naturally in the environment at low levels. Possible sources of manganese to ocean sediments include river flows and terrestrial runoff, pesticides, shampoos, the production of glass, pigments, rubber, metal alloys, textiles, petroleum, medical therapeutics, and photo emulsion (Mearns et al. 1991).

Detection rates for selenium were 57% pre-discharge, with concentrations up to 0.9 ppm, and 45% post-discharge, with concentrations up to 0.8 ppm (Tables C1-3 and C1-4). These values are similar to background shelf sediment conditions reported by Young (1975) and slightly less than values reported during regional Bight surveys (Table C1-2). For example, more than 99% of samples from near-ZID and farfield stations had selenium values below the upper tolerance interval bound of 0.7 ppm for the San Diego mainland shelf (see Appendix C2). There were no outfall-related patterns within the PLOO region, as selenium was detected sporadically with variable concentrations from 1991 through 2020 (Figure C1-20).

**Silver**: Silver has historically been present in wastewater as a result of its use in photography and dentistry (Mearns et al. 1991). However, these inputs have dropped significantly over the years with the implementation of stringent source control measures. Dredged sediments from San Diego Bay deposited at the LA-5 disposal site may also be a source of silver to the Point Loma region, as silver levels have been found to be high in Bay sediments (Mearns et al. 1991).

Silver has only rarely been detected in Point Loma sediments, with a detection rate of 3%

during the pre-discharge period, at concentrations up to 4.0 ppm, and 15% afterward, at concentrations up to 67.4 ppm (Tables C1-3 and C1-4). Silver values infrequently exceeded the ERL of 1.0 ppm, and a single value reported from near-ZID station E11 during 2018 exceeded of the ERM of 3.7 ppm (Figure C1-21; see City of San Diego 2020b; Long et al. 1995). Levels of silver within the PLOO region remain consistent with values recorded during regional surveys off San Diego and the rest of the SCB (Table C1-2). Additionally, 99% of samples from near-ZID stations, and all samples from farfield stations, had silver values below the upper tolerance interval bound of 6.07 ppm for the San Diego mainland shelf (see Appendix C2).

**Zinc**: Zinc is used routinely in batteries, vehicle tires, and a variety of industrial, commercial, and household products, and it has been found distributed throughout the southern California marine environment. Zinc is ubiquitous in the environment, has many industrial uses, and is a biologically essential micronutrient. Zinc is widely used as component in batters and vehicle tires. Sources include municipal wastes, direct industrial discharges, surface run-off, atmospheric fallout, and corrosion protection devices for boats and ships (Young et al 1980).

Zinc was detected in all Point Loma sediment samples collected from 1991 through 2020 (Table C1-3), with mean concentrations of 28.0 ppm during the pre-discharge period and 28.2 ppm afterwards (Tables C1-4). Zinc levels at Point Loma sites were far below the ERL of 150 ppm (Long et al. 1995), and lower than those reported for reference areas in the SCB (Table C1-2). Additionally, more than 99% of samples from near-ZID and farfield stations had zinc values below the upper tolerance interval bound of 74.1 ppm for the San Diego mainland shelf (see Appendix C2). A comparison of zinc data over time revealed no evidence of any outfall-related changes (Figure C1-22).

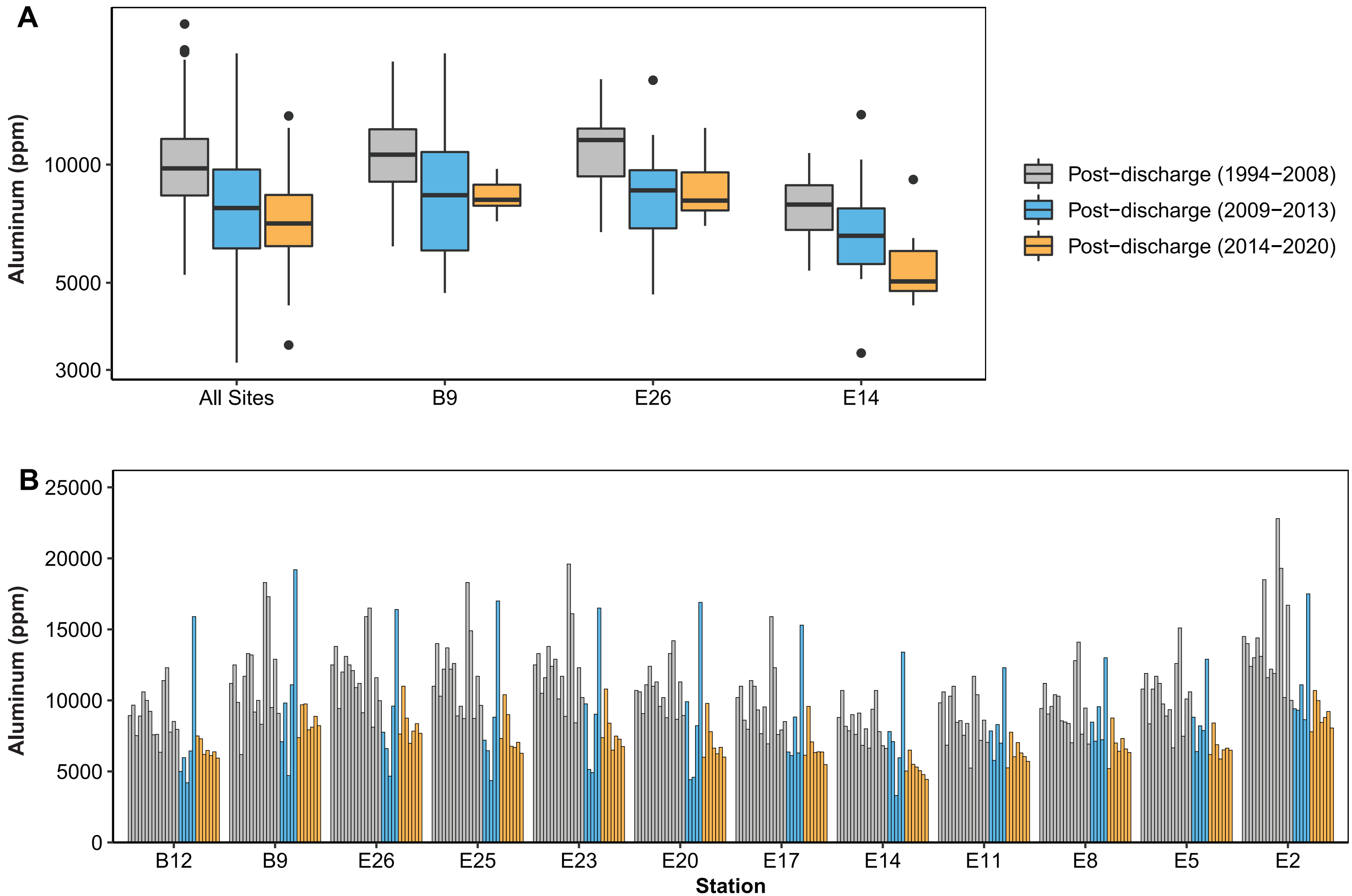


**FIGURE C1-9**
Aluminum in sediments at outfall discharge depths near the PLOO from 1994 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

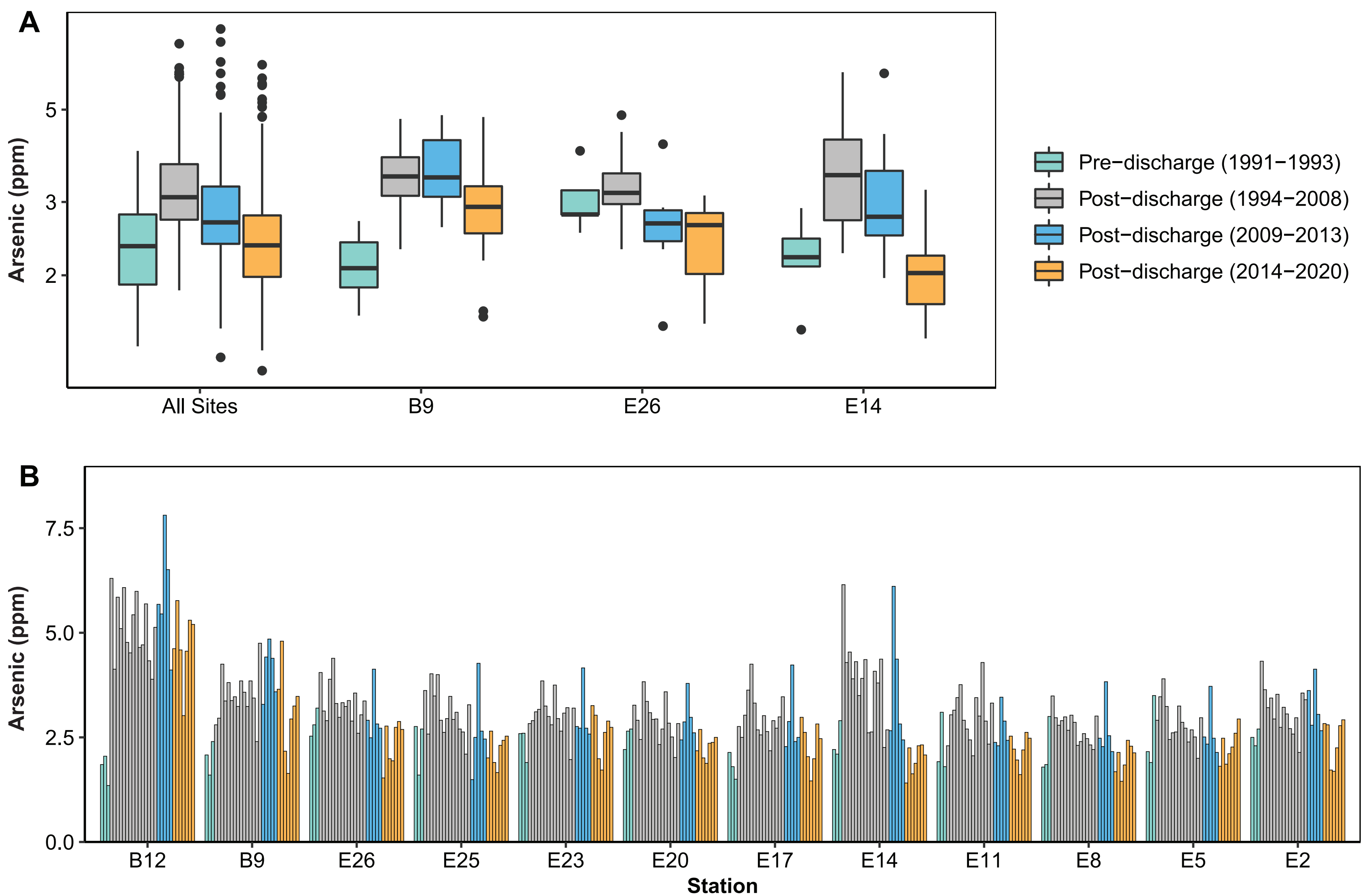


**FIGURE C1-10**

Arsenic in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

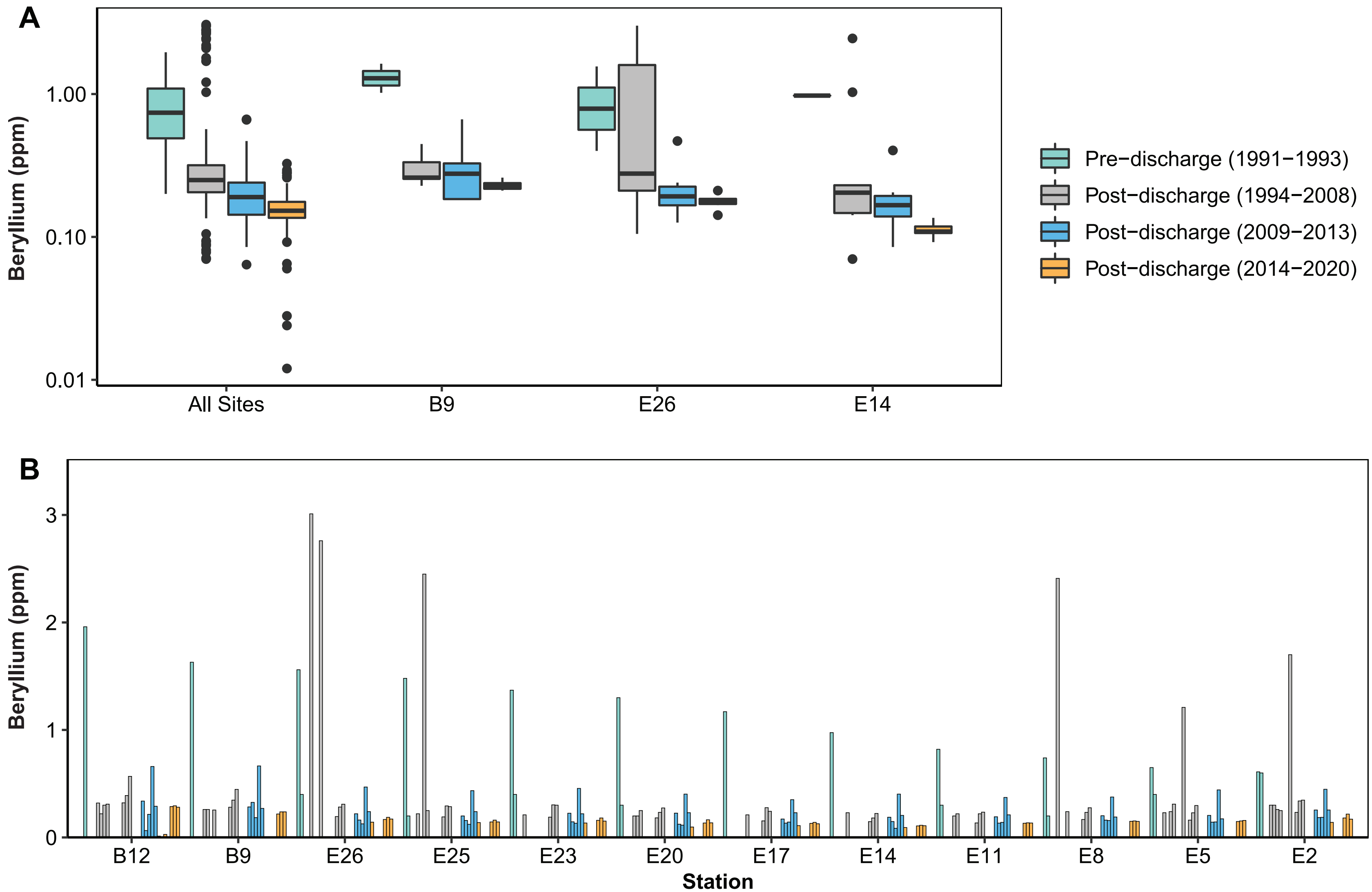


**FIGURE C1-11**
Beryllium in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

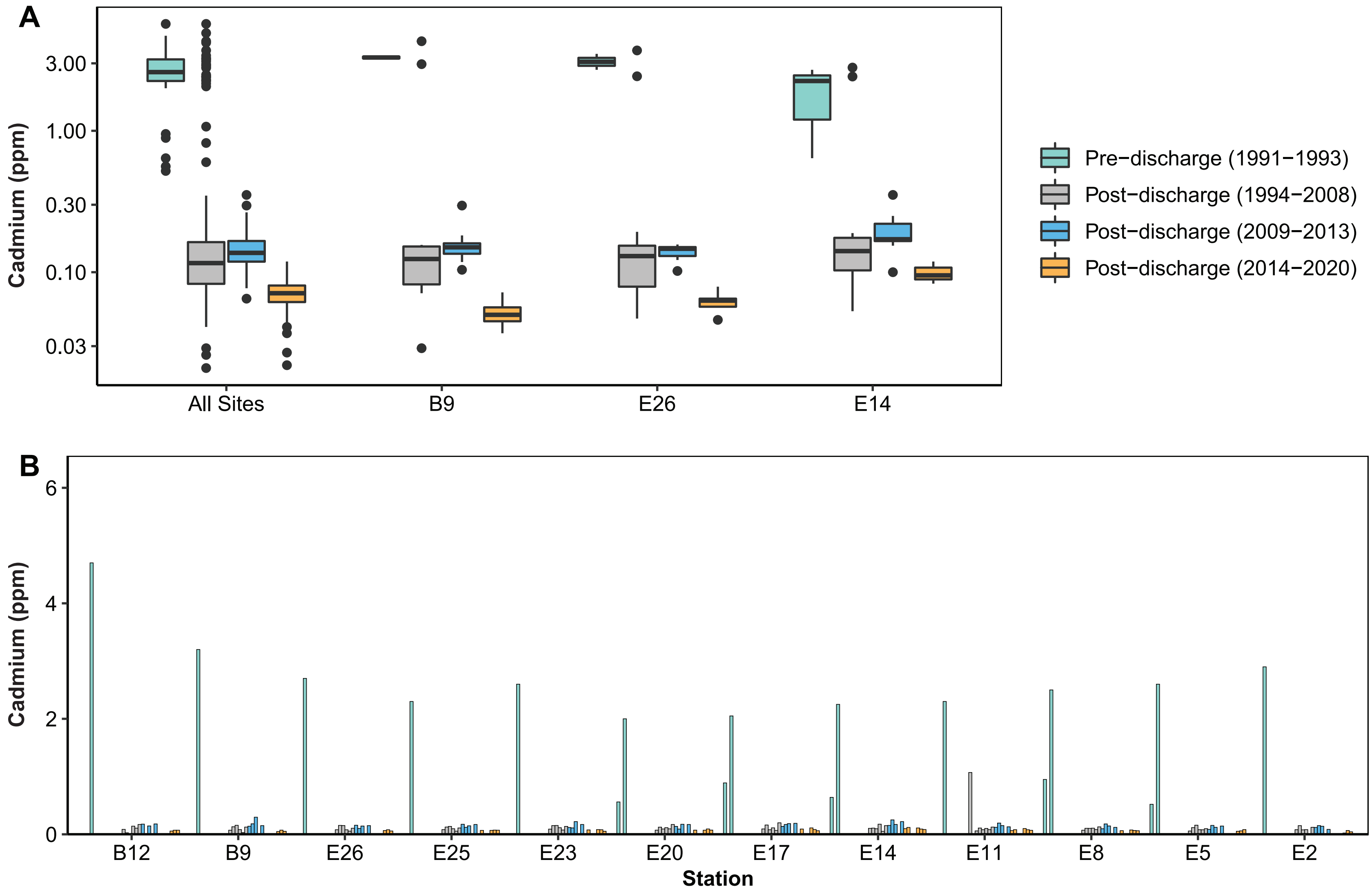


**FIGURE C1-12**
Cadmium in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

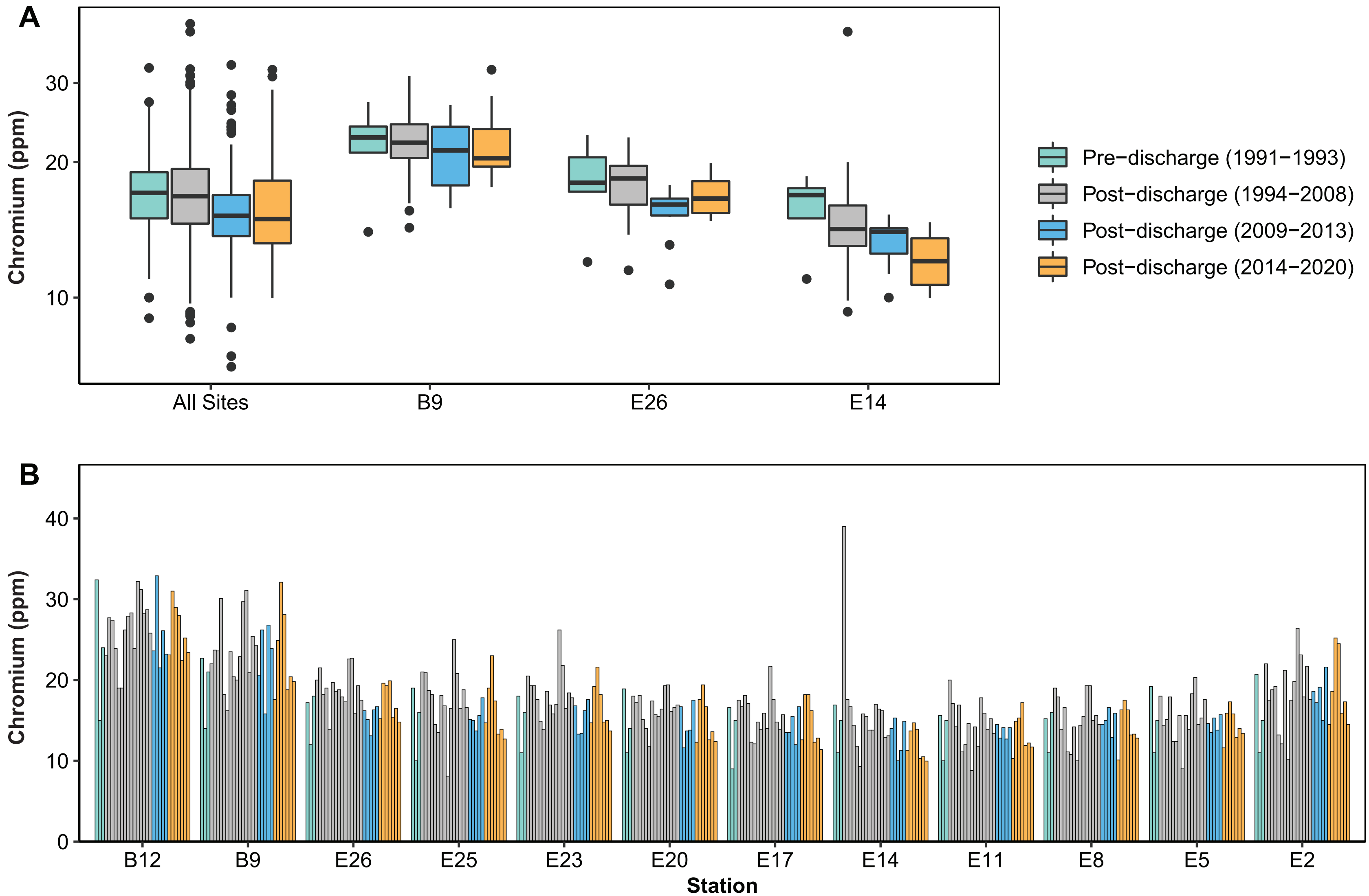


**FIGURE C1-13**

Chromium in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

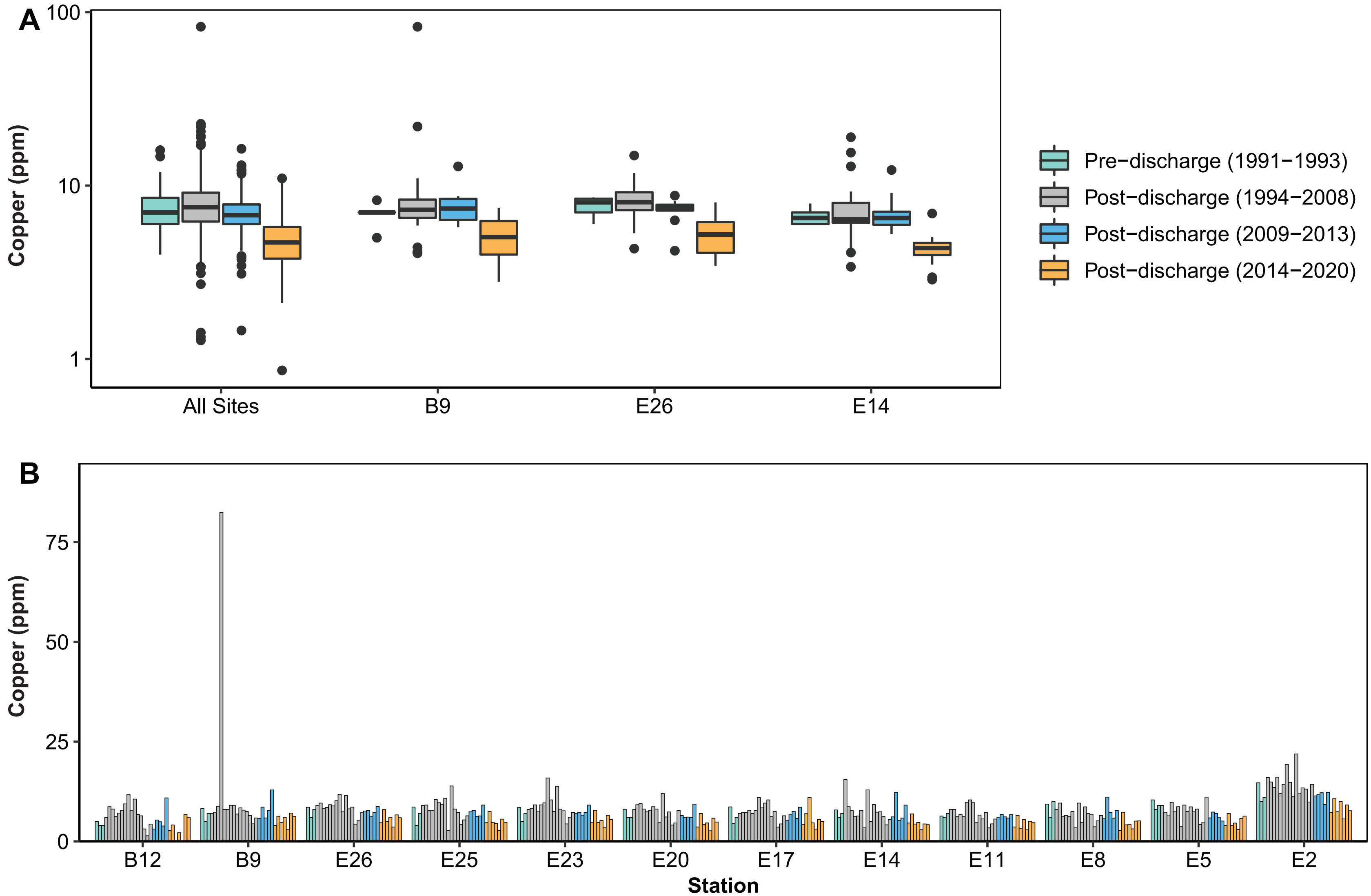


**FIGURE C1-14**
Copper in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

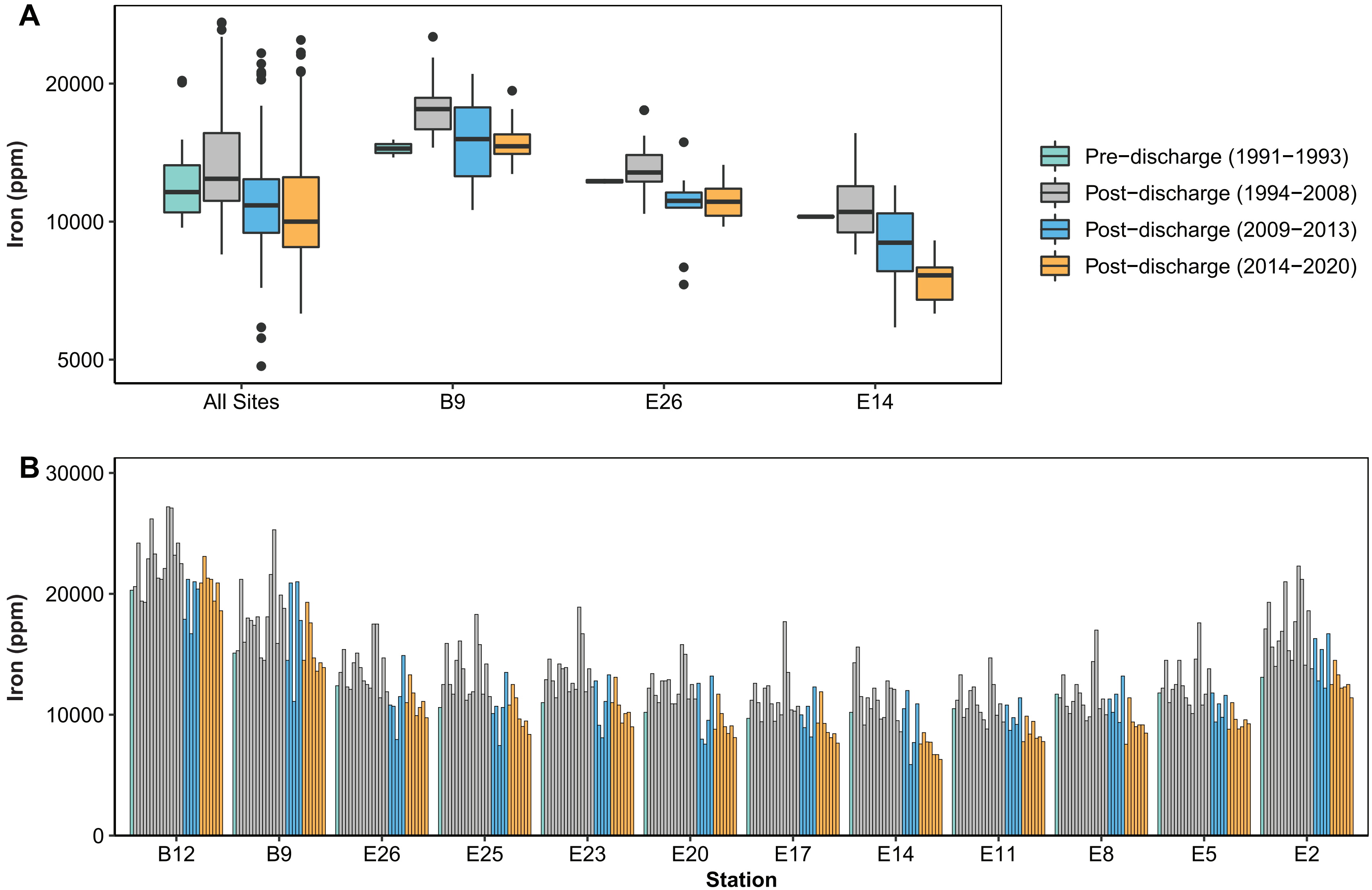


**FIGURE C1-15**
Iron in sediments at outfall discharge depths near the PLOO from 1993 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

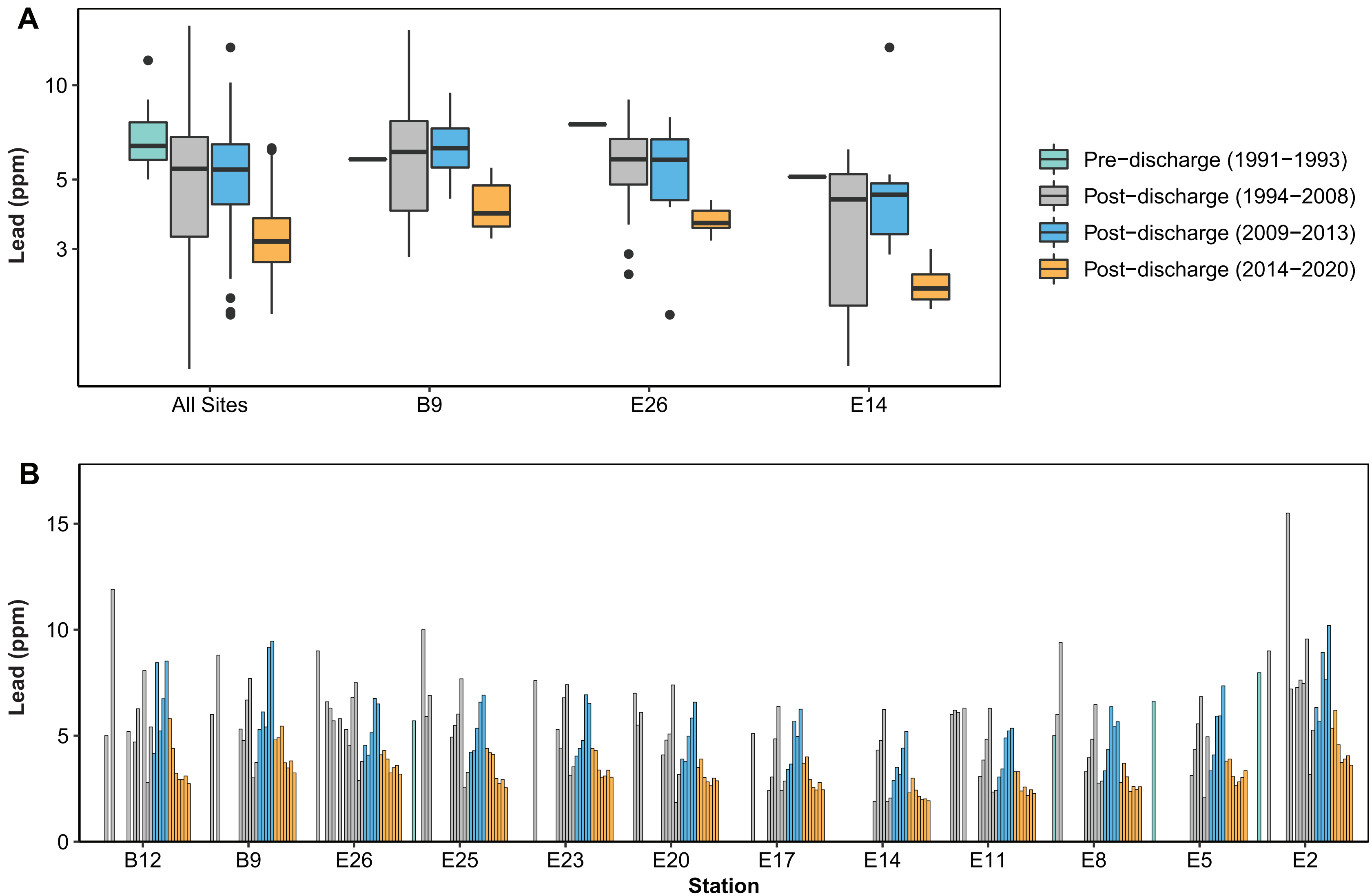


**FIGURE C1-16**

Lead in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

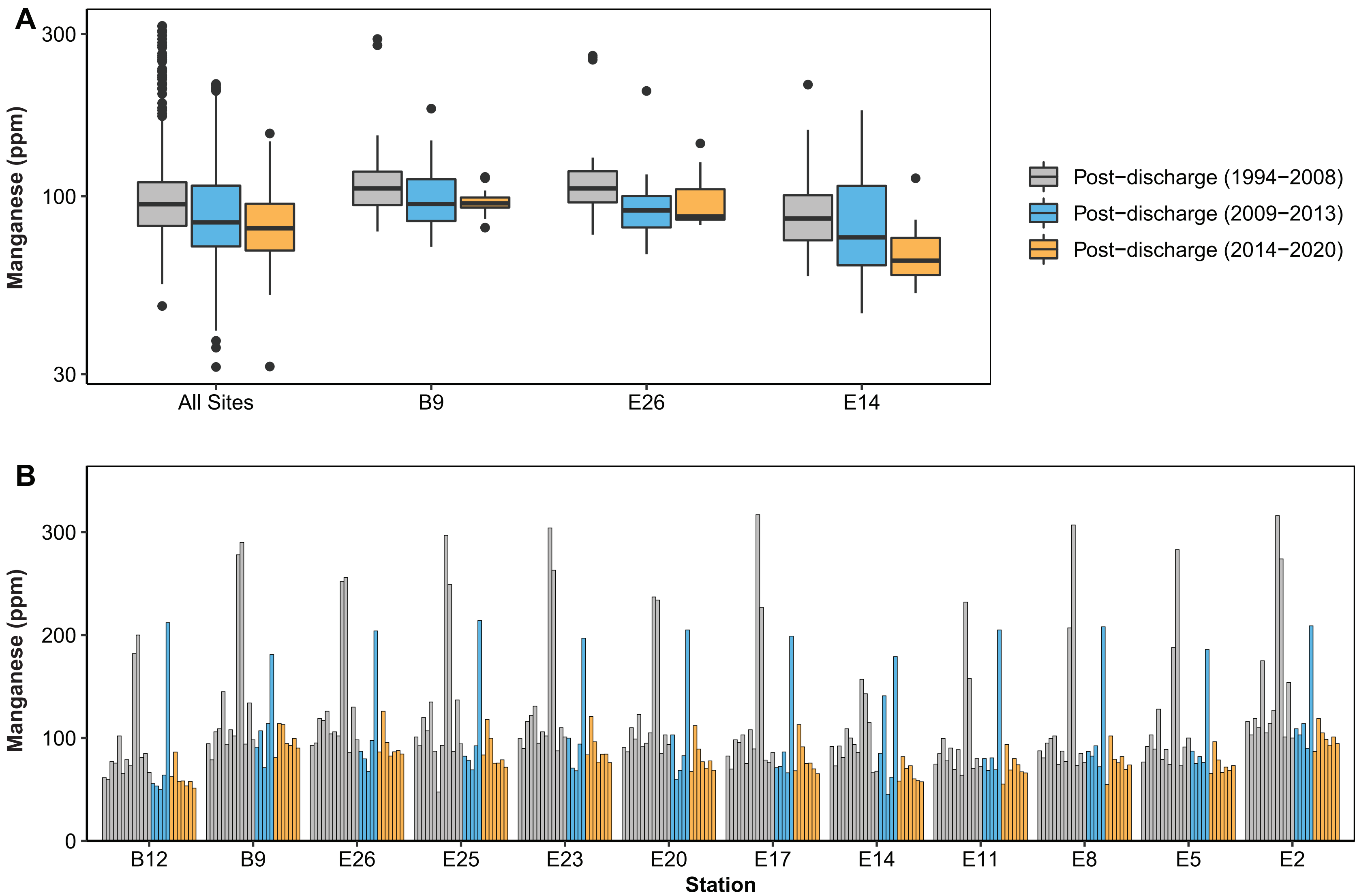


**FIGURE C1-17**

Manganese in sediments at outfall discharge depths near the PLOO from 1996 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

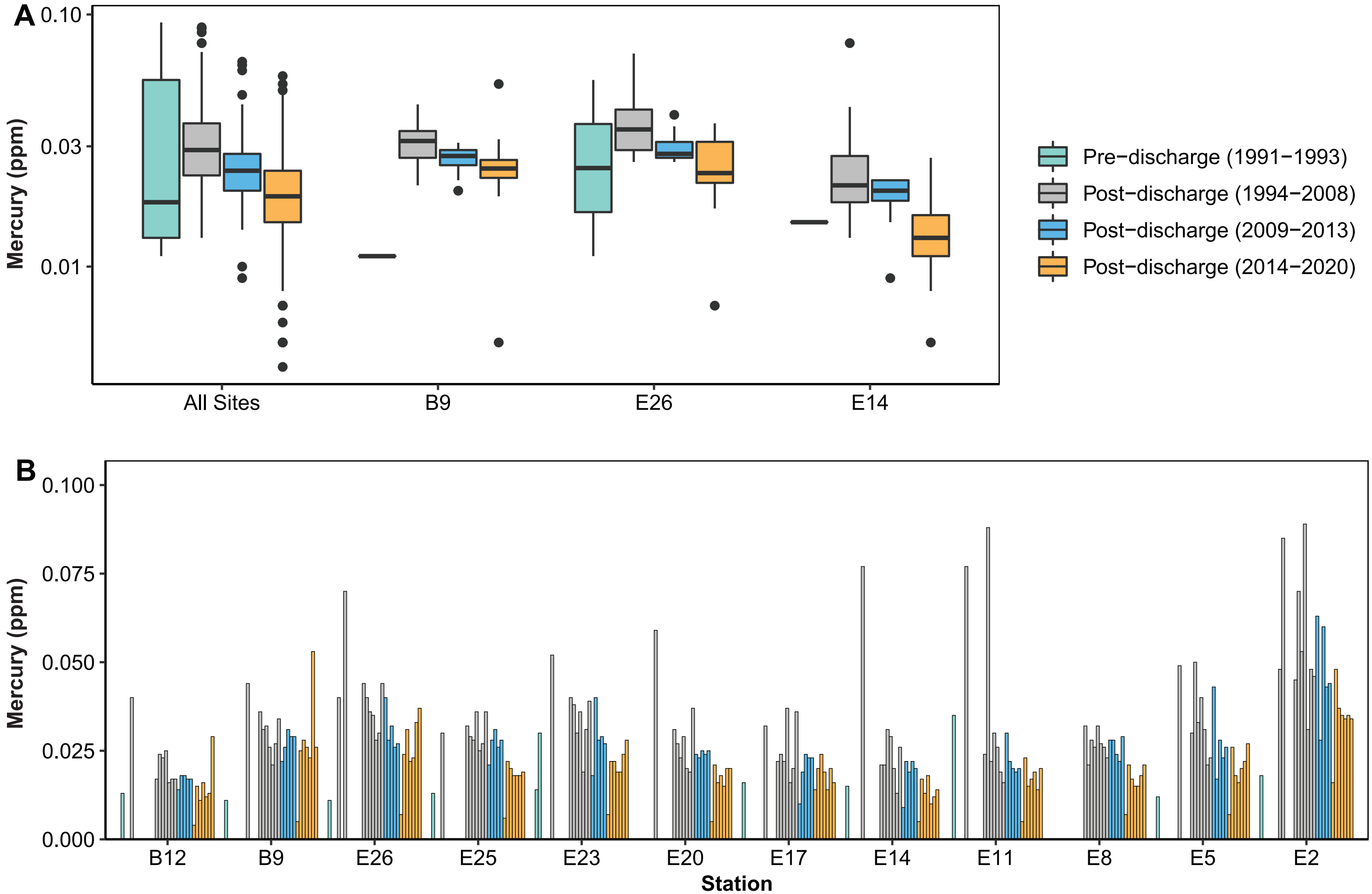


**FIGURE C1-18**

Mercury in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

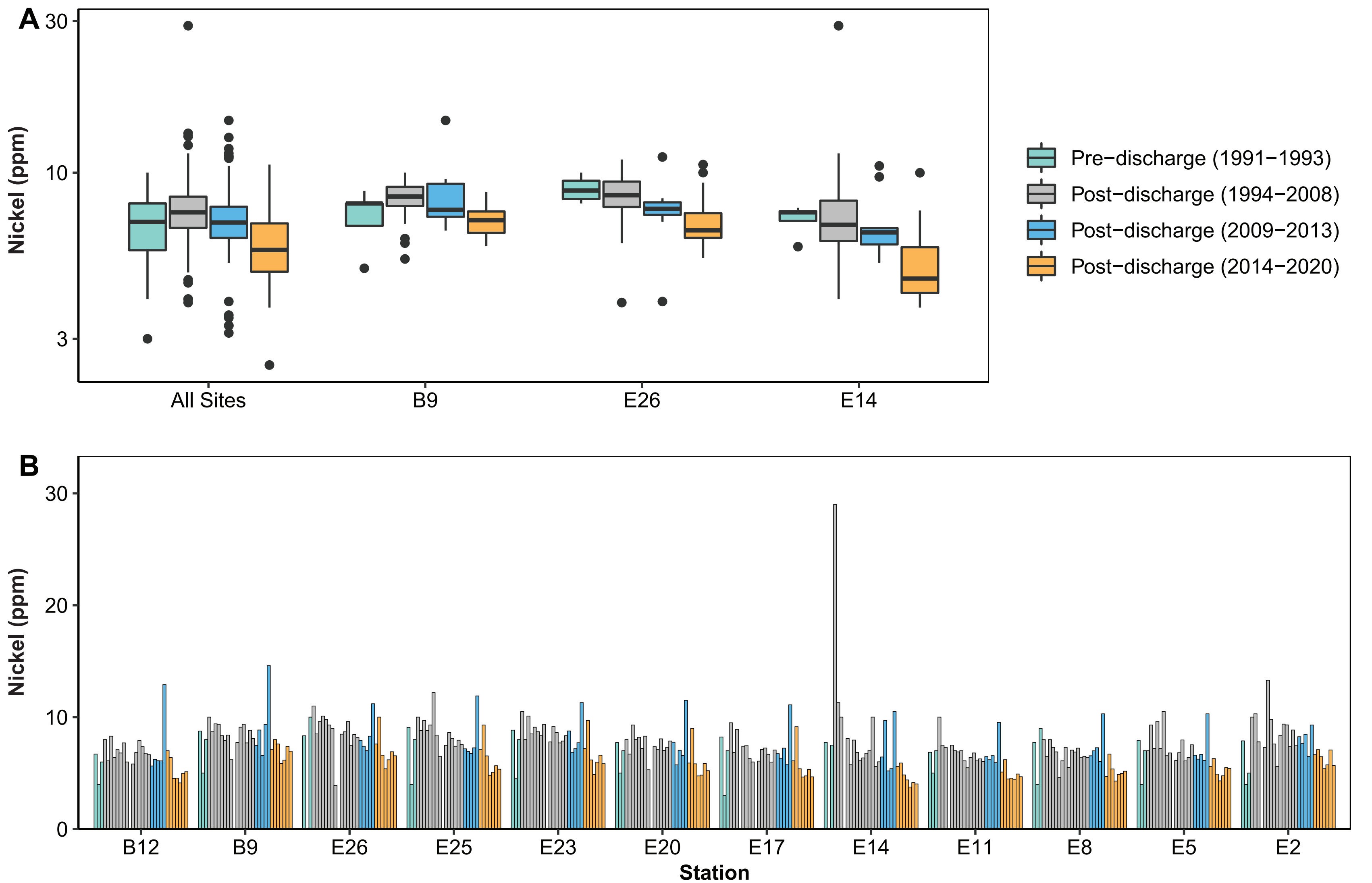


**FIGURE C1-19**
Nickel in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

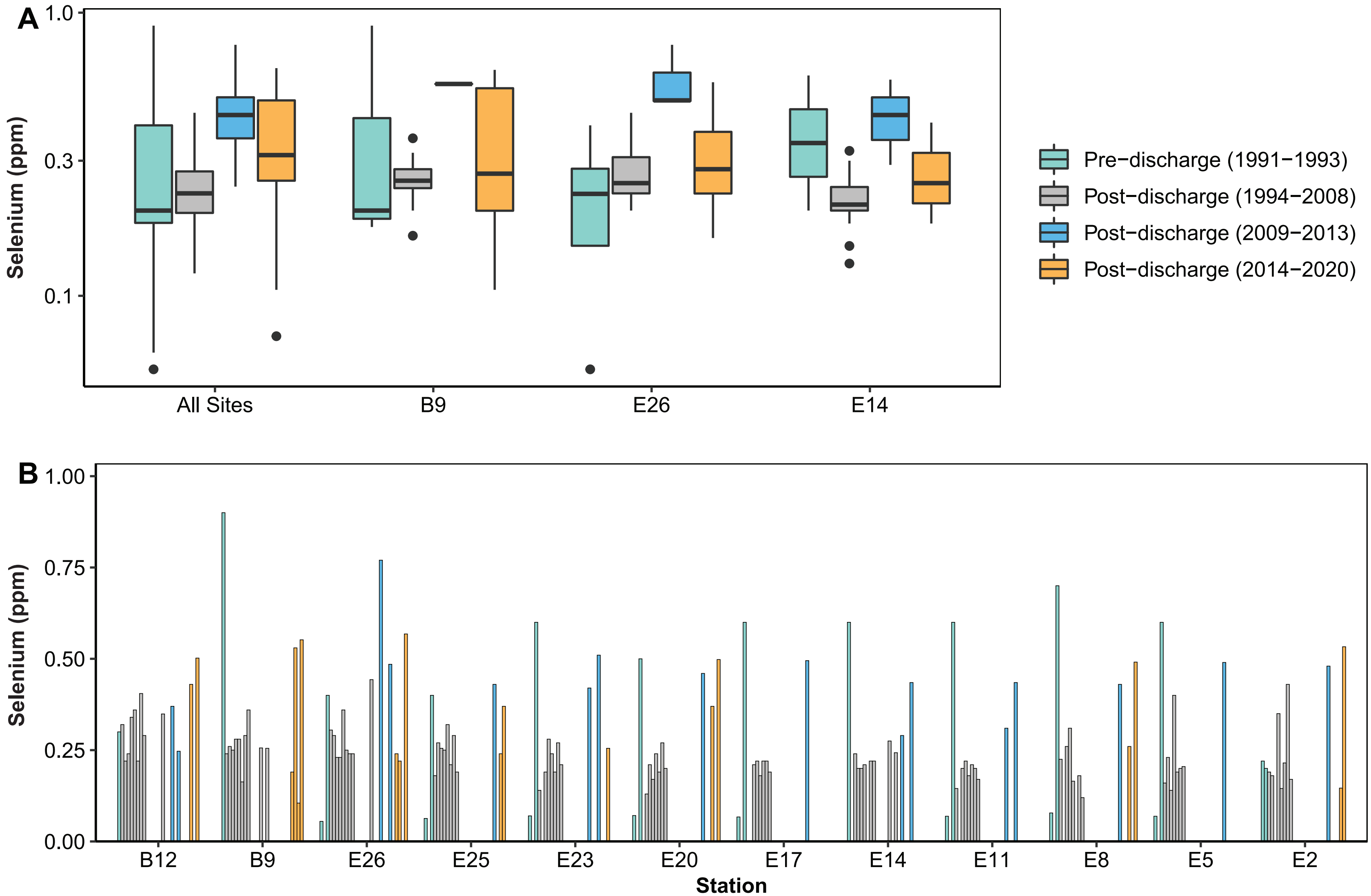


**FIGURE C1-20**

Selenium in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

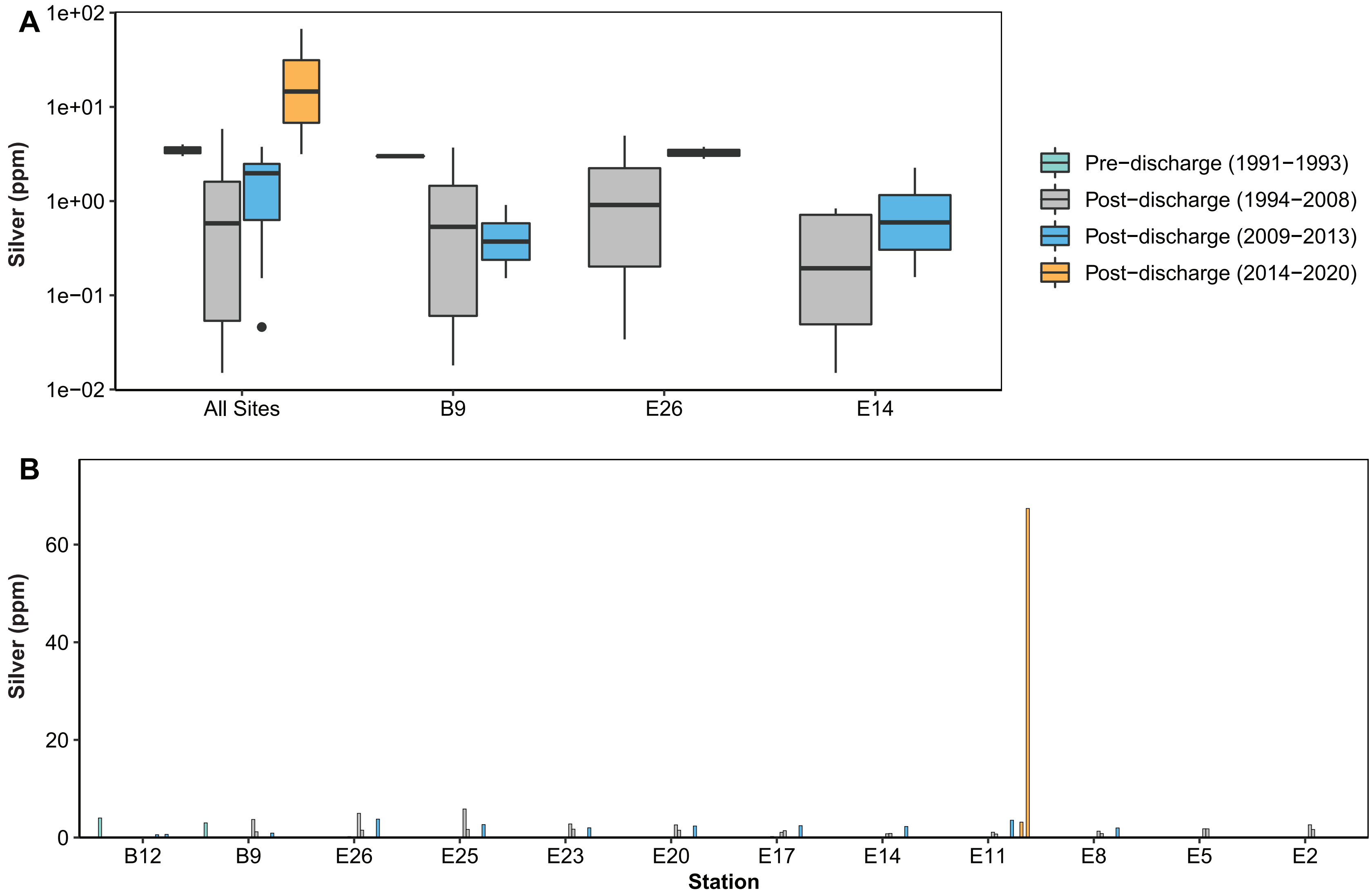


**FIGURE C1-21**
Silver in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

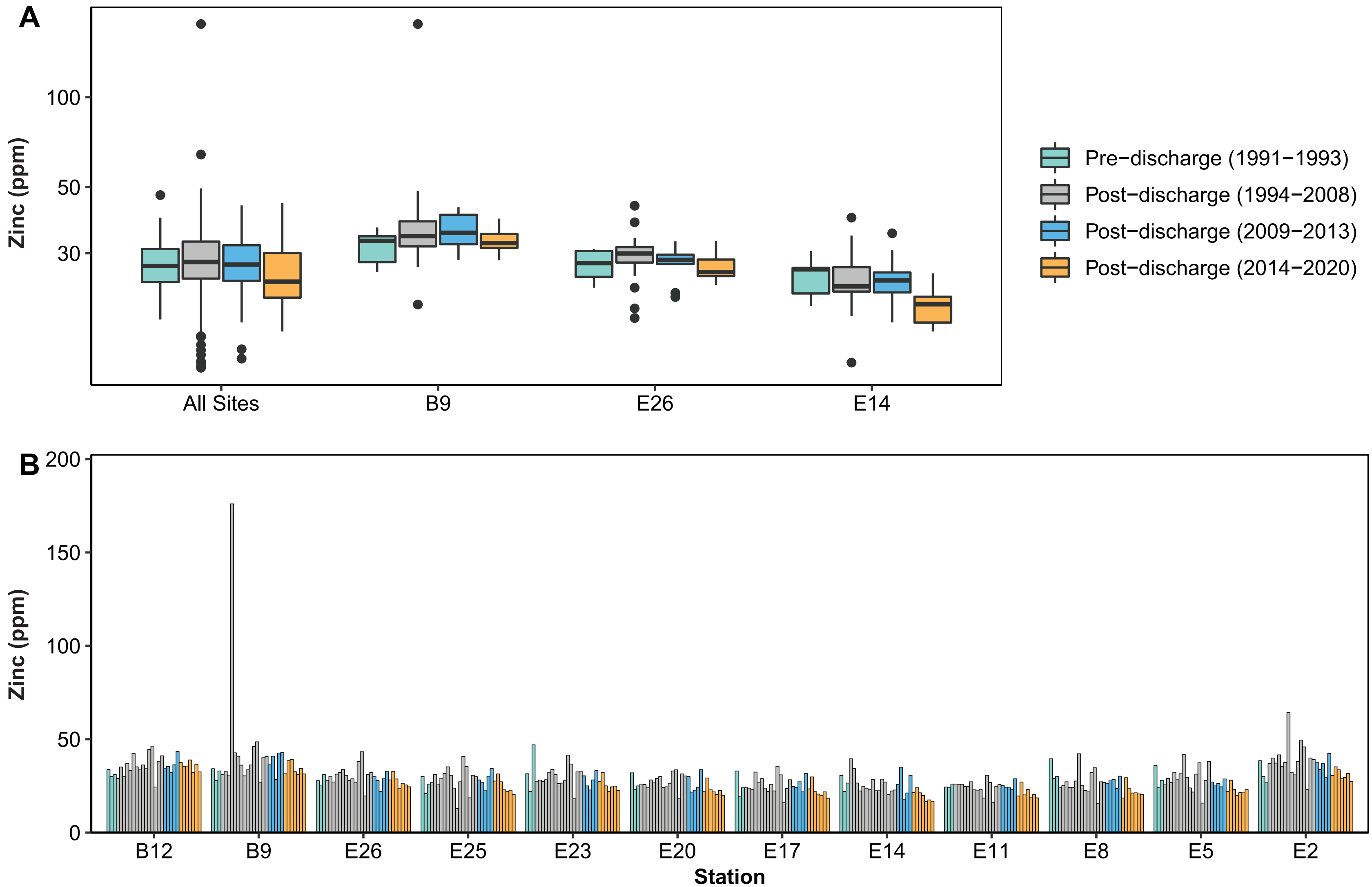


**FIGURE C1-22**
Zinc in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

### *Pesticides, PCBs, and PAHs*

Chlorinated hydrocarbons like DDT and PCBs are persistent environmental contaminants with widespread distribution and well-known bioaccumulation in southern California (Mearns et al. 1991). Some PAHs are also known to be ubiquitous in nature. However, chlorinated pesticides, PCBs, and PAHs have historically been detected sporadically and at low concentrations within the PLOO region (City of San Diego 2020b). Overall, DDT has been the most commonly detected pesticide, however various forms of chlordane, endrin, endosulfan, hexachlorocyclohexane, along with dieldrin, hexachlorobenzene, and mirex, have also been reported. Higher detection rates of pesticides, PCBs and PAHs over recent years is most likely due to improved methods that lower method detection limits, thereby increasing the likelihood of detecting these parameters (Dodder et al. 2016).

**Total DDT:** DDT is a pesticide that was applied indiscriminately following World War II to control a broad spectrum of agricultural, silvicultural, and household insect pests until its acute toxic effects became known and manufacturing was suspended in the US in 1972 (Mearns et al. 1991). Since the ban of these chemicals in the early 1970s, environmental levels have steadily decreased.

DDT was detected at all primary core stations off Point Loma, although somewhat sporadically, and there was no evidence of any effects related to the discharge of wastewater (Figure C1-23). Detection rates increased over each post-discharge period (28% to 99%) (Table C1-3), likely due to improved instrumentation. While detection rates have increased, sediment concentrations of total DDT have remained low, with mean detected values of 2,022 and 1,208 parts per trillion (ppt) during the pre- and post-discharge periods, respectively (Table C1-4). Concentrations of DDT at PLOO sites rarely exceeded the ERL of 1,580 ppt, never exceeded the ERM of 461,00 ppt, and values were considerably less than those reported for reference areas in the SCB (Table C1-2). Additionally, all samples from near-ZID stations, and 99% of samples from farfield stations, had total DDT concentrations below the upper tolerance interval bound of 17,000 ppt for the San Diego mainland shelf (see Appendix C2). Exceptionally high DDT values (17,830–44,830 ppt) were reported on three occasions at outfall depths off Point Loma, including at northern reference station B9 in winter 1999 and summer 2014, and at southern farfield station E2 in summer 1995 (Figure C1-23B).

**Total PCB**: PCBs have historically been used in a wide variety of industrial applications, including insulation for electrical capacitors and transformers, hydraulic fluids, plasticizers in waxes, additives in paints and other compounds, and components in the manufacture of paper (USEPA 1984, Mearns et al. 1991). Overall, the most probable source of any PCB contamination in the benthos off Point Loma is the disposal of dredged sediments from San Diego Bay at the LA-5 dredged materials disposal site (see Parnell et al. 2008). Mearns et al. (1991) found sediments from San Diego Bay had PCB levels that were orders of magnitudes higher than the Point Loma shelf (2.25 ppm in the Bay, versus 0.0002 ppm on the coast).

PCBs were measured as Aroclors prior to April 1998 and as congeners since that time. Consequently, the data from these two periods were not comparable. No PCB Aroclors were detected in sediments at PLOO primary core stations from 1991 through 1998. As with DDT, detection rates of PCB increased over each post-discharge period (1% to 49%) (Table C1-3), likely due to improved instrumentation. Overall, total PCB concentrations from PLOO primary core stations were considerably less than those reported for reference areas in the SCB (Table C1-2). All samples from near-ZID stations, and more than 98% of samples from farfield stations, had concentrations of total PCB below the upper tolerance interval bound of 12,430 ppm for the San Diego mainland shelf (see Appendix C2). There were no patterns in PCB distributions relative to outfall operation and the discharge of wastewater. PCBs were detected most frequently, and with the highest concentrations, at southern station E2, located near the LA-5 dredged materials disposal site (Figures C1-24 and C1-25).

**Total PAH**: PAHs are only one of several groups of hydrocarbons found in fossil fuels (petroleum, coal) and their refined or combustion products. Possible sources to ocean sediments include oil spills, aerial fallout, petroleum refinery wastes, natural oil seeps, and hydrothermal seeps (Mearns et al. 1991). Terrestrial runoff is also considered a primary source of PAH, as was wastewater discharge until the 1980s. More recently, PAH inputs from stormwater runoff are thought to exceed that from wastwater. Dredged sediments from San Diego Bay deposited at the LA-5 disposal site may also be a source of PAHs to the Point Loma region, as (Mearns et al. (1991) found PAH levels in sediments from San Diego Bay much higher than on the coast.

PAHs have been detected sporadically in sediments off Point Loma, typically in low concentrations near or below MDLs, at concentrations well below the ERL of 4,022 ppb (Tables C1-3 and C1-4; Long et al. 1995). Overall, total PAH concentrations from PLOO primary core stations were considerably less than those reported for reference areas in the SCB (Table C1-2), and all samples from near-ZID and farfield stations had concentrations of total PAH below the upper tolerance interval bound of 3640 ppm for the San Diego mainland shelf (see Appendix C2). Historically, PAHs have been detected most frequently in sediments from station E2; these have largely been attributed to short dumps intended for the LA-5 dredged materials disposal site (see Anderson et al. 1993). However, an exceptionally high total PAH value of 3,024 ppb was reported from farfield station E23 during summer 2004. Overall, there were no patterns in PAH distributions surrounding the PLOO that could be attributed to wastewater discharge (see Figures C1-26 and C1-27).

## Summary of Sediment Conditions

Wastewater discharge is not significantly affecting sediment quality in the vicinity of the Point Loma outfall. After 27 years of outfall operation, there is little to no evidence of organic or contaminant loading in the area, with measured parameters existing at levels within the range of natural variability for reference areas off San Diego and throughout the SCB. Overall, ≥89% of the sediment particle size and sediment chemistry values from PLOO primary core stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020 were below the upper tolerance interval bounds calculated using reference data, which represent thresholds in the direction of response predicted from environmental impact (see Appendix C2). Additionally, almost all samples had concentrations of parameters below the

ERL and ERM sediment quality thresholds of Long et al. (1995). Although there were increases in levels of a few trace metals in 1994 shortly after discharge began, these increases were only temporary. The only sustained effects were generally restricted to a few sites located within about 200 m of the ZID, including near-ZID station E14 just west of the center of the outfall wye, and near-ZID stations E11 and E17 located off the ends of the southern and northern diffuser legs, respectively. These effects included measurable increases in the percentage of coarse sediments (i.e., decrease in percent fines) and sulfide concentrations in near-ZID sediments, as well as smaller increases in sediment BOD levels. Consequently, there is no evidence that the discharge of wastewater via the PLOO is affecting the quality of benthic sediments to the point that it will degrade the resident marine biota. These findings are supported by the assessment of combined chemical parameters to determine chemical exposure, along with sediment toxicity testing and the evaluation of benthic community condition (see Section C1-4 below, and Appendix C3 in this application).

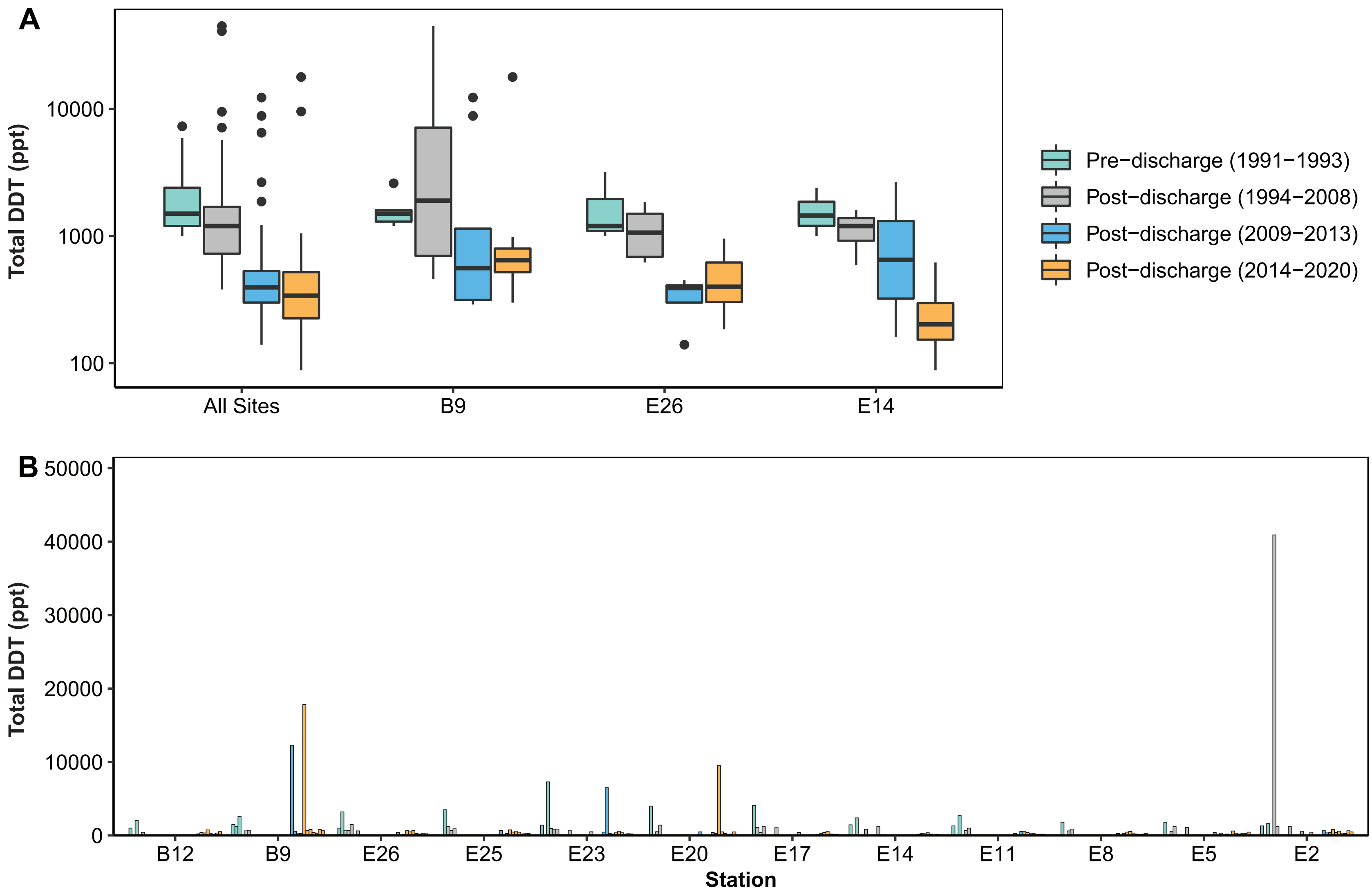


**FIGURE C1-23**
Total DDT in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

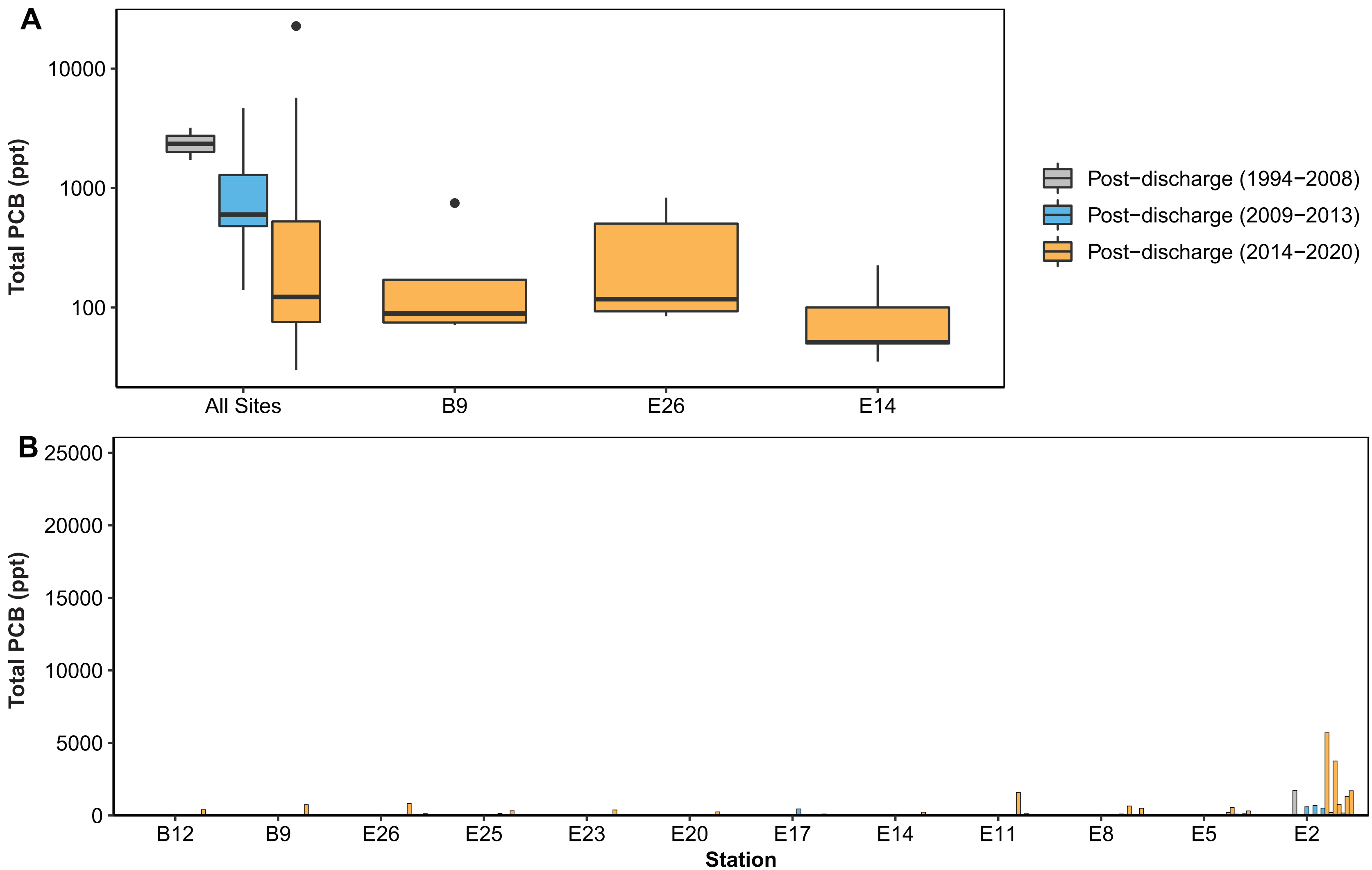


**FIGURE C1-24**
Total PCB, calculated with all detected congeners, in sediments at outfall discharge depths near the PLOO from 1998 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

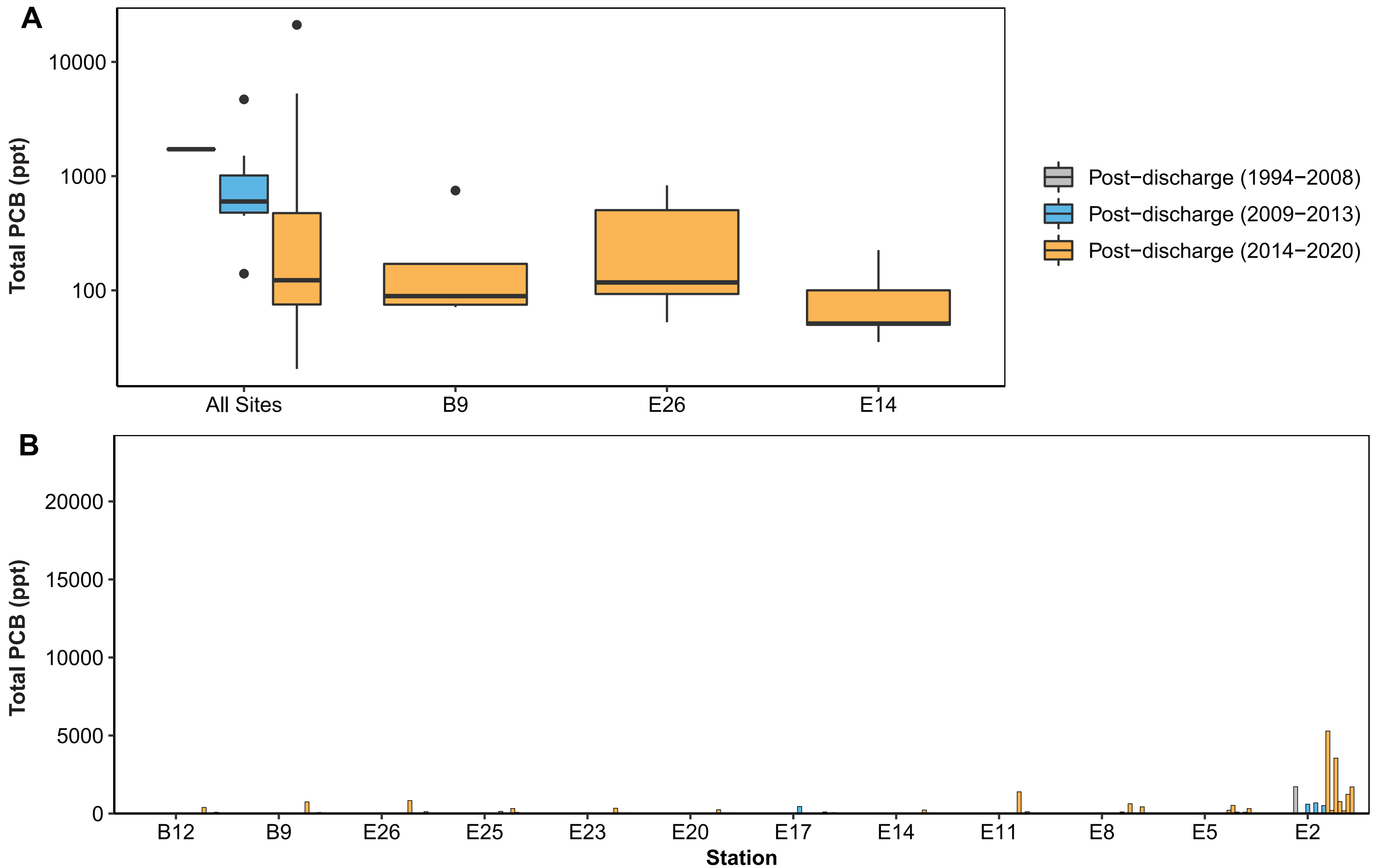


**FIGURE C1-25**
Total PCB, calculated with congeners analyzed consistently over all years, in sediments at outfall discharge depths near the PLOO from 1998 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

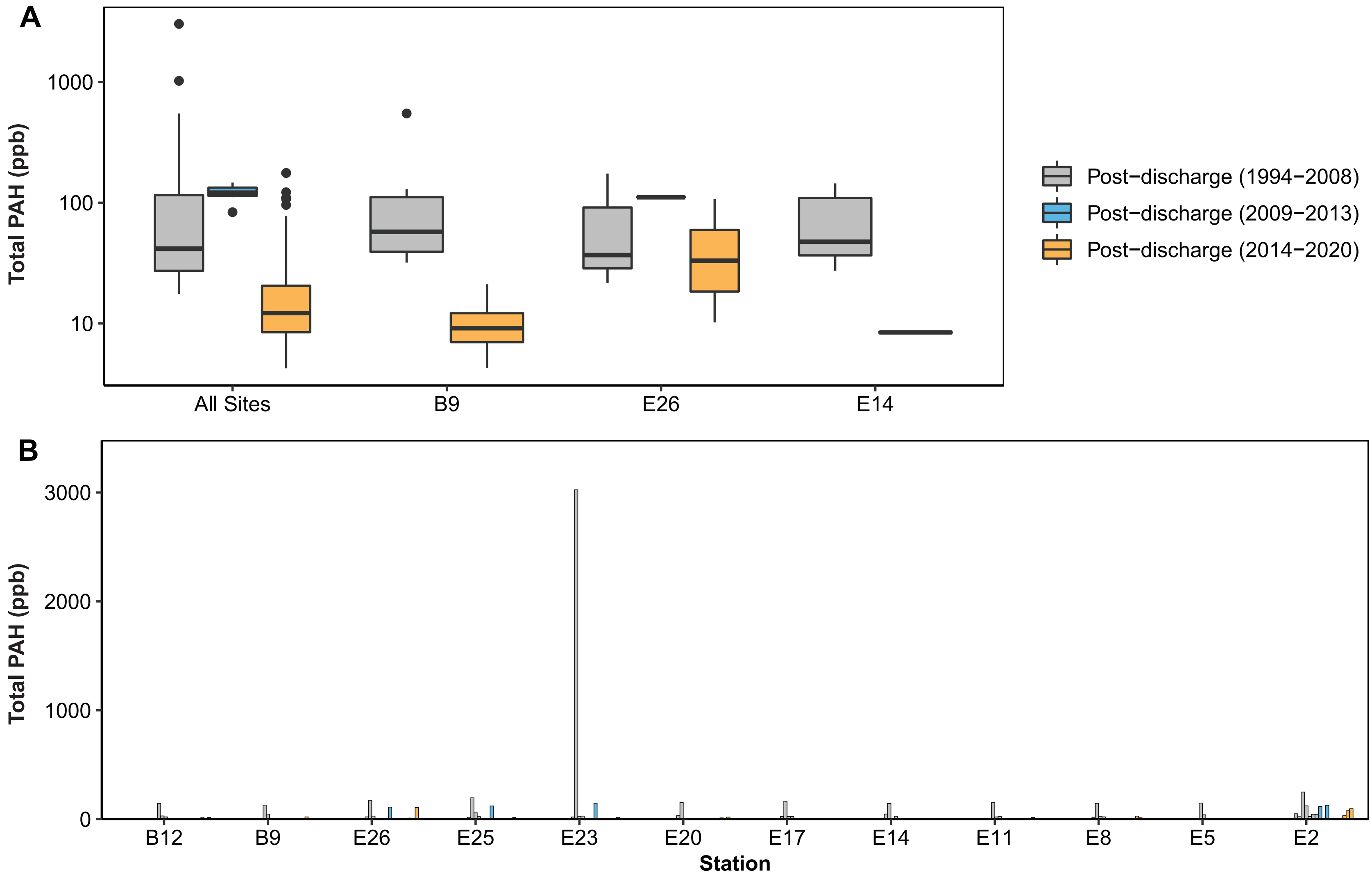


**FIGURE C1-26**

Total PAH, calculated with all detected constituents, in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

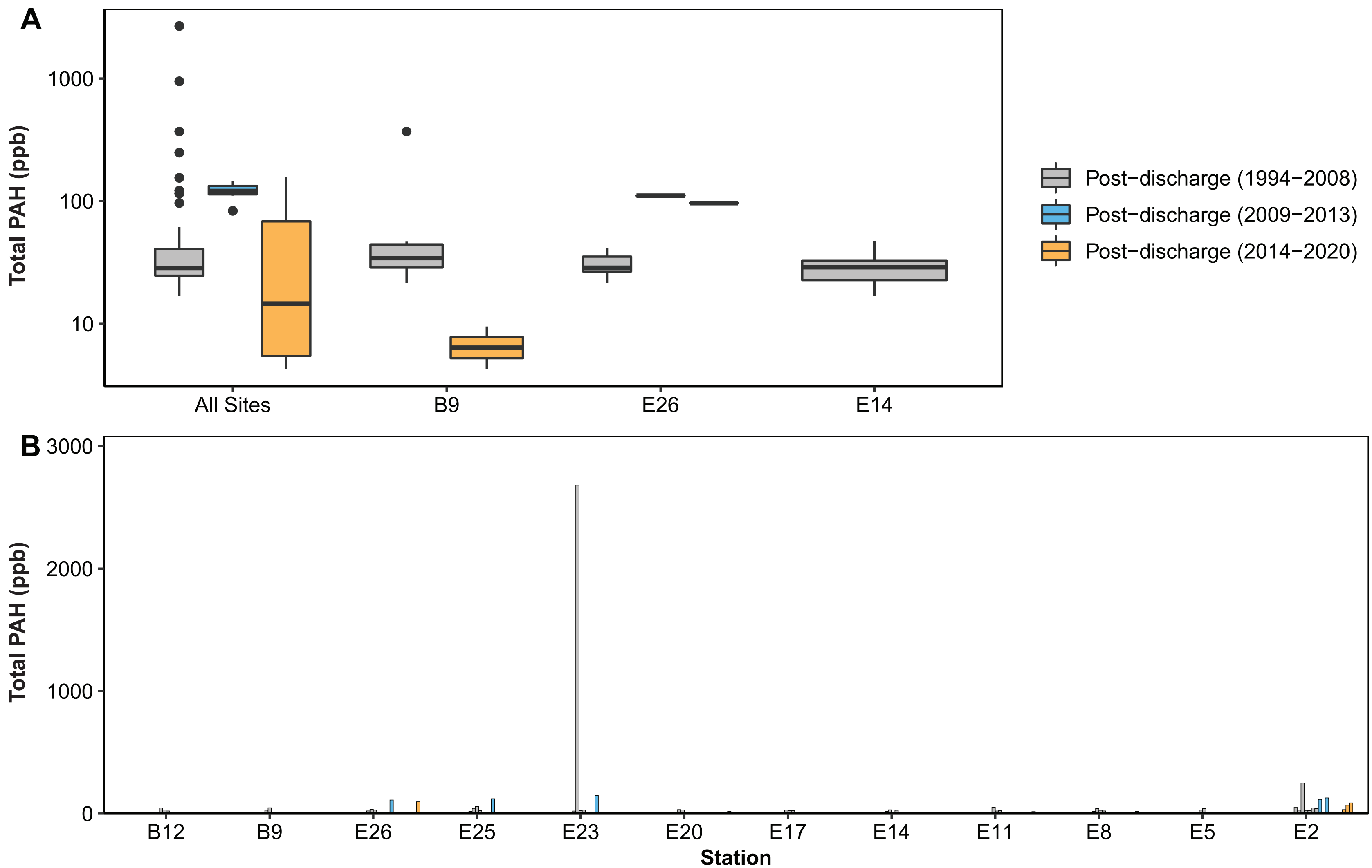


**FIGURE C1-27**

Total PAH, calculated with constituents anaylzed consistently across all year, in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

# SECTION C1-4 | BENTHIC INFAUNA

The City has been monitoring benthic infaunal (macrofaunal) communities around the extended PLOO since 1991. Benthic surveys were conducted quarterly from July 1991 through July 2003, after which sampling was modified to semiannual surveys during winter (typically January) and summer (typically July) of each year. The locations for all benthic stations sampled during these periods are shown in Figure C1-1. This section focuses on the results of the benthic infaunal analyses from the pre- and post-discharge monitoring periods to evaluate the possible effects of wastewater discharge.

## Analyses

The analyses included herein are based on data from winter and summer surveys conducted from 1991 through 2020 at the 12 primary core stations located at outfall discharge depths (see Section C1-2 for a complete description of dataset reduction). This dataset includes 60 grab samples collected during the five pre-discharge surveys (summer 1991-summer 1993), and 647 grabs collected during the 54 post-discharge surveys (winter 1994-summer 2020). Of the 707 total infauna grabs included in this assessment, 168 have not been analyzed as part of previous PLWTP modified permit applications (City of San Diego 2007c, 2015).

The primary core stations E14, E11 and E17 are located within about 100–300 m of the outfall diffuser legs (i.e., within 200 m of the zone of initial dilution, or ZID) and are considered nearfield or near-ZID sites. Station E14 is nearest the outfall, located adjacent to the ZID boundary about 103 m west of the center of the outfall wye. This station is the site most likely to be impacted by wastewater discharge. Stations E11 and E17 are located a little farther away off the ends of the southern and northern diffuser legs, respectively. Station E11 is located about 149 m from the southern ZID boundary, while E17 is located about 197 m from the northern ZID boundary. The remaining seven "E" stations are considered farfield sites. The "B" stations are located more than 11 km north of the outfall and were originally selected to represent reference or control sites. However, benthic communities differed between the "B" and "E" stations prior to operation of the outfall (Smith and Riege 1994; City of San Diego 1995a). Thus, farfield station E26 was chosen to represent an additional reference site. This station is located approximately eight km north of the outfall and is considered the least likely "E" station to be impacted by wastewater discharge.

The following key community parameters were evaluated per grab sample in assessing impacts on the benthos: (1) species richness (number of species); (2) abundance (number of individuals); (3) Shannon Diversity Index (H'); (4) Swartz Dominance Index (see Swartz et al. 1986, Ferraro et al. 1994); (5) Benthic Response Index (BRI) (see Smith et al. 2001); (6) abundances of major taxa groups (e.g., polychaete annelids, echinoderms, crustacean arthropods, molluscs); (7) abundances of various pollution sensitive, pollution tolerant, or opportunistic species (i.e., indicator species); and (8) abundances of numerically dominant taxa from both the pre- and post-discharge periods (i.e., top 10 species by abundance). Throughout this application, including Appendices C1, C2, and C4, "species" were calculated as distinct taxa, which may or may not be identified at the species level. Additional comparisons of changes in the benthos were made using the Before-After-Control-Impact-Paired (BACIP) statistical design (Box A).

The focus of most comparisons in this appendix is between conditions present during the 2.5-year pre-discharge period (July 1991-1993) and the entire 27-year post-discharge period (1994-2020). Exceptions are noted when data were not available for part of the pre-discharge period for specific parameters. Additionally, the post-discharge period is broken down into three periods (1994-2008, 2009-2013, 2014-2020) in some tables and figures to emphasize any patterns or trends during the period since the last PLWTP modified permit application. Finally, presentations of results over time at each primary core station are limited to data collected only during the summer (typically July) surveys to minimize differences due to natural seasonal fluctuations.

## Results

A total of 239,586 benthic organisms, from 979 taxa (most identified to species), were collected in 707 grab samples collected off Point Loma during winter and summer surveys conducted from 1991 through 2020. All benthic invertebrates are summarized as the number of individuals per species (taxa), with taxonomic arrangement according to SCAMIT (2018) in Attachment C1-B.

### *Major Community Parameters*

**Species Richness**: One potential indicator of environmental degradation would be a reduction in benthic species diversity or the number of species near an outfall compared to those at reference stations. Species richness off Point Loma averaged 66 and 86 species per 0.1 $m^2$ grab sample during the pre- and post-discharge periods, respectively (Table C1-5). Although highly variable (range=41-140 species per grab), the number of species per grab was generally higher at all stations during the post-discharge period (Figure C1-28). This post-discharge increase was apparent at several stations including near-ZID stations E14 and E11, southern farfield station E2 near the LA-5 dredged materials disposal site, and northern reference stations B9 and B12. The results of BACIP analyses demonstrated a significant change in the difference in species diversity between impact station E14 and both control station B9 and reference station E26 (Table C1-7). However, 86% of all species richness values were within the tolerance interval bounds of 61-113 species per grab calculated for the San Diego mainland shelf (see Appendix C2, this application).

No conclusions can be drawn regarding whether the above increases in species richness were related to wastewater discharge. First, the increase could be part of a larger regional phenomenon, as the number of species began to increase prior to wastewater discharge off Point Loma, and this increase has generally occurred at all stations regardless of proximity to the outfall. Second, the increase in number of species at near-ZID station E14 may be related to proximity to the physical structure of the outfall pipe and associated sediment heterogeneity (e.g., patchy sediments related to presence of ballast materials) aside from organic enrichment. Additionally, two other stations characterized by relatively coarse and unstable sediments, stations E2 to the south and B12 to the north, also displayed relatively large increases in species diversity. Third, the numbers of infaunal species near the outfall were still generally

## Box A

### BACIP Analysis Methods

A BACIP (Before-After-Control-Impact-Paired) statistical model was used to test the null hypothesis ($H_0$) that there were no changes in various benthic community parameters due to operation of the Point Loma Ocean Outfall (see Bernstein and Zalinski 1983; Stewart-Oaten et al. 1986, 1992; Osenberg et al. 1994). Briefly, the BACIP model tests differences between control (reference) and impact sites at times before and after a disturbance or 'impact' event (e.g., onset of wastewater discharge). Overall, the Point Loma outfall dataset includes 2.5 years (10 quarterly surveys) of 'Before Impact' data (1991–1993) and 20 years (59 quarterly or semiannual surveys) of 'After Impact' data (1994–2013). However, the data were limited to only winter (January) and summer (July) surveys conducted each year for the analyses presented herein (see Section C.1-3), which resulted in a reduced data set of five pre-discharge surveys and 40 post-discharge surveys. The 'E' benthic stations for the Pt Loma monitoring program, located within 8 km of the outfall, are the most likely to be affected by wastewater discharge. Near-ZID station E14 was selected as the impact site for all BACIP analyses since this station is located nearest the Zone of Initial Dilution (ZID) and is probably the site most susceptible to wastewater influence. In contrast, the 'B' stations are located at least 11 km north of the outfall and are the obvious candidates for reference or 'control' sites. However, benthic community structure already differed between the 'E' and 'B' stations prior to operation of the outfall (Smith and Riege 1994; City of San Diego 1995a). Consequently, two stations (E26 and B9) were selected to represent separate control sites in subsequent analyses. Farfield station E26 is located ~8 km from the outfall and is considered the least likely 'E' station to be impacted, while previous analyses suggested that reference station B9 was the most appropriate 'B' station for comparisons (Smith and Riege 1994; City of San Diego 1995a). Six dependent variables were analyzed, including three community parameters (number of species, infaunal abundance, and BRI) and abundances of three benthic invertebrate taxa (or species groups) known to be sensitive to organic enrichment. These indicators included ophiuroids in the genus *Amphiodia* (mostly *A. urtica*) and amphipods in the genera *Ampelisca* (Family Ampeliscidae) and *Rhepoxynius* (Family Phoxocephalidae).

All BACIP analyses were first interpreted using a Type I error rate of $\alpha = 0.05$. However, the substantial spatial and temporal variation inherent in many biological communities may often lead to an increased chance of Type II error and falsely conclude that no impact has occurred when it has happened (e.g., see Underwood 1990; Fairweather 1991; Otway 1995; Otway et al. 1996). One possible solution to this problem is to increase the probability of Type I error (i.e., falsely conclude an impact has occurred) by changing $\alpha$ from 0.05 to 0.10, and thereby increase the power of the t-tests to make the detection of any 'impact' less conservative (Otway 1995; Otway et al. 1996). Thus, all non-significant BACIP test results at $\alpha = 0.05$ were subsequently interpreted using the higher Type I error rate of $\alpha = 0.10$.

within the range of natural variability reported for reference areas in the SCB and observed during San Diego regional surveys (Table C1-6; Appendix C2, this application). Regardless, wastewater discharge via the Point Loma outfall is not causing any reduction in the number of benthic species in the area, indicating a lack of negative environmental impact.

**Infaunal Abundance**: Changes in total infaunal abundance are often used to demonstrate an effect of an ocean outfall discharge, although specific changes may vary depending upon the level of organic enrichment. For example, abundances of benthic invertebrates are generally predicted to increase in response to low to moderate levels of enrichment. This increase is generally not considered adverse unless it is accompanied by a reduction in the number of species present or a significant change in the feeding dynamics of the infaunal community. As organic input increases, the total number of species or diversity may begin to decline while populations of pollution tolerant species increase. Extremely high infaunal abundances associated with reduced numbers of species are often considered an indication of an adverse outfall effect. Benthic abundances would then be expected to decline when levels of organic enrichment reach the point of causing anoxic sediment conditions. Thus, evidence of high organic loadings coupled with reduced benthic abundances would be indicative of polluted or degraded conditions.

The number of infaunal animals at outfall depths off Point Loma averaged 269 per grab over all pre-discharge surveys and 346 per grab during the post-discharge period (Table C1-5). Overall, this represents about a 29% increase between the pre- and post-discharge periods. Despite this general increase, there were no clear spatial patterns in the region, and 96% of the infaunal abundances at all stations were within the tolerance interval bounds of 144-644 animals per grab for the San Diego mainland shelf (see Appendix C2). Although highly variable (range=94-788 animals per grab), abundances were generally higher at all stations in the post-discharge period (Figure C1-29). For example, densities at near-ZID station E14 increased from an average of 279 animals per grab during the pre-discharge years to 351 per grab during the post-discharge period. Although the increase at station E14 could be an enhancement effect, infaunal abundances also increased at other sites considered beyond the outfall's influence (e.g., stations E26 and B9). According to BACIP results, there was a significant change in the difference in abundance values between impact station E14 and both control sites (Table C1-7). Although these results support an outfall enrichment pattern, the effect appears minor as infaunal abundances at all sites off Point Loma were generally like those reported for reference areas throughout the SBC, and from regional surveys conducted throughout San Diego (Table C1-6). This suggests that abundances near the Point Loma outfall were within the range of natural variability seen throughout mainland shelf benthic habitats of the SCB.

**Benthic Response Index**: The benthic response index (BRI) is an important tool for gauging anthropogenic impacts to coastal seafloor habitats throughout the SCB. BRI values below 25 are considered indicative of reference conditions, while values between 34 and 44 represent increasing, though still minor, levels of disturbance or environmental degradation (Smith et al. 2001). Because the BRI was developed from data collected within the SCB over several decades, the index is largely driven by the abundance of many of the species that are common off Point Loma.
Overall, benthic communities surrounding the PLOO continue to reflect reference conditions,

with 100% of BRI values falling below 25 at all sites except near-ZID station E14 over the past 30 years (Figures C1-31 and C1-32). Additionally, BRI values for more than 92% of near-ZID samples and 99% of farfield samples have remained below the upper tolerance bound of 18 for the San Diego mainland shelf (see Appendix C2) and all values fell within the range reported for the entire SCB (Table C1-6). There has been an increase in BRI values subsequent to the initiation of wastewater discharge via the PLOO, with values at all 12 PLOO primary core stations ranging from -4.2 to 12.0 per grab during the pre-discharge period and from -4.3 to 37.4 per grab during the post-discharge period (Table C1-5). The highest BRI occurred at station E14 nearest the outfall, where values have become elevated relative to other sites since 1994. BACIP t-test results indicated a net change in the difference of BRI values between this near-ZID station and both control sites (Table C1-7). Although these data suggest an outfall related pattern, the effect is relatively minor, with 95% of grabs from station E14 having BRI values below 34, and is restricted to this ZID boundary site, with values at the nearest upcoast (E17) and downcoast (E11) stations only minimally elevated and never exceeding the reference condition threshold (Figure C1-31). The highest BRI values reported at station E14 (≤37.4) were limited to just three surveys (winter 2017 – winter 2018). Therefore, changes in benthic communities reflected in the elevated BRI values have been a highly localized, temporary in nature, and, along with other community metrics discussed in this section, are not considered indicative of degraded benthic habitats (see Smith et al. 2001).

**Dominance and Diversity**: Dominance is an indicator of benthic community structure which reflects shifts in the relative abundance of species (rather than the total number of species) while diversity integrates species richness with their populations and provides a more nuanced metric than species richness alone. Severely polluted or impacted habitats are typically dominated by a few pollution tolerant species with low diversity, whereas more natural areas tend to have greater numbers of more evenly distributed species. One measure of dominance is the minimum number of species whose combined abundance accounts for 75% of the individuals in a sample (Swartz et al. 1986, Ferraro et al. 1994). Consequently, dominance as discussed herein is inversely proportional to numerical dominance, such that low index values indicate communities dominated by few species. The Shannon diversity index (H’) ranges in value from zero (a population of a single species) to five (very high diversity), although values greater than four are rarely encountered.

Overall, benthic infaunal communities around the PLOO have not become numerically dominated by a few pollution tolerant species following the initiation of wastewater discharge. Instead, dominance decreased (i.e., index values were higher) region-wide off Point Loma (Figure C1-30). For example, the Swartz dominance values averaged 18 over all sites during the pre-discharge period and 28 during the post-discharge period (Table C1-5). Thus, post-discharge benthic communities in the region as a whole were characterized by a more even distribution of species than prior to discharge. Additionally, all samples from the near-ZID stations, and over 99% of the farfield samples, were within the tolerance interval bounds of 7 to 48 taxa for the San Diego mainland shelf (Appendix C2, this application). Diversity was also higher in the PLOO region post-discharge (mean=3.3 pre-discharge versus 3.7 post-discharge), and more than 99% of samples from near-ZID and farfield stations were within the tolerance interval bounds of 2.5 to 4.3 for the San Diego mainland shelf (Appendix C2).

**TABLE C1-5**

Summary of benthic infauna abundance, species richness (no. of species), Swartz dominance, diversity (H'), and benthic response index (BRI) values for PLOO primary core stations located at outfall depths (n=12). Data are for winter and summer surveys only from 1991−2020; pre-discharge surveys = 1991−1993 (n=5); post-discharge surveys = 1994−2020 (n=54). See text for details of data reductions.

| | Pre-Discharge (1991−1993) | | | | | 1994−2008 Post-Discharge | | | 2009−2013 Post-Disharge | | | 2014−2020 Post-Disharge | | | All Post-Disharge | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Sites | | | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | | | Outfall Stn. E14 | Ref. Stn. B9 |
| | Mean | Min | Max | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Min | Max | Mean | Mean |
| **Abundance** | | | | | | | | | | | | | | | | | | | |
| All Invertebrates | 269 | 124 | 498 | 279 | 254 | 352 | 452 | 310 | 333 | 433 | 310 | 341 | 351 | 311 | 346 | 94 | 788 | 422 | 310 |
| Annelids[a] | 151 | 50 | 375 | 170 | 143 | 208 | 307 | 185 | 190 | 292 | 184 | 209 | 209 | 221 | 205 | 40 | 670 | 279 | 194 |
| Arthropods[b] | 44 | 10 | 102 | 44 | 52 | 56 | 75 | 52 | 77 | 72 | 63 | 37 | 36 | 26 | 57 | 2 | 178 | 64 | 47 |
| Molluscs | 19 | 4 | 102 | 14 | 13 | 29 | 45 | 20 | 28 | 52 | 32 | 57 | 91 | 27 | 36 | 2 | 283 | 58 | 24 |
| Echinoderms | 51 | 9 | 84 | 47 | 43 | 50 | 18 | 50 | 32 | 6 | 27 | 31 | 3 | 29 | 42 | 0 | 175 | 12 | 41 |
| Misc. Other Taxa | 3 | 0 | 11 | 4 | 4 | 6 | 7 | 4 | 5 | 11 | 5 | 8 | 13 | 8 | 6 | 0 | 51 | 10 | 5 |
| **Species Richness** | 66 | 44 | 100 | 63 | 68 | 89 | 99 | 82 | 92 | 103 | 94 | 77 | 69 | 85 | 86 | 41 | 140 | 92 | 85 |
| **BRI** | 4.6 | -4 | 12 | 4.8 | 7.0 | 7.5 | 15.1 | 4.0 | 14.2 | 22.7 | 9.4 | 13.2 | 30.4 | 9.6 | 10.2 | -4 | 37 | 20.5 | 6.4 |
| **Swartz Dominance** | 18 | 9 | 30 | 18 | 20 | 28 | 29 | 26 | 32 | 32 | 36 | 24 | 18 | 30 | 28 | 4 | 50 | 26 | 29 |
| **Diversity (H')** | 3.3 | 2.7 | 3.9 | 3.3 | 3.4 | 3.8 | 3.8 | 3.6 | 3.9 | 3.9 | 4.0 | 3.6 | 3.4 | 3.8 | 3.7 | 2.0 | 4.4 | 3.7 | 3.8 |

[a] Annelids = mostly polychaetes
[b] Arthropods = mostly crustaceans

**TABLE C1-6**
Comparison of benthic infauna species richness, abundance, and benthic response index (BRI) values for the PLOO benthic stations with data from the Southern California Bight (SCB) 1994, 1998, 2003, 2008, 2013, and 2018 regional surveys and annual San Diego regional surveys (1995−2020). PLOO data are presented for 98-m outfall depth stations sampled during winter and summer surveys with data expressed as means (ranges) for all 12 stations combined during the pre-discharge (1991−1993) and post-discharge (1994−2020) periods. SCB and San Diego regional survey data are expressed as mean values for the "mid-shelf" strata.

| | Southern California Bight Regional Surveys | | | | | | San Diego Regional Surveys | PLOO Surveys (1991−2020) | |
|---|---|---|---|---|---|---|---|---|---|
| | **1994** | **1998** | **2003** | **2008** | **2013** | **2018[b]** | | **Pre-Dis** | **Post-Dis** |
| **Species Richness** | 85 (18−162) | 62 (7−166) | 62 (2−158) | 99 (30−153) | 90 (45−171) | 91 (26−156) | 91 (19−198) | 66 (44−100) | 86 (41−140) |
| **Abundance** | 385 (3−1,696) | 292 (11−1,830) | 274 (5−2,298) | 393 (79−1,159) | 491 (142−2,718) | 417 (68−1,150) | 376 (47−1,467) | 269 (124−498) | 346 (94−788) |
| **BRI[a]** | — | 16.6 (-15.8−47.3) | 15.8 (-12.0−47.3) | 14.8 (2.0−25.8) | 18.0 (7.0−37.0) | 17.5 (8.5−28.8) | 12.0 (-2.0−42.3) | 4.6 (-4.2−12.0) | 10.2 (-4.3−37.4) |

[a] BRI values not calculated for SCBPP surveys
[b] Values for Bight'18 are estimates pending final publication of the summary report

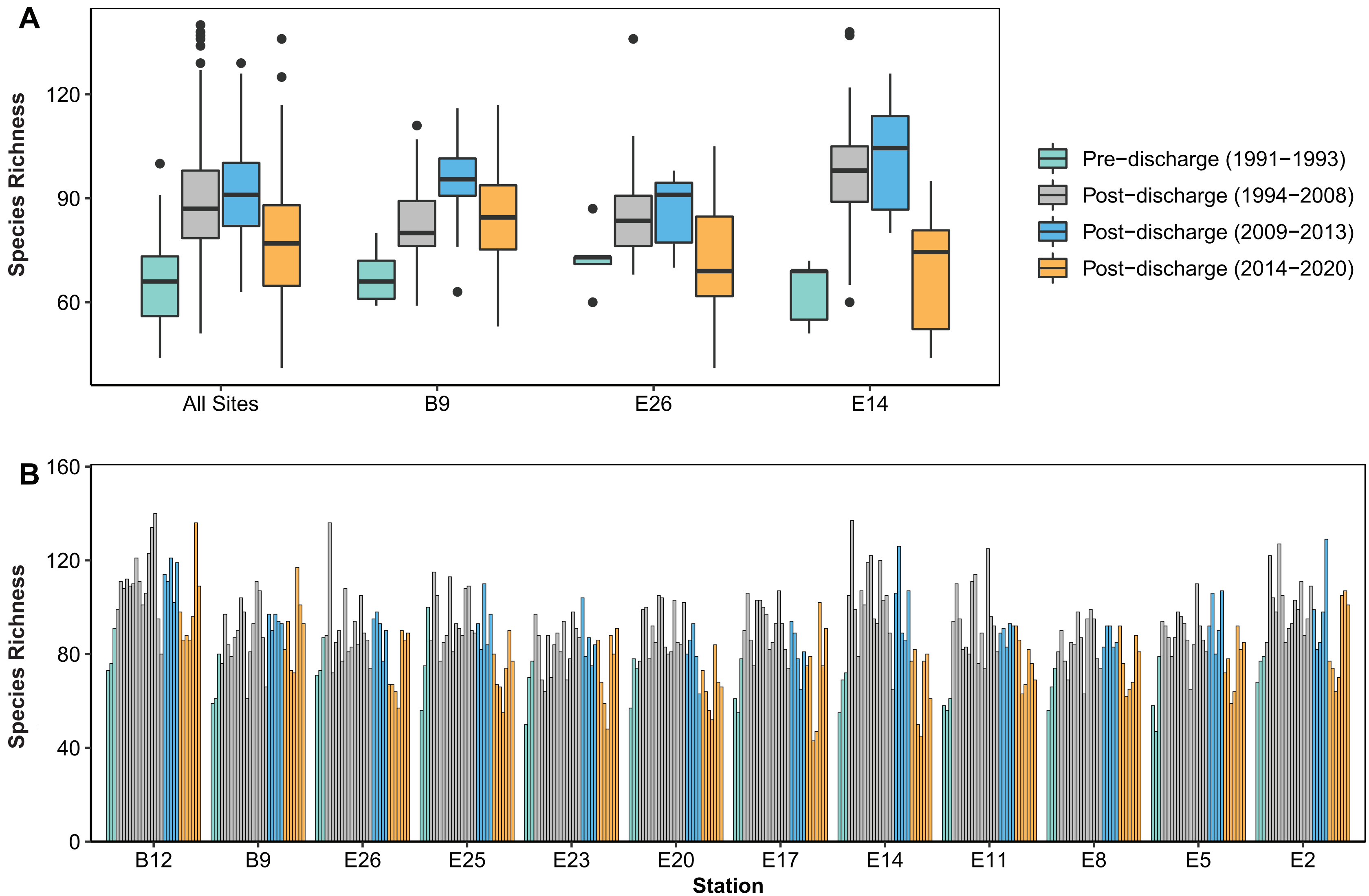


**FIGURE C1-28**

Benthic infauna species richness at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

**TABLE C1-7**

Results of BACIP t-tests for species richness, total infaunal abundance, benthic response index (BRI), and the abundance of several benthic indicator taxa around the PLOO (1991−2020). Indicator taxa = ophiuroids (*Amphiodia* spp) and amphipods (*Ampelisca* spp and *Rhepoxynius* spp). Impact site = near-ZID station E14. Control sites = farfield station E26 and reference station B9. Before Impact period = July 1991 to July 1993 (n = 5 surveys); After Impact period = January 1994 to July 2020 (n= 54 surveys). NS = not significant at either the *alpha* = 0.05 or *alpha* = 0.1 levels.

| | Comparison | Before Impact | | After Impact | | | |
|---|---|---|---|---|---|---|---|
| | Control vs. Impact | Mean Δ | Variance | Mean Δ | Variance | t | p-value |
| Species Richness | E26 vs E14 | 9.6 | 6.7 | 15.5 | 3.5 | -1.86 | 0.03 |
| | B9 vs E14 | 8.8 | 10.3 | 19.1 | 4.5 | -2.67 | 0.00 |
| Abundance | E26 vs E14 | 77.4 | 360.0 | 116.4 | 180.1 | -1.68 | 0.05 |
| | B9 vs E14 | 77.2 | 471.5 | 138.5 | 264.2 | -2.26 | 0.01 |
| BRI | E26 vs E14 | 3.7 | 1.7 | 12.1 | 0.7 | -5.45 | <0.001 |
| | B9 vs E14 | 5.4 | 2.3 | 14.0 | 0.7 | -5.01 | <0.001 |
| *Amphiodia* spp | E26 vs E14 | 16.2 | 35.8 | 31.5 | 6.9 | -2.33 | 0.01 |
| | B9 vs E14 | 21.6 | 46.7 | 27.0 | 6.1 | -0.75 | NS |
| *Ampelisca* spp | E26 vs E14 | 7.6 | 3.5 | 7.1 | 0.6 | 0.26 | NS |
| | B9 vs E14 | 6.0 | 2.3 | 5.7 | 0.4 | 0.18 | NS |
| *Rhepoxynius* spp | E26 vs E14 | 5.6 | 4.1 | 3.8 | 0.2 | 0.89 | NS |
| | B9 vs E14 | 4.4 | 2.5 | 3.9 | 0.1 | 0.34 | NS |

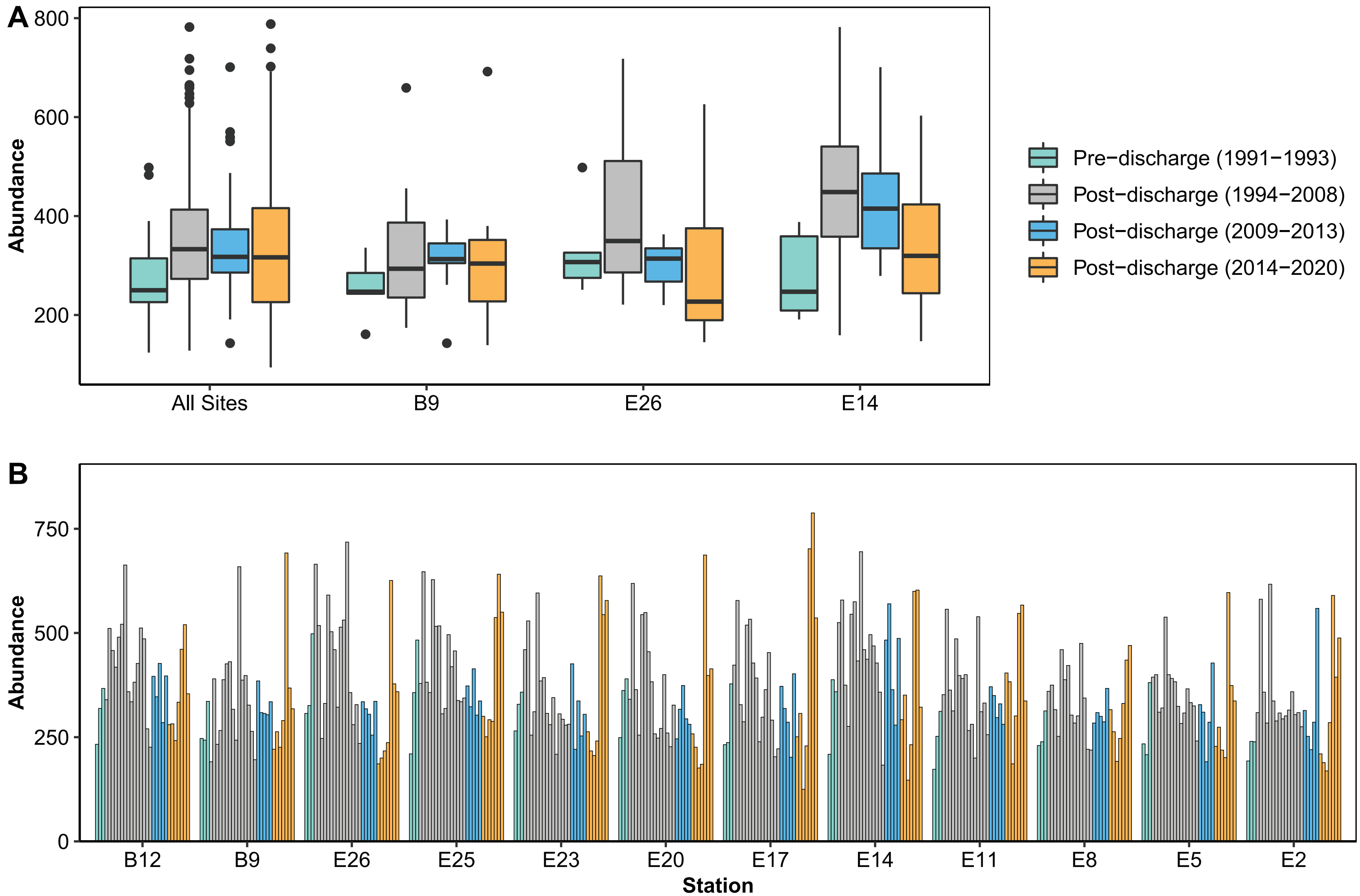


**FIGURE C1-29**
Abundance of all benthic infauna at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

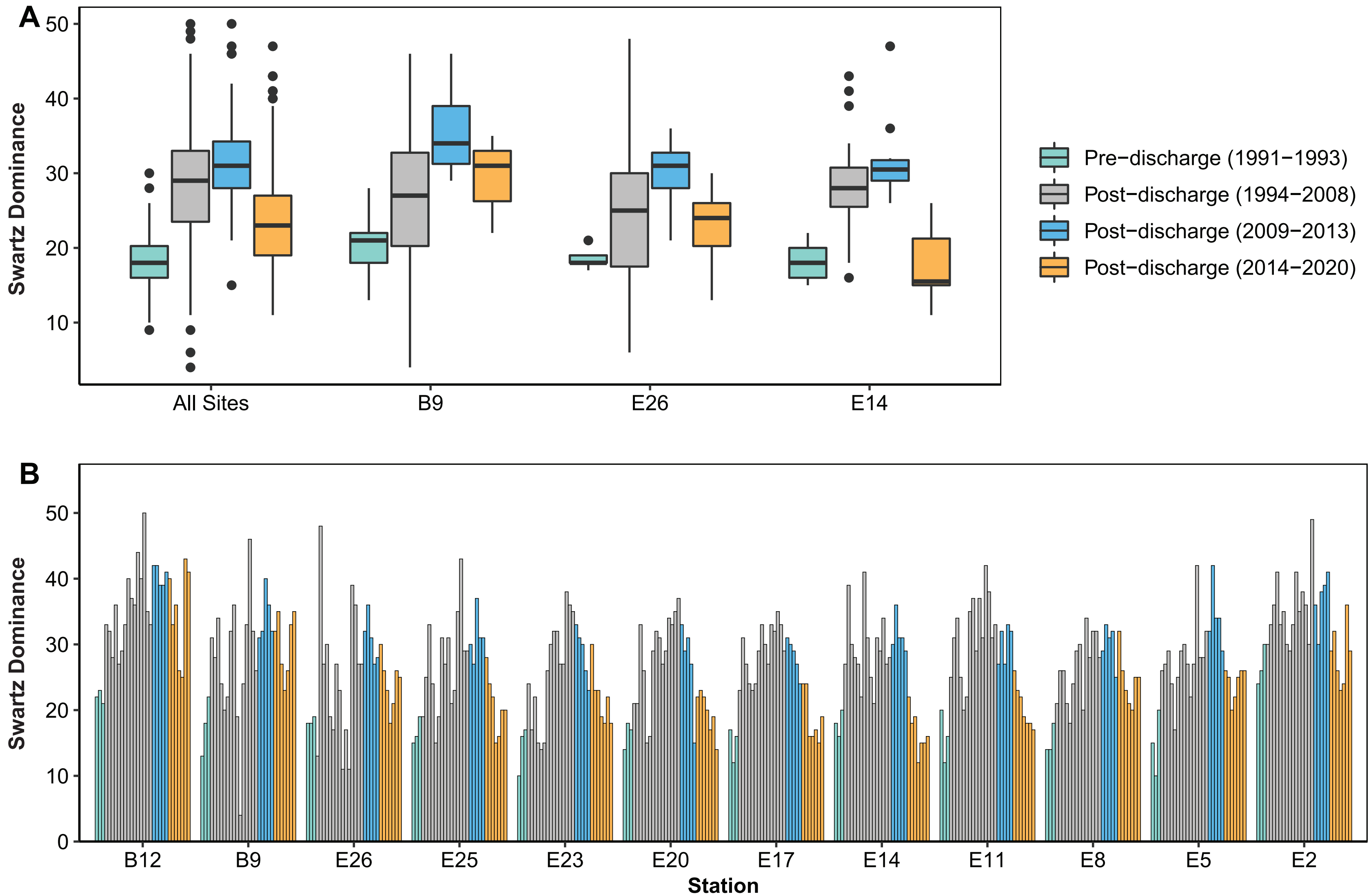


**FIGURE C1-30**
Swartz dominance values for benthic infauna at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

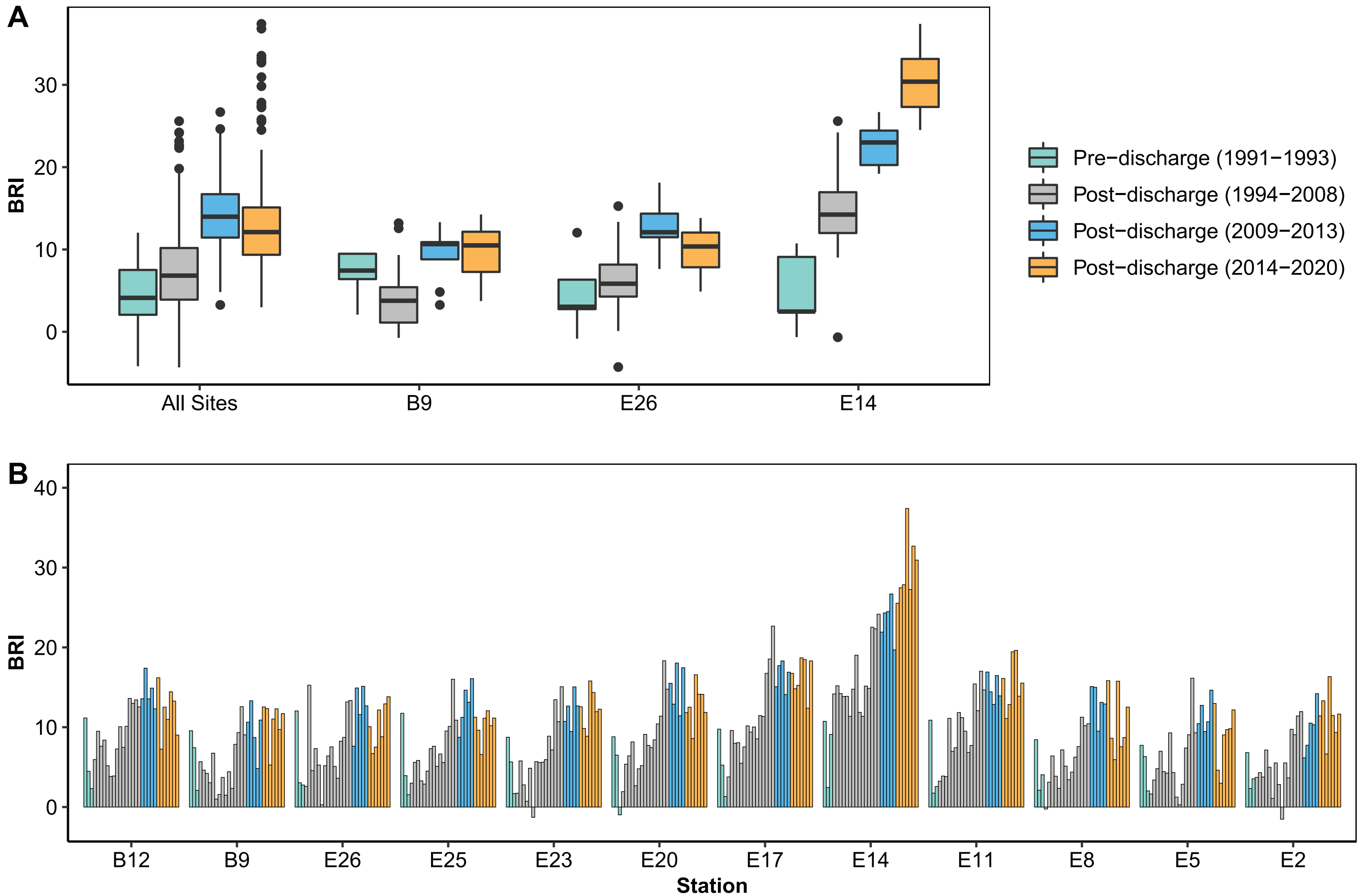


**FIGURE C1-31**
Benthic response index (BRI) values at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

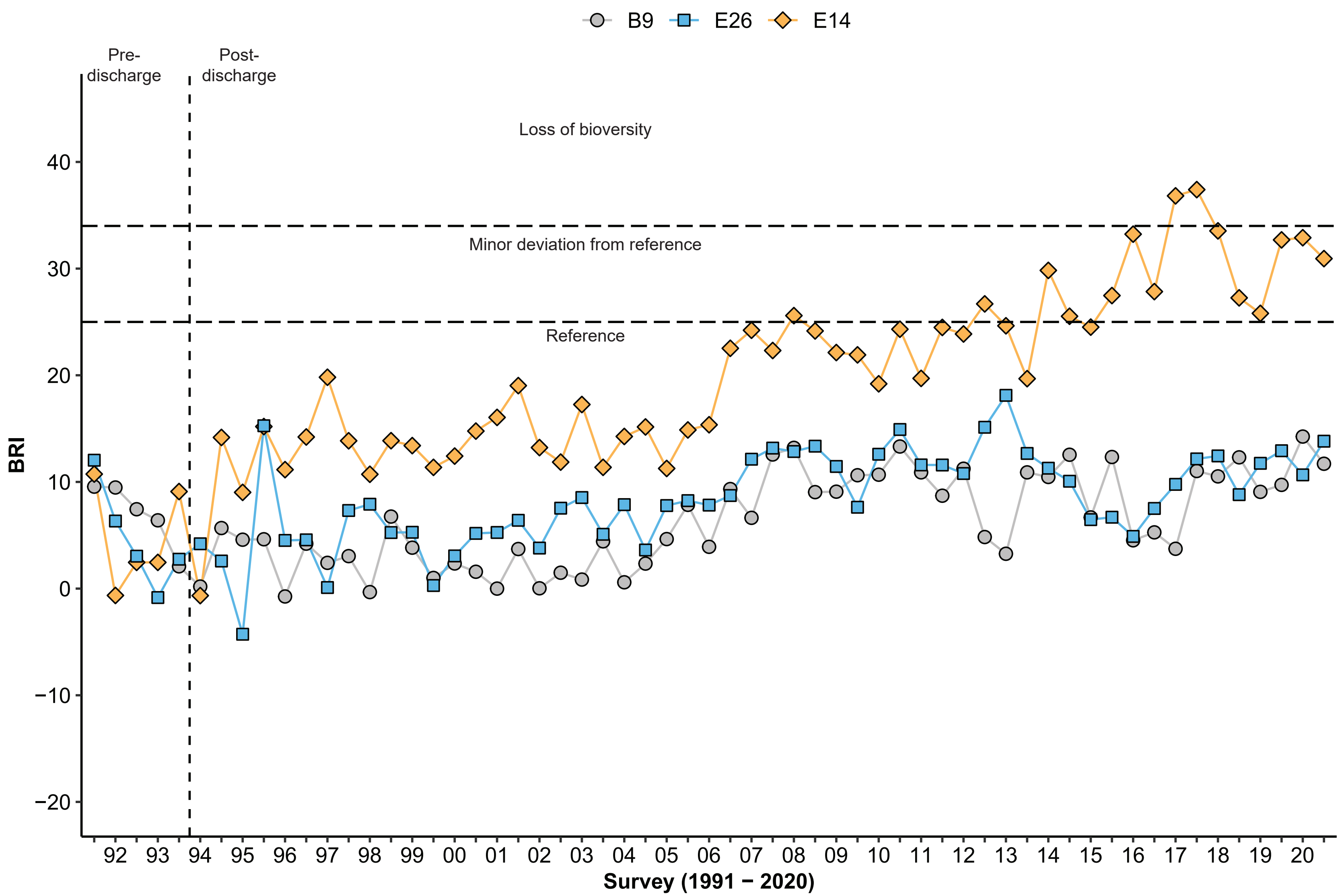


**FIGURE C1-32**
BRI values at near-ZID station E14, farfield station E26, and reference station B9 along the PLOO discharge depth contour from 1991 through 2020.

### *Abundance of Major Taxa & Indicator Species*

**Annelida, Polychaeta**: Polychaete worms (Phylum Annelida) represented the most abundant benthic invertebrates off Point Loma, comprising 56% and 59% of the macrofauna at the primary core outfall depth stations during the pre- and post-discharge periods, respectively (Table C1-5). Although the proportion of polychaetes has remained relatively stable between these periods, actual densities increased approximately 36% from an average of 151 worms per grab prior to outfall operation to 205 worms per grab during the post-discharge period.

A comparison of data collected during the summer surveys suggested little evidence of any temporal or spatial trends related to the outfall (Figure C1-33). Although the number of polychaetes increased sharply near the outfall (i.e., near-ZID station E14) immediately after discharge began in 1994 and 1995, this appeared to be a continuation of a general pattern at all stations that began prior to wastewater discharge. Polychaete populations then declined considerably during 1996 and 1997, after which they increased again between 1998 and 2000 at station E14. Similar alternating patterns of population growth and decline have occurred throughout the region since that time, regardless of proximity to the PLOO, and are likely related to natural population responses to changing oceanographic conditions (e.g., El Niño/La Niña and the concomitant influx of the pelagic red crab, *Pleuroncodes planipes*; see Section C1-5) or longer-term climatic shifts or regime changes such as the Pacific Decadal Oscillation or ocean acidification (see Kroeker et al. 2011). For example, there was little difference in the changes that occurred near the outfall and at station E26 located to the north, beyond the outfall's influence. Much of the change in densities is in response to the cyclical nature of some numerically dominant polychaetes. For instance, populations of two such polychaetes, *Myriochele striolata* and *Proclea* sp A, have varied considerably over time (e.g., City of San Diego 2007a). Such variation can have significant effects on other community descriptive statistics (e.g., dominance, diversity, and abundance) or environmental indices (i.e., BRI) that use the abundance of indicator species in their equations.

Three species of polychaetes were among the 10 most abundant taxa over all primary core sites during both the pre- and post-discharge periods (Table C1-8). These included the spionid *Spiophanes duplex* (Figure C1-34; previously reported as *S. missionensis*), and the terebellids *Proclea* sp A (Figure C1-35) and *Phisidia sanctaemariae* (Figure C1-36; previously reported as *Lanassa* sp D). Of these species, *S. duplex* showed the greatest change, decreasing from an average of 33 animals per grab prior to discharge to about 13 animals per grab during the post-discharge period. In contrast, populations of the two terebellid species remained fairly stable when averaged over all sites, with *Proclea* sp A decreasing from 15 to 10 animals per grab, and *Phisidia sanctamariae* increasing slightly from 9 to 10 animals per grab. Populations of the oweniid polychaete, *Myriochele striolata*, increased initially from an average of 5 individuals per grab during the pre-discharge period to 16 per grab during the 1994 to 2008 post-discharge period but have since fallen off to less than one individual per grab from 2014 to 2020 (Figure C1-37).

Several species of polychaetes that occur in southern California waters are useful indicators of organic loading. These include the well-known pollution indicator species *Capitella teleta*, other capitellids in the genus *Mediomastus*, the dorvilleid *Dorvillea longicornis*, and the opheliid *Armandia brevis*. *Capitella teleta* was previously considered part of a cosmopolitan species complex of several physiologically and genetically distinct sibling species (see Grassle and Grassle 1974, 1976, 1978, Blake et al. 2009). Overall, these worms are recognized for experiencing rapid population expansions in areas of organic loading or other disturbances (see Word et al. 1977; Grassle and Grassle 1976, 1978; Cuomo 1985; Tenore and Chesney 1985). Although background densities of various *Capitella* species (spp) are usually near zero, abundances may be higher where organic detritus accumulates naturally or where sediments are physically disturbed.

*Capitella teleta* occurs rarely and typically in low abundances at outfall depths off Point Loma (Figure C1-38), with populations averaging less than one worm per grab before discharge and about two worms per grab during the post-discharge period (Table C1-8), and more than 89% of samples from near-ZID stations with abundances of *C. teleta* below the upper tolerance interval bound of 1 individual for the San Diego mainland shelf (see Appendix C2). Populations of this species have shown a minor outfall related pattern with densities increasing from an average of zero to 14 worms per grab at near-ZID station E14 since discharge began. Although the highest number of *C. teleta* reported since 1991 (140/grab) occurred at this near-ZID station in January 2013 (see City of San Diego, 2014b), this abundance was still characteristic of undisturbed habitats. For example, *C. teleta* commonly reaches densities as high as 500 individuals per 0.1 $m^2$ in polluted sediments (Reish 1957, Swartz et al. 1986). Overall, the relatively low abundance and sporadic occurrence of this polychaete off Point Loma suggests no substantial organic loading or habitat degradation is occurring near the outfall. Instead, population fluctuations of *C. teleta* at station E14 located near the ZID boundary, and to a lesser extent at stations E11 and E17 located farther away but still within 200 m of the ZID, may be related to local physical disturbances associated with proximity to the outfall as well as to minor organic enrichment.

Capitellid polychaetes of the genus *Mediomastus* are also capable of population expansion in transitional areas of moderate organic enrichment, where they typically exceed densities of 10 worms per 0.1 $m^2$ (see Word et al. 1977). Overall, more than 93% of samples from near-ZID stations, and more than 91% of samples from farfield stations, had abundances of *Mediomastus* within the tolerance interval bounds of 0–15 individuals for the San Diego mainland shelf (Appendix C2). *Mediomastus* densities did increase after initiation of wastewater discharge from the PLOO, averaging about one animal per grab at outfall depths during the pre-discharge period compared to about 9 animals per grab during the post-discharge period (Table C1-8; Figure C1-39). Although *Mediomastus* densities increased from about 4 to 21 worms per grab at near-ZID station E14 between these periods, these values were indicative of only moderate organic enrichment.

Other polychaetes that may be useful indicators of organic loading in SCB benthic sediments include species within the dorvilleid genus *Dorvillea* sp (including *Dorvillea* (*Schistomeringos*) *annualata* and *D. (S.) longicornis*) and the opheliid *Armandia brevis*. However, these polychaetes have occurred only rarely off Point Loma, with a combined total of 38 specimens from the winter and summer surveys analyzed herein. These records include 22 specimens of *Dorvillea* sp collected during the post-discharge period between 1994 and 2010 at near-ZID station E14. The *A. brevis* records include 16 specimens collected during 2007-2020 in the post-discharge period at stations E5, E11, E14, E17 and B12. Consequently, populations of these indicator species provide little evidence of organic loading in benthic sediments, which indicates habitat degradation is likely not occurring off Point Loma.

## TABLE C1-8

Abundances of benthic infauna indicator taxa and dominant species for PLOO primary core stations located at outfall depths (n=12). Data are for winter and summer surveys only from 1991−2020; pre-discharge surveys = 1991−1993 (n=5); post-discharge surveys = 1994−2020 (n=54). See text for details of data reductions.

| | Pre-Discharge (1991−1993) | | | | | 1994−2008 Post-Disharge | | | 2009−2013 Post-Discharge | | | 2014−2020 Post-Disharge | | | All Post-Discharge (1994−2020) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Sites | | | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | Outfall Stn. E14 | Ref. Stn. B9 | All Sites | | | Outfall Stn. E14 | Ref. Stn. B9 |
| | Mean | Min | Max | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Mean | Min | Max | Mean | Mean |
| **SCB Representative Indicator Taxa** | | | | | | | | | | | | | | | | | | | |
| *Capitella teleta* (P) | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 0 | 2 | 24 | 0 | 2 | 15 | 0 | 2 | 0 | 140 | 14 | 0 |
| *Mediomastus* spp (P) | 1 | 0 | 16 | 4 | 3 | 6 | 16 | 2 | 9 | 17 | 5 | 14 | 33 | 10 | 9 | 0 | 152 | 21 | 5 |
| *Amphiodia* spp (EO) | 43 | 5 | 79 | 40 | 35 | 39 | 11 | 43 | 26 | 2 | 23 | 24 | 1 | 21 | 33 | 0 | 124 | 7 | 34 |
| *Ampelisca* spp (CA) | 7 | 0 | 17 | 9 | 8 | 10 | 8 | 12 | 13 | 8 | 14 | 8 | 3 | 8 | 10 | 0 | 33 | 7 | 11 |
| *Rhepoxynius* spp (CA) | 5 | 0 | 16 | 4 | 7 | 5 | 5 | 3 | 6 | 5 | 3 | 6 | 3 | 3 | 5 | 0 | 30 | 4 | 3 |
| *Euphilomedes* spp (CO) | 17 | 3 | 48 | 17 | 22 | 17 | 30 | 10 | 29 | 33 | 8 | 11 | 22 | 1 | 18 | 0 | 91 | 28 | 7 |
| *Parvilucina tenuisculpta* (MB) | 3 | 0 | 19 | 1 | 4 | 3 | 8 | 2 | 1 | 4 | 0 | 2 | 6 | 2 | 2 | 0 | 54 | 7 | 2 |
| *Solemya pervernicosa* (MB) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 1 | 7 | 0 | 0 | 0 | 20 | 3 | 0 |
| **Dominant Taxa off Point Loma** | | | | | | | | | | | | | | | | | | | |
| *Spiophanes duplex* (P) [A,B] | 33 | 2 | 109 | 41 | 28 | 11 | 6 | 12 | 1 | 0 | 0 | 26 | 8 | 24 | 13 | 0 | 130 | 5 | 13 |
| *Proclea* sp A (P) [A,B,C] | 15 | 0 | 78 | 14 | 7 | 17 | 13 | 11 | 2 | 1 | 5 | 1 | 0 | 2 | 10 | 0 | 81 | 7 | 7 |
| *Phisidia sanctaemariae* (P) [A,B] | 9 | 0 | 39 | 11 | 4 | 14 | 22 | 10 | 1 | 1 | 2 | 10 | 1 | 14 | 10 | 0 | 217 | 13 | 10 |
| *Myriochele striolata* (P) [B] | 5 | 0 | 44 | 2 | 1 | 16 | 34 | 32 | 0 | 0 | 0 | 0 | 1 | 0 | 9 | 0 | 424 | 19 | 18 |
| *Mediomastus* sp (P) [B,C] | 1 | 0 | 16 | 4 | 3 | 6 | 16 | 2 | 9 | 17 | 5 | 14 | 33 | 9 | 9 | 0 | 152 | 21 | 5 |
| *Prionospio jubata* (P) [B] | 3 | 0 | 2 | 4 | 2 | 7 | 11 | 3 | 12 | 15 | 8 | 10 | 12 | 9 | 9 | 0 | 79 | 12 | 5 |
| *Chaetozone hartmanae* (P) [B] | 1 | 0 | 6 | 0 | 0 | 9 | 17 | 9 | 11 | 13 | 23 | 6 | 4 | 16 | 8 | 0 | 65 | 13 | 14 |
| *Pectinaria californiensis* (P) [A] | 11 | 0 | 34 | 7 | 17 | 7 | 5 | 6 | 1 | 1 | 1 | 3 | 9 | 1 | 5 | 0 | 76 | 5 | 4 |
| Maldanidae (P) [A] | 7 | 0 | 22 | 7 | 8 | 3 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 0 | 14 | 3 | 2 |
| *Polycirrus californicus* (P) [A] | 7 | 0 | 38 | 8 | 5 | 1 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 70 | 2 | 0 |
| *Amphiodia urtica* (EO) [A,B,C] | 38 | 0 | 79 | 35 | 30 | 26 | 6 | 31 | 21 | 2 | 20 | 19 | 0 | 16 | 23 | 0 | 78 | 4 | 25 |
| *Euphilomedes producta* (CO) [A,B,C] | 12 | 2 | 36 | 11 | 21 | 9 | 12 | 9 | 16 | 12 | 8 | 6 | 6 | 1 | 9 | 0 | 53 | 10 | 7 |
| *Euphilomedes carcharodonta* (CO) [A,C] | 5 | 0 | 37 | 6 | 0 | 8 | 18 | 1 | 13 | 21 | 0 | 5 | 15 | 0 | 8 | 0 | 70 | 18 | 1 |
| *Axinopsida serricata* (MB) [B] | 0 | 0 | 2 | 0 | 0 | 2 | 3 | 2 | 6 | 6 | 10 | 23 | 30 | 5 | 8 | 0 | 183 | 11 | 4 |
| *Huxleyia munita* (MB) [A] | 5 | 0 | 35 | 7 | 0 | 3 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 48 | 2 | 0 |

Taxa Codes: EO=Echinodermata, Ophiuroidea; P=Polychaeta; CO=Crustacea, Ostracoda; CA=Crustacea, Amphipoda; MB=Mollusca, Bivalvia

[A] One of 10 most abundant taxa during the pre-discharge period

[B] One of 10 most abundant taxa during the post-discharge period

[C] Also an indicator species

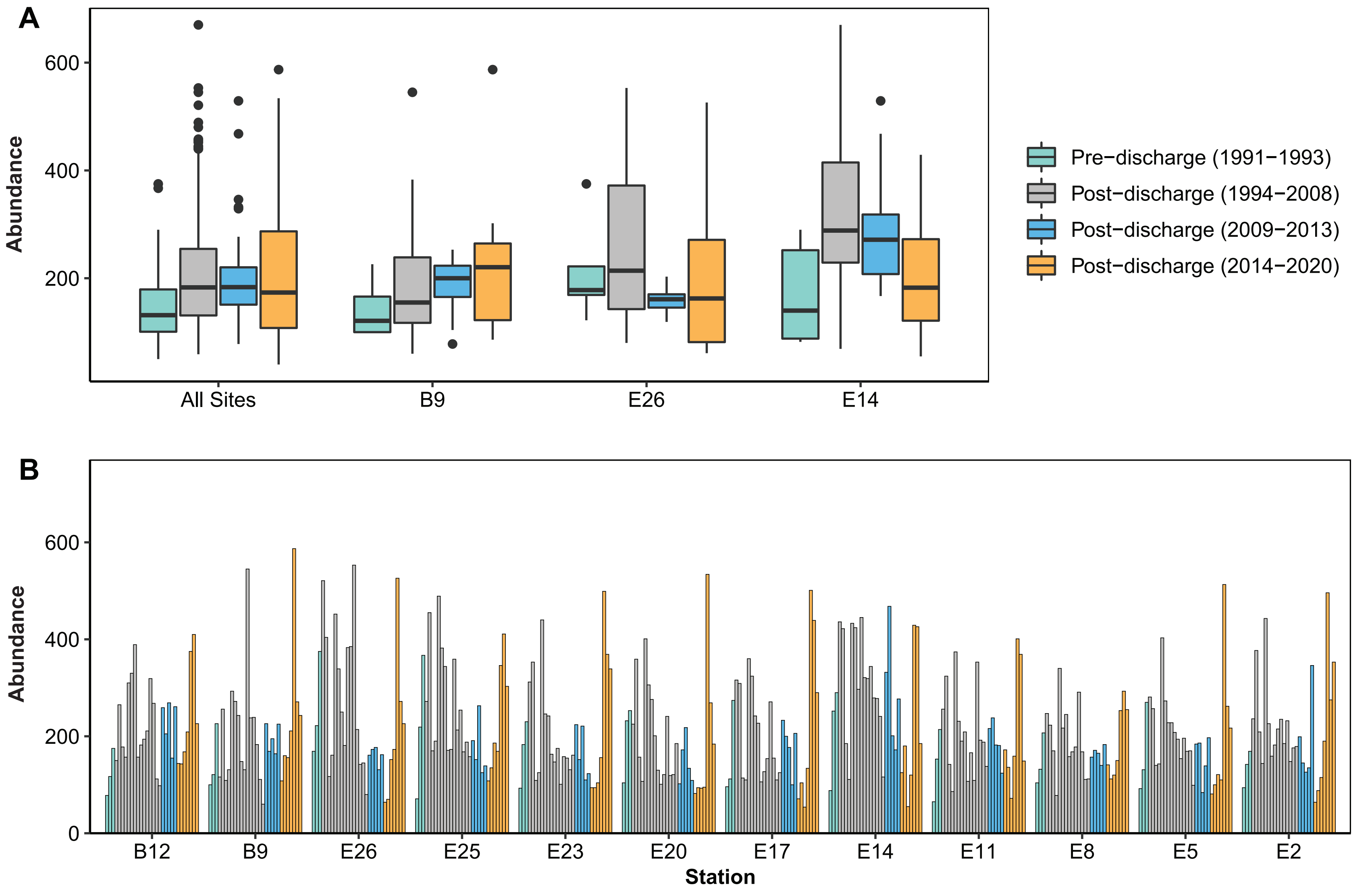


**FIGURE C1-33**
Abundance of all annelids (mostly polychaetes) occurring at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

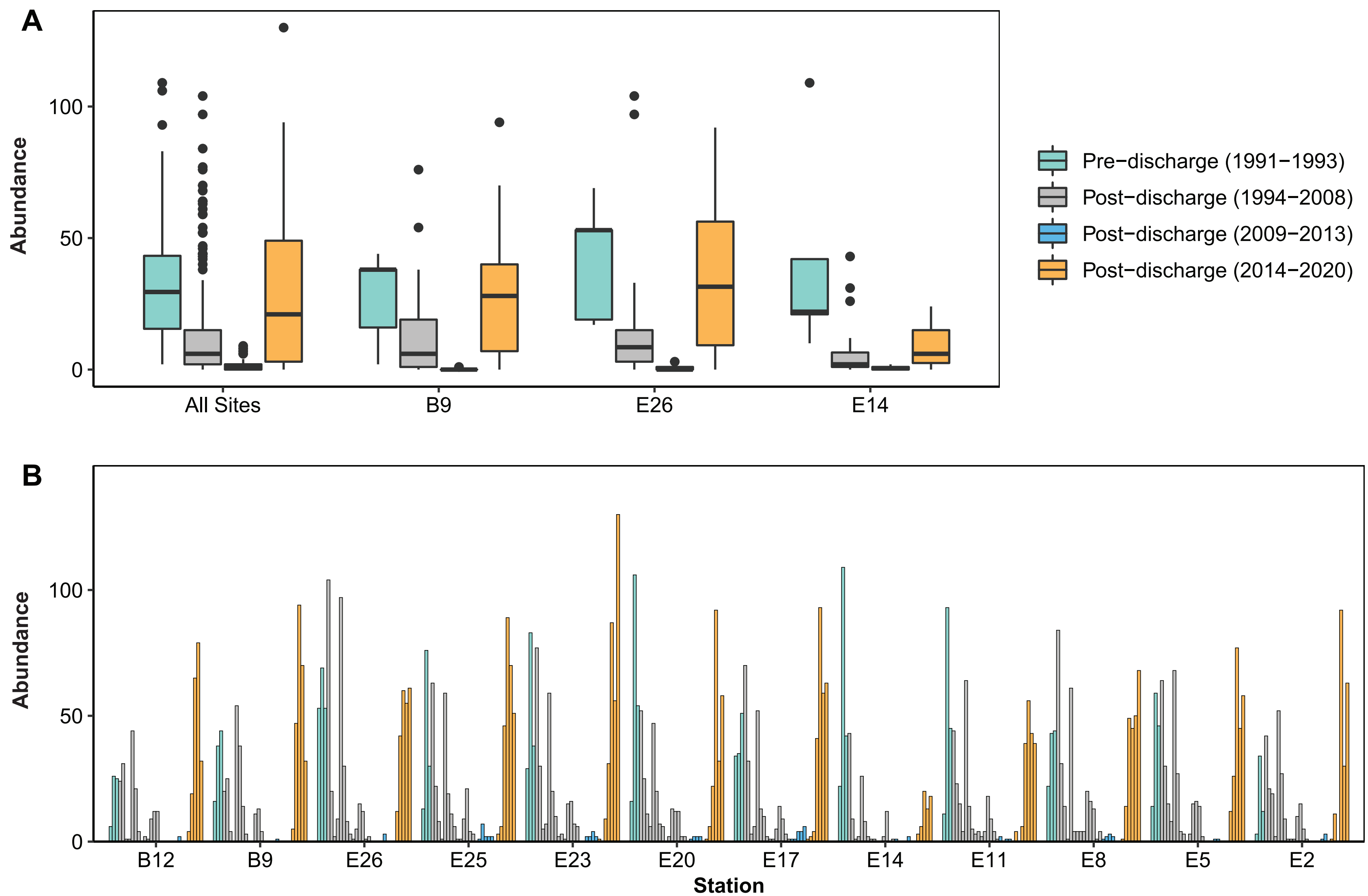


**FIGURE C1-34**
Abundance of the spionid polychaete *Spiophanes duplex* at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

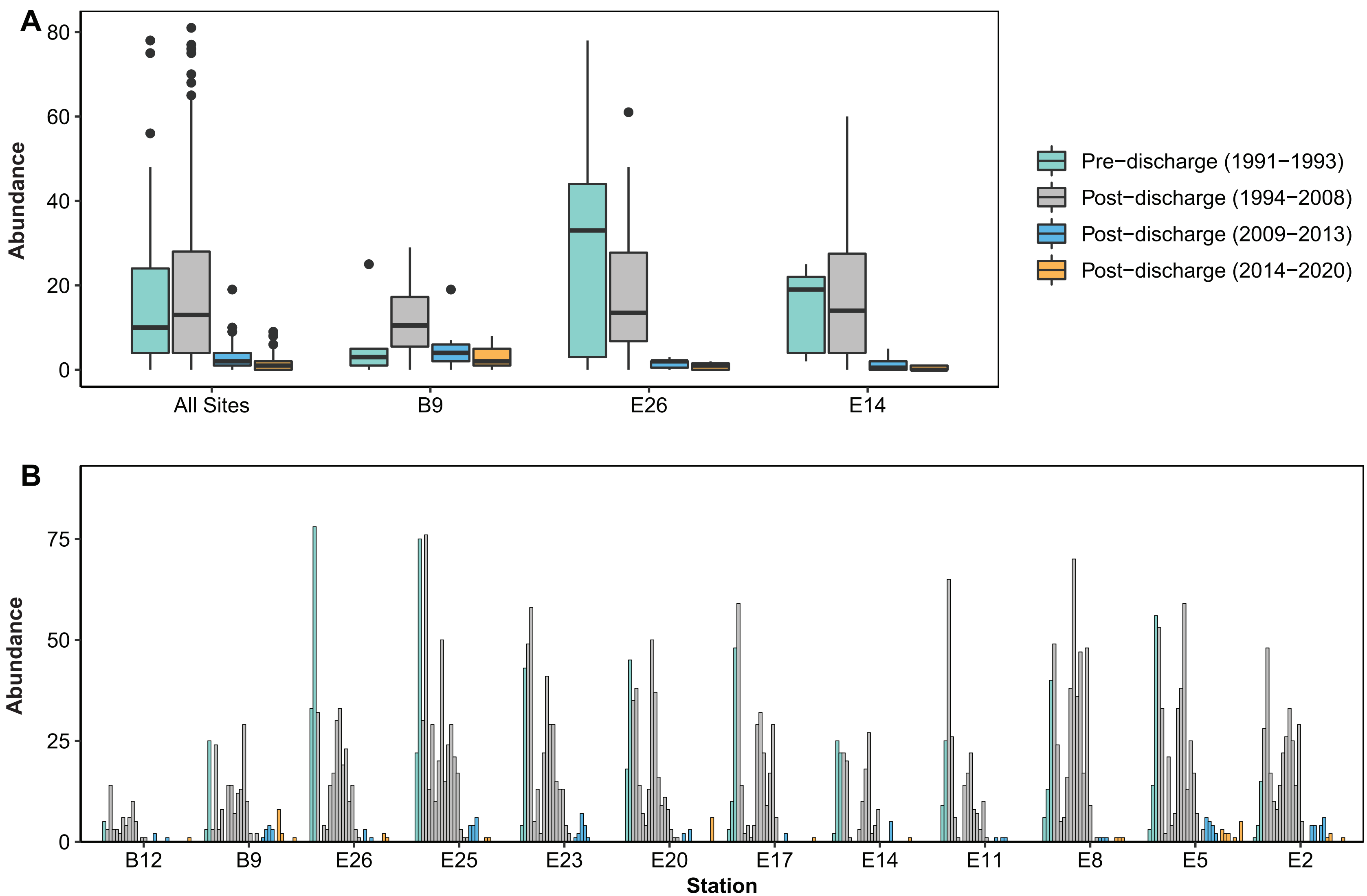


**FIGURE C1-35**

Abundance of the terebellid polychaete *Proclea* sp A at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

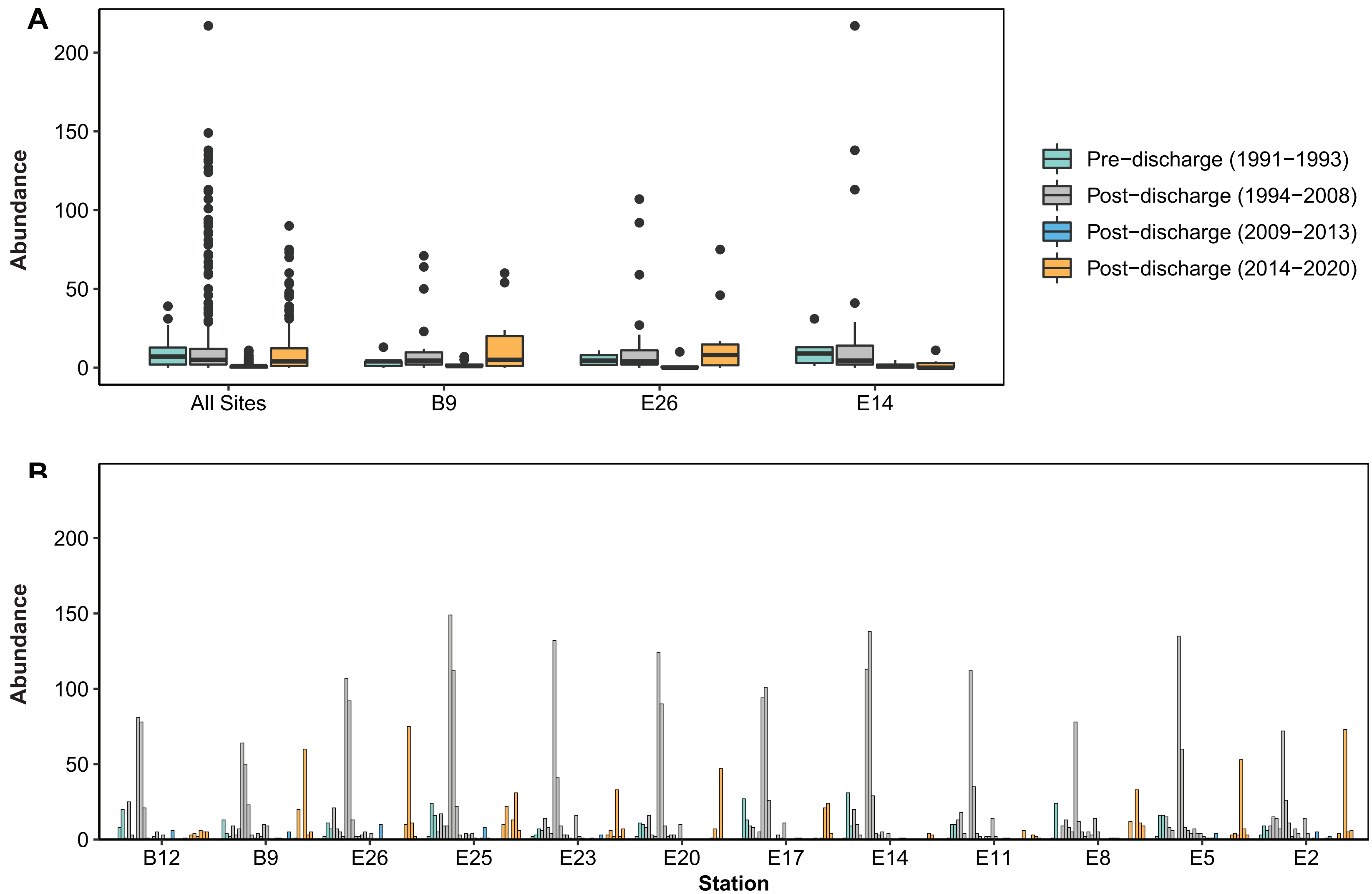


**FIGURE C1-36**

Abundance of the terebellid polychaete *Phisidia sanctaemariae* at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

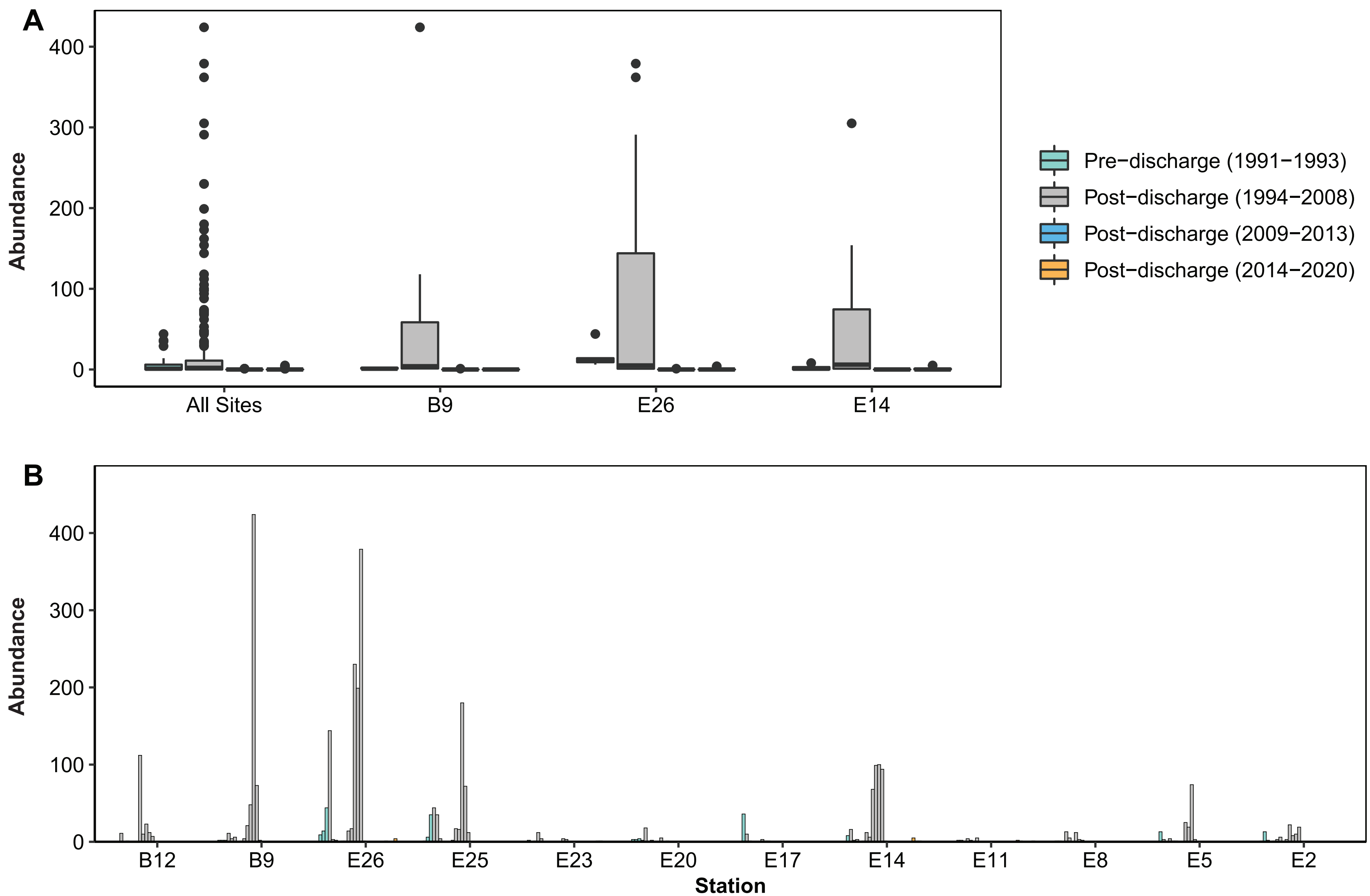


**FIGURE C1-37**

Abundance of the oweniid polychaete *Myriochele striolata* at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

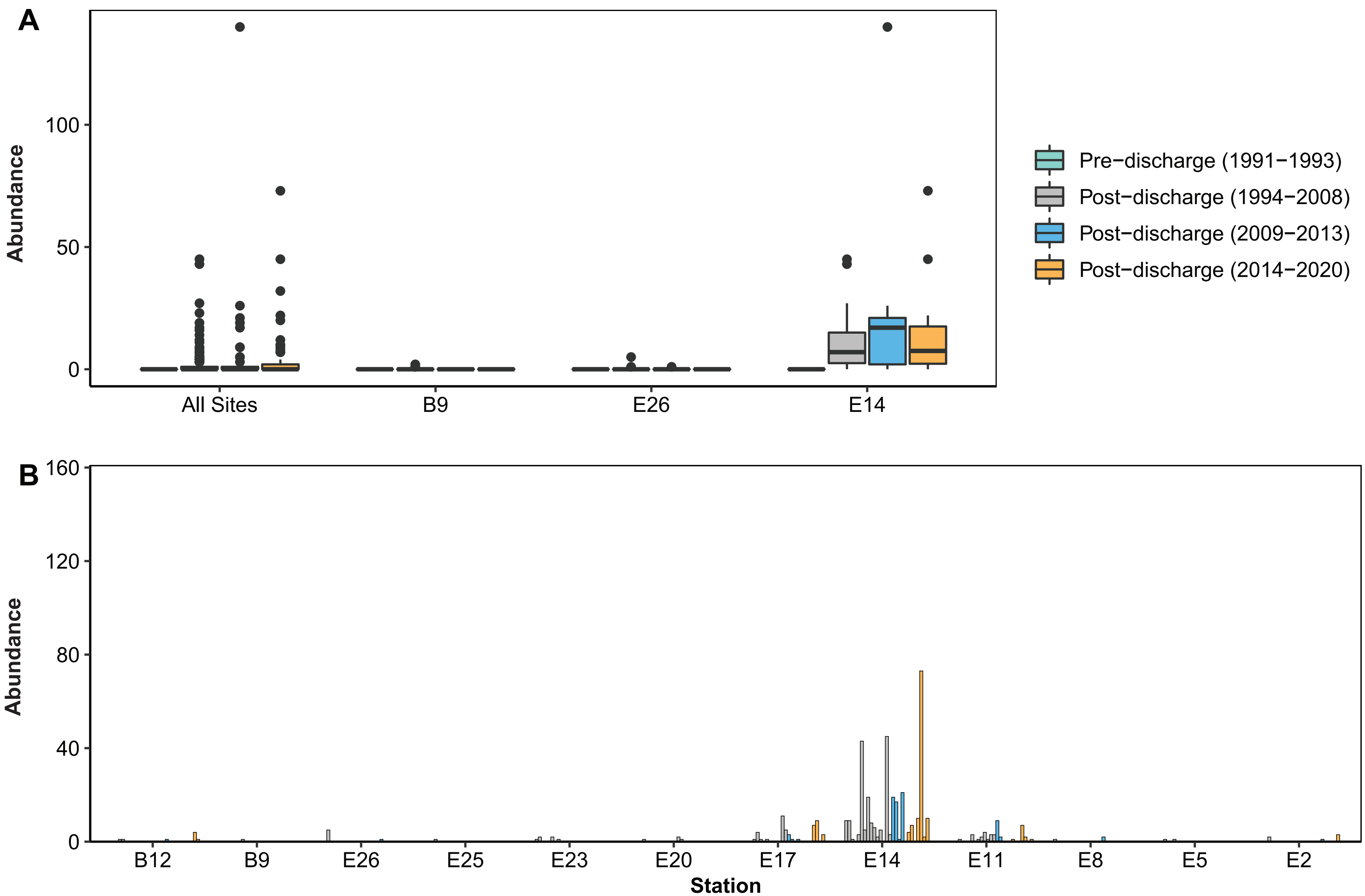


**FIGURE C1-38**

Abundance of the capitellid polychaete *Capitella teleta* at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

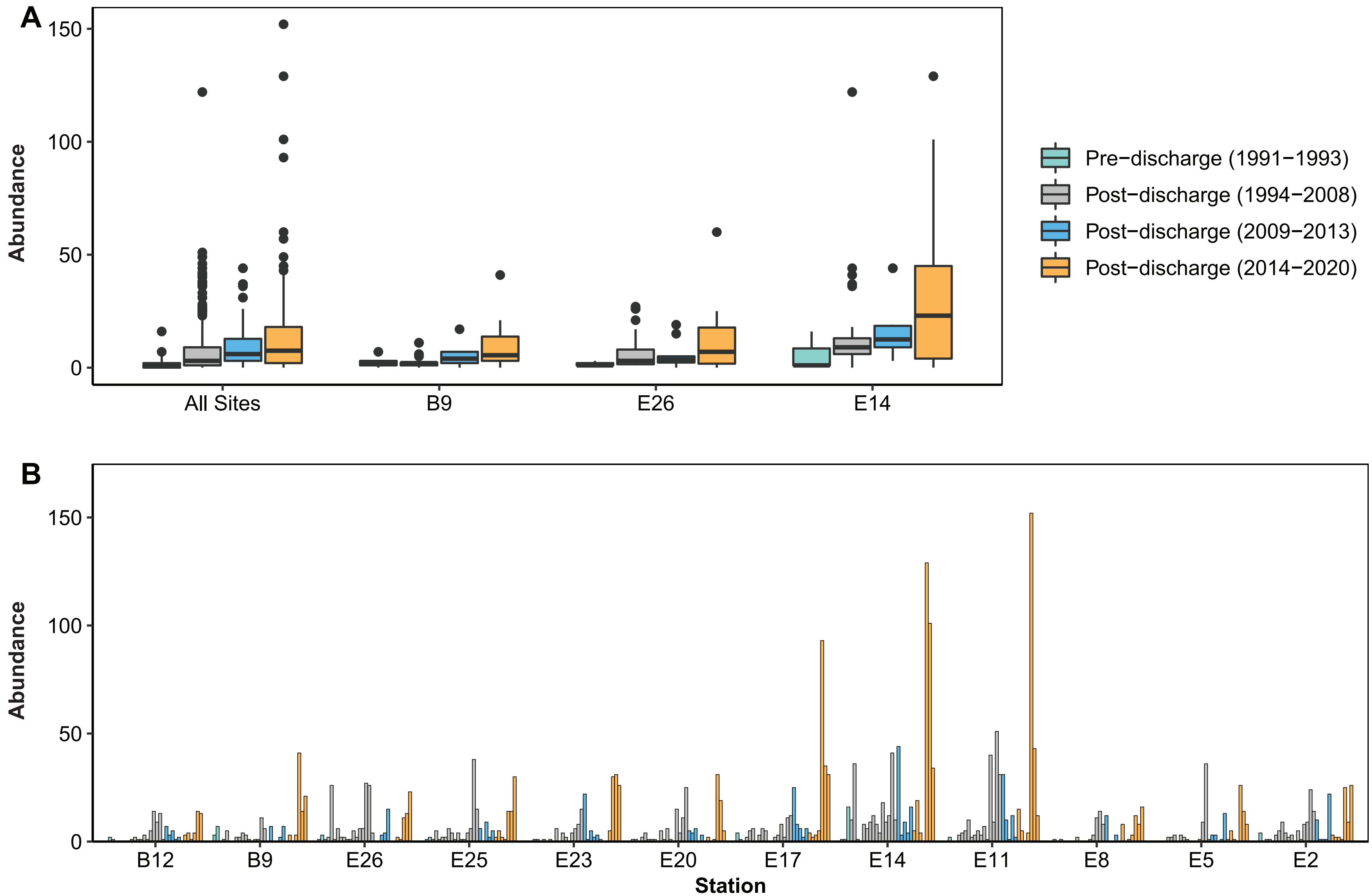


**FIGURE C1-39**

Abundance of the capitellid polychaetes *Mediomastus* spp at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

**Echinodermata**: Echinoderms accounted for about 19% of the total infaunal abundance at outfall depths off Point Loma prior to discharge and about 12% during the post-discharge period (Table C1-5, Figure C1-40). This small decrease, which represents about nine individuals per grab, appears mostly driven by region-wide decreases in brittle stars of the genus *Amphiodia* (predominantly *A. urtica*), especially over the past seven years (see Figure C1-41).

The ophiuroid *Amphiodia urtica* is considered a key bioindicator of the southern California benthos whose populations tend to decline in areas impacted by wastewater outfalls or other forms of disturbance (e.g., Barnard and Ziesenhenne 1961; Thompson, et al. 1993; Bergen 1995; Scanland 1995; Mauer and Nguyen 1996). *Amphiodia urtica* remains the most abundant echinoderm in the Point Loma region after 27 years of outfall operation, although it comprised at least 75% of all echinoderms sampled during the pre-discharge period compared to only about 55% during the post-discharge period (Table C1-8). This species has also been the most abundant invertebrate overall. Populations of *A. urtica* averaged about 38 animals per grab during the pre-discharge period compared to about 23 per grab during the post-discharge period. Although these changes suggest an area-wide decrease after wastewater discharge began, other factors may be responsible for this apparent change. For example, juvenile *A. urtica* are difficult or impossible to identify reliably to species, and identifications of young animals therefore tend to be recorded either at the genus (i.e., *Amphiodia* sp) or family (Amphiuridae) level. Both taxa have also been recorded as dominant taxa off Point Loma over the past 30 years. Additionally, a congener of this species, *A. digitata*, also occurs in the region, although in much lower numbers and typically in coarser sediments. This species accounted for about 5% of all *Amphiodia* off Point Loma. Combined occurrences of *Amphiodia* (i.e., *Amphiodia* spp), abundances averaged about 43 and 33 animals per grab in the above two periods. Abundances varied between stations, with near-ZID station E14 and northern reference station B12 having the lowest abundances during the post-discharge years (Figure C1-41). These stations also had lower fine particles and higher amounts of coarse particles than other stations (see Section C1-4). *Amphiodia urtica* is known to occur most frequently in areas of fine sediments (Bergen 1995). However, over 97% of all stations had *Amphiodia* abundances that were within the tolerance interval bounds of 2–191 individuals for the San Diego mainland shelf (see Appendix C2).

Results of BACIP t-tests indicated a significant change in the difference in abundances between impact station E14 and station E26 since the outfall began operation, but there was no difference from reference station B9 (Table C1-7). For example, average *Amphiodia* abundances decreased about 82% at E14 compared to a 29% decrease at E26 (see Figure C1-41A). Although this pattern is consistent with the predicted effects of organic enrichment, predation by fish predators (e.g., basses and surfperch) attracted to the outfall pipe may also contribute to reduced *Amphiodia* numbers in nearby areas such as station E14 (see Davis et al. 1982, Ambrose and Anderson 1990, Posey and Ambrose 1994). For example, *Amphiodia* abundances at stations E11 and E17 located within 200 m of the ZID appear much less affected by the wastewater discharge (Figure C1-41B). A general decline in *Amphiodia* populations has been observed in mid-shelf habitats across the SCB where their contribution to the benthic infauna population has dropped from about 12% during the Bight 2008 survey to about 5% in the Bight 2013 survey (Ranasinghe et al. 2012, Gillett et al. 2017). However, abundances of *Amphiodia* near the outfall and elsewhere were still within the range of natural variability seen at similar depths throughout the SCB (e.g., Bergen et al. 1998, 2001; Ranasinghe et al. 2003, 2007, 2012, Gillett et al. 2017).

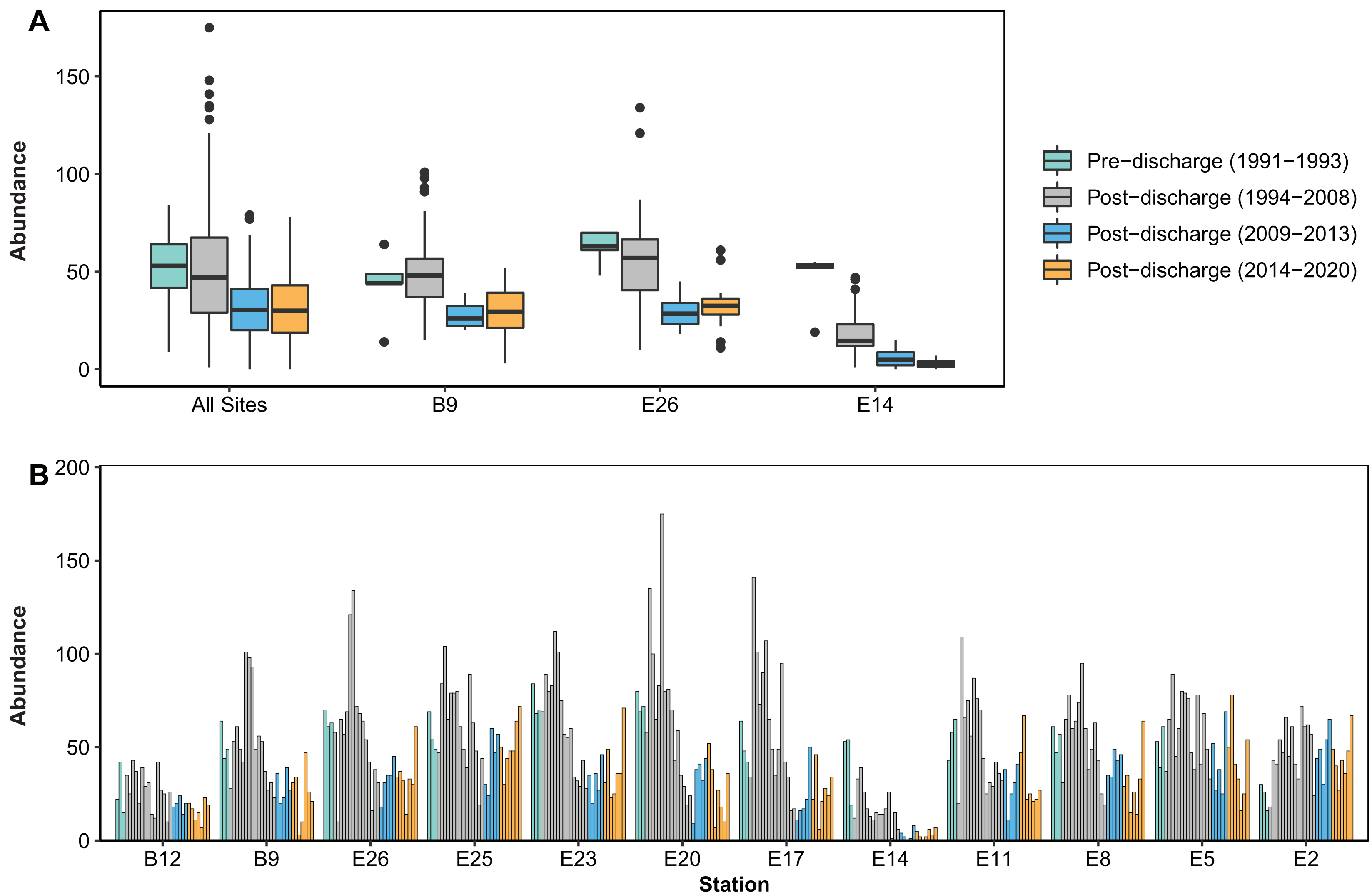


**FIGURE C1-40**

Abundance of all Echinoderms (mostly ophiuroids) in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

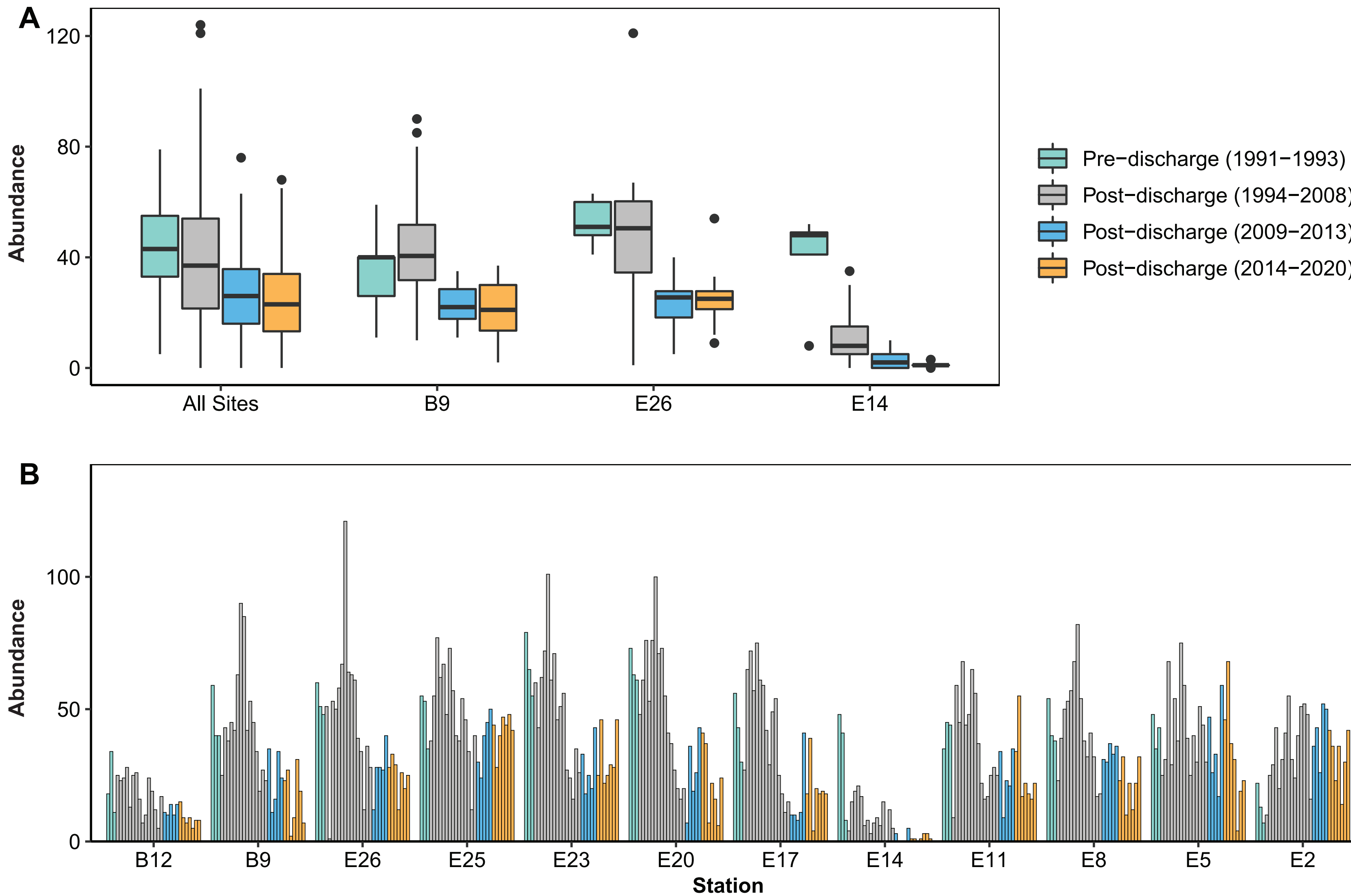


**FIGURE C1-41**
Abundance of the ophiuroids *Amphiodia* spp in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

**Arthropoda, Crustacea**: As a group, crustaceans (Phylum Arthropoda) represented about 16% of the total infaunal abundance at outfall depths off Point Loma, both prior to discharge and afterwards (Table C1-5). However, following a peak in numbers (23% of total) during the 2009–2013 post-discharge period, crustacean abundances decreased to about 11% of the total population during the 2014-2020 post-discharge period (Figure C1-42). Since this decline was evident across the entire region, there does not appear to be any consistent outfall-related pattern in crustacean abundances, although the change was most apparent at near-ZID station E14 (from 17% to 10% of the total abundance) (Figure C1-42).

The ostracod *Euphilomedes producta* has been the most abundant crustacean inhabiting the benthos off Point Loma (Table C1-8). This species and its congener, *E. carcharodonta*, are of interest as bioindicators since their abundances are generally considered to increase near outfalls. Although there appeared to be a slight enhancement in numbers of *Euphilomedes* near the outfall (e.g., at near-ZID stations E11, E14 and E17) through 2006, their populations increased at most stations in the region, peaking between 2013 and 2015 before declining to their current low levels (Figure C1-43). For example, average abundances of these species combined (*Euphilomedes* spp) increased from about 17 per 0.1 m2 grab at station E14 during the pre-discharge period to around 28 animals per grab afterwards. In contrast, abundances of these ostracods decreased from about 22 to 7 individuals per grab at reference station B9 over this same period. *Euphilomedes* abundances above the upper tolerance interval of 28 per grab for the San Diego mainland shelf have been observed at 12% of farfield stations and approximately 9% of near-ZID stations (see Appendix C2). This may be indicative of region-wide effects associated with inputs from storm related discharges, plankton degradation, or other sources of enrichment.

Abundances of other crustacean taxa known to be sensitive to organic enrichment were also examined. These included amphipods in the genera *Ampelisca* (Family Ampeliscidae) and *Rhepoxynius* (Family Phoxocephalidae). The BACIP t-test results show no significant change in populations of these amphipods between near-ZID station E14 and either of the control stations (Table C1-7). In general, caution should be exercised in interpreting these results given the relatively low abundances and natural population fluctuations of these amphipods (see Figures C1-44 and C1-45). Overall, average abundances of these amphipods have changed very little near the Point Loma outfall and over 90% of all samples were within the tolerance interval boundaries calculated for the San Diego mainland shelf (see Appendix C2). This suggests that whatever changes were occurring had little to do with wastewater discharge. *Ampelisca* spp, for example, averaged 9 and 7 amphipods per grab at station E14 during the pre- and post-discharge periods, respectively, while *Rhepoxynius* was unchanged at 4 individuals per grab during each of these times. In contrast, abundances of *Ampelisca* at reference station B9 increased slightly from 8 to 11 individuals per grab, while abundances of *Rhepoxynius* declined from 7 to 3 individuals per grab.

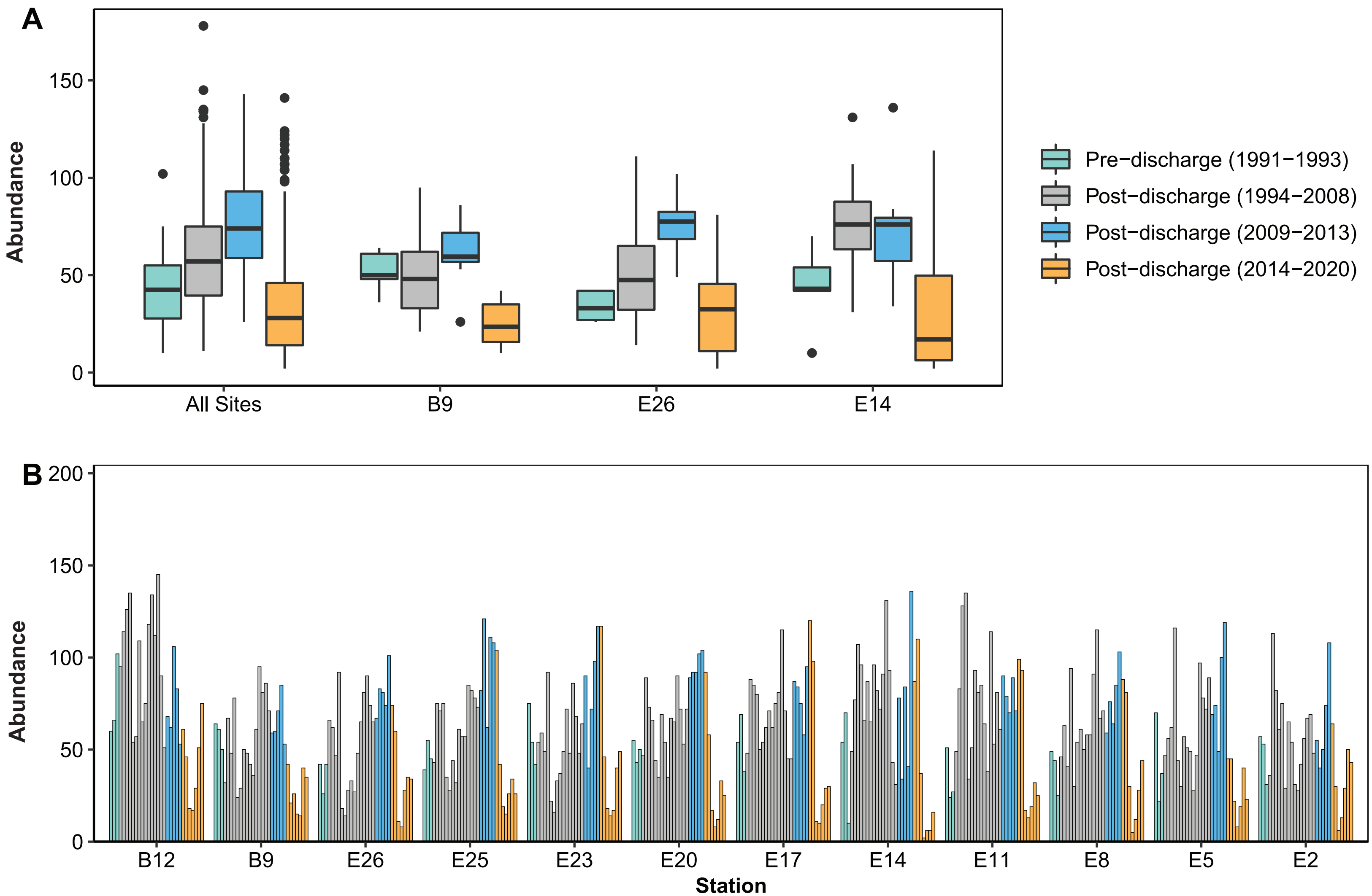


**FIGURE C1-42**

Abundance of all arthropods (mostly crustaceans) in sediments at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

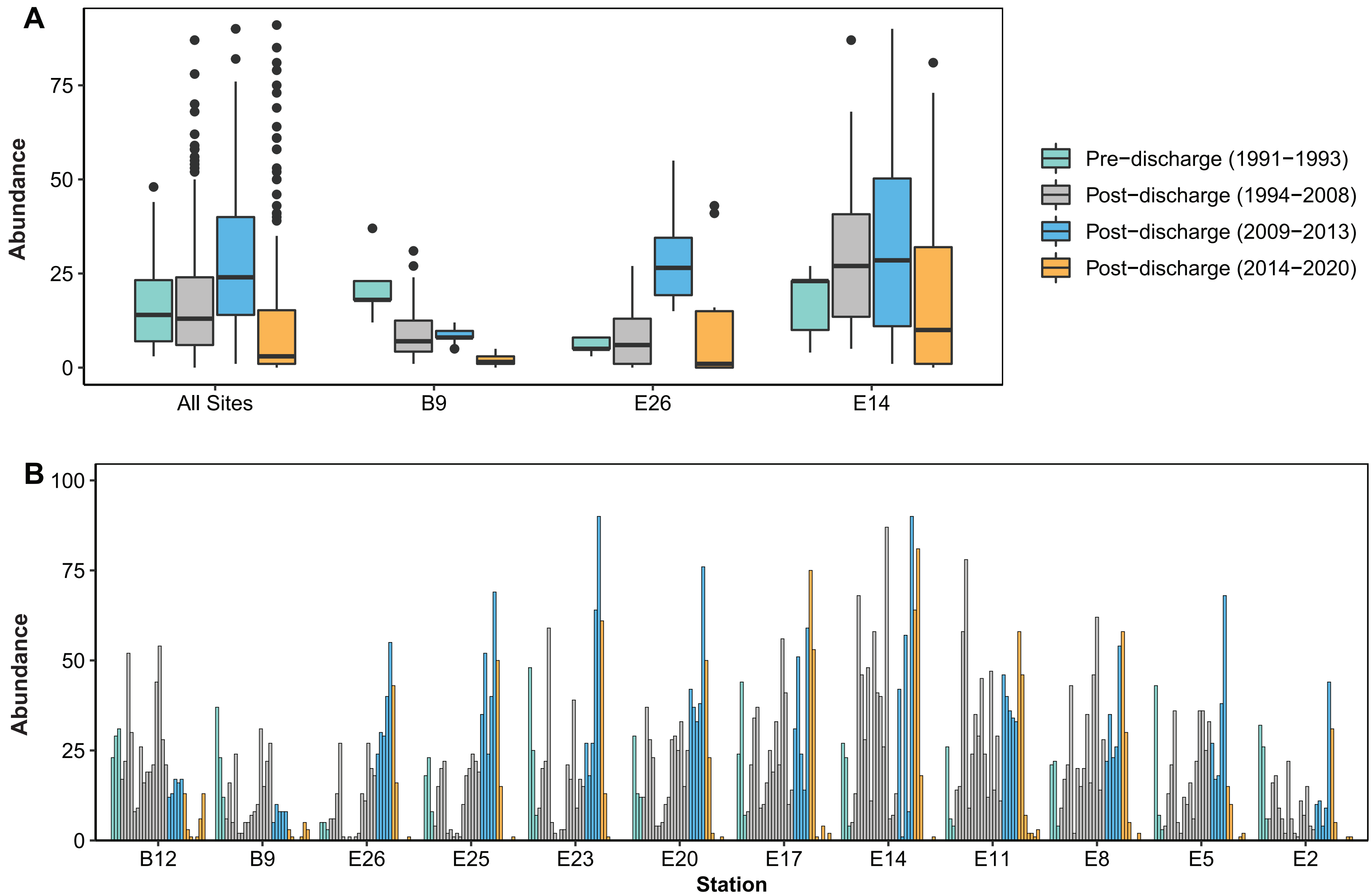


**FIGURE C1-43**

Abundance of the ostracods *Euphilomedes* spp in sediments at outfall discharge depths near the PLOO from 1996 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

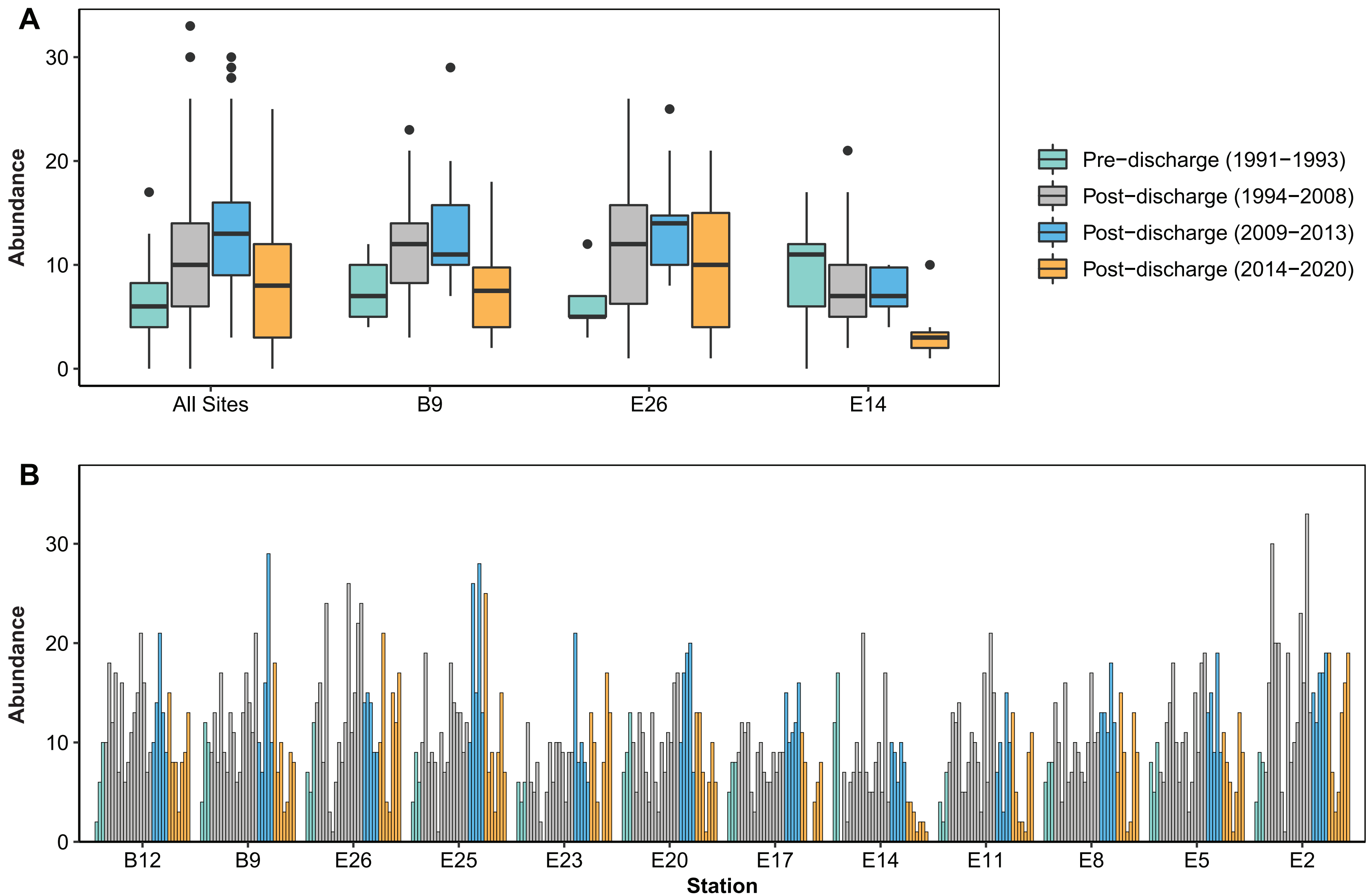


**FIGURE C1-44**

Abundance of the ampeliscid amphipods *Ampelisca* spp at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

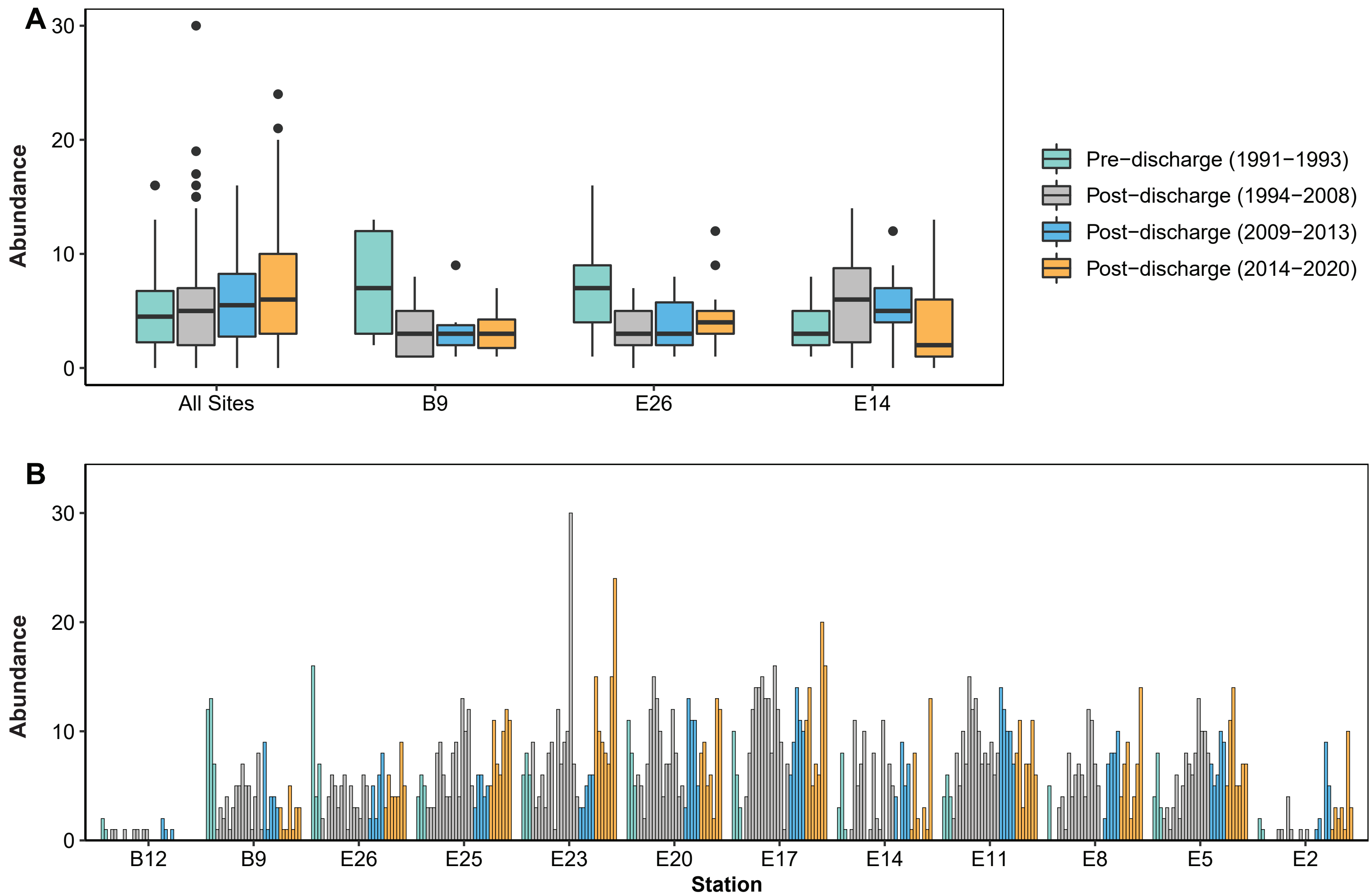


**FIGURE C1-45**

Abundance of the phoxocephalid amphipods *Rhepoxynius* spp at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

**Mollusca**: Molluscs, mostly bivalves and gastropods, represented about 7% of the total infaunal abundance off Point Loma during the pre-discharge period and increased modestly to 10% of the population during the post-discharge era (Table C1-5). In contrast to the arthropods, molluscan abundance has increased to 17% of the total population during the most recent post-discharge era (2014-2020). Changes in molluscan populations suggest a possible outfall-related pattern, with densities increasing more near the outfall than at sites further away during much of the post-discharge period (Figure C1-46). For example, the average number of molluscs increased from 14 to 58 animals per grab at near-ZID station E14 nearest the outfall between these periods. However, other notable increases in molluscan densities have been occurring at many of the E stations over the past seven years, suggesting that factors unrelated to the outfall may be affecting these populations (see Figure C1-46B).

The bivalve *Parvilucina tenuisculpta* has been suggested as an indicator species that may occur in high abundances in areas of moderate organic enrichment. However, populations of this species off Point Loma have actually decreased over time, averaging approximately 3 animals per 0.1 m2 grab during the pre-discharge period to only 2 animals per grab afterwards (Table C1-8). Comparison among sites did indicate that numbers of *P. tenuisculpta* increased somewhat at the near-ZID stations initially and decreased at the farfield stations after the onset of discharge (Figure C1-47). However, this pattern has not been sustained and values above the upper tolerance interval bound for this bivalve of 8 individuals per grab have only occurred 2.5% to 3% of the time at near-ZID and farfield stations, respectively (see Appendix C2). Additionally, although these minor increases near the outfall are consistent with an enrichment effect, *Parvilucina* densities off Point Loma were still within the range of those that occur at similar depths throughout the SCB (e.g., Bergen et al. 1998, 2001; Ranasinghe et al. 2003, 2007, 2012, Gillett et al. 2017). Additionally, the bivalve *Solemya pervernicosa* may be indicative of a reducing environment, as its gills contain sulfur-oxidizing bacteria. Small numbers of this bivalve have been observed at near-ZID station E14 in the post-discharge period, increasing from zero to three individuals per grab (Table C1-8). However, this small increase remains below the threshold of what might be expected in a degraded environment. Their presence remains highly localized and are not an indication of habitat degradation occurring off Point Loma. This conclusion is supported by the more than 95% of samples from near-ZID stations, and more than 99% of samples from farfield stations, that had Solemya pervernicosa abundances below the upper tolerance interval bound for the San Diego mainland shelf (see Appendix C2).

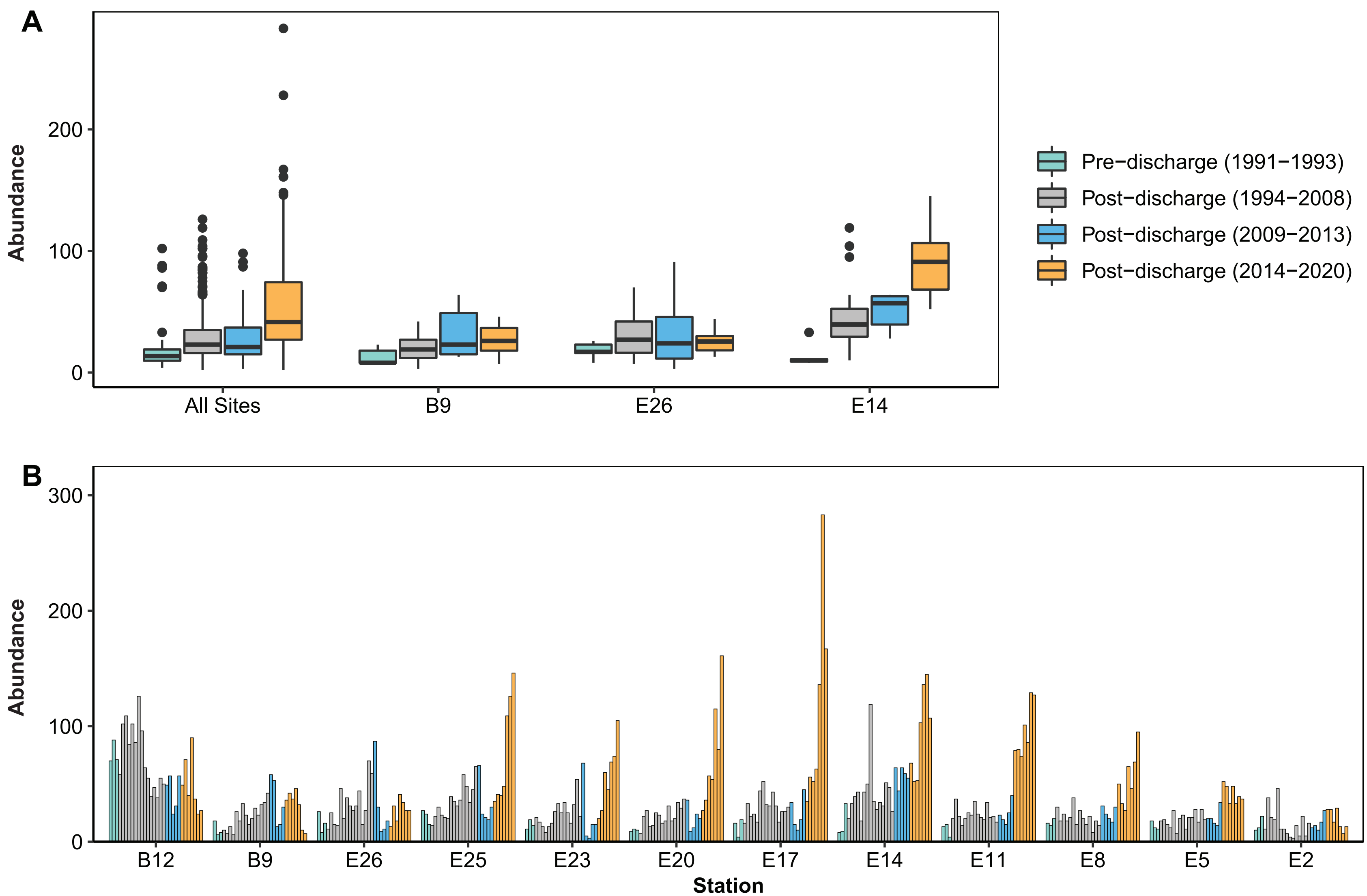


**FIGURE C1-46**

Abundance of all molluscs at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

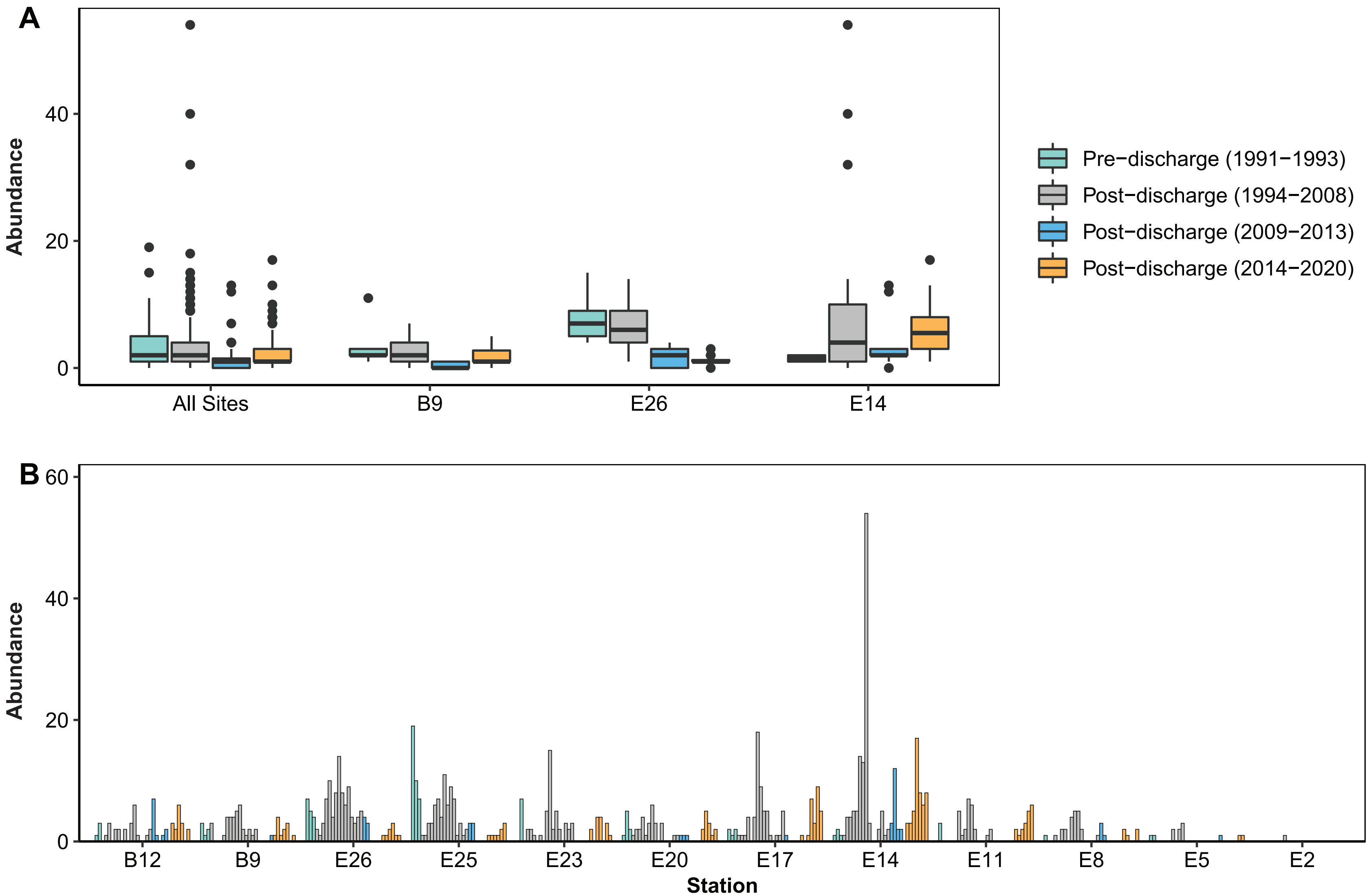


**FIGURE C1-47**
Abundance of the bivalve *Parvilucina tenuisculpta* at outfall discharge depths near the PLOO from 1991 through 2020. (A) pre-discharge vs. post-discharge summary; (B) summer surveys only. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

## Summary of Effects on Benthic Infauna Communities

Benthic communities around the Point Loma Ocean Outfall continue to be dominated by ophiuroid-polychaete based assemblages, with few major changes having occurred since monitoring began (see City of San Diego 1995–2021). The brittle star *Amphiodia urtica* and several species of polychaetes (e.g., *Spiophanes duplex*, *Proclea* sp A, *Phisidia sanctaemariae*) dominated assemblages during both the pre- and post-discharge periods. Polychaetes continue to account for the greatest number of species and individuals, while *A. urtica* has been the most abundant species in both periods. Similar assemblages have been described by Barnard and Ziesenhenne (1961), Jones (1969), Fauchald and Jones (1979), Thompson et al. (1987, 1992, 1993), EcoAnalysis et al. (1993), Zmarzly et al. (1994), Diener and Fuller (1995), Bergen et al. (1998, 2001), and Ranasinghe et al. (2003, 2007, 2012). This wide-spread assemblage dominates the southern California benthos, including mainland shelf depths throughout the entire San Diego coastal region (see City of San Diego 1995–2021), although patches of other benthic assemblages occur where different sediment types are found (e.g., near river mouths and submarine canyons). The shifts in community composition that have occurred over time likely represent variation in southern California assemblages related to large-scale oceanographic events (e.g., El Niño/La Niña conditions), stochastic natural events, or natural population fluctuations.

Although variable, benthic communities off Point Loma have remained relatively similar between years in terms of the number of species, number of individuals, dominance, and diversity (e.g., see City of San Diego 2020b for recent years). In addition, values for these parameters are similar to those described for other sites throughout southern California (e.g., Thompson et al. 1992; EcoAnalysis et al. 1993; Bergen et al. 1998, 2001; Ranasinghe et al. 2003, 2007, 2012). Despite this overall stability, a comparison of pre- and post-discharge data for the Point Loma region indicates some general trends. For example, there was an overall increase in the number of species and infaunal abundances after discharge began. However, the increase in species appeared most pronounced nearest the outfall, a pattern opposite that expected if environmental degradation were occurring. In addition, the increase in abundances was accompanied by little change in dominance near the outfall, a pattern also inconsistent with predicted pollution effects. There appeared to be a minor shift in the relative abundance of phyla at some sites that may be related to the outfall, with echinoderms decreasing and polychaetes and molluscs increasing after the onset of wastewater discharge. However, after evaluating the net effects it is evident that benthic communities surrounding the Point Loma outfall are not numerically dominated by a few pollution tolerant species as would be expected if there were an adverse environmental impact.

The results of BACIP t-tests revealed a few patterns in the difference between the likely impact site (near-ZID station E14) and the two "control" sites (stations E26 and B9) that could be attributed to the onset of discharge. The total number of species, infaunal abundance, and BRI values demonstrated a significant change between the impact site and both "control" sites since the outfall began operation. It is unclear what caused the difference in the number of infaunal species, since species richness has increased across all sampling sites. Higher species richness values near the outfall may be related to the greater variability at the impact site or to a decline in ophiuroid populations (see Ambrose 1993). A significant difference in the abundance of ophiuroids in the genus *Amphiodia* was observed at reference station E26 but not station B9. This localized difference in *Amphiodia* populations is likely due to a larger decrease in numbers near the outfall than at corresponding "control" sites during the post-discharge period. Although the decrease near the outfall is consistent with organic enrichment predictions, reduced *Amphiodia* numbers could also be an artifact of the outfall pipe attracting predators (e.g., Davis et al. 1982) or physical differences in the sediment particle size composition (see Section C1-3). In addition, populations of Amphiodia have declined throughout the SCB in recent years, an effect that may be related to natural population fluctuations or climate change. Whether or not these population changes are due to wastewater discharge, increased predation pressure, or some other factor, abundances of *Amphiodia* near the outfall and elsewhere are still within the range of natural variability seen at similar depths throughout the SCB (see Bergen et al. 1998, 2001; Ranasinghe et al. 2003, 2007, 2012, Gillett et al. 2017). The difference in BRI values was due to a larger increase in this index at the impact site after discharge began and a corresponding smaller increase at the reference sites. Although this pattern is consistent with a disturbance event, BRI values at this and all other sites are still considered characteristic of relatively undisturbed conditions, especially within the context of other community indices. The results for abundances of amphipod crustaceans showed no significant difference between the control and impact sites. Additionally, values for both genera at near-ZID station E14 were typically within tolerance limits calculated from the San Diego region (see Appendix C2).

Patterns of change in populations of the polychaete *Capitella teleta*, the bivalves *Parvilucina tenuiscuplta* and *Solemya pervernicosa*, and ostracods of the genus *Euphilomedes* suggest a slight enrichment effect near the outfall; however, densities of these organisms are still generally within the range of natural variation for the SCB (see Bergen et al. 1998, 2001; Ranasinghe et al. 2003, 2007, 2012, Gillett et al. 2017). Other polychaetes that have been suggested as bioindicators also revealed little evidence of outfall related changes. For example, populations of worms in the genera *Mediomastus*, *Dorvillea* and *Armandia* underwent few changes that could indicate significant organic loading or habitat degradation in the vicinity of the outfall. A few other changes near the outfall may suggest some effects coincident with anthropogenic activities. For example, the increased variability in number of species and infaunal abundance at near-ZID station E14 since discharge began may be indicative of community destabilization (see Warwick and Clarke 1993; Zmarzly et al. 1994). Sediment sulfide and BOD concentrations have also increased at this station since 1993 (see Section C1-3). Finally, the occurrence of coarse sediments at station E14 at various times and the corresponding shifts in assemblage structure suggest that some of these changes may be related to localized physical disturbances associated with the presence of the outfall pipe (e.g., shifting or patchy sediments, presence of construction debris), as well as to organic enrichment (e.g., see City of San Diego 1999b, 2000b).

While it is difficult to detect specific or direct effects of the City's ocean outfall on the offshore benthos, it is possible to see some changes occurring nearest the discharge site. Perhaps because of the minimal extent of these changes, it is not possible to determine whether these effects are due to the physical structure of the outfall or to organic enrichment associated with the discharge of effluent. Such impacts have spatial and temporal dimensions that vary depending on a range of biological and physical factors in this highly dynamic system. In addition, abundances of soft-bottom invertebrates exhibit substantial spatial and temporal variability that may mask the effects of any disturbance event (Morrisey et al. 1992a,b; Otway 1995). The effects associated with the discharge of advanced primary treated and secondary treated sewage may also be negligible or difficult to detect in areas subjected to strong currents that facilitate the dispersion of the wastewater plume (see Diener and Fuller 1995). The minimal impact reported for San Diego's previous shallow water outfall (e.g., Zmarzly et al. 1994), combined with the high level of wastewater treatment (i.e., advanced primary treatment), an increased minimum dilution factor of 204:1 (vs. 113:1 at the old discharge site), and the deepwater location of the extended outfall decrease the chances that this discharge has or will impact the nearby benthos. A further complicating factor is the unknown effects of climate change, both on ocean currents which could affect the recruitment and retention of planktonic larvae (i.e., Bani et al 2021), as well as ocean acidification which could impact organismal development (see Byrne and Fitzer 2020, and the references therein). Although some highly localized changes in benthic assemblages have occurred, assemblages near the outfall are still generally similar to those observed prior to discharge and to natural indigenous communities of the southern California continental mid-shelf.

Thus, after 27 years of operation, wastewater discharge through the Point Loma outfall has not caused degradation in benthic community structure. This conclusion is further supported by the supplemental analyses presented in Appendices C3 and C4 of this application. In Appendix C3, an evaluation of benthic community condition integrated with results from sediment toxicity testing results and the assessment of potential chemical exposure demonstrated that benthic habitats and associated macrobenthic communities off San Diego were healthy, or representative of conditions undisturbed by pollutants in sediments, from 2016 through 2020. These findings span the time period during which the three highest BRI values were recorded. In Appendix C4, a rigorous assessment of Point Loma macrobenthic communities utilized multivariate analyses to evaluate changes in community structure without a priori assignment of near-ZID versus farfield location, or pre- and post-discharge time periods. This assessment demonstrated that assemblages from 96% of macrofaunal grabs collected from 1991 through 2020 were representative of background conditions typical for this portion of the southern California coast, and consistent with results of regional surveys off San Diego and other areas of the SCB.

# SECTION C1-5 | DEMERSAL FISHES & INVERTEBRATES

The City has been monitoring demersal fish and megabenthic invertebrate communities in the offshore region surrounding the extended PLOO since July 1991. Trawl surveys were conducted quarterly from July 1991 through July 2003, after which sampling was modified to semiannual surveys during winter (typically January) and summer (typically July) of each year (Figure C1-48). This section summarizes the results of the trawl surveys conducted during the pre- and post-discharge monitoring periods to evaluate possible effects of wastewater discharge via the PLOO.

## Analyses

The analyses included herein are based on data from winter and summer surveys conducted from 1991 through 2020 at six stations located at outfall discharge depths (see Section C1-2 for a complete description of dataset reduction). From north to south, these stations are SD14, SD13, SD12, SD10, SD8, and SD7 (Figure C1-48). These stations are located at depths of approximately 100 m (330 ft) and range from about 8 km north to 9 km south of the outfall (Figure C1-48). For purposes of analysis and discussion, these stations are grouped into nearfield and farfield stations. Stations SD10 and SD12 are located within 1.2 km of the outfall and are considered the nearfield stations. Stations SD7, SD8, SD13 and SD14 are located farther away and are considered the farfield stations; SD7 and SD8 are the southern farfield stations, and SD13 and SD14 are the northern farfield stations.

Overall, the dataset used for analyses in this appendix includes 30 trawls conducted during the five pre-discharge surveys (summer 1991–summer 1993), and 291 trawls conducted during the 54 post-discharge surveys (winter 1994–summer 2020). Of the 321 total trawl events included in this assessment, 59 have not been analyzed as part of previous PLWTP modified permit applications (City of San Diego 2007c, 2015a).

The following key community parameters were evaluated per trawl for demersal fishes and megabenthic invertebrates: (1) species richness (number of species); (2) abundance (number of individuals); (3) Shannon Diversity Index (H’); (4) abundances of numerically dominant taxa from both the pre- and post-discharge periods (i.e., top 10 species by abundance).

The focus of most comparisons in this section is between conditions present during the 2.5-year pre-discharge period (July 1991-1993) and the entire 27-year post-discharge period (1994-2020). Additionally, the post-discharge period is broken down into three periods (1994-2008, 2009-2013, 2014-2020) in some tables and figures to emphasize any patterns or trends during the past seven years (2014-2020) compared to the last PLWTP modified permit application or the years immediately following the initiation of discharge.

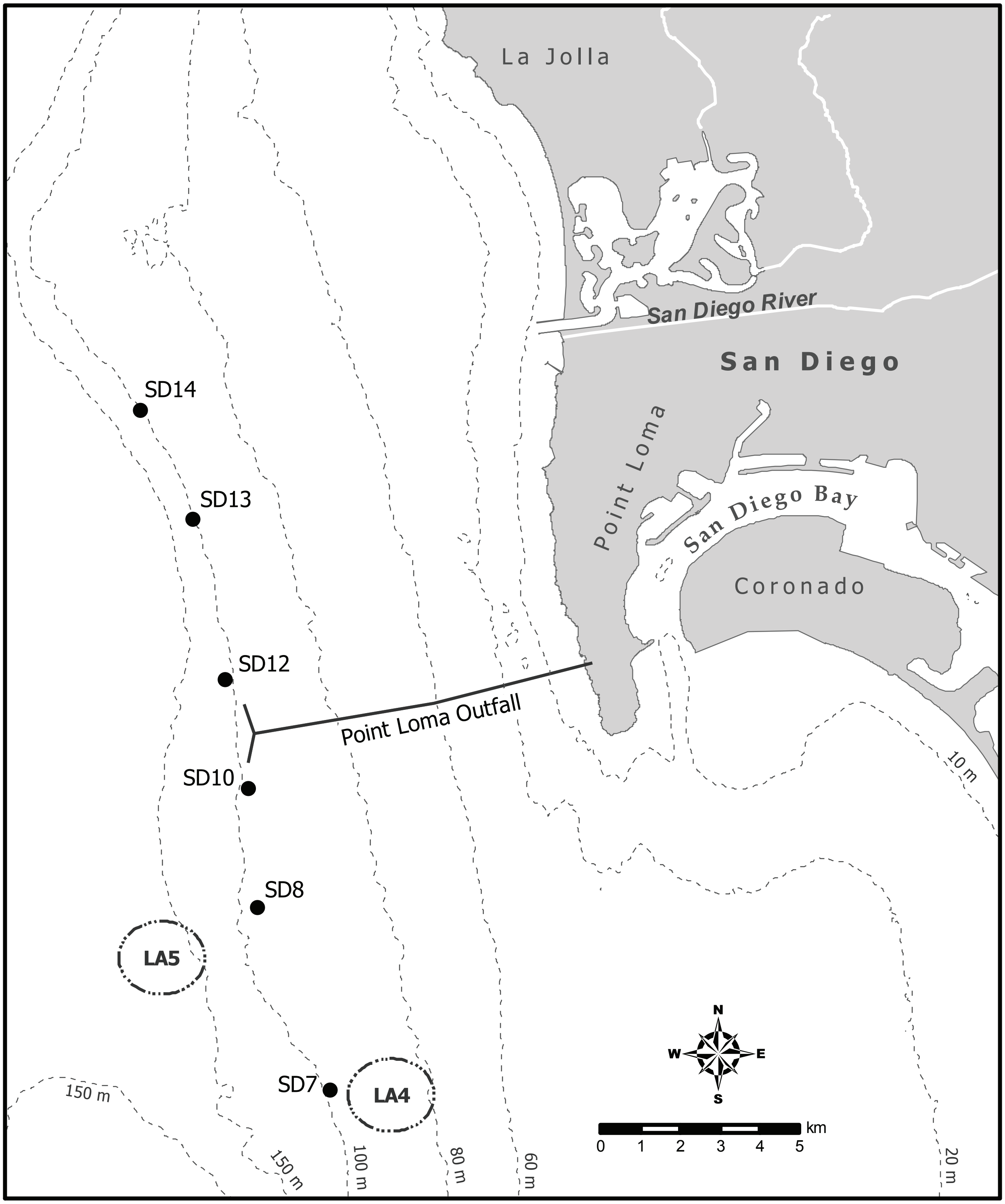


**FIGURE C1-48**

Trawl station locations sampled around the PLOO as part of the City of San Diego's Ocean Monitoring Program. Stations SD7, SD8, SD10, SD12, SD13, and SD14 = six monitoring sites that are the focus of the analyses presented in this 301(h) modified permit application. LA-4 and LA-5 = USEPA designated dredged materials disposal sites.

## Results - Demersal Fishes

A total of 111,601 demersal fishes were collected in 321 trawls conducted off Point Loma during winter and summer from 1991 through 2020. These fishes comprised 95 taxa, including 89 distinct species, and are summarized as the total number of individuals, minimum, maximum, and mean standard length per species, with taxonomic arrangement and scientific names according to Eschmeyer and Herald (1998) and Lawrence et al. (2013) in Attachment C1-C.

### *Major Community Parameters*

**Species Richness**: As with benthic infauna, a reduction in demersal fish species diversity or the number of species encountered near an outfall compared to those at reference stations could be a potential indicator of environmental degradation. For nearfield and farfield trawl stations sampled within the PLOO region over the past 30 years, species richness was highly variable, ranging from 6 to 26 species per trawl (Table C1-9, Figure C1-49). Overall, species richness averaged 14 species per haul during the pre-discharge years and 15 species per haul during the post-discharge years, and patterns of change observed over time at the nearfield trawl stations were similar to those observed at the farfield stations. In addition, no changes in species richness were detected near the outfall that coincided with the onset of wastewater discharge at the end of 1993. Further, values reported for PLOO trawl stations were within the range of natural variability observed during SCB regional surveys. Consequently, there were no apparent temporal or spatial trends in the number of fish species that might suggest an outfall-related impact.

**Demersal Fish Abundance**: The total fish catch was also highly variable over time, ranging from 44 to 2,322 fishes per haul (Table C1-9, Figure C1-50). Overall, abundances were higher during the post-discharge period than the pre-discharge period at both nearfield and farfield stations, with hauls increasing about 95% (from 208 to 406 individuals) at the nearfield stations and about 48% (from 217 to 322 individuals) at the farfield stations between these periods. Most of this change, however, appears to have occurred between 2001 and 2006. As with species richness, variability in fish abundances over time at the nearfield stations was generally within the range of abundances observed for the farfield stations (Figure C1-50B). The exceptions occurred in winter 2005 at stations SD10 and SD12 and in winter 2019 at station SD10 when large numbers of Halfbanded Rockfish (*Sebastes semicinctus*) were collected (City of San Diego 2006a, 2020b). Another exception occurred in winter 2020, when low numbers of fishes were caught at nearfield station SD12. Overall, there were no discernible changes at the two nearfield stations that coincided with the onset of wastewater discharge, and abundance values reported for PLOO trawl stations were within the range of natural variability observed during SCB regional surveys.

**Diversity**: There was no reduction in demersal fish diversity associated with proximity to the PLOO, or onset of wastewater discharge. Reflecting changes in the number of species, and the abundance per species, diversity (H') values were highly variable (range=0.7 to 2.3 per trawl) over the past 30 years, and patterns of change were similar at the nearfield and farfield stations during the pre-discharge and post-discharge periods (Table C1-9). Diversity values reported for PLOO trawl stations were within the range of natural variability observed during the SCB regional surveys.

### *Dominant Demersal Fish Species*

A large amount of the variability described above for the demersal fish communities off Point Loma is due to fluctuations in populations of common species across the region during both pre- and post-discharge periods (Figure C1-51). Overall, these communities were dominated by 13 different species that, combined, accounted for 95% of all fishes captured over the past 30 years (Table C1-10), and are typical for the soft-bottom habitats that characterize much of the PLOO region and the mainland shelf of the SCB (Allen et al. 1998, 2002, 2007, 2011, Walther et al. 2017).

Pacific Sanddab (*Citharichthys sordidus*) was by far the most abundant species across the entire region, accounting for approximately 55% of the total catch during the pre-discharge period and 47% during the post-discharge years (Table C1-10). The dramatic region-wide decrease in sanddab abundances between 1997 and 1998 was probably related to warmer waters associated with the 1997–1998 El Niño since this species tends to be associated with cooler waters (see Eschmeyer et al. 1983). However, it is unclear what may have caused similar, but less dramatic declines in Pacific Sanddab populations around 2001–2002 and 2007–2008 when El Niño conditions were not present (see Figure C1-51).

Two other species that represented at least 10% of the total fish catch across all stations during either the pre-discharge or post-discharge periods were Halfbanded Rockfish and Yellowchin Sculpin (*Icelinus quadriseriatus*). Halfbanded Rockfish represented only 2% of the pre-discharge catch but have increased to 11% of the catch since 1994. This change reflects many fluctuations in Halfbanded Rockfish populations since monitoring began, with both abundance per trawl and variability across stations increasing in the post-discharge period. Yellowchin Sculpin accounted for only 6% of the catch prior to discharge but has since increased to represent 9% of the catch between 1994 and 2020.

Populations of several other dominant or occasionally abundant species also displayed considerable variability. At farfield stations, California Lizardfish (*Synodus lucioceps*) increased from about 1% pre-discharge to 12% post-discharge. Dover Sole (*Microstomus pacificus*) appeared to have undergone cyclic population fluctuations, possibly associated with changes in oceanic temperatures (i.e., higher numbers during colder regimes). Populations of species such as Longspine Combfish (*Zaniolepis latipinnis*) and Stripetail Rockfish (*Sebastes saxicola*) occurred sporadically in high numbers. Longspine Combfish represented at least 10% of total fish catch at nearfield stations, due to large hauls in winter 2002 and 2005, and from winter 2012 through summer 2013. Stripetail Rockfish were collected in large numbers at nearfield stations in winter 2004 and 2011. The remaining dominant species accounted for only about 1–5% of the total fish catch across all stations during either the pre-discharge or post-discharge periods.

**TABLE C1-9**
Comparison of demersal fish species richness, abundance, and diversity (H') for the PLOO trawl stations with data from the Southern California Bight (SCB) 1994, 1998, 2003, 2008, 2013, and 2018 regional surveys. PLOO data are presented for 10 minute trawls conducted during winter and summer surveys with data expressed as means (ranges) for all six stations combined, and separately for the two nearfield stations (SD10, SD12) and four farfield stations (SD7, SD8, SD13, SD14) during the pre-discharge (Pre-Dis; 1991−1993) and post-discharge (Post-Dis; 1994−2020) periods. SCB regional survey data are expressed as mean values for the "mid-shelf" strata.

| | Southern California Bight Regional Surveys | | | | | | PLOO Surveys (1991−2020) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Pre-Dis | | | Post-Dis | | |
| | 1994 | 1998 | 2003 | 2008 | 2013 | 2018 | Nearfield | Farfield | All Stations | Nearfield | Farfield | All Stations |
| Species Richness | 13 (7−23) | 11 (3−26) | 16 (8−25) | 15 (4−22) | 16 (5−25) | 13 (6−27) | 13 (8−19) | 14 (9−22) | 14 (8−22) | 15 (6−21) | 16 (9−26) | 15 (6−26) |
| Abundance | 157 (23−726) | 174 (6−757) | 400 (39−1569) | 301 (18−1005) | 534 (12−2450) | 392 (33−3196) | 208 (63−399) | 217 (51−453) | 214 (51−453) | 406 (44−2,322) | 332 (50−1060) | 357 (44−2322) |
| Diversty | 1.6 (0.9−2.2) | 1.5 (0.5−2.4) | 1.7 (0.3−2.2) | 1.6 (0.9−2.3) | 1.7 (0.7−2.3) | 1.5 (0.5−2.1) | 1.4 (0.7−2.3) | 1.5 (1.1−2.0) | 1.4 (0.7−2.3) | 1.5 (0.7−2.2) | 1.5 (0.8−2.2) | 1.5 (0.7−2.2) |

**TABLE C1-10**

Summary of dominant fish species collected off Point Loma during winter and summer community trawls from 1991 through 2020 (n=57 surveys); these fishes represent at least 95% of the total abundance caught during this time. Data are presented for both pre-discharge (1991−1993) and post-discharge (1994−2020) periods and summarized for all six trawl stations combined and separately for the two nearfield stations (SD10, SD12) and four farfield stations (SD7, SD8, SD13, SD14). Data are expressed as the percent abundance (number of individuals per species/total abundance of all species) and as the mean abundance per occurence (number of individuals per species/number of sites at which the species was collected), and are limited to 10-minute trawls.

| | Pre-Discharge (1991−1993) | | | 1994−2008 Post-Disharge | | | 2009−2013 Post-Discharge | | | 2014−2020 Post-Disharge | | | All Post Discharge (1994-2020) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Sites | Nearfield | Farfield | All Sites | Nearfield | Farfield | All Sites | Nearfield | Farfield | All Sites | Nearfield | Farfield | All Sites | Nearfield | Farfield |
| **Percent Abundance** | | | | | | | | | | | | | | | |
| Pacific Sanddab | 55 | 57 | 55 | 50 | 41 | 54 | 46 | 40 | 50 | 42 | 41 | 43 | 47 | 41 | 51 |
| Halfbanded Rockfish | 2 | 3 | 1 | 5 | 17 | 3 | 7 | 6 | 8 | 21 | 28 | 18 | 11 | 17 | 8 |
| Yellowchin Sculpin | 6 | 3 | 8 | 14 | 13 | 13 | 5 | 5 | 5 | 1 | 1 | 2 | 9 | 9 | 8 |
| Longspine Combfish | 4 | 4 | 3 | 5 | 7 | 4 | 11 | 17 | 7 | 7 | 7 | 6 | 7 | 9 | 5 |
| Dover Sole | 4 | 4 | 4 | 5 | 6 | 5 | 4 | 5 | 3 | 5 | 5 | 5 | 5 | 6 | 5 |
| California Lizardfish | 1 | 2 | 1 | <1 | <1 | <1 | 11 | 10 | 12 | 9 | 8 | 10 | 4 | 3 | 5 |
| Stripetail Rockfish | 4 | 7 | 2 | 3 | 2 | 4 | 5 | 7 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| Plainfin Midshipman | 10 | 8 | 11 | 4 | 2 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 | 3 |
| Longfin Sanddab | 3 | 2 | 3 | 4 | 1 | 3 | <1 | <1 | <1 | 1 | 1 | 1 | 2 | 1 | 2 |
| Shortspine Combfish | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| Pink Seaperch | 3 | 2 | 3 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 |
| English Sole | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| California Tonguefish | 1 | 1 | 1 | 1 | 1 | 1 | 1 | <1 | 1 | <1 | <1 | <1 | 1 | 1 | 1 |
| | | | | | | | | | | | | | | | |
| **Mean Abundance** | | | | | | | | | | | | | | | |
| Pacific Sanddab | 118 | 164 | 178 | 164 | 167 | 117 | 165 | 119 | 163 | 185 | 167 | 168 | 167 | 167 | 157 |
| Halfbanded Rockfish | 4 | 19 | 28 | 82 | 40 | 5 | 67 | 3 | 8 | 30 | 71 | 26 | 70 | 25 | 107 |
| Yellowchin Sculpin | 13 | 44 | 19 | 6 | 31 | 7 | 38 | 17 | 38 | 17 | 7 | 27 | 54 | 22 | 3 |
| Longspine Combfish | 8 | 19 | 42 | 25 | 24 | 9 | 38 | 8 | 13 | 27 | 24 | 18 | 30 | 70 | 28 |
| Dover Sole | 9 | 20 | 14 | 18 | 18 | 9 | 24 | 9 | 17 | 10 | 19 | 16 | 26 | 22 | 17 |
| California Lizardfish | 3 | 1 | 42 | 35 | 16 | 4 | 14 | 3 | 1 | 43 | 37 | 16 | <1 | 41 | 29 |
| Stripetail Rockfish | 8 | 10 | 18 | 9 | 11 | 15 | 12 | 4 | 11 | 13 | 9 | 11 | 8 | 27 | 8 |
| Plainfin Midshipman | 22 | 10 | 3 | 9 | 8 | 17 | 7 | 24 | 10 | 3 | 12 | 9 | 9 | 3 | 3 |
| Longfin Sanddab | 5 | 19 | <1 | 2 | 6 | 4 | 4 | 6 | 10 | <1 | 3 | 7 | 6 | <1 | 2 |
| Shortspine Combfish | 3 | 4 | 9 | 7 | 6 | 2 | 6 | 4 | 4 | 9 | 8 | 5 | 5 | 9 | 5 |
| Pink Seaperch | 6 | 19 | 7 | 5 | 5 | 5 | 5 | 6 | 3 | 8 | 6 | 5 | 5 | 5 | 4 |
| English Sole | 2 | 3 | 7 | 7 | 5 | 1 | 6 | 2 | 3 | 6 | 6 | 4 | 3 | 9 | 8 |
| California Tonguefish | 2 | 4 | 2 | 2 | 3 | 2 | 3 | 2 | 4 | 2 | 2 | 3 | 4 | 2 | 1 |

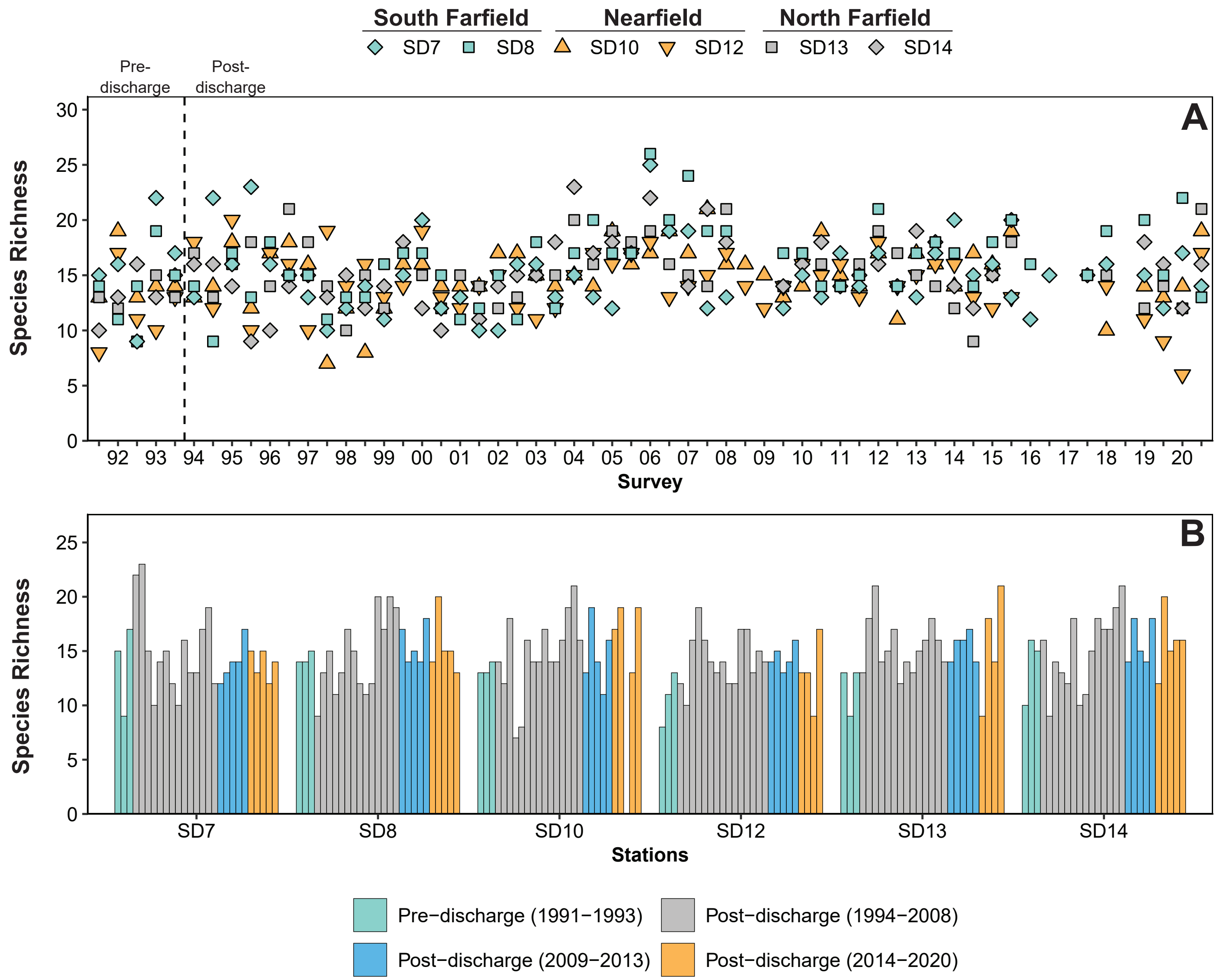


**FIGURE C1-49**
Demersal fish species richness at PLOO trawl stations (A) from 1991 through 2020; (B) summer surveys only.

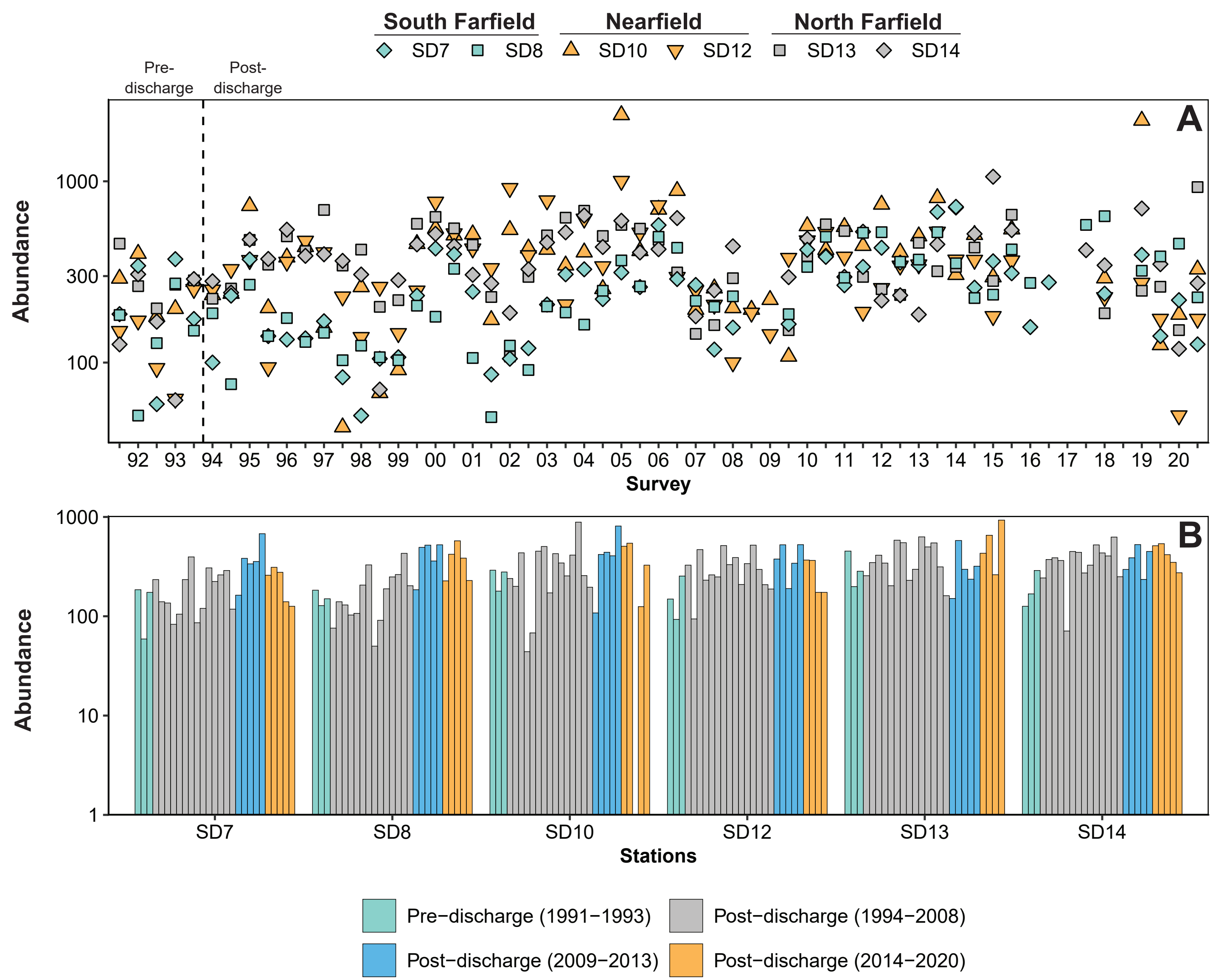


**FIGURE C1-50**
Demersal fish abundance at PLOO trawl stations (A) from 1991 through 2020; (B) summer surveys only.

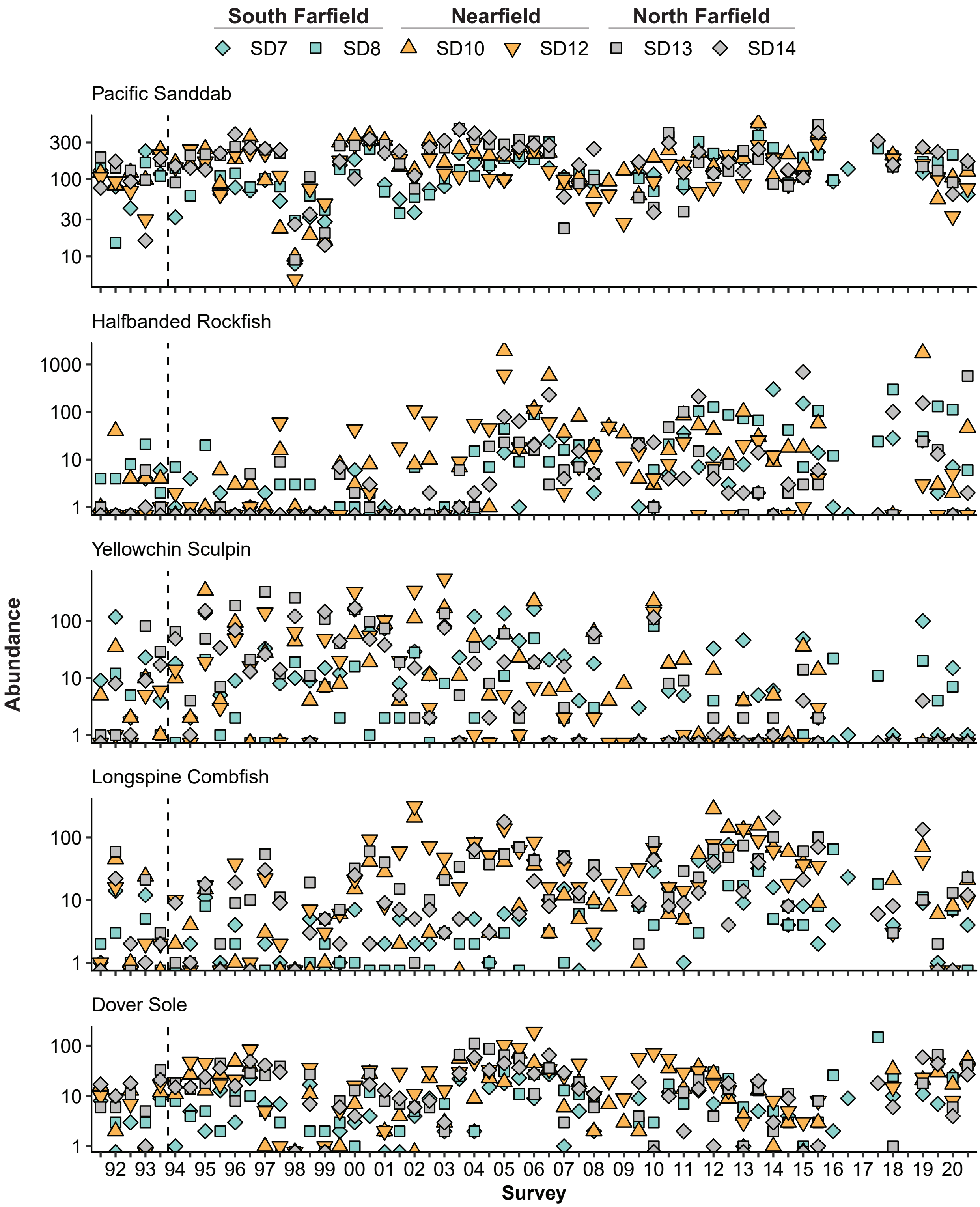


**FIGURE C1-51**
The ten most abundant demersal fish species (presented in order) collected near the PLOO from 1991 through 2020. Data are limited to 10-minute trawls and are total values per haul. Dashed lines indicate onset of wastewater discharge.

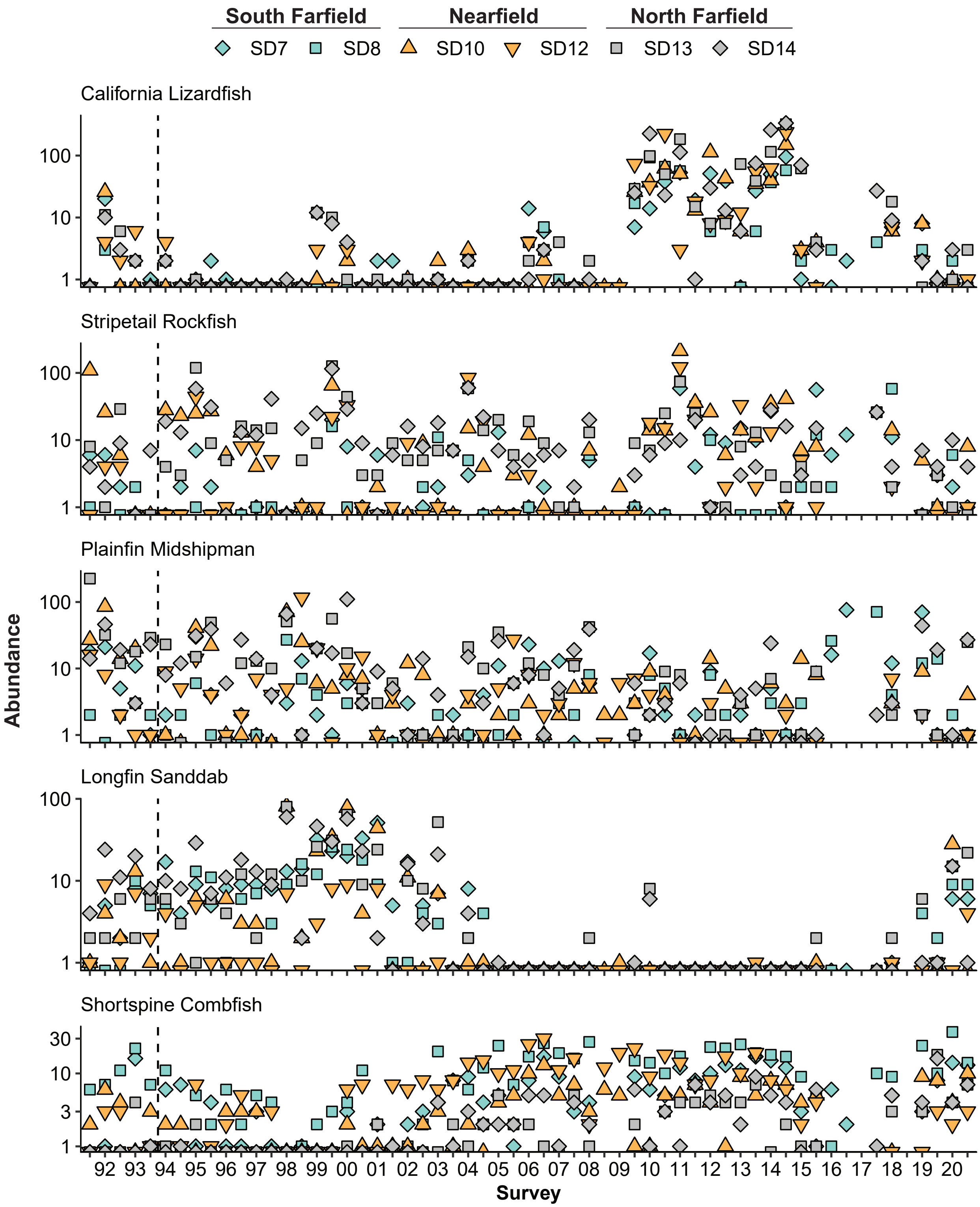


**FIGURE C1-51** *continued*

## Results – Megabenthic Invertebrates

A total of 955,386 megabenthic invertebrates were recorded in the 321 trawls conducted off Point Loma during winter and summer from 1991 through 2020. These invertebrates comprised 183 taxa, including 143 distinct species, and are summarized as the total number of individuals per species, with taxonomic arrangement according to SCAMIT (2018) in Attachment C1-D.

### *Major Community Parameters*

Species Richness: As with benthic infauna, a reduction in megabenthic invertebrate diversity or the number of species encountered near an outfall compared to those at reference stations could be a potential indicator of environmental degradation. The number of invertebrate species collected ranged from 2 to 29 per haul, with there being little difference in average numbers between the nearfield and farfield stations or between the pre-discharge and post-discharge periods (Table C1-11, Figure C1-52). Overall, species richness for trawl-caught invertebrate communities off Point Loma averaged about 11 species per haul during the pre-discharge period and 12 species per haul during the post-discharge period. Patterns of change observed over time at the nearfield trawl stations were similar to those observed at the farfield stations, and values from all stations were within the range of natural variability observed during the SCB regional surveys.

In addition, no clear spatial patterns were found that coincided with the onset of wastewater discharge. Instead, higher species richness at the three stations south of the outfall (SD7, SD8, SD10) relative to those to the north (SD12, SD13, SD14) are likely due to differences in sediment composition and not proximity to the discharge zone. Stations north of the outfall comprise mainly fine sands and particles, whereas stations south of the outfall also occasionally have medium-coarse sands (e.g., see Section C1-3). Moreover, although species richness increased in 1994 shortly after discharge began, the increase occurred at all stations and then returned to pre-discharge levels by summer 1997. This cyclic pattern has continued over time, with no spatial trends in the number of trawl-caught invertebrate species that might suggest an outfall-related impact.

**Megabenthic Invertebrate Abundance**: The total invertebrate catch varied widely between trawls, ranging from 24 to 8,026 individuals per haul during the pre-discharge period, and from 14 to 46,255 individuals per haul during the post-discharge period (Table C1-11, Figure C1-53). The largest trawls were collected during the 2014-2020 post-discharge years, reflecting the huge hauls of red crab Pleuroncodes planipes encountered across the region (see below). These crabs were not encountered in the same numbers in other areas of the SCB, and so the range of invertebrate abundance values reported for PLOO trawl stations exceeded the range of natural variability observed during SCB regional surveys.

**Diversity**: There was no reduction in trawl invertebrate diversity associated with proximity to the PLOO, or onset of wastewater discharge. Reflecting changes in the number of species, and the abundance per species, diversity (H') values were highly variable (range=0–2.1 per trawl) over the past 30 years, and patterns of change were similar at the nearfield and farfield stations during the pre-discharge and post-discharge periods (Table C1-11). Diversity values reported for PLOO trawl stations were within the range of natural variability observed during the SCB surveys. It is likely that very low diversity values reflect large hauls of either the sea urchin *Lytechinus pictus* or red crab *Pleuroncodes planipes*.

### *Dominant Megabenthic Invertebrate Species*

Whereas variability in demersal fish abundances reflected several common species, a large amount of the variability described for total megabenthic invertebrate abundance was due to fluctuations in populations of just a few species (Figures C1-53 and C1-54). For example, over the past 30 years, the sea urchin *Lytechinus pictus* and red crab *Pleuroncodes planipes*, have been collected in numbers as high as an average of 2,264 and 6,405 individuals per haul (Table C1-12). *Lytechinus pictus* accounted for about 97% of the total catch during the pre-discharge period and at least 62% of the catch in the post-discharge period. *Pleuroncodes planipes* has been recorded sporadically over the years, typically in association with El Niño conditions present in 1992-1993, 1998, and the marine heat wave of 2014-2016 (see Appendix E), and occasionally persisting after the El Niño conditions transitioned to neutral or La Niña conditions (e.g., late 2017 through early 2018). The latter is why this crab accounted for at least 31% of the catch from 2014 through 2020. Other occasionally abundant species included the brittle star *Ophiura luetkenii*, the sea pen *Acanthoptilum* sp, the shrimp *Sicyonia ingentis*, and the sea urchin *Strongylocentrotus fragilis* (previously reported as *Allocentrotus fragilis*). These species had higher mean abundances per haul across all stations during the post-discharge period. Most of the remaining species were captured infrequently or in low numbers, with 99 taxa being represented by fewer than 10 individuals total since monitoring began.

## Summary of Effects on Fish & Invertebrate Communities

Overall, there has been no evidence that wastewater discharged through the PLOO affected demersal fish and megabenthic invertebrate communities, as the abundance and distribution of species generally varied similarly at nearfield and farfield stations, and the high degree of variability in these assemblages was consistent across all surveys, including before wastewater discharge began. Multivariate analyses used to evaluate changes in trawled fish and invertebrate community structure within the PLOO region without *a priori* assignment of nearield versus farfield location, or pre- and post-discharge time periods support this conclusion (City of San Diego 2020b). This type of variability is consistent with what has been observed in similar habitats elsewhere off the coast of southern California (Allen et al. 1998, 2002, 2007, 2011, Walther et al. 2017). Consequently, changes in local populations of demersal fish and megabenthic invertebrate communities are more likely due to natural factors, such as changes in ocean temperatures associated with El Niño, or other large-scale oceanographic events. Finally, the rarity of disease indicators, or other physical abnormalities, in local fishes suggests that populations in the Point Loma outfall regions continue to be healthy (City of San Diego 2020b, 2021a).

**TABLE C1-11**
Comparison of megabenthic invertebrate species richness, abundance, and diversity (H') for the PLOO trawl stations with data from the Southern California Bight (SCB) 1994, 1998, 2003, 2008, 2013, and 2018 regional surveys. PLOO data are presented for 10 minute trawls conducted during winter and summer surveys with data expressed as means (ranges) for all six stations combined, and separately for the two nearfield stations (SD10, SD12) and four farfield stations (SD7, SD8, SD13, SD14) during the pre-discharge (Pre-Dis; 1991−1993) and post-discharge (Post-Dis; 1994−2020) periods. SCB regional survey data are expressed as mean values for the "mid-shelf" strata.

| | Southern California Bight Regional Surveys | | | | | | PLOO Surveys (1991−2020) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Pre-Dis | | | Post-Dis | | |
| | 1994 | 1998 | 2003 | 2008 | 2013 | 2018 | Nearfield | Farfield | All Stations | Nearfield | Farfield | All Stations |
| Species Richness | 14 (6−41) | 10 (1−19) | 13 (3−33) | 12 (3−21) | 11 (2−24) | 9 (3−21) | 11 (6−16) | 11 (5−20) | 11 (5−20) | 12 (3−29) | 12 (2−26) | 12 (2−29) |
| Abundance | 805 (13−11,616) | 769 (1−10,005) | 531 (21−5617) | 1085 (23−22,179) | 814 (2−17,973) | 214 (4−1,069) | 2,458 (1,104−8,026) | 1,791 (24−6,047) | 2,013 (24−8,026) | 3,177 (36−46,255) | 1,855 (14−36,118) | 2,300 (14−46,255) |
| Diversty | 1.05 (0.03−2.42) | 0.9 (0−2.3) | 1.4 (0.1−2.5) | 1 (0−2.2) | 1.1 (0.1−2.5) | 1.2 (0.4−2.6) | 0.14 (0.03−0.29) | 0.65 (0.03−1.92) | 0.48 (0.03−1.92) | 0.4 (0−2) | 0.6 (0−2.1) | 0.5 (0−2.1) |

**TABLE C1-12**
Summary of megabenthic invertebrate species collected off Point Loma during winter and summer community trawls from 1991 through 2020 (n=57 surveys); these invertebrates represent at least 95% of the total abundance caught during this time. Data are presented for both pre-discharge (1991−1993) and post-discharge (1994−2020) periods and summarized for all six trawl stations combined and separately for the two nearfield stations (SD10, SD12) and four farfield stations (SD7, SD8, SD13, SD14). Data are expressed as the percent abundance (number of individuals per species/total abundance of all species) and as the mean abundance per occurence (number of individuals per species/number of sites at which the species was collected), and are limited to 10-minute trawls.

| | Pre-Discharge (1991−1993) | | | 1994−2008 Post-Disharge | | | 2009−2013 Post-Discharge | | | 2014−2020 Post-Disharge | | | All Post Discharge (1994-2020) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Sites | Nearfield | Farfield | All Sites | Nearfield | Farfield | All Sites | Nearfield | Farfield | All Sites | Nearfield | Farfield | All Sites | Nearfield | Farfield |
| **Percent Abundance** | | | | | | | | | | | | | | | |
| *Pleuroncodes planipes* | <1 | <1 | <1 | <1 | <1 | <1 | 0 | 0 | 0 | 81 | 73 | 89 | 31 | 26 | 37 |
| *Lytechinus pictus* | 97 | 97 | 99 | 93 | 93 | 94 | 83 | 76 | 94 | 16 | 21 | 10 | 62 | 64 | 59 |
| *Ophiura luetkenii* | <1 | <1 | <1 | <1 | <1 | <1 | 10 | 15 | 2 | 2 | 4 | <1 | 2 | 4 | <1 |
| *Acanthoptilum* sp | <1 | <1 | <1 | 3 | 2 | 4 | 1 | 1 | 3 | <1 | <1 | <1 | 2 | 1 | 2 |
| *Strongylocentrotus fragilis* | 1 | 1 | <1 | 1 | 2 | <1 | 4 | 6 | 1 | 1 | 1 | <1 | 1 | 2 | <1 |
| *Sicyonia ingentis* | <1 | <1 | <1 | <1 | 1 | <1 | <1 | <1 | <1 | 1 | 1 | 1 | <1 | 1 | <1 |
| *Luidia foliolata* | <1 | <1 | <1 | <1 | <1 | <1 | 1 | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| *Apostichopus californicus* | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| *Astropecten californicus* | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| *Platymera gaudichaudii* | <1 | 0 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| *Florometra serratissima* | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 0 | <1 | <1 | <1 |
| *Pleurobranchaea californica* | <1 | <1 | 0 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| *Octopus rubescens* | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **Mean Abundance** | | | | | | | | | | | | | | | |
| *Pleuroncodes planipes* | 6 | 8 | 4 | <1 | <1 | <1 | 0 | 0 | 0 | 3554 | 2302 | 6405 | 721 | 489 | 1177 |
| *Lytechinus pictus* | 1959 | 1728 | 2421 | 1690 | 1393 | 2264 | 1346 | 1140 | 1718 | 689 | 669 | 734 | 1421 | 1192 | 1872 |
| *Ophiura luetkenii* | 1 | 2 | 1 | 2 | 2 | 1 | 157 | 228 | 30 | 85 | 121 | 2 | 48 | 69 | 7 |
| *Acanthoptilum* sp | 1 | 1 | <1 | 58 | 36 | 102 | 24 | 11 | 47 | 2 | 2 | 1 | 40 | 24 | 72 |
| *Strongylocentrotus fragilis* | 16 | 22 | 5 | 22 | 30 | 8 | 60 | 85 | 16 | 24 | 32 | 4 | 30 | 41 | 9 |
| *Sicyonia ingentis* | <1 | <1 | <1 | 8 | 10 | 4 | 1 | 1 | 1 | 30 | 21 | 51 | 11 | 10 | 12 |
| *Luidia foliolata* | 4 | 4 | 4 | 3 | 4 | 3 | 9 | 10 | 7 | 2 | 2 | 2 | 4 | 4 | 4 |
| *Apostichopus californicus* | 6 | 8 | 1 | 5 | 6 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 4 | 4 | 2 |
| *Astropecten californicus* | 3 | 3 | 4 | 5 | 4 | 6 | 3 | 2 | 3 | 1 | 2 | 1 | 4 | 3 | 5 |
| *Platymera gaudichaudii* | <1 | 0 | <1 | 2 | 2 | <1 | <1 | <1 | <1 | 9 | 2 | 25 | 3 | 2 | 5 |
| *Florometra serratissima* | 2 | 2 | <1 | <1 | 1 | <1 | 2 | 3 | <1 | 3 | 4 | 0 | 1 | 2 | <1 |
| *Pleurobranchaea californica* | <1 | <1 | 0 | 1 | 1 | 1 | 4 | 4 | 3 | <1 | <1 | <1 | 1 | 1 | 1 |
| *Octopus rubescens* | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | <1 | 1 | 1 | 1 | 1 | 1 | 1 |

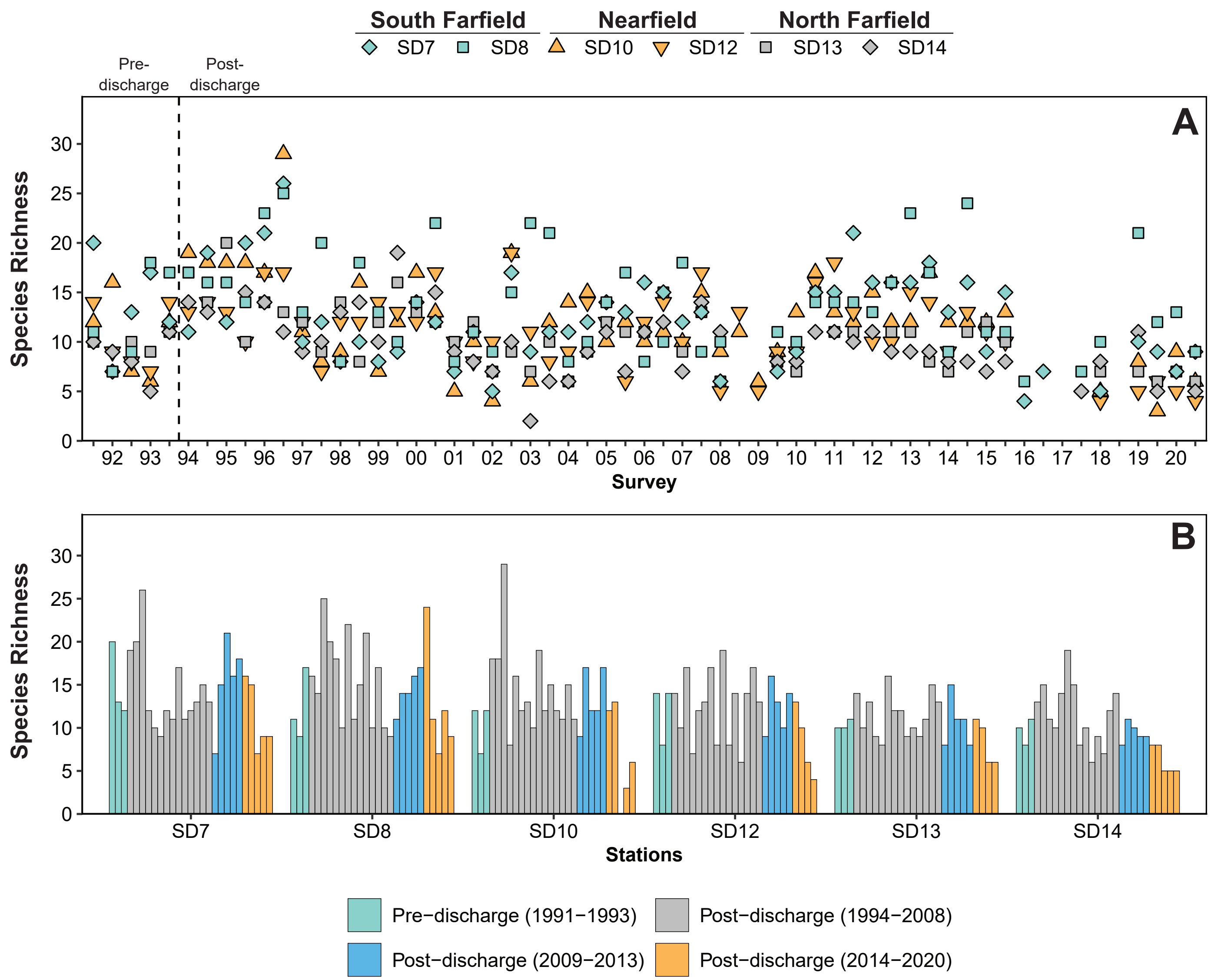


**FIGURE C1-52**
Megabenthic invertebrate species richness at PLOO trawl stations (A) from 1991 through 2020; (B) summer surveys only.

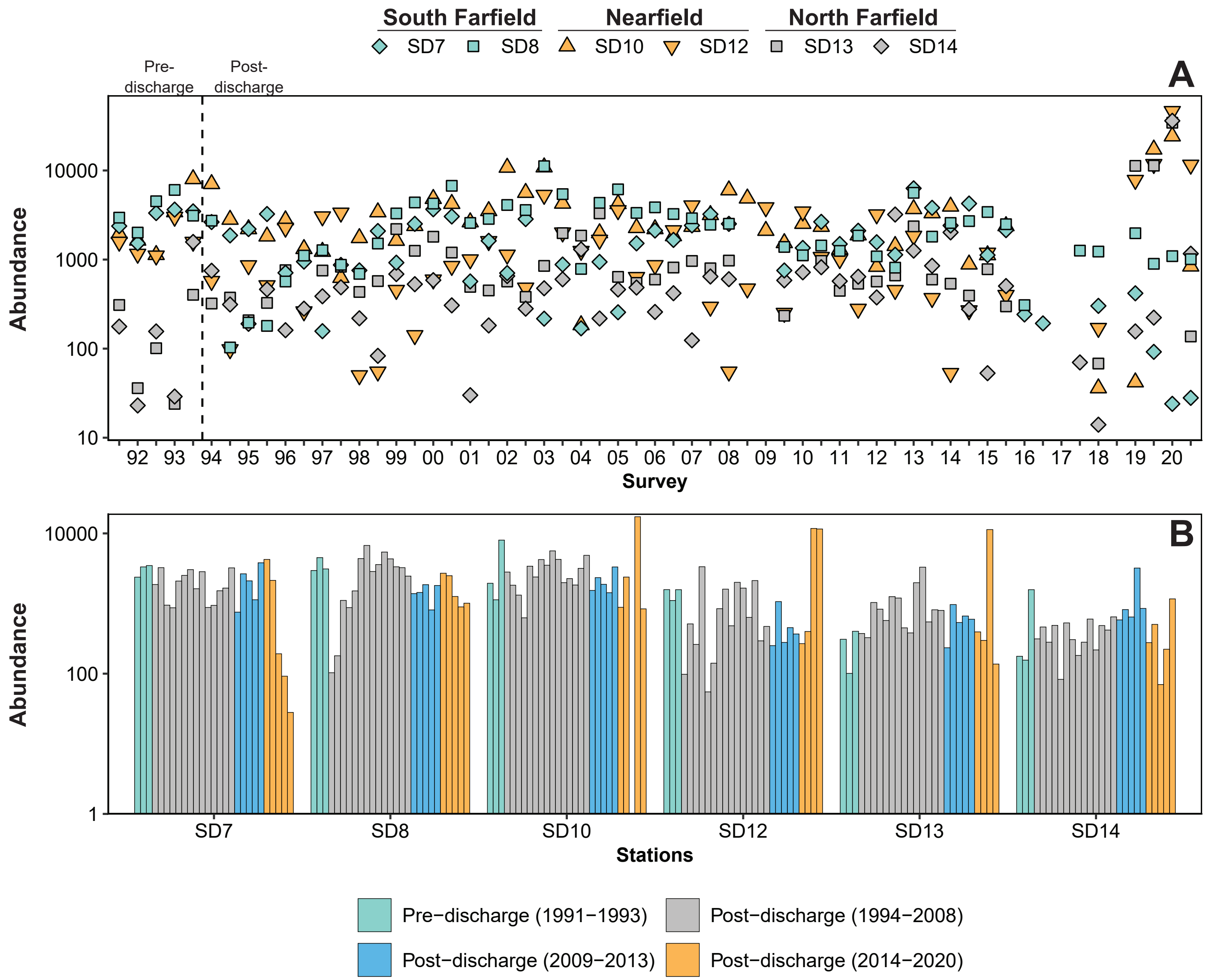


**FIGURE C1-53**

Megabenthic invertebrate abundance at PLOO trawl stations (A) from 1991 through 2020; (B) summer surveys only.

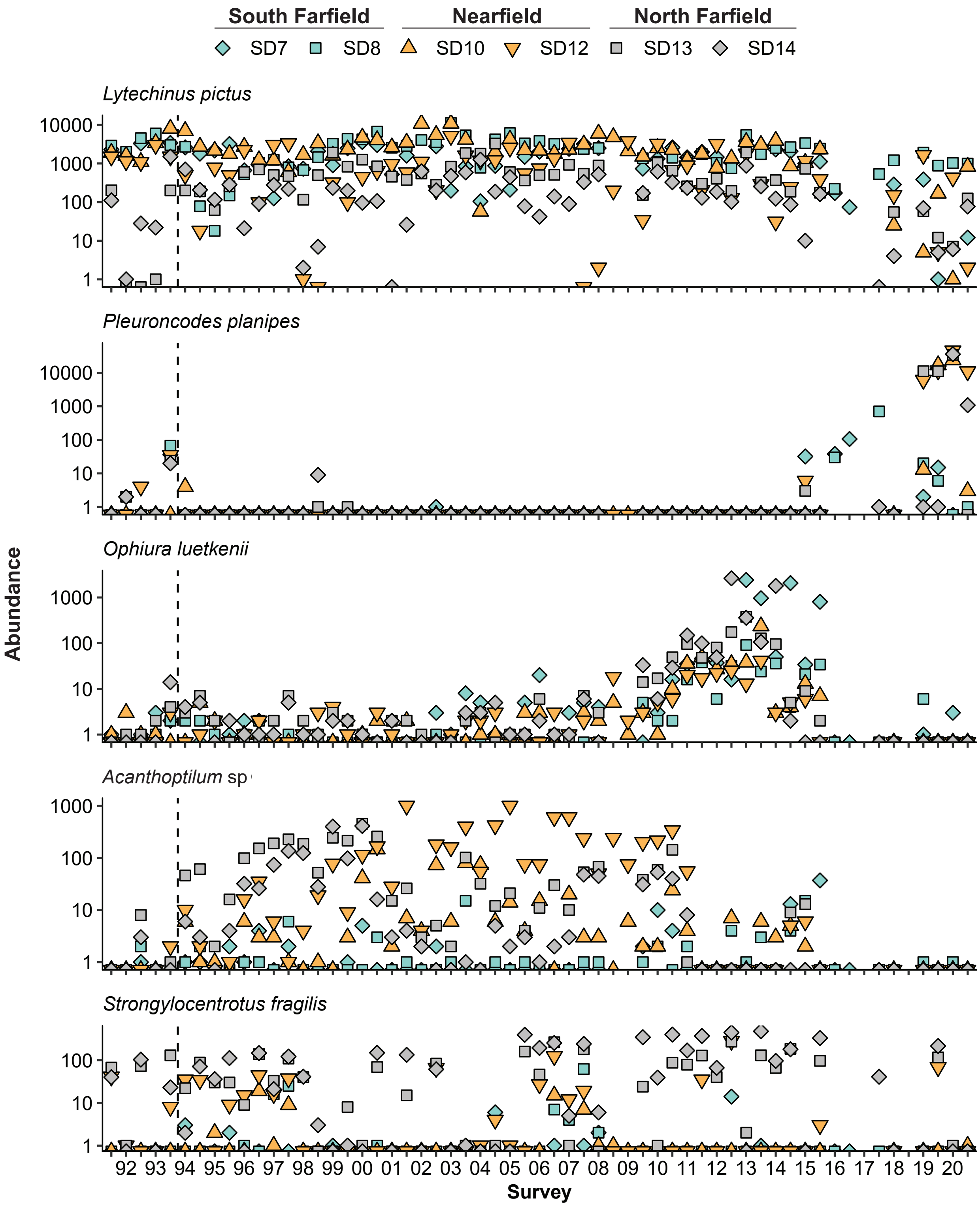


**FIGURE C1-54**
The ten most abundant megabenthic invertebrate species (presented in order) collected near the PLOO from 1991 through 2020. Data are limited to 10-minute trawls and are total values per haul. Dashed lines indicate onset of wastewater discharge.

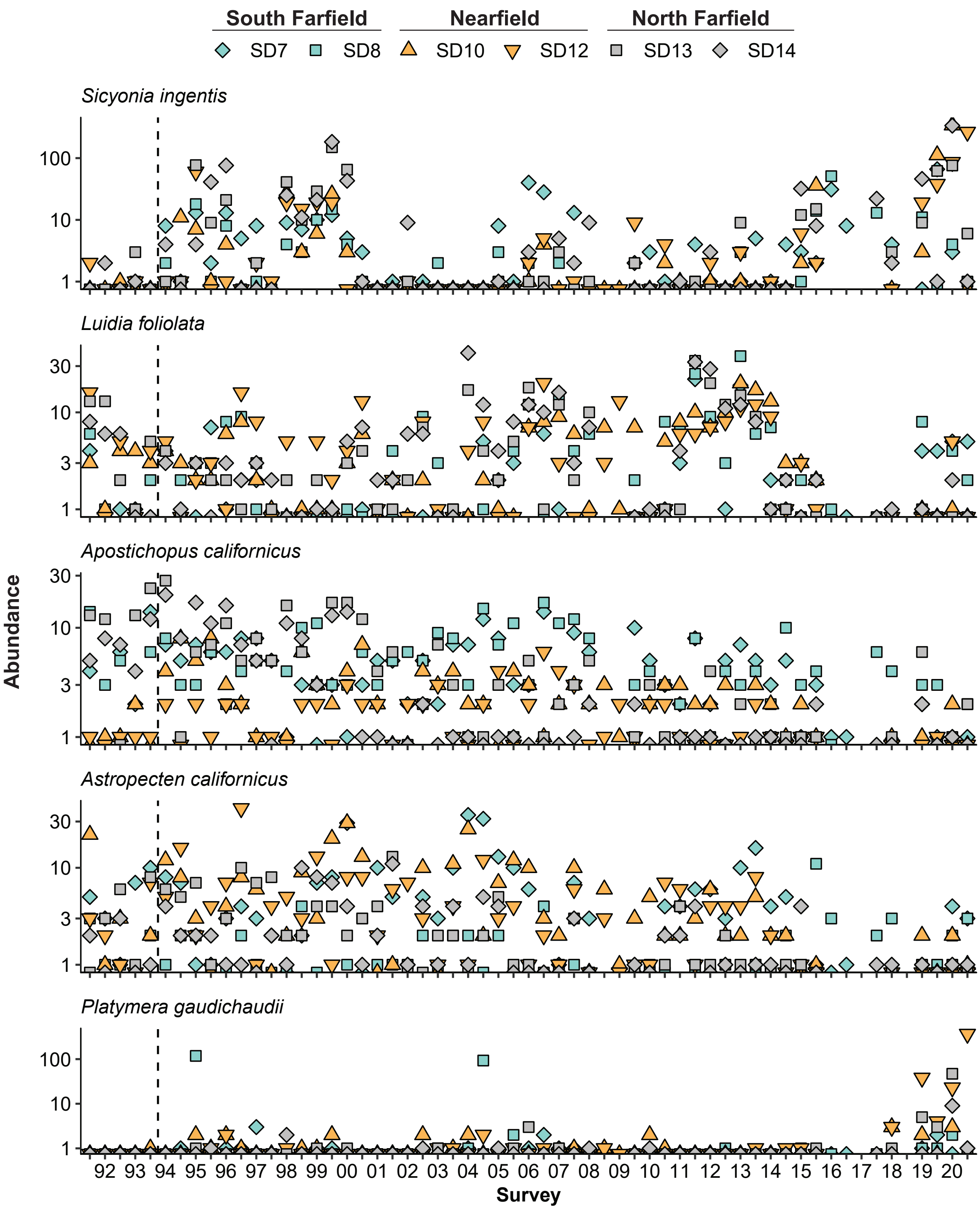


**FIGURE C1-54** *continued*

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**ATTACHMENT C1-A**

Summary of years analyzed and method detection limits for each sediment chemistry parameter analyzed from 1991 through 2020.

| Parameter | Start | End | min | max |
|---|---|---|---|---|
| ***Organic Indicators*** | | | | |
| Biochemical Oxygen Demand (BOD, ppm) | 1991 | 2020 | 2 | 2 |
| Total Sulfides (ppm) | 1991 | 2020 | 0.05 | 1.5 |
| Total Nitrogen (TN, % wt) | 1993 | 2020 | 0.001 | 0.012 |
| Total Organic Carbon (TOC, % wt) | 1993 | 2020 | 0.005 | 0.07 |
| Total Volatile Solids (TVS, % wt) | 1991 | 2020 | 0.11 | 0.11 |
| ***Metals (ppm)*** | | | | |
| Aluminum | 1994 | 2020 | 1.15 | 8.02 |
| Antimony | 1991 | 2020 | 0.13 | 5 |
| Arsenic | 1991 | 2020 | 0.08 | 0.663 |
| Beryllium | 1991 | 2020 | 0.001 | 0.5 |
| Cadmium | 1991 | 2020 | 0.01 | 0.5 |
| Chromium | 1991 | 2020 | 0.016 | 5 |
| Copper | 1991 | 2020 | 0.028 | 2 |
| Iron | 1993 | 2020 | 0.75 | 9 |
| Lead | 1991 | 2020 | 0.1 | 5 |
| Manganese | 1996 | 2020 | 0.004 | 0.48 |
| Mercury | 1991 | 2020 | 0.003 | 0.058 |
| Nickel | 1991 | 2020 | 0.036 | 4 |
| Selenium | 1991 | 2020 | 0.11 | 0.463 |
| Silver | 1991 | 2020 | 0.013 | 3 |
| Zinc | 1991 | 2020 | 0.052 | 4 |
| ***Chlorinated Pesticides (ppt)*** | | | | |
| *Hexachlorocyclohexane (HCH)* | | | | |
| HCH, Alpha isomer | 1991 | 2020 | 100 | 730 |
| HCH, Beta isomer | 1991 | 2020 | 1000 | 85.6 |
| HCH, Delta isomer | 1991 | 2020 | 100 | 90.2 |
| HCH, Gamma isomer | 1991 | 2020 | 10 | 88.6 |
| *Chlordane* | | | | |
| Alpha(cis)Chlordane | 1991 | 2020 | 1000 | 96.8 |
| Alpha-Chlordene | 1991 | 2016 | 160 | 160 |
| Cis-Nonachlor | 1994 | 2020 | 1150 | 81.9 |
| Gamma(trans)Chlordane | 1991 | 2020 | 103 | 76 |
| Gamma-Chlordene | 1991 | 2016 | 120 | 450 |
| Heptachlor | 1991 | 2020 | 1000 | 76 |
| Heptachlor epoxide | 1991 | 2020 | 1000 | 74.1 |
| Methoxychlor | 1991 | 2020 | 101 | 90 |
| Oxychlordane | 1991 | 2020 | 10 | 99.6 |
| Trans-Nonachlor | 1991 | 2020 | 10 | 770 |
| *Dichlorodiphenyltrichloroethane (DDT)* | | | | |
| o,p-DDD | 1991 | 2020 | 100 | 90 |
| o,p-DDE | 1991 | 2020 | 110 | 720 |
| o,p-DDT | 1991 | 2020 | 1000 | 94 |
| p,p-DDD | 1991 | 2020 | 1000 | 910 |
| p,p-DDE | 1991 | 2020 | 1000 | 90 |
| p,p-DDT | 1991 | 2020 | 1000 | 940 |
| p,-p-DDMU | 2004 | 2020 | 15.4 | 55.4 |
| *Miscellaneous Pesticides* | | | | |
| Aldrin | 1991 | 2020 | 1000 | 8830 |
| Alpha-Endosulfan | 1991 | 2020 | 10000 | 89.2 |

| Parameter | Start | End | min | max |
|---|---|---|---|---|
| Beta-Endosulfan | 1991 | 2020 | 10000 | 780 |
| Dieldrin | 1991 | 2020 | 1000 | 79.5 |
| Endosulfan Sulfate | 2014 | 2020 | 104 | 75.5 |
| Endrin | 1991 | 2020 | 1000 | 830 |
| Endrin aldehyde | 1991 | 2020 | 10000 | 830 |
| Hexachlorobenzene | 1991 | 2020 | 1210 | 750 |
| Mirex | 1991 | 2020 | 10000 | 79.5 |
| ***Polychlorinated Biphenyl Congeners (PCBs) (ppt)*** | | | | |
| PCB 8 | 2018 | 2018 | 54.3 | 57.7 |
| PCB 18 | 1998 | 2020 | 1000 | 90 |
| PCB 28 | 1998 | 2020 | 22.8 | 960 |
| PCB 37 | 1998 | 2020 | 16.9 | 90.6 |
| PCB 44 | 1998 | 2020 | 100 | 980 |
| PCB 49 | 1998 | 2020 | 1300 | 850 |
| PCB 52 | 1998 | 2020 | 1000 | 90 |
| PCB 66 | 1998 | 2020 | 100 | 920 |
| PCB 70 | 1998 | 2020 | 1000 | 700 |
| PCB 74 | 1998 | 2020 | 100 | 900 |
| PCB 77 | 1998 | 2020 | 110 | 790 |
| PCB 81 | 1998 | 2020 | 130 | 700 |
| PCB 87 | 1998 | 2020 | 1800 | 75.3 |
| PCB 99 | 1998 | 2020 | 101 | 80 |
| PCB 101 | 1998 | 2020 | 100 | 700 |
| PCB 105 | 1998 | 2020 | 23.4 | 930 |
| PCB 110 | 1998 | 2020 | 110 | 990 |
| PCB 114 | 1998 | 2020 | 1000 | 78 |
| PCB 118 | 1998 | 2020 | 110 | 90 |
| PCB 119 | 1998 | 2020 | 117 | 85.6 |
| PCB 123 | 1998 | 2020 | 130 | 9600 |
| PCB 126 | 1998 | 2020 | 1100 | 98 |
| PCB 128 | 1998 | 2020 | 110 | 8900 |
| PCB 138 | 1998 | 2020 | 1900 | 80 |
| PCB 149 | 1998 | 2020 | 106 | 700 |
| PCB 151 | 1998 | 2020 | 1100 | 81 |
| PCB 153 | 1998 | 2000 | 1200 | 1200 |
| PCB 153/168 | 2000 | 2020 | 100 | 91.3 |
| PCB 156 | 1998 | 2020 | 1800 | 90 |
| PCB 157 | 1998 | 2020 | 100 | 92 |
| PCB 158 | 1998 | 2020 | 108 | 91.1 |
| PCB 167 | 1998 | 2020 | 19.4 | 700 |
| PCB 168 | 1998 | 2000 | 1400 | 1400 |
| PCB 169 | 1998 | 2020 | 17.3 | 90 |
| PCB 170 | 1998 | 2020 | 1600 | 97.2 |
| PCB 177 | 1998 | 2020 | 2300 | 71.6 |
| PCB 180 | 1998 | 2020 | 100 | 80 |
| PCB 183 | 1998 | 2020 | 1400 | 700 |
| PCB 187 | 1998 | 2020 | 110 | 96 |
| PCB 189 | 1998 | 2020 | 100 | 99.1 |
| PCB 194 | 1998 | 2020 | 110 | 80 |
| PCB 195 | 2018 | 2018 | 38.7 | 42.2 |
| PCB 201 | 1998 | 2020 | 21.4 | 72.1 |
| PCB 206 | 1998 | 2020 | 1900 | 91.3 |

| Parameter | Start | End | min | max |
|---|---|---|---|---|
| ***Polycyclic Aromatic Hydrocarbons (PAHs) (ppb)*** | | | | |
| 1-methylnaphthalene | 1995 | 2020 | 12 | 9.87 |
| 1-methylphenanthrene | 1995 | 2020 | 10.7 | 8.86 |
| 2-methylnaphthalene | 1995 | 2020 | 102 | 9.32 |
| 2,3,5-trimethylnaphthalene | 1995 | 2020 | 11.2 | 8.23 |
| 2,6-dimethylnaphthalene | 1995 | 2020 | 106 | 8.86 |
| 3,4-benzo(B)fluoranthene | 1991 | 2020 | 160 | 9.93 |
| Acenaphthene | 1991 | 2020 | 10.9 | 79 |
| Acenaphthylene | 1991 | 2020 | 10 | 9.87 |
| Anthracene | 1991 | 2020 | 10.8 | 9.77 |
| Benzo[A]anthracene | 1991 | 2020 | 106 | 7.06 |
| Benzo[A]pyrene | 1991 | 2020 | 12.5 | 6.8 |
| Benzo[e]pyrene | 1995 | 2020 | 11.4 | 73 |
| Benzo[G,H,I]perylene | 1991 | 2020 | 10 | 66 |
| Benzo[K]fluoranthene | 1991 | 2020 | 13.9 | 82 |
| Biphenyl | 1995 | 2019 | 10 | 9.79 |
| Chrysene | 1991 | 2020 | 12 | 6.89 |
| Dibenzo(A,H)anthracene | 1991 | 2020 | 1.86 | 97 |
| Fluoranthene | 1991 | 2020 | 12 | 70 |
| Fluorene | 1991 | 2020 | 11.1 | 77 |
| Indeno(1,2,3-CD)pyrene | 1991 | 2020 | 106 | 76 |
| Naphthalene | 1991 | 2020 | 16 | 8.21 |
| Perylene | 1995 | 2020 | 14.6 | 6.3 |
| Phenanthrene | 1991 | 2020 | 14.3 | 9.54 |
| Pyrene | 1991 | 2020 | 126 | 8.67 |

**ATTACHMENT C1-A**
Summary of benthic macrofauna invertebrate species collected from outfall discharge depths near the Point Loma Ocean Outfall from 1991 through 2020. Data include total number of individuals collected (N). Taxonomic arrangement according to SCAMIT (2018).

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| **Cnidaria** | | | | |
| Hydrozoa | | | | 1 |
| | Anthoathecata | Corymorphidae | *Corymorpha bigelowi* | 6 |
| | | | *Euphysa* sp A | 2 |
| | Leptothecata | Campanulariidae | *Laomedea calceolifera* | 6 |
| Anthozoa | | | | 10 |
| | Alcyonacea | Plexauridae | *Thesea* sp B | 3 |
| | Pennatulacea | Virgulariidae | | 19 |
| | | | *Acanthoptilum* sp | 327 |
| | | | *Stylatula* sp A | 21 |
| | | | *Stylatula* sp | 8 |
| | | | *Virgularia agassizii* | 8 |
| | | | *Virgularia californica* | 2 |
| | | | *Virgularia* sp | 1 |
| | -- | | Ceriantharia | 11 |
| | Penicillaria | Arachnactidae | *Arachnanthus* sp A | 5 |
| | Actiniaria | | | 11 |
| | | Edwardsiidae | | 66 |
| | | | *Edwardsia juliae* | 11 |
| | | | *Edwardsia olguini* | 89 |
| | | | *Edwardsia* sp SD1 | 4 |
| | | | *Scolanthus triangulus* | 115 |
| | | Halcampidae | *Halcampa decemtentaculata* | 26 |
| | | | *Halianthella* sp A | 81 |
| | | Limnactiniidae | | 2 |
| | | Haloclavidae | *Anemonactis* sp A | 2 |
| **Platyhelminthes** | | | | |
| Rhabditophora | Polycladida | | | 7 |
| | | Callioplanidae | *Koinostylochus burchami* | 1 |
| | | Stylochidae | *Stylochus exiguus* | 2 |
| | | | *Stylochus franciscanus* | 1 |
| | | Cryptocelidae | *Cryptocelis occidentalis* | 1 |
| | | Plehniidae | *Diplehnia caeca* | 18 |
| | | Leptoplanidae | | 1 |
| | | | Leptoplanidae sp A | 1 |
| | | Euryleptidae | *Acerotisa langi* | 1 |
| **Nemertea** | | | | 73 |
| Anopla | | | | 24 |
| | Archinemertea | Cephalotrichidae | *Cephalothrix* sp | 1 |
| | Palaeonemertea | | | 42 |
| | | Carinomidae | *Carinoma mutabilis* | 124 |
| | | | *Carinomella lactea* | 2 |
| | | Tubulanidae | | 32 |
| | | | *Tubulanus albocinctus* | 1 |
| | | | *Tubulanus cingulatus* | 88 |
| | | | *Tubulanus polymorphus* | 218 |
| | | | *Tubulanus* sp A | 22 |
| | | | *Tubulanus* sp | 2 |
| | | | Tubulanidae sp A | 1 |
| | | | Tubulanidae sp B | 1 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | | Tubulanidae sp D | 2 |
| | | | Tubulanidae sp E | 3 |
| | Heteronemertea | | | 8 |
| | | Lineidae | | 394 |
| | | | *Cerebratulus albifrons* | 1 |
| | | | *Cerebratulus californiensis* | 51 |
| | | | *Cerebratulus* sp | 3 |
| | | | Lineidae sp SD1 | 6 |
| | | | *Lineus bilineatus* | 486 |
| | | | *Lineus rubescens* | 2 |
| | | | *Lineus* cf *torquatus* | 1 |
| | | | *Lineus* sp | 18 |
| | | | *Maculaura alaskensis* Cmplx | 3 |
| | | | *Micrura* sp | 8 |
| | | | *Zygeupolia rubens* | 12 |
| | | -- | Heteronemertea sp SD2 | 438 |
| Enopla | | | | 10 |
| | | | Hoplonemertea | 18 |
| | Monostilifera | | | 1 |
| | | Emplectonematidae | *Cryptonemertes actinophila* | 3 |
| | | | *Paranemertes californica* | 122 |
| | | Prosorhochmidae | *Prosorhochmus albidus* | 1 |
| | | Oerstediidae | *Oerstedia dorsalis* Cmplx | 5 |
| | | Amphiporidae | *Amphiporus flavescens* | 1 |
| | | | *Amphiporus* sp | 7 |
| | | | *Zygonemertes virescens* | 1 |
| | | Tetrastemmatidae | *Tetrastemma candidum* | 3 |
| | | | *Tetrastemma* sp | 4 |
| | -- | -- | Hoplonemertea sp A | 4 |
| | | | Hoplonemertea sp B | 1 |
| | | | Hoplonemertea cf sp B | 1 |
| | | | Hoplonemertea sp C | 1 |
| | | | Hoplonemertea sp D | 1 |
| | | | Hoplonemertea sp SD3 | 1 |
| | | | Enopla sp B | 2 |
| **Mollusca** | | | | |
| Caudofoveata | Chaetodermatida | | | 38 |
| | | Chaetodermatidae | *Chaetoderma marinelli* | 5 |
| | | | *Chaetoderma pacificum* | 2 |
| | | | *Falcidens longus* | 14 |
| Polyplacophora | Lepidopleurida | Leptochitonidae | *Leptochiton rugatus* | 1 |
| Gastropoda | | | | 20 |
| | | Calliostomatidae | *Calliostoma turbinum* | 2 |
| | | Solariellidae | *Solariella peramabilis* | 62 |
| | | Skeneidae | *Skenea coronadoensis* | 1 |
| | Sorbeoconcha | Cerithiidae | *Lirobittium larum* | 254 |
| | | | *Lirobittium rugatum* Cmplx | 5 |
| | | | *Lirobittium* sp | 7 |
| | | Turritellidae | *Turritella cooperi* | 1 |
| | Hypsogastropoda | Ovulidae | *Simnia barbarensis* | 1 |
| | | Littorinidae | *Lacuna unifasciata* | 1 |
| | | Naticidae | *Neverita draconis* | 11 |
| | | | *Neverita recluziana* | 16 |
| | | | *Sinum scopulosum* | 6 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | Rissoidae | *Alvania rosana* | 146 |
| | | Barleeiidae | *Lirobarleeia kelseyi* | 1 |
| | | Caecidae | *Caecum crebricinctum* | 1138 |
| | | Velutinidae | *Lamellaria diegoensis* | 1 |
| | | Epitoniidae | *Epitonium sawinae* | 10 |
| | | Eulimidae | *Eulima raymondi* | 12 |
| | | | *Melanella rosa* | 7 |
| | | | *Polygireulima rutila* | 3 |
| | | | *Vitreolina columbiana* | 2 |
| | | Columbellidae | *Amphissa bicolor* | 1 |
| | | | *Amphissa undata* | 67 |
| | | | *Astyris* sp | 1 |
| | | Nassariidae | | 4 |
| | | | *Caesia perpinguis* | 1 |
| | | | *Tritia insculpta* | 4 |
| | | Borsoniidae | *Ophiodermella inermis* | 8 |
| | | | *Ophiodermella* sp | 1 |
| | | Mangeliidae | | 1 |
| | | | *Kurtzia arteaga* | 43 |
| | | | *Kurtzina beta* | 621 |
| | | Drillidae | *Elaeocyma empyrosia* | 6 |
| | | Pseudomelatomidae | *Antiplanes catalinae* | 6 |
| | | | *Megasurcula carpenteriana* | 25 |
| | | | *Megasurcula stearnsiana* | 1 |
| | | Cancellariidae | *Cancellaria cooperii* | 1 |
| | | | *Cancellaria crawfordiana* | 1 |
| | | | *Admete gracilior* | 2 |
| | -- | Acteonidae | | 1 |
| | | | *Acteon traskii* | 26 |
| | | | *Rictaxis punctocaelatus* | 149 |
| | | Aplustridae | *Parvaplustrum cadieni* | 17 |
| | -Lower Heterobranchia- | Pyramidellidae | *Odostomia* sp SD1 | 9 |
| | | | *Odostomia sp* | 261 |
| | | | *Turbonilla chocolata* | 50 |
| | | | *Turbonilla santarosana* | 217 |
| | | | *Turbonilla* sp A | 73 |
| | | | *Turbonilla* sp SD5 | 68 |
| | | | *Turbonilla* sp SD6 | 23 |
| | | | *Turbonilla* sp SD9 | 1 |
| | | | *Turbonilla* sp | 6 |
| | | Amathinidae | *Iselica obtusa* | 3 |
| | Nudibranchia | Goniodorididae | *Okenia* sp A | 5 |
| | | Onchidorididae | *Acanthodoris brunnea* | 2 |
| | | Arminidae | *Armina californica* | 3 |
| | | Cumanotidae | *Cumanotus fernaldi* | 1 |
| | | Dotoidae | *Doto* sp | 1 |
| | Pleurobranchomorpha | Pleurobranchidae | *Pleurobranchaea californica* | 4 |
| | Cephalaspidea | | | 3 |
| | | Retusidae | *Sulcoretusa xystrum* | 3 |
| | | Rhizoridae | *Volvulella californica* | 35 |
| | | | *Volvulella catharia* | 3 |
| | | | *Volvulella cylindrica* | 70 |
| | | | *Volvulella panamica* | 30 |
| | | | *Volvulella* sp | 1 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | Acteocinidae | *Acteocina cerealis* | 543 |
| | | | *Acteocina harpa* | 3 |
| | | | *Acteocina* sp | 7 |
| | | Philinidae | *Philine auriformis* | 60 |
| | | | *Philine ornatissima* | 7 |
| | | Aglajidae | *Aglaja ocelligera* | 14 |
| | | | *Melanochlamys diomedea* | 5 |
| | | Gastropteridae | *Gastropteron pacificum* | 36 |
| | | Laonidae | *Laona californica* | 7 |
| | | Cylichnidae | *Cylichna diegensis* | 266 |
| | | Diaphanidae | *Diaphana californica* | 5 |
| | | family uncertain | Bullomorpha sp A | 11 |
| Bivalvia | | | | 51 |
| | Nuculida | Nuculidae | *Acila castrensis* | 13 |
| | | | *Ennucula tenuis* | 1205 |
| | Solemyida | Solemyidae | *Solemya pervernicosa* | 169 |
| | | Nucinellidae | *Huxleyia munita* | 1490 |
| | Nuculanida | Nuculanidae | *Nuculana hamata* | 104 |
| | | | *Nuculana taphria* | 3 |
| | | | *Nuculana* sp A | 2328 |
| | Mytilida | Mytilidae | | 1 |
| | | | *Crenella decussata* | 1 |
| | | | *Solamen columbianum* | 27 |
| | | | *Modiolinae* | 3 |
| | | | *Amygdalum pallidulum* | 195 |
| | | | *Modiolatus neglectus* | 1 |
| | Limida | Limidae | *Limatula saturna* | 23 |
| | Ostreida | Pectinidae | | 2 |
| | | | *Leptopecten latiauratus* | 2 |
| | | Propeamussiidae | *Cyclopecten catalinensis* | 7 |
| | Carditida | Carditidae | *Cyclocardia ventricosa* | 35 |
| | Lucinida | Lucinidae | *Parvilucina tenuisculpta* | 1653 |
| | | | *Lucinoma annulatum* | 262 |
| | | Thyasiridae | | 1 |
| | | | *Adontorhina cyclia* | 1251 |
| | | | *Axinopsida serricata* | 5347 |
| | | | *Thyasira flexuosa* | 36 |
| | | | Thyasiridae sp LA1 | 1 |
| | Venerida | Lasaeidae | | 1 |
| | | | *Kurtiella grippi* | 4 |
| | | | *Kurtiella mortoni* | 3 |
| | | | *Kurtiella tumida* | 66 |
| | | | *Kurtiella* sp C | 1 |
| | | | *Kurtiella* sp D | 119 |
| | | | *Kurtiella* sp | 3 |
| | | | *Neaeromya rugifera* | 1 |
| | | Cardiidae | *Keenaea centifilosum* | 466 |
| | | Tellinidae | | 3 |
| | | | *Tellina carpenteri* | 2244 |
| | | | *Tellina modesta* | 8 |
| | | | *Tellina* sp B | 1320 |
| | | | *Tellina* sp | 23 |
| | | | *Macoma carlottensis* | 68 |
| | | | *Macoma yoldiformis* | 4 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | | *Macoma* sp | 51 |
| | | Hiatellidae | *Saxicavella nybakkeni* | 48 |
| | | | *Saxicavella pacifica* | 33 |
| | | Veneridae | *Compsomyax subdiaphana* | 11 |
| | | | *Nutricola cymata* | 3 |
| | | | *Nutricola ovalis* | 2 |
| | | Petricolidae | *Cooperella subdiaphana* | 14 |
| | | Corbulidae | *Caryocorbula luteola* | 2 |
| | | | *Caryocorbula porcella* | 4 |
| | Pholadomyida | Pandoridae | *Pandora bilirata* | 37 |
| | | Lyonsiidae | | 18 |
| | | Lyonsiidae | *Lyonsia californica* | 12 |
| | | -- | Thracioidea | 1 |
| | | Thraciidae | | 3 |
| | | | *Cyathodonta pedroana* | 4 |
| | | | *Thracia trapezoides* | 6 |
| | | | *Thracia* sp | 6 |
| | | Periplomatidae | *Periploma planiusculum* | 1 |
| | | Cuspidariidae | | 1 |
| | | | *Cardiomya pectinata* | 15 |
| | | | *Cardiomya planetica* | 2 |
| | | | *Cuspidaria parapodema* | 28 |
| | | Verticordiidae | *Trigonulina novemcostatus* | 3 |
| Scaphopoda | | | | 7 |
| | Dentaliida | Dentaliidae | *Dentalium neohexagonum* | 1 |
| | | | *Dentalium vallicolens* | 3 |
| | Gadilida | | | 1 |
| | | Gadilidae | *Polyschides quadrifissatus* | 718 |
| | | | *Gadila aberrans* | 22 |
| | | uncertain | *Compressidens stearnsii* | 149 |
| Cephalopoda | Myopsida | Loliginidae | *Doryteuthis opalescens* | 1 |
| **Sipuncula** | | | | 18 |
| Sipunculidea | Golfingiida | Golfingiidae | *Nephasoma diaphanes* | 9 |
| | | | *Thysanocardia nigra* | 26 |
| | | Phascolionidae | *Phascolion* sp A | 267 |
| | | Sipunculidae | *Siphonosoma ingens* | 1 |
| **Annelida** | | | | |
| Polychaeta | | | Echiura | 1 |
| | Echiuridea | Thalassematidae | | 1 |
| | | | *Listriolobus pelodes* | 111 |
| | Amphinomida | Amphinomidae | *Chloeia pinnata* | 3432 |
| | Eunicida | Dorvilleidae | | 1 |
| | | | *Dorvillea (Schistomeringos) annulata* | 3 |
| | | | *Dorvillea (Schistomeringos) longicornis* | 12 |
| | | | *Dorvillea (Schistomeringos)* sp | 7 |
| | | | *Parougia caeca* | 2 |
| | | | *Protodorvillea gracilis* | 2 |
| | | Eunicidae | | 11 |
| | | | *Leodice americana* | 31 |
| | | | *Marphysa* sp | 2 |
| | | Lumbrineridae | | 12 |
| | | | Lumbrineridae Group III | 81 |
| | | | Lumbrineridae Group IV | 7 |
| | | | *Eranno bicirrata* | 63 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | | *Eranno lagunae* | 109 |
| | | | *Eranno* sp | 2 |
| | | | *Lumbrineris cruzensis* | 1390 |
| | | | *Lumbrineris latreilli* | 144 |
| | | | *Lumbrineris ligulata* | 52 |
| | | | *Lumbrineris limicola* | 26 |
| | | | *Lumbrineris* sp Group I | 1731 |
| | | | *Lumbrineris* sp Group II | 71 |
| | | | *Lumbrineris* sp | 17 |
| | | | *Ninoe tridentata* | 8 |
| | | | *Scoletoma tetraura* Cmplx | 185 |
| | | | *Scoletoma* sp | 3 |
| | | Oenonidae | | 4 |
| | | | *Arabella* sp | 2 |
| | | | *Drilonereis falcata* | 30 |
| | | | *Drilonereis mexicana* | 5 |
| | | | *Drilonereis* sp A | 17 |
| | | | *Drilonereis* sp | 178 |
| | | | *Notocirrus californiensis* | 59 |
| | | Onuphidae | | 230 |
| | | | *Diopatra ornata* | 3 |
| | | | *Diopatra tridentata* | 5 |
| | | | *Diopatra* sp | 12 |
| | | | *Hyalinoecia juvenalis* | 3 |
| | | | *Mooreonuphis exigua* | 130 |
| | | | *Mooreonuphis nebulosa* | 59 |
| | | | *Mooreonuphis segmentispadix* | 30 |
| | | | *Mooreonuphis stigmatis* | 7 |
| | | | *Mooreonuphis* sp SD1 | 25 |
| | | | *Mooreonuphis* sp SD2 | 2 |
| | | | *Mooreonuphis* sp | 101 |
| | | | *Nothria occidentalis* | 30 |
| | | | *Nothria* sp | 6 |
| | | | *Onuphis affinis* | 1 |
| | | | *Onuphis eremita parva* | 4 |
| | | | *Onuphis geophiliformis* | 20 |
| | | | *Onuphis iridescens* | 22 |
| | | | *Onuphis multiannulata* | 1 |
| | | | *Onuphis* sp A | 136 |
| | | | *Onuphis* sp | 17 |
| | | | *Paradiopatra parva* | 3204 |
| | | | *Rhamphobrachium longisetosum* | 6 |
| | Phyllodocida | Acoetidae | *Acoetes pacifica* | 48 |
| | | Aphroditidae | *Aphrodita castanea* | 2 |
| | | | *Aphrodita japonica* | 1 |
| | | | *Aphrodita* sp | 20 |
| | | Polynoidae | | 6 |
| | | | *Lepidasthenia berkeleyae* | 1 |
| | | | *Lepidasthenia longicirrata* | 2 |
| | | | Polynoinae | 3 |
| | | | *Harmothoe fragilis* | 1 |
| | | | *Malmgreniella baschi* | 73 |
| | | | *Malmgreniella macginitiei* | 11 |
| | | | *Malmgreniella nigralba* | 1 |

| Taxonomic Classification | | | N |
|---|---|---|---|
| | | *Malmgreniella sanpedroensis* | 64 |
| | | *Malmgreniella scriptoria* | 12 |
| | | *Malmgreniella* sp A | 321 |
| | | *Malmgreniella* sp SD2 | 2 |
| | | *Malmgreniella* sp | 85 |
| | | *Subadyte mexicana* | 60 |
| | | *Tenonia priops* | 49 |
| | | *Ysideria hastata* | 1 |
| | Pholoidae | *Pholoe glabra* | 897 |
| | Sigalionidae | | 2 |
| | | *Pholoides asperus* | 64 |
| | | *Sigalion spinosus* | 470 |
| | | *Sthenelais fusca* | 11 |
| | | *Sthenelais tertiaglabra* | 334 |
| | | *Sthenelais* sp | 5 |
| | | *Sthenelanella uniformis* | 793 |
| | Glyceridae | | 2 |
| | | *Glycera americana* | 66 |
| | | *Glycera macrobranchia* | 3 |
| | | *Glycera nana* | 1375 |
| | | *Glycera oxycephala* | 6 |
| | | *Glycera tesselata* | 3 |
| | | *Glycera* sp | 9 |
| | Goniadidae | | 1 |
| | | *Glycinde armigera* | 370 |
| | | *Goniada brunnea* | 142 |
| | | *Goniada maculata* | 478 |
| | Hesionidae | | 1 |
| | | *Micropodarke dubia* | 2 |
| | | *Podarkeopsis glabrus* | 50 |
| | | *Podarkeopsis* sp A | 1 |
| | Nereididae | *Alitta succinea* | 1 |
| | | *Gymnonereis crosslandi* | 24 |
| | | *Nereis* sp A | 95 |
| | | *Platynereis bicanaliculata* | 1 |
| | Pilargidae | *Ancistrosyllis groenlandica* | 1 |
| | | *Sigambra setosa* | 1 |
| | | *Sigambra tentaculata* | 1 |
| | Syllidae | | 2 |
| | | *Syllides mikeli* | 1 |
| | | *Epigamia-Myrianida* Cmplx | 1 |
| | | *Proceraea* sp | 3 |
| | | Eusyllinae | 2 |
| | | *Eusyllis blomstrandi* Cmplx | 5 |
| | | *Eusyllis habei* | 3 |
| | | *Eusyllis* sp SD2 | 5 |
| | | *Odontosyllis phosphorea* | 3 |
| | | *Paraehlersia articulata* | 61 |
| | | *Exogone dwisula* | 1 |
| | | *Exogone lourei* | 139 |
| | | *Exogone* sp | 2 |
| | | *Parexogone breviseta* | 2 |
| | | *Parexogone molesta* | 6 |
| | | *Syllis heterochaeta* | 146 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | | *Syllis hyperioni* | 2 |
| | | Nephtyidae | | 3 |
| | | | *Aglaophamus verrilli* | 143 |
| | | | *Bipalponephtys cornuta* | 34 |
| | | | *Nephtys caecoides* | 252 |
| | | | *Nephtys ferruginea* | 849 |
| | | | *Nephtys* sp | 6 |
| | | Sphaerodoridae | *Ephesiella brevicapitis* | 1 |
| | | | *Sphaerodoridium* sp A | 7 |
| | | | *Sphaerodorum papillifer* | 1 |
| | | Phyllodocidae | | 4 |
| | | | *Eteone brigitteae* | 2 |
| | | | *Eteone leptotes* | 4 |
| | | | *Eteone pigmentata* | 51 |
| | | | *Eteone* sp | 8 |
| | | | *Eulalia californiensis* | 1 |
| | | | *Eulalia levicornuta* Cmplx | 31 |
| | | | *Eulalia quadrioculata* | 1 |
| | | | *Eulalia* sp SD4 | 2 |
| | | | *Eulalia* sp | 3 |
| | | | *Eumida longicornuta* | 29 |
| | | | *Mystides* sp | 1 |
| | | | *Sige* sp A | 87 |
| | | | *Sige* sp | 1 |
| | | | *Clavadoce* sp | 1 |
| | | | *Nereiphylla* sp 2 | 13 |
| | | | *Nereiphylla* sp SD1 | 1 |
| | | | *Paranaitis polynoides* | 20 |
| | | | *Paranaitis* sp SD1 | 5 |
| | | | *Phyllodoce cuspidata* | 21 |
| | | | *Phyllodoce groenlandica* | 54 |
| | | | *Phyllodoce hartmanae* | 167 |
| | | | *Phyllodoce longipes* | 107 |
| | | | *Phyllodoce medipapillata* | 2 |
| | | | *Phyllodoce pettiboneae* | 103 |
| | | | *Phyllodoce* sp | 13 |
| | Sabellida | Oweniidae | | 16 |
| | | | *Galathowenia pygidialis* | 46 |
| | | | *Myriochele gracilis* | 2194 |
| | | | *Myriochele olgae* | 42 |
| | | | *Myriochele striolata* | 6212 |
| | | | *Myriochele* sp | 4 |
| | | | *Myriowenia californiensis* | 5 |
| | | | *Owenia collaris* | 16 |
| | | Sabellariidae | *Neosabellaria cementarium* | 3 |
| | | Sabellidae | | 35 |
| | | | Sabellinae | 1 |
| | | | *Acromegalomma pigmentum* | 9 |
| | | | *Acromegalomma splendidum* | 17 |
| | | | *Acromegalomma* sp | 6 |
| | | | *Bispira* sp | 2 |
| | | | *Chone* sp | 7 |
| | | | *Dialychone albocincta* | 91 |
| | | | *Dialychone trilineata* | 752 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | | *Dialychone veleronis* | 15 |
| | | | *Euchone arenae* | 125 |
| | | | *Euchone hancocki* | 43 |
| | | | *Euchone incolor* | 428 |
| | | | *Euchone* sp A | 39 |
| | | | *Euchone* sp | 6 |
| | | | *Jasmineira* sp B | 68 |
| | | | *Myxicola* sp | 15 |
| | | | *Paradialychone bimaculata* | 2 |
| | | | *Paradialychone ecaudata* | 13 |
| | | | *Paradialychone harrisae* | 43 |
| | | | *Paradialychone paramollis* | 29 |
| | | | *Parasabella* sp | 1 |
| | | | *Potamethus* sp A | 66 |
| | | | *Pseudopotamilla* sp | 3 |
| | | Serpulidae | *Protula superba* | 1 |
| | Spionida | Apistobranchidae | *Apistobranchus ornatus* | 4 |
| | | Longosomatidae | *Heterospio catalinensis* | 36 |
| | | Magelonidae | | 11 |
| | | | *Magelona berkeleyi* | 68 |
| | | | *Magelona hartmanae* | 13 |
| | | | *Magelona hobsonae* | 1 |
| | | | *Magelona* sp A | 4 |
| | | | *Magelona* sp B | 16 |
| | | | *Magelona* sp | 9 |
| | | Poecilochaetidae | *Poecilochaetus johnsoni* | 17 |
| | | | *Poecilochaetus martini* | 1 |
| | | | *Poecilochaetus* sp | 3 |
| | | Spionidae | | 10 |
| | | | *Boccardiella* sp | 1 |
| | | | *Carazziella* sp A | 4 |
| | | | *Dipolydora giardi* | 1 |
| | | | *Dipolydora socialis* | 105 |
| | | | *Dipolydora* sp | 3 |
| | | | *Laonice cirrata* | 181 |
| | | | *Laonice nuchala* | 163 |
| | | | *Laonice* sp | 1 |
| | | | *Malacoceros indicus* | 3 |
| | | | *Microspio pigmentata* | 330 |
| | | | *Paraprionospio alata* | 1404 |
| | | | *Polydora* sp | 19 |
| | | | *Prionospio dubia* | 2976 |
| | | | *Prionospio ehlersi* | 1 |
| | | | *Prionospio jubata* | 5692 |
| | | | *Prionospio lighti* | 150 |
| | | | *Prionospio pygmaeus* | 6 |
| | | | *Prionospio* sp | 1 |
| | | | *Scolelepis (Parascolelepis) texana* | 7 |
| | | | *Scolelepis (Parascolelepis) tridentata* | 1 |
| | | | *Scolelepis (Scolelepis) occidentalis* | 12 |
| | | | *Scolelepis (Scolelepis) squamata* | 1 |
| | | | *Scolelepis* sp | 3 |
| | | | *Spio filicornis* | 181 |
| | | | *Spio maciolekae* | 2 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | | *Spio maculata* | 1 |
| | | | *Spiophanes berkeleyorum* | 2303 |
| | | | *Spiophanes duplex* | 10509 |
| | | | *Spiophanes kimballi* | 2202 |
| | | | *Spiophanes norrisi* | 61 |
| | | | *Spiophanes wigleyi* | 26 |
| | | | *Spiophanes* sp | 17 |
| | Terebellida | Cirratulidae | | 222 |
| | | | *Aphelochaeta glandaria* Cmplx | 2205 |
| | | | *Aphelochaeta monilaris* | 835 |
| | | | *Aphelochaeta petersenae* | 36 |
| | | | *Aphelochaeta phillipsi* | 37 |
| | | | *Aphelochaeta tigrina* | 103 |
| | | | *Aphelochaeta williamsae* | 39 |
| | | | *Aphelochaeta* sp HYP2 | 4 |
| | | | *Aphelochaeta* sp HYP4 | 1 |
| | | | *Aphelochaeta* sp LA1 | 744 |
| | | | *Aphelochaeta* sp SD5 | 23 |
| | | | *Aphelochaeta* sp | 484 |
| | | | *Chaetozone corona* | 9 |
| | | | *Chaetozone hartmanae* | 5461 |
| | | | *Chaetozone hedgpethi* | 77 |
| | | | *Chaetozone lunula* | 13 |
| | | | *Chaetozone setosa* Cmplx | 70 |
| | | | *Chaetozone spinosa* | 3 |
| | | | *Chaetozone* sp SD1 | 21 |
| | | | *Chaetozone* sp SD2 | 23 |
| | | | *Chaetozone* sp SD3 | 44 |
| | | | *Chaetozone* sp SD4 | 30 |
| | | | *Chaetozone* sp SD5 | 52 |
| | | | *Chaetozone* sp SD7 | 88 |
| | | | *Chaetozone* sp | 272 |
| | | | *Cirratulus* sp | 2 |
| | | | *Kirkegaardia cryptica* | 375 |
| | | | *Kirkegaardia serratiseta* | 8 |
| | | | *Kirkegaardia siblina* | 759 |
| | | | *Kirkegaardia tesselata* | 132 |
| | | | *Kirkegaardia* sp SD9 | 30 |
| | | | *Kirkegaardia* sp | 36 |
| | | | *Protocirrineris* sp A | 1 |
| | | | *Protocirrineris* sp B | 10 |
| | | | *Protocirrineris* sp | 1 |
| | | Fauveliopsidae | *Fauveliopsis* sp SD1 | 563 |
| | | | *Fauveliopsis* sp | 1 |
| | | Flabelligeridae | | 4 |
| | | | *Brada pilosa* | 15 |
| | | | *Brada pluribranchiata* | 34 |
| | | | *Flabelligera infundibularis* | 6 |
| | | | *Lamispina schmidtii* | 23 |
| | | | *Pherusa neopapillata* | 42 |
| | | | *Trophoniella harrisae* | 24 |
| | | Sternaspidae | *Sternaspis affinis* | 2937 |
| | | Ampharetidae | | 324 |
| | | | *Amage anops* | 29 |

| Taxonomic Classification | | | N |
|---|---|---|---|
| | | *Amage scutata* | 450 |
| | | *Ampharete acutifrons* | 13 |
| | | *Ampharete finmarchica* | 263 |
| | | *Ampharete labrops* | 48 |
| | | *Ampharete* sp | 84 |
| | | *Ampharetidae* sp SD1 | 71 |
| | | *Amphicteis glabra* | 3 |
| | | *Amphicteis mucronata* | 24 |
| | | *Amphicteis scaphobranchiata* | 400 |
| | | *Amphicteis* sp | 5 |
| | | *Amphisamytha bioculata* | 12 |
| | | *Anobothrus gracilis* | 796 |
| | | *Asabellides lineata* | 162 |
| | | *Eclysippe trilobata* | 3681 |
| | | *Lysippe* sp A | 1273 |
| | | *Lysippe* sp B | 1455 |
| | | *Lysippe* sp | 4 |
| | | *Sabellides manriquei* | 68 |
| | | *Samytha californiensis* | 25 |
| | | *Schistocomus* sp A | 1 |
| | | *Sosane occidentalis* | 104 |
| | | *Sosanopsis* sp A | 1 |
| | | *Melinna heterodonta* | 1 |
| | | *Melinna oculata* | 94 |
| | Pectinariidae | *Pectinaria californiensis* | 3715 |
| | Terebellidae | | 114 |
| | | *Amaeana occidentalis* | 151 |
| | | *Polycirrus californicus* | 1090 |
| | | *Polycirrus* sp I | 10 |
| | | *Polycirrus* sp A | 2954 |
| | | *Polycirrus* sp OC1 | 727 |
| | | *Polycirrus* sp SD3 | 2 |
| | | *Polycirrus* sp | 950 |
| | | Terebellinae | 22 |
| | | *Artacama coniferi* | 22 |
| | | *Eupolymnia heterobranchia* | 10 |
| | | *Lanassa venusta venusta* | 1829 |
| | | *Lanassa* sp | 5 |
| | | *Lanice conchilega* | 28 |
| | | *Phisidia sanctaemariae* | 7277 |
| | | *Pista brevibranchiata* | 65 |
| | | *Pista estevanica* | 512 |
| | | *Pista moorei* | 23 |
| | | *Pista wui* | 98 |
| | | *Pista* sp | 39 |
| | | *Proclea* sp A | 7262 |
| | | *Scionella japonica* | 3 |
| | | *Streblosoma crassibranchia* | 3 |
| | | *Streblosoma* sp B | 25 |
| | | *Streblosoma* sp C | 1 |
| | | *Streblosoma* sp SF1 | 1 |
| | | *Streblosoma* sp | 8 |
| | | *Thelepus hamatus* | 10 |
| | | *Thelepus* sp | 1 |

| Taxonomic Classification | | | N |
|---|---|---|---|
| | Trichobranchidae | | 3 |
| | | *Terebellides californica* | 1472 |
| | | *Terebellides reishi* | 91 |
| | | *Terebellides* sp Type C | 13 |
| | | *Terebellides* sp Type D | 30 |
| | | *Terebellides* sp | 76 |
| | | *Trichobranchus hancocki* | 53 |
| | Chaetopteridae | | 5 |
| | | *Chaetopterus variopedatus* Cmplx | 2 |
| | | *Mesochaetopterus* sp | 3 |
| | | *Phyllochaetopterus limicolus* | 17 |
| | | *Phyllochaetopterus prolifica* | 2 |
| | | *Phyllochaetopterus* sp | 5 |
| | | *Spiochaetopterus costarum* Cmplx | 535 |
| -- | Capitellidae | | 18 |
| | | *Capitella teleta* | 977 |
| | | *Decamastus gracilis* | 1084 |
| | | *Mediomastus acutus* | 3 |
| | | *Mediomastus* sp | 5658 |
| | | *Notomastus hemipodus* | 811 |
| | | *Notomastus latericeus* | 23 |
| | | *Notomastus lineatus* | 1 |
| | | *Notomastus magnus* | 2 |
| | | *Notomastus* sp | 85 |
| | Cossuridae | | 1 |
| | | *Cossura bansei* | 1 |
| | | *Cossura candida* | 196 |
| | | *Cossura* sp A | 28 |
| | | *Cossura* sp | 66 |
| | Maldanidae | | 1908 |
| | | Euclymeninae | 433 |
| | | *Axiothella* sp | 5 |
| | | *Clymenella complanata* | 2 |
| | | *Clymenella* sp | 1 |
| | | *Clymenura gracilis* | 2075 |
| | | Euclymeninae sp A | 1702 |
| | | *Isocirrus longiceps* | 3 |
| | | *Petaloclymene pacifica* | 232 |
| | | *Praxillella gracilis* | 48 |
| | | *Praxillella pacifica* | 3258 |
| | | *Notoproctus pacificus* | 24 |
| | | Maldaninae | 14 |
| | | *Maldane sarsi* | 681 |
| | | *Maldane* sp | 1 |
| | | *Metasychis disparidentatus* | 42 |
| | | *Nicomache lumbricalis* | 1 |
| | | *Petaloproctus neoborealis* | 12 |
| | | *Praxillura maculata* | 2 |
| | | *Rhodine bitorquata* | 849 |
| | Opheliidae | *Armandia brevis* | 16 |
| | | *Ophelina acuminata* | 29 |
| | | *Ophelina* sp SD1 | 15 |
| | | *Ophelina* sp | 1 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | Orbiniidae | | 4 |
| | | | *Leitoscoloplos pugettensis* | 21 |
| | | | *Naineris uncinata* | 3 |
| | | | *Naineris* sp | 2 |
| | | | *Scoloplos acmeceps* | 3 |
| | | | *Scoloplos armiger* Cmplx | 2239 |
| | | | *Scoloplos* sp | 7 |
| | | Paraonidae | | 76 |
| | | | *Aricidea (Acmira) catherinae* | 2381 |
| | | | *Aricidea (Acmira) horikoshii* | 6 |
| | | | *Aricidea (Acmira) lopezi* | 577 |
| | | | *Aricidea (Acmira) rubra* | 23 |
| | | | *Aricidea (Acmira) simplex* | 1111 |
| | | | *Aricidea (Acmira)* sp | 14 |
| | | | *Aricidea (Aedicira) pacifica* | 1 |
| | | | *Aricidea (Aricidea) pseudoarticulata* | 5 |
| | | | *Aricidea (Aricidea) wassi* | 85 |
| | | | *Aricidea (Aricidea)* sp SD3 | 1 |
| | | | *Aricidea (Aricidea)* sp | 3 |
| | | | *Aricidea (Strelzovia) antennata* | 326 |
| | | | *Aricidea (Strelzovia) hartleyi* | 45 |
| | | | *Aricidea (Strelzovia)* sp A | 689 |
| | | | *Aricidea (Strelzovia)* sp SD1 | 1 |
| | | | *Aricidea (Strelzovia)* sp | 4 |
| | | | *Cirrophorus furcatus* | 3 |
| | | | *Levinsenia gracilis* | 329 |
| | | | *Levinsenia kirbyae* | 150 |
| | | | *Levinsenia* sp | 2 |
| | | | *Paradoneis spinifera* | 1 |
| | | | *Paradoneis* sp SD1 | 2 |
| | | | *Paradoneis* sp | 9 |
| | | Scalibregmatidae | *Asclerocheilus kudenovi* | 1 |
| | | | *Scalibregma californicum* | 254 |
| | | Travisiidae | *Travisia brevis* | 1095 |
| | | | *Travisia pupa* | 1 |
| | | | *Travisia* sp | 1 |
| **Arthropoda** | | | | |
| Pycnogonida | Pantopoda | Phoxichilidiidae | *Anoplodactylus erectus* | 3 |
| Ostracoda | | | | 6 |
| | Myodocopida | Cypridinidae | *Vargula tsujii* | 26 |
| | | Cylindroleberididae | | 4 |
| | | | *Bathyleberis cf garthi* | 11 |
| | | | *Diasterope pilosa* | 1 |
| | | | *Postasterope barnesi* | 8 |
| | | | *Xenoleberis californica* | 233 |
| | | Philomedidae | *Anarthron* sp SD1 | 2 |
| | | | *Euphilomedes carcharodonta* | 5573 |
| | | | *Euphilomedes producta* | 6836 |
| | | | *Harbansus* sp SD1 | 1 |
| | | | *Scleroconcha trituberculata* | 16 |
| | | Sarsiellidae | *Eusarsiella* sp A | 6 |
| | | Rutidermatidae | *Rutiderma lomae* | 51 |
| | | | *Rutiderma rostratum* | 4 |
| | Podocopida | | | 1 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| Malacostraca | Leptostraca | Nebaliidae | *Nebalia daytoni* | 1 |
| | | | *Nebalia pugettensis* Cmplx | 35 |
| | | | *Nebalia* sp | 1 |
| | Stomatopoda | Hemisquillidae | *Hemisquilla californiensis* | 2 |
| | | Squillidae | *Schmittius politus* | 8 |
| | Mysida | Mysidae | | 3 |
| | | | *Pseudomma californica* | 3 |
| | | | *Mysidella americana* | 7 |
| | | | *Inusitatomysis insolita* | 9 |
| | | | *Pacifacanthomysis nephrophthalma* | 4 |
| | Amphipoda | | *Corophiida* | 7 |
| | | Caprellidae | | 26 |
| | | | Caprellinae | 1 |
| | | | *Caprella mendax* | 183 |
| | | | *Caprella penantis* | 2 |
| | | | *Caprella* sp | 4 |
| | | | *Mayerella banksia* | 40 |
| | | | *Tritella pilimana* | 2 |
| | | | *Hemiproto* sp A | 4 |
| | | Podoceridae | *Podocerus cristatus* | 8 |
| | | Ischyroceridae | *Ericthonius brasiliensis* | 8 |
| | | Kamakidae | *Amphideutopus oculatus* | 6 |
| | | Photidae | *Gammaropsis martesia* | 1 |
| | | | *Gammaropsis thompsoni* | 11 |
| | | | *Photis bifurcata* | 33 |
| | | | *Photis brevipes* | 9 |
| | | | *Photis californica* | 298 |
| | | | *Photis chiconola* | 3 |
| | | | *Photis lacia* | 271 |
| | | | *Photis macrotica* | 9 |
| | | | *Photis parvidons* | 65 |
| | | | *Photis* sp B | 1 |
| | | | *Photis* sp C | 9 |
| | | | *Photis* sp SD12 | 2 |
| | | | *Photis* sp | 264 |
| | | | *Podoceropsis ociosa* | 54 |
| | | Aoridae | *Aoroides inermis* | 21 |
| | | | *Aoroides intermedia* | 1 |
| | | | *Aoroides* sp A | 69 |
| | | | *Aoroides* sp | 15 |
| | | | *Bemlos audbettius* | 3 |
| | | Corophiidae | *Protomedeia articulata* Cmplx | 574 |
| | | Maeridae | *Elasmopus* sp | 1 |
| | | | *Maera similis* | 1 |
| | | Melitidae | | 1 |
| | | | *Desdimelita desdichada* | 13 |
| | | Megaluropidae | *Gibberosus myersi* | 1 |
| | | Oedicerotidae | | 26 |
| | | | *Americhelidium rectipalmum* | 1 |
| | | | *Americhelidium shoemakeri* | 136 |
| | | | *Americhelidium* sp SD1 | 6 |
| | | | *Americhelidium* sp SD4 | 20 |
| | | | *Americhelidium* sp | 2 |
| | | | *Bathymedon pumilus* | 388 |

| Taxonomic Classification | | | N |
|---|---|---|---|
| | | *Deflexilodes norvegicus* | 403 |
| | | *Hartmanodes hartmanae* | 3 |
| | | *Hartmanodes* sp SD1 | 1 |
| | | *Hartmanodes* sp | 1 |
| | | *Monoculodes emarginatus* | 787 |
| | | *Monoculodes* sp | 4 |
| | | *Westwoodilla tone* | 333 |
| | Eusiridae | *Rhachotropis* sp A | 51 |
| | Liljeborgiidae | *Listriella eriopisa* | 4 |
| | | *Listriella goleta* | 72 |
| | | *Listriella melanica* | 13 |
| | | *Listriella* sp A | 1 |
| | | *Listriella* sp SD1 | 3 |
| | Amphilochidae | *Gitana calitemplado* | 1 |
| | Pleustidae | *Gracilipleustes monocuspis* | 1 |
| | | *Dactylopleustes* sp A | 2 |
| | | *Pleusymtes subglaber* | 4 |
| | Stenothoidae | *Metopa dawsoni* | 4 |
| | | *Stenothoe frecanda* | 3 |
| | | *Stenothoides bicoma* | 1 |
| | Leucothoidae | *Leucothoe spinicarpa* | 1 |
| | Dexaminidae | *Guernea reduncans* | 3 |
| | Melphidippidae | *Melphisana bola* Cmplx | 10 |
| | Pardaliscidae | *Halicoides synopiae* | 239 |
| | | *Nicippe tumida* | 279 |
| | | *Pardaliscella symmetrica* | 2 |
| | Ampeliscidae | | 1 |
| | | *Ampelisca agassizi* | 54 |
| | | *Ampelisca brevisimulata* | 812 |
| | | *Ampelisca* cf *brevisimulata* | 306 |
| | | *Ampelisca careyi* | 1804 |
| | | *Ampelisca cristata cristata* | 81 |
| | | *Ampelisca cristata microdentata* | 25 |
| | | *Ampelisca hancocki* | 775 |
| | | *Ampelisca indentata* | 77 |
| | | *Ampelisca lobata* | 1 |
| | | *Ampelisca milleri* | 6 |
| | | *Ampelisca pacifica* | 1956 |
| | | *Ampelisca pugetica* | 941 |
| | | *Ampelisca romigi* | 50 |
| | | *Ampelisca* sp | 137 |
| | | *Byblis millsi* | 167 |
| | | *Byblis veleronis* | 9 |
| | | *Byblis* sp | 38 |
| | Synopiidae | *Garosyrrhoe bigarra* | 4 |
| | | *Metatiron tropakis* | 2 |
| | | *Tiron biocellata* | 2 |
| | Argissidae | *Argissa hamatipes* | 32 |
| | Urothoidae | *Urothoe elegans* Cmplx | 447 |
| | Phoxocephalidae | | 23 |
| | | *Foxiphalus golfensis* | 2 |
| | | *Foxiphalus obtusidens* | 60 |
| | | *Foxiphalus similis* | 331 |
| | | *Foxiphalus* sp | 3 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | | *Rhepoxynius bicuspidatus* | 3125 |
| | | | *Rhepoxynius lucubrans* | 3 |
| | | | *Rhepoxynius menziesi* | 650 |
| | | | *Rhepoxynius stenodes* | 5 |
| | | | *Rhepoxynius variatus* | 1 |
| | | | *Rhepoxynius* sp | 11 |
| | | | *Eyakia robusta* | 743 |
| | | | *Cephalophoxoides homilis* | 51 |
| | | | *Metaphoxus frequens* | 76 |
| | | | *Heterophoxus affinis* | 1 |
| | | | *Heterophoxus ellisi* | 98 |
| | | | *Heterophoxus oculatus* | 1082 |
| | | | *Heterophoxus* sp | 61 |
| | | -- | Lysianassoidea | 4 |
| | | Lysianassidae | *Aruga holmesi* | 20 |
| | | | *Aruga oculata* | 94 |
| | | Opisidae | *Opisa tridentata* | 23 |
| | | Uristidae | *Anonyx lilljeborgi* | 119 |
| | | Tryphosidae | *Hippomedon columbianus* | 3 |
| | | | *Hippomedon* sp A | 141 |
| | | | *Hippomedon* sp | 36 |
| | | | *Lepidepecreum serraculum* | 3 |
| | | | *Orchomenella decipiens* | 8 |
| | | | *Orchomenella pacifica* | 3 |
| | | | *Orchomenella pinguis* | 1 |
| | | Acidostomatidae | *Acidostoma hancocki* | 5 |
| | | Aristiidae | *Aristias* sp | 1 |
| | | Pakynidae | *Pachynus barnardi* | 14 |
| | | | *Prachynella lodo* | 20 |
| | | | *Prachynella oculata* | 1 |
| | Isopoda | Aegidae | *Rocinela belliceps* | 3 |
| | | Cirolanidae | *Eurydice caudata* | 38 |
| | | Gnathiidae | | 175 |
| | | | *Caecognathia crenulatifrons* | 1154 |
| | | | *Caecognathia* sp SD1 | 5 |
| | | Anthuridae | *Haliophasma geminata* | 421 |
| | | Arcturidae | *Neastacilla californica* | 14 |
| | | Idoteidae | | 1 |
| | | | *Synidotea magnifica* | 2 |
| | | Sphaeromatidae | | 1 |
| | | | *Paracerceis sculpta* | 1 |
| | | Serolidae | *Heteroserolis carinata* | 13 |
| | | Joeropsididae | *Joeropsis concava* | 4 |
| | | | *Joeropsis dubia* | 1 |
| | | Paramunnidae | *Pleurogonium californiense* | 6 |
| | Tanaidacea | | | 89 |
| | | Akanthophoreidae | *Akanthophoreus phillipsi* | 18 |
| | | | *Chauliopleona dentata* | 317 |
| | | | *Parakanthophoreus bisetulosus* | 2 |
| | | Anarthruridae | | 2 |
| | | | Anarthruridae sp 1 | 1 |
| | | | Anarthruridae sp 3 | 1 |
| | | | *Siphonolabrum californiensis* | 118 |
| | | Leptocheliidae | *Chondrochelia dubia* Cmplx | 1267 |

| Taxonomic Classification | | | | N |
| --- | --- | --- | --- | --- |
| | | Tanaellidae | *Araphura breviaria* | 329 |
| | | | *Araphura cuspirostris* | 32 |
| | | | *Araphura* sp SD1 | 87 |
| | | | *Araphura* sp | 89 |
| | | | *Tanaella propinquus* | 648 |
| | | Typhlotanaidae | *Typhlotanais crassus* | 5 |
| | | | *Typhlotanais williamsae* | 147 |
| | | | *Typhlotanais* sp | 22 |
| | | Tanaopsidae | *Tanaopsis cadieni* | 626 |
| | Cumacea | | | 6 |
| | | Bodotriidae | *Cyclaspis* sp | 1 |
| | | | *Glyphocuma* sp A | 3 |
| | | Leuconidae | *Eudorella pacifica* | 271 |
| | | | *Eudorellopsis longirostris* | 9 |
| | | | *Leucon falcicosta* | 2 |
| | | | *Leucon subnasica* | 4 |
| | | Nannastacidae | | 1 |
| | | | *Campylaspis biplicata* | 1 |
| | | | *Campylaspis blakei* | 1 |
| | | | *Campylaspis canaliculata* | 58 |
| | | | *Campylaspis hartae* | 1 |
| | | | *Campylaspis rubromaculata* | 15 |
| | | | *Cumella californica* | 1 |
| | | | *Procampylaspis caenosa* | 227 |
| | | Lampropidae | | 1 |
| | | | *Hemilamprops californicus* | 10 |
| | | | *Mesolamprops bispinosus* | 65 |
| | | Diastylidae | *Diastylis californica* | 5 |
| | | | *Diastylis crenellata* | 748 |
| | | | *Diastylis sentosa* | 1 |
| | | | *Diastylis* sp | 1 |
| | | | *Leptostylis abditis* | 27 |
| | | | *Leptostylis calva* | 43 |
| | | | *Leptostylis* sp | 1 |
| | Decapoda | Solenoceridae | *Solenocera mutator* | 4 |
| | | -- | Caridea | 3 |
| | | Alpheidae | | 1 |
| | | Crangonidae | *Metacrangon spinosissima* | 1 |
| | | | *Neocrangon zacae* | 7 |
| | | Callianassidae | *Neotrypaea* sp | 1 |
| | | Upogebiidae | *Upogebia lepta* | 1 |
| | | -- | Anomura | 1 |
| | | | Paguroidea | 4 |
| | | Diogenidae | | 1 |
| | | | *Paguristes turgidus* | 11 |
| | | Paguridae | | 2 |
| | | | *Enallopaguropsis guatemoci* | 1 |
| | | | *Pagurus hartae* | 1 |
| | | | *Parapagurodes laurentae* | 6 |
| | | | *Pylopagurus holmesi* | 2 |
| | | Munididae | *Pleuroncodes planipes* | 4 |
| | | -- | Brachyura | 4 |
| | | Cyclodorippidae | *Deilocerus decorus* | 9 |
| | | | *Deilocerus planus* | 3 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| | | Calappidae | *Platymera gaudichaudii* | 2 |
| | | Leucosiidae | *Randallia ornata* | 2 |
| | | Pinnotheridae | | 4 |
| | | | *Pinnixa franciscana* | 1 |
| | | | *Pinnixa longipes* | 1 |
| | | | *Pinnixa occidentalis* Cmplx | 63 |
| | | | *Pinnixa tubicola* | 2 |
| | | | *Pinnixa* sp | 20 |
| Hexanauplia | Harpacticoida | | | 1 |
| | -- | | Cirripedia | 1 |
| | Scalpelliformes | Scalpellidae | *Hamatoscalpellum californicum* | 9 |
| **Nematoda** | | | | 120 |
| **Echinodermata** | | | | |
| Asteroidea | | | | 124 |
| | Paxillosida | Luidiidae | *Luidia foliolata* | 1 |
| | Paxillosida | Astropectinidae | *Astropecten californicus* | 18 |
| | Paxillosida | Astropectinidae | *Astropecten* sp | 9 |
| Ophiuroidea | | | | 120 |
| | Ophiurida | Ophiuridae | *Ophiura luetkenii* | 110 |
| | Ophioscolecida | Ophioscolecidae | *Ophiuroconis bispinosa* | 54 |
| | Amphilepidida | Amphiuridae | | 4073 |
| | | | *Amphichondrius granulatus* | 462 |
| | | | *Amphiodia digitata* | 1370 |
| | | | *Amphiodia urtica* | 17409 |
| | | | *Amphiodia* sp | 4847 |
| | | | *Amphioplus strongyloplax* | 6 |
| | | | *Amphioplus* sp A | 24 |
| | | | *Amphioplus* sp | 9 |
| | | | *Amphipholis pugetana* | 1 |
| | | | *Amphipholis squamata* | 64 |
| | | | *Amphiura arcystata* | 230 |
| | | | *Dougaloplus amphacanthus* | 96 |
| | | | *Dougaloplus* sp A | 20 |
| | | | *Dougaloplus* sp | 5 |
| Echinoidea | | | | 63 |
| | Camarodonta | Toxopneustidae | *Lytechinus pictus* | 210 |
| | | Strongylocentrotidae | *Strongylocentrotus fragilis* | 2 |
| | Spatangoida | | | 8 |
| | | Schizasteridae | *Brisaster latifrons* | 1 |
| | | Brissidae | *Brissopsis pacifica* | 13 |
| | | Spatangidae | *Spatangus californicus* | 5 |
| | | Loveniidae | *Lovenia cordiformis* | 3 |
| Holothuroidea | | | | 1 |
| | Dendrochirotida | Phyllophoridae | | 1 |
| | | | *Pentamera populifera* | 29 |
| | | | *Pentamera pseudopopulifera* | 3 |
| | | | *Pentamera* sp | 13 |
| | | | *Thyone benti* | 1 |
| | Apodida | Synaptidae | *Leptosynapta* sp | 487 |
| | | Chiridotidae | *Chiridota* sp | 212 |
| | Molpadida | Molpadiidae | *Molpadia arenicola* | 1 |
| | | | *Molpadia intermedia* | 12 |

| Taxonomic Classification | | | | N |
|---|---|---|---|---|
| **Phoronida** | | | | 9 |
| | | Phoronidae | *Phoronis* sp SD1 | 21 |
| | | | *Phoronis* sp | 148 |
| **Brachiopoda** | | | | |
| Lingulata | Lingulida | Lingulidae | *Glottidia albida* | 2 |
| **Chordata** | | | | |
| Enteropneusta | | | | 90 |
| | | Ptychoderidae | *Balanoglossus* sp | 51 |
| | | Spengeliidae | *Schizocardium* sp | 8 |
| | | Harrimaniidae | *Saccoglossus* sp | 3 |
| | | | *Stereobalanus* sp | 80 |
| Ascidiacea | | | | 26 |
| | Phlebobranchiata | Agneziidae | *Agnezia septentrionalis* | 3 |
| | Stolidobranchiata | | | 1 |
| | | Styelidae | *Styela coriacea* | 2 |
| | | | *Styela* sp | 2 |
| | | Molgulidae | | 2 |
| | | | *Eugyra* sp | 4 |
| | | | *Molgula napiformis* | 30 |
| | | | *Molgula pugetiensis* | 20 |
| | | | *Molgula regularis* | 3 |
| | | | *Molgula* sp | 10 |

**ATTACHMENT C1-B**

Summary of demersal fish species captured at six trawl stations (SD7, SD8, SD10, SD12, SD13, and SD14) around the PLOO from the January and July surveys, 1991 through 2020. Data are number of individuals (N), minimum (Min), maximum (Max), and mean standard length (cm). Taxonomic arrangement and scientific names are of Eschmeyer and Herald (1998) and Lawrence et al. (2013).

| | | | | | Length (cm) | | |
|---|---|---|---|---|---|---|---|
| **Taxon/Species** | | | | **N** | **Min** | **Max** | **Mean** |
| **MYXINIFORMES** | | | | | | | |
| | Myxinidae | *Eptatretus stoutii* | Pacific Hagfish | 2 | 23 | 52 | 38 |
| **CHIMAERIFORMES** | | | | | | | |
| | Chimaeridae | *Hydrolagus colliei* | Spotted Ratfish | 16 | 24 | 44 | 35 |
| **HETERODONTIFORMES** | | | | | | | |
| | Heterodontidae | *Heterodontus francisci* | Horn Shark | 7 | 5 | 5 | 5 |
| **CARCHARHINIFORMES** | | | | | | | |
| | Scyliorhinidae | *Cephaloscyllium ventriosum* | Swell Shark | 1 | 27 | 27 | 27 |
| **TORPEDINIFORMES** | | | | | | | |
| | Torpedinidae | *Torpedo californica* | Pacific Electric Ray | 1 | 22 | 22 | 22 |
| **RAJIFORMES** | | | | | | | |
| | Rajidae | *Bathyraja interrupta* | Sandpaper Skate | 1 | 20 | 20 | 20 |
| | | *Raja binoculata* | Big Skate | 2 | 19 | 45 | 32 |
| | | *Raja inornata* | California Skate | 134 | 10 | 60 | 32 |
| | | *Raja rhina* | Longnose Skate | 1 | 19 | 19 | 19 |
| | | *Raja stellulata* | Starry Skate | 6 | 15 | 38 | 23 |
| | Platyrhynidae | *Platyrhinoidis triseriata* | Thornback | 1 | 17 | 17 | 17 |
| **CLUPEIFORMES** | | | | | | | |
| | Engraulidae | *Engraulis mordax* | Northern Anchovy | 1 | 13 | 13 | 13 |
| **ARGENTINIFORMES** | | | | | | | |
| | Argentinidae | *Argentina sialis* | Pacific Argentine | 520 | 3 | 13 | 7 |
| **AULOPIFORMES** | | | | | | | |
| | Synodontidae | *Synodus lucioceps* | California Lizardfish | 4,630 | 7 | 40 | 13 |
| **LAMPRIFORMES** | | | | | | | |
| | Trachipteridae | *Trachipterus altivelis* | King-of-the-salmon | 1 | 11 | 11 | 11 |
| **GADIFORMES** | | | | | | | |
| | Merlucciidae | *Merluccius productus* | Pacific Hake | 5 | 20 | 38 | 27 |
| **OPHIDIIFORMES** | | | | | | | |
| | Ophidiidae | *Chilara taylori* | Spotted Cusk-eel | 120 | 10 | 24 | 16 |
| | | *Ophidion scrippsae* | Basketweave Cusk-eel | 7 | 15 | 18 | 17 |
| | Bythitidae | *Brosmophycis marginata* | Red Brotula | 2 | 14 | 37 | 26 |
| **BATRACHOIDIFORMES** | | | | | | | |
| | Batrachoididae | *Porichthys myriaster* | Specklefin Midshipman | 19 | 4 | 29 | 11 |
| | | *Porichthys notatus* | Plainfin Midshipman | 3,104 | 3 | 21 | 10 |
| **LOPHIIFORMES** | | | | | | | |
| | Ogcocephalidae | *Zalieutes elater* | Roundel Batfish | 1 | 15 | 15 | 15 |
| **GASTEROSTEIFORMES** | | | | | | | |
| | Syngnathidae | *Syngnathus californiensis* | Kelp Pipefish | 3 | 13 | 17 | 14 |
| | Macroramphosidae | *Macroramphosus gracilis* | Slender Snipefish | 1 | 10 | 10 | 10 |
| **SCORPAENIFORMES** | | | | | | | |
| | Scorpaenidae | *Scorpaena guttata* | California Scorpionfish | 512 | 10 | 47 | 19 |
| | Sebastidae | *Sebastes caurinus* | Copper Rockfish | 1 | 28 | 28 | 28 |
| | | *Sebastes chlorostictus* | Greenspotted Rockfish | 109 | 4 | 26 | 11 |
| | | *Sebastes constellatus* | Starry Rockfish | 1 | 10 | 10 | 10 |
| | | *Sebastes dallii* | Calico Rockfish | 6 | 3 | 14 | 10 |
| | | *Sebastes elongatus* | Greenstriped Rockfish | 297 | 3 | 31 | 8 |
| | | *Sebastes eos* | Pink Rockfish | 26 | 5 | 15 | 9 |
| | | *Sebastes goodei* | Chilipepper | 20 | 10 | 16 | 14 |
| | | *Sebastes helvomaculatus* | Rosethorn Rockfish | 7 | 7 | 21 | 11 |
| | | *Sebastes hopkinsi* | Squarespot Rockfish | 242 | 7 | 23 | 14 |
| | | *Sebastes jordani* | Shortbelly Rockfish | 46 | 9 | 16 | 10 |
| | | *Sebastes levis* | Cowcod | 13 | 6 | 19 | 8 |
| | | *Sebastes miniatus* | Vermilion Rockfish | 64 | 9 | 36 | 20 |
| | | *Sebastes rosaceus* | Rosy Rockfish | 1 | 8 | 8 | 8 |
| | | *Sebastes rosenblatti* | Greenblotched Rockfish | 155 | 3 | 29 | 10 |
| | | *Sebastes rubrivinctus* | Flag Rockfish | 49 | 3 | 24 | 8 |
| | | *Sebastes saxicola* | Stripetail Rockfish | 3,469 | 4 | 16 | 8 |
| | | *Sebastes semicinctus* | Halfbanded Rockfish | 11,670 | 4 | 18 | 10 |
| | | *Sebastes umbrosus* | Honeycomb Rockfish | 1 | 14 | 14 | 14 |
| | | *Sebastes zacentrus* | Sharpchin Rockfish | 2 | 11 | 12 | 12 |

| Taxon/Species | | | N | Length (cm) Min | Max | Mean |
|---|---|---|---|---|---|---|
| | *Sebastes* sp | Rockfish Unidentified | 106 | 2 | 13 | 5 |
| Triglidae | *Prionotus stephanophrys* | Lumptail Searobin | 4 | 7 | 15 | 10 |
| Hexagrammidae | *Ophiodon elongatus* | Lingcod | 16 | 11 | 47 | 18 |
| | *Zaniolepis frenata* | Shortspine Combfish | 1,712 | 6 | 19 | 13 |
| | *Zaniolepis latipinnis* | Longspine Combfish | 7,353 | 5 | 17 | 11 |
| Cottidae | *Chitonotus pugetensis* | Roughback Sculpin | 311 | 1 | 17 | 8 |
| | *Icelinus filamentosus* | Threadfin Sculpin | 1 | 8 | 8 | 8 |
| | *Icelinus fimbriatus* | Fringed Sculpin | 7 | 14 | 18 | 15 |
| | *Icelinus quadriseriatus* | Yellowchin Sculpin | 9,452 | 3 | 11 | 6 |
| | *Icelinus tenuis* | Spotfin Sculpin | 303 | 3 | 15 | 8 |
| | *Radulinus asprellus* | Slim Sculpin | 1 | 8 | 8 | 8 |
| Agonidae | *Odontopyxis trispinosa* | Pygmy Poacher | 57 | 6 | 15 | 10 |
| | *Xeneretmus latifrons* | Blacktip Poacher | 61 | 3 | 17 | 13 |
| | *Xeneretmus triacanthus* | Bluespotted Poacher | 28 | 8 | 16 | 12 |
| **PERCIFORMES** | | | | | | |
| Carangidae | *Trachurus symmetricus* | Jack Mackerel | 2 | 4 | 17 | 10 |
| Sciaenidae | *Genyonemus lineatus* | White Croaker | 35 | 15 | 27 | 20 |
| Embiotocidae | *Cymatogaster aggregata* | Shiner Perch | 2 | 11 | 12 | 12 |
| | *Zalembius rosaceus* | Pink Seaperch | 1,583 | 4 | 16 | 8 |
| Bathymasteridae | *Rathbunella alleni* | Stripefin Ronquil | 4 | 10 | 15 | 12 |
| | *Rathbunella hypoplecta* | Bluebanded Ronquil | 25 | 8 | 20 | 13 |
| Zoarcidae | *Lycodes cortezianus* | Bigfin Eelpout | 25 | 14 | 25 | 20 |
| | *Lycodes pacificus* | Blackbelly Eelpout | 191 | 12 | 26 | 19 |
| Stichaeidae | *Plectobranchus evides* | Bluebarred Prickleback | 1 | 10 | 10 | 10 |
| Anarhichadidae | *Anarrhichthys ocellatus* | Wolf-eel | 1 | 105 | 105 | 105 |
| Uranoscopidae | *Kathetostoma averruncus* | Smooth Stargazer | 6 | 8 | 19 | 11 |
| Callionymidae | *Synchiropus atrilabiatus* | Blacklip Dragonet | 1 | 9 | 9 | 9 |
| Gobiidae | *Lepidogobius lepidus* | Bay Goby | 240 | 4 | 8 | 6 |
| | *Rhinogobiops nicholsii* | Blackeye Goby | 11 | 4 | 8 | 6 |
| | Gobiidae | Gobiidae Unidentified | 1 | 3 | 3 | 3 |
| Scombridae | *Scomber japonicus* | Pacific Chub Mackerel | 1 | 20 | 20 | 20 |
| Centrolophidae | *Icichthys lockingtoni* | Medusafish | 3 | 6 | 7 | 7 |
| Stromateidae | *Peprilus simillimus* | Pacific Pompano | 1 | 8 | 8 | 8 |
| **PLEURONECTIFORMES** | | | | | | |
| Paralichthyidae | *Citharichthys fragilis* | Gulf Sanddab | 72 | 6 | 15 | 11 |
| | *Citharichthys sordidus* | Pacific Sanddab | 52,111 | 3 | 27 | 9 |
| | *Citharichthys stigmaeus* | Speckled Sanddab | 7 | 4 | 11 | 6 |
| | *Citharichthys xanthostigma* | Longfin Sanddab | 1,886 | 3 | 24 | 12 |
| | Paralichthyidae | Citharichthys sp | 3 | 3 | 4 | 3 |
| | *Hippoglossina stomata* | Bigmouth Sole | 343 | 5 | 31 | 17 |
| | *Paralichthys californicus* | California Halibut | 1 | 52 | 52 | 52 |
| | *Xystreurys liolepis* | Fantail Sole | 3 | 18 | 35 | 27 |
| Pleuronectidae | *Glyptocephalus zachirus* | Rex Sole | 3 | 11 | 15 | 13 |
| | *Lyopsetta exilis* | Slender Sole | 552 | 4 | 18 | 13 |
| | *Microstomus pacificus* | Dover Sole | 5,653 | 4 | 25 | 11 |
| | *Parophrys vetulus* | English Sole | 1,390 | 7 | 31 | 17 |
| | *Pleuronichthys decurrens* | Curlfin Sole | 12 | 11 | 20 | 15 |
| | *Pleuronichthys verticalis* | Hornyhead Turbot | 348 | 7 | 29 | 15 |
| **PLEURONECTIDAE** | | | | | | |
| | Pleuronectidae | Flatfish Unidentified | 47 | 3 | 8 | 4 |
| **PLEURONECTIFORMES** | | | | | | |
| Cynoglossidae | *Symphurus atricaudus* | California Tonguefish | 976 | 5 | 20 | 13 |
| | *Pleuronichthys verticalis* | Hornyhead Turbot | 349 | 7 | 29 | 15 |
| | | Flatfish Unidentified | 47 | 3 | 8 | 4 |
| Cynoglossidae | *Symphurus atricaudus* | California Tonguefish | 976 | 5 | 20 | 13 |

**ATTACHMENT C1-C**
Summary of megabenthic invertebrate species captured at six trawl stations (SD7, SD8, SD10, SD12, SD13, and SD14) around the PLOO from the January and July surveys, 1991 through 2020. Data include total number of individuals collected (N). Taxonomic arrangement according to SCAMIT (2018).

| Taxon | | | | Species | N |
|---|---|---|---|---|---|
| **SILICEA/CALCAREA** | | | | | |
| | | | | SILICEA/CALCAREA | 14 |
| **SILICEA** | | | | | |
| | HEXACTINELLIDA | Lyssacinosida | Rossellidae | *Aphorme horrida* | 1 |
| | | | | Acanthascinae | 1 |
| | DEMOSPONGIAE | | | Demospongiae | 1 |
| | | Suberitida | Suberitidae | *Suberites latus* | 25 |
| | | | Halichondriidae | *Halichondria* sp | 1 |
| **CNIDARIA** | | | | | |
| | ANTHOZOA | | | Anthozoa | 4 |
| | | Alcyonacea | | Stolonifera | 1 |
| | | | Clavulariidae | *Telesto californica* | 3 |
| | | | Gorgoniidae | Gorgoniidae | 3 |
| | | | | *Adelogorgia phyllosclera* | 13 |
| | | | | *Eugorgia rubens* | 4 |
| | | | | *Leptogorgia chilensis* | 1 |
| | | | Plexauridae | *Thesea* sp B | 489 |
| | | Pennatulacea | Virgulariidae | Virgulariidae | 17 |
| | | | | *Acanthoptilum* sp | 18,367 |
| | | | | *Stylatula elongata* | 4 |
| | | | | *Virgularia agassizii* | 30 |
| | | | | *Virgularia californica* | 1 |
| | | | Pennatulidae | *Pennatula phosphorea* | 2 |
| | | | | *Ptilosarcus gurneyi* | 1 |
| | | Actiniaria | | Actiniaria | 1 |
| | | | Metridiidae | *Metridium farcimen* | 243 |
| **MOLLUSCA** | | | | | |
| | POLYPLACOPHORA | | | Polyplacophora | 2 |
| | | Chitonida | Ischnochitonidae | *Lepidozona golischi* | 1 |
| | | | | *Lepidozona retiporosa* | 3 |
| | | | | *Lepidozona scrobiculata* | 1 |
| | | | | *Lepidozona* sp | 1 |
| | GASTROPODA | | | Gastropoda | 2 |
| | | | Addisoniidae | *Addisonia brophyi* | 1 |
| | | | Calliostomatidae | *Calliostoma tricolor* | 7 |
| | | | | *Calliostoma turbinum* | 53 |
| | | | Turbinidae | *Chlorostoma aureotincta* | 1 |
| | | Hypsogastropoda | Ovulidae | *Simnia barbarensis* | 106 |
| | | | | *Simnia vidleri* | 5 |
| | | | Naticidae | *Calinaticina oldroydii* | 4 |
| | | | | *Neverita draconis* | 6 |
| | | | Bursidae | *Crossata ventricosa* | 5 |
| | | | Velutinidae | *Lamellaria diegoensis* | 4 |
| | | | Fasciolariidae | *Araiofusus eueides* | 46 |
| | | | Nassariidae | *Tritia insculpta* | 20 |
| | | | Muricidae | *Austrotrophon catalinensis* | 3 |
| | | | | *Pteropurpura macroptera* | 3 |
| | | | | *Pteropurpura vokesae* | 1 |
| | | | | *Pteropurpura* sp | 1 |

| Taxon | | | | Species | N |
|---|---|---|---|---|---|
| | | | Pseudomelatomidae | *Antiplanes catalinae* | 20 |
| | | | | *Megasurcula carpenteriana* | 177 |
| | | | Cancellariidae | *Cancellaria cooperii* | 28 |
| | | | | *Cancellaria crawfordiana* | 41 |
| | | Nudibranchia | | Nudibranchia | 1 |
| | | | | Doridoidea | 1 |
| | | | Dorididae | *Doris montereyensis* | 1 |
| | | | Discodorididae | *Platydoris macfarlandi* | 11 |
| | | | Goniodorididae | *Okenia vancouverensis* | 1 |
| | | | Onchidorididae | *Acanthodoris brunnea* | 38 |
| | | | Arminidae | *Armina californica* | 70 |
| | | | Tritoniidae | *Tritonia tetraquetra* | 69 |
| | | | Dendronotidae | *Dendronotus iris* | 1 |
| | | | | *Dendronotus venustus* | 1 |
| | | Pleurobranchomorpha | Pleurobranchidae | *Pleurobranchaea californica* | 492 |
| | | Cephalaspidea | Philinidae | *Philine auriformis* | 161 |
| | | | | *Philine* sp | 2 |
| | | | Philinorbidae | *Philinorbis albus* | 58 |
| | BIVALVIA | Ostreida | Pectinidae | *Leopecten diegensis* | 1 |
| | | Venerida | Chamidae | *Chama granti* | 1 |
| | CEPHALOPODA | Sepiida | Sepiolidae | *Rossia pacifica* | 254 |
| | | Myopsida | Loliginidae | *Doryteuthis opalescens* | 699 |
| | | Octopoda | Octopodidae | *Octopus californicus* | 2 |
| | | | | *Octopus rubescens* | 503 |
| | | | | *Octopus veligero* | 3 |
| **ANNELIDA** | | | | | |
| | POLYCHAETA | Amphinomida | Amphinomidae | *Chloeia pinnata* | 29 |
| | | Phyllodocida | Aphroditidae | *Aphrodita refulgida* | 3 |
| | | | | *Aphrodita* sp | 3 |
| | | | Polynoidae | *Arctonoe pulchra* | 113 |
| | | | | *Hololepida magna* | 3 |
| | | | | *Halosydna johnsoni* | 2 |
| | | Sabellida | Serpulidae | *Protula superba* | 24 |
| **ARTHROPODA** | | | | | |
| | PYCNOGONIDA | Pantopoda | Nymphonidae | *Nymphon pixellae* | 246 |
| | MALACOSTRACA | Stomatopoda | | Stomatopoda | 1 |
| | | | Hemisquillidae | *Hemisquilla californiensis* | 21 |
| | | | Squillidae | *Schmittius politus* | 14 |
| | | Isopoda | Aegidae | *Rocinela angustata* | 1 |
| | | | Corallanidae | *Excorallana truncata* | 2 |
| | | Decapoda | | Penaeoidea | 1 |
| | | | Solenoceridae | *Solenocera mutator* | 13 |
| | | | Sicyoniidae | *Sicyonia ingentis* | 4,086 |
| | | | | *Sicyonia penicillata* | 22 |
| | | | | Caridea | 8 |
| | | | Hippolytidae | *Eualus subtilis* | 1 |
| | | | | *Heptacarpus stimpsoni* | 1 |
| | | | | *Heptacarpus tenuissimus* | 2 |
| | | | | *Lysmata californica* | 1 |
| | | | Pandalidae | *Pandalus danae* | 4 |
| | | | | *Pandalus platyceros* | 9 |
| | | | | *Pantomus affinis* | 28 |

| Taxon | | | Species | N |
|---|---|---|---|---|
| | | Crangonidae | Crangonidae | 13 |
| | | | *Crangon alaskensis* | 329 |
| | | | *Crangon nigromaculata* | 1 |
| | | | *Metacrangon spinosissima* | 6 |
| | | | *Neocrangon resima* | 16 |
| | | | *Neocrangon zacae* | 135 |
| | | Axiidae | *Calocarides spinulicauda* | 1 |
| | | | Paguroidea | 35 |
| | | Diogenidae | *Paguristes bakeri* | 44 |
| | | | *Paguristes turgidus* | 72 |
| | | | *Paguristes ulreyi* | 1 |
| | | Paguridae | Paguridae | 1 |
| | | | *Enallopaguropsis guatemoci* | 2 |
| | | | *Orthopagurus minimus* | 3 |
| | | | *Pagurus armatus* | 3 |
| | | | *Pagurus spilocarpus* | 2 |
| | | | *Parapagurodes laurentae* | 2 |
| | | | *Parapagurodes makarovi* | 1 |
| | | | *Phimochirus californiensis* | 2 |
| | | | *Pylopagurus holmesi* | 3 |
| | | Galatheidae | *Janetogalathea californiensis* | 1 |
| | | Munididae | *Pleuroncodes planipes* | 212,620 |
| | | Lithodidae | *Paralithodes californiensis* | 1 |
| | | | *Paralithodes rathbuni* | 8 |
| | | | *Paralithodes* sp | 1 |
| | | Homolidae | *Moloha faxoni* | 9 |
| | | Calappidae | *Platymera gaudichaudii* | 833 |
| | | | Majoidea | 3 |
| | | Epialtidae | *Pugettia venetiae* | 1 |
| | | | *Loxorhynchus crispatus* | 27 |
| | | | *Loxorhynchus grandis* | 15 |
| | | Inachidae | *Coryrhynchus lobifrons* | 63 |
| | | | *Ericerodes hemphillii* | 7 |
| | | Inachoididae | *Pyromaia tuberculata* | 12 |
| | | Parthenopidae | *Latulambrus occidentalis* | 1 |
| | | Cancridae | Cancridae | 1 |
| | | | *Metacarcinus anthonyi* | 2 |
| | | | *Romaleon antennarium* | 1 |
| | | Pilumnoididae | *Pilumnoides rotundus* | 1 |
| | | Palicidae | *Palicus cortezi* | 1 |
| HEXANAUPLIA | Scalpelliformes | Scalpellidae | *Hamatoscalpellum californicum* | 79 |
| **ECHINODERMATA** | | | | |
| CRINOIDEA | Comatulida | Antedonidae | *Florometra serratissima* | 483 |
| ASTEROIDEA | | | Asteroidea | 9 |
| | Paxillosida | Luidiidae | *Luidia armata* | 154 |
| | | | *Luidia asthenosoma* | 249 |
| | | | *Luidia foliolata* | 1,782 |
| | | | *Luidia* sp | 6 |
| | | Astropectinidae | *Astropecten californicus* | 1,817 |
| | | | *Astropecten ornatissimus* | 21 |
| | | | *Astropecten* sp | 5 |
| | Valvatida | Odontasteridae | *Odontaster crassus* | 2 |
| | | Goniasteridae | *Ceramaster patagonicus* | 2 |
| | | | *Mediaster aequalis* | 27 |

| Taxon | | | | Species | N |
|---|---|---|---|---|---|
| | | | Asterinidae | *Patiria miniata* | 2 |
| | | | Poraniidae | *Poraniopsis inflata* | 1 |
| | | Spinulosida | Echinasteridae | *Henricia* sp | 3 |
| | | Forcipulatida | Asteriidae | Asteriidae | 1 |
| | | | | *Rathbunaster californicus* | 5 |
| | | | | *Stylasterias forreri* | 1 |
| | | | Pycnopodiidae | *Pycnopodia helianthoides* | 13 |
| | OPHIUROIDEA | | | Ophiuroidea | 4 |
| | | Ophiurida | Ophiuridae | *Ophiura luetkenii* | 14,281 |
| | | Ophiacanthida | Ophiopteridae | *Ophiopteris papillosa* | 48 |
| | | | Ophiacanthidae | Ophiacanthidae | 1 |
| | | | | *Ophiacantha diplasia* | 7 |
| | | Amphilepidida | Ophionereididae | *Ophionereis eurybrachiplax* | 1 |
| | | | Amphiuridae | Amphiuridae | 31 |
| | | | | *Amphichondrius granulatus* | 137 |
| | | | | *Amphiodia urtica* | 19 |
| | | | | *Amphiodia* sp | 7 |
| | | | | *Amphipholis squamata* | 8 |
| | | | | *Amphiura arcystata* | 3 |
| | | | Ophiopholidae | *Ophiopholis bakeri* | 113 |
| | | | Ophiotrichidae | *Ophiothrix spiculata* | 406 |
| | ECHINOIDEA | | | Echinoidea | 3 |
| | | Camarodonta | Toxopneustidae | *Lytechinus pictus* | 680,676 |
| | | | Strongylocentrotidae | *Strongylocentrotus fragilis* | 11,671 |
| | | | | *Strongylocentrotus purpuratus* | 7 |
| | | Spatangoida | Brissidae | *Brissopsis pacifica* | 18 |
| | | | Spatangidae | *Spatangus californicus* | 278 |
| | | | Loveniidae | *Lovenia cordiformis* | 1 |
| | HOLOTHUROIDEA | Aspidochirotida | Stichopodidae | *Apostichopus californicus* | 1,930 |
| **BRACHIOPODA** | | | | | |
| | RHYNCHONELLATA | Terebratulida | Terebrataliidae | *Dallinella occidentalis* | 3 |
| **CHORDATA** | | | | | |
| | ASCIDIACEA | | | Ascidiacea | 2 |
| | | Phlebobranchiata | Cionidae | *Ciona robusta* | 3 |
| | | Stolidobranchiata | Styelidae | *Styela* sp | 1 |
| | | | Pyuridae | *Halocynthia igaboja* | 1 |
| | | | | *Pyura* sp | 1 |
| | | Phlebobranchiata | Cionidae | *Ciona robusta* | 3 |
| | | Stolidobranchiata | Styelidae | *Styela* sp | 1 |
| | | | Pyuridae | *Halocynthia igaboja* | 1 |
| | | | | *Pyura* sp | 1 |

# APPENDIX C2

## SAN DIEGO BENTHIC TOLERANCE INTERVALS

### 24-Year San Diego Regional Benthic Assessment and Reference Tolerance Intervals

March 2022

# APPENDIX C2

# San Diego Benthic Tolerance Intervals

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C2.A Deep Benthic Habitat Assessment Study

# APPENDIX C2
# San Diego Benthic Tolerance Intervals

## SECTION C2-1 | INTRODUCTION

An understanding of reference conditions is crucial to evaluating the results from environmental monitoring studies. Characterization of these background conditions using relevant indicators help to define what is natural (i.e., not anthropogenically impacted), allows for the establishment of baselines and the identification of appropriate reference sites. The City of San Diego has conducted regional benthic surveys of the continental shelf off San Diego since 1994 (i.e., San Diego "mini" regional surveys). The main objectives of these surveys are to characterize the benthic conditions for this diverse coastal region from the US/Mexico border to northern San Diego County and to identify areas impacted by anthropogenic or natural events. These regional surveys typically occur at an array of 40 stations selected each year using a probability-based, random stratified sampling design as described in Bergen (1996), Stevens (1997), and Stevens and Olsen (2004). During 1995–1997, 1999–2002, and 2005–2007, the surveys off San Diego were restricted to continental shelf depths <200 meters (m). However, beginning in 2009, the survey area was expanded to include deeper habitats along the upper continental slope (i.e., 200–500 m). In 1994, 1998, 2003, 2008, and 2013, regional surveys were conducted as part of the larger Southern California Bight (SCB) Regional Monitoring Program (i.e., Bight regional surveys; see Bergen et al. 1998, 2001, Schiff and Gossett 1998, Noblet et al. 2002, Schiff et al. 2006, 2011, Maruya and Schiff 2009, Ranasinghe et al. 2003, 2007, 2010, 2012, Dodder et al. 2016, Gillett et al. 2017). Additionally, two special process studies produced reference data from the shelf and slope off San Diego, including Phase I of the *San Diego Sediment Mapping Study* designed to estimate spatial variance in benthic conditions over an area spanning both the Point Loma and South Bay Ocean Outfall (PLOO and SBOO, respectively) monitoring regions (>400 km$^2$) (see Stebbins et al. 2004 and Appendix C.4, City of San Diego 2015a), and the *San Diego Deep Benthic Pilot Study* designed to assess the condition of deeper (>200 m) continental slope habitats off San Diego (see Stebbins et al. 2005). In total, more than 863 different stations were sampled off San Diego from 1994 through 2017.

For environmental data, the tolerance interval is a statistical tool used to define the putative natural range of values for reference variables. It is the confidence interval bound of a specific percentile of a data distribution. For example, it can describe with a desired degree of statistical certainty, the lower 10$^{th}$ and upper 90$^{th}$ percentile of benthic macrofaunal (e.g., worms, crabs, clams, brittle stars, other small invertebrates) abundance found among regional monitoring stations. Since the tolerance interval bound describes a range instead of a parameter (e.g., the mean), it compensates for the greater variability commonly found in environmental monitoring data. Also, since it incorporates confidence intervals, it allows for a more statistically rigorous comparison of reference versus impacted sites than means or ranges. For in-depth statistical descriptions of tolerance intervals used in environmental monitoring see Smith and Riege (1998), Smith (2002) and Smith et al. (2005).

The objectives of this appendix are to identify benthic sites or communities likely to provide the most appropriate reference values for environmental indicators within the PLOO region and to quantify their tolerance intervals. Ordination and cluster analyses of macrofauna data were used to identify appropriate reference sites off San Diego for comparisons with regular PLOO monitoring stations. Because these analyses are performed without *a-priori* consideration of depth or sample date, they represent an improvement over other studies (e.g., Smith and Riege 1998, Smith 2001) where reference stations were selected solely based on comparable depth ranges, thus failing to account for temporal or spatial heterogeneity (e.g., varying sediment composition, organic loading) within different depth strata.

## SECTION C2-2 | DATASET AND METHODS

The benthic samples used to identify reference sites were collected annually from 1994 through 2017 as part of multiple regional and special study surveys. The "mini" regional surveys conducted in 1995–1997, 1999–2002, 2005–2007, 2009–2012, and 2014–2017 were performed as part of the National Pollutant Discharge Elimination System (NPDES) monitoring programs for the Point Loma and South Bay Ocean Outfalls (see City of San Diego 2020 for details), while sampling in 1994, 1998, 2003, 2008, and 2013 was conducted as part of the 1994 Southern California Bight Pilot Project Bight, Bight'98, Bight'03, Bight'08 and Bight'13 (Bergen et al. 1998, 2001, Schiff and Gossett 1998, Noblet et al. 2002, Schiff et al. 2006, 2011, Maruya and Schiff 2009, Ranasinghe et al. 2003, 2007, 2010, 2012, Dodder et al. 2016, Gillett et al. 2017). These surveys were all conducted using the United States Environmental Protection Agency (USEPA) probability-based Environmental Monitoring and Assessment (EMAP) random sampling design (see Bergen et al. 1998). Data from the *San Diego Sediment Mapping Study* (Phase I), conducted in 2004 (Stebbins et al. 2004), and the *San Diego Deep Benthic Pilot Study*, conducted in 2005 (Stebbins et al. 2005), were also included with analyses of the EMAP based data. The study area ranged from off Oceanside in northern San Diego County south to the US/Mexico border. A total of 863 sites, ranging in depth from 5 to 1023 m, were sampled over this 24-year period (1994–2017). Patterns of benthic community structure were assessed using multivariate ordination and cluster analyses based on the Bray-Curtis measure of similarity (see details in Parnell et al. 2021). All identifications followed nomenclatural standards established by the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT 2014).

Following the selection of appropriate reference sites, tolerance intervals were calculated for 26 sediment parameters and 15 biological indicators, selected to match parameters assessed in Appendix C1 of this application. Data were tested for approximation to a normal distribution using the Shapiro-Wilk test for normality and transformed when appropriate. Where transformation did not improve normality, nonparametric tolerance intervals were computed from raw data. Parametric tolerance intervals were computed for the 10th and 90th percentiles with confidence intervals of 95% ($\alpha$=0.05). Nonparametric tolerance intervals were computed for the 5th and 95th percentiles with confidence intervals of 95% ($\alpha$=0.05). Sediment and biological indicator variables from PLOO primary core stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020 were compared to the calculated tolerance intervals. Comparisons were split for near-ZID versus farfield stations. The three near-ZID sites include station E14 located near the ZID boundary just west of the center of the outfall wye, and stations E11 and E17 located off the ends of the southern and northern diffuser legs, respectively. Station E11 is located about 149 m from the southern ZID boundary, while E17 is located about 197 m from the northern ZID boundary. See Appendix C1 for specifics on PLOO benthic sediment and infauna data handling.

## SECTION C2-3 | RESULTS

A total of 1,732 taxa (mostly species) comprising 307,815 small benthic invertebrates (macrofauna) were identified from 1,027 0.1-m$^2$ grab samples collected on the continental shelf and slope off San Diego from 1994 through 2017. Region wide, macrofaunal abundances ranged from 10 to 2,736 individuals per sample (mean=300 individuals) and the total number of species ranged from 8 to 198 per sample (mean=75 species). Cluster analysis and ordination of macrofauna data from these grab samples discriminated between 14 habitat-related benthic infauna assemblages off San Diego (cluster groups A–N in Figure C2-1, Tables C2-1, C2-2, Attachment C2.A-5; from Parnell et al. 2021). These groups were stratified along depth contours and sediment types associated with variations in seafloor topography, with very little temporal partitioning evident, and displayed no spatial patterns relative to point source inputs (Figure C2-1). Of the 14 cluster groups, eight were largely representative of assemblages found at shallower depths (mean depths ≤214 m) on the continental shelf (groups A–H), while six were representative of assemblages found at deeper depths (mean depths ≥359 m) on the continental slope (groups I–N). The latter six cluster groups are essentially an update of the eight cluster groups described in the Deep Benthic Habitat Assessment Study (see Attachment C2.A). Species composition differed among all of the cluster groups, and relative abundances of dominant taxa defined the assemblages (see Parnell et al. 2021).

The stations comprising the largest macrofauna cluster, group A (369 of the 1027 samples), mirrored the PLOO primary core stations in terms of geographic location and depth (Figure C2-1). These similarities suggest that group A represents suitable reference macrofaunal assemblages for comparisons of environmental variables to the PLOO stations. Group A stations were generally confined between the 30-m and 200-m depth contours ranging from near Carlsbad in the north to the Tijuana River region in the south. Sediment particle sizes at these stations were mixed, averaging about 47% fine particles, 34% very fine sand, 14% fine sand, 3% medium sand, 1% coarse sand, with trace coarse particles (Table C2-2). This particle size composition matches very closely with results from cluster analyses of particle size data collected over 29 years at the PLOO primary core stations (see Appendix C4, this application). Total organic carbon (TOC) at group A stations ranged from not detected to 3.3% (mean=0.7%). Finally, previous studies have suggested minor changes have occurred in the macrofaunal community at a few sites located within about 0.5 km of the outfall discharge site. Consequently, a conservative approach was taken, and group A stations located within 1.5 km of the PLOO were eliminated from the tolerance interval calculations as their indicator values could potentially be affected by discharge or the physical structure of the wye (Figure C2-1).

Tolerance intervals for the group A reference data (excluding those closest to the PLOO) are shown in Tables C2-3 and C2-4. Both upper and lower bounds are reported with bolded values indicating thresholds for the direction of response expected from environmental impact. Tolerance intervals for biochemical oxygen demand (BOD) (no transformation), log-transformed total polychlorinated biphenyl compounds (PCBs), and log-transformed species richness were computed parametrically. Non-parametric tolerance intervals were calculated for all other variables.

Overall, 85% of the sediment particle size, sediment chemistry, and biological indicator values from the 12 primary core PLOO benthic stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020 were found to be within tolerance intervals calculated using reference data (Tables C2-3 – C2-4, Figures C2-2 – C2-8). For most parameters, upper tolerance interval bounds represent thresholds for the direction of response predicted from environmental impact. Exceedances of these thresholds were most frequent for TOC (near-ZID=0%, farfield=4.5%), BOD (near-ZID=3%, farfield=5%), sulfides (near-ZID=5%, farfield=1%), beryllium (near-ZID=1%, farfield=5.5%), cadmium (near-ZID=4%, farfield=11%), Benthic Response Index (BRI) (near-ZID=7%, farfield=1%), *Proclea* sp A (near-ZID=2%, farfield=7%), *Euphilomedes* spp (near-ZID=9%, farfield=12%), *Mediomastus* spp (near-ZID=7%, farfield=8%), *Solemya pervernicosa* (near-ZID=5%, farfield=<1%), and *Capitella teleta* (near-ZID=11%, farfield=2%). These findings demonstrate that all stations within the PLOO monitoring region are largely indicative of background conditions and support the overall conclusion presented in the various appendices of this application that local benthic infauna communities remain relatively unaffected by the effluent discharge.

## SECTION C2-4 | DISCUSSION

Tolerance interval bounds computed from macrofauna cluster group A sites provide an accurate assessment of reference conditions based on environmental variables. The use of tolerance interval bounds for benthic monitoring provides a level of statistical certainty when comparing impacted to reference sites. Further, tolerance interval bounds compliment other statistically rigorous methods of impact detection like Before-After Control-Impact Paired Series (BACIPS) analyses and can be used in conjunction to provide a broader context to the data (see Appendix C1, this application). Tolerance interval bounds help to put assumed impacts into perspective. For example, if the value of an indicator variable from an impact site is near or within the interval bounds, impact can be deemed minimal or nonexistent. The further impact values deviate from the reference bound, the more serious the impact may be judged.

Previous studies have calculated tolerance interval bounds for the San Diego region between 1994–1996 (Smith and Riege 1998) and 1994–1999 (Smith 2001). This study builds on those works and is comparable to their findings. Reference data collected for this study covered 1,027 benthic samples from the continental shelf and slope off San Diego and spanned 24 years (1994–2017). This large sample size and longer temporal component increases sensitivity and effectiveness of detecting impacts as well as integrates changes to the indicator variables across time (Hunt et al. 2001). Further, the use of cluster analysis to identify an appropriate reference area is novel and avoids arbitrary site selection in favor of an ecological approach. Overall, these bounds provide a robust and appropriate reference for comparison to potential impacts to the region due to discharge from the PLOO. Lastly, tolerance intervals should be updated over time to incorporate spatio-temporal changes (e.g., ENSO events or shifts in sediment composition) that may affect tolerance interval bounds of reference conditions in the PLOO region.

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# APPENDIX C2

## San Diego Benthic Tolerance Intervals

### FIGURES & TABLES

A

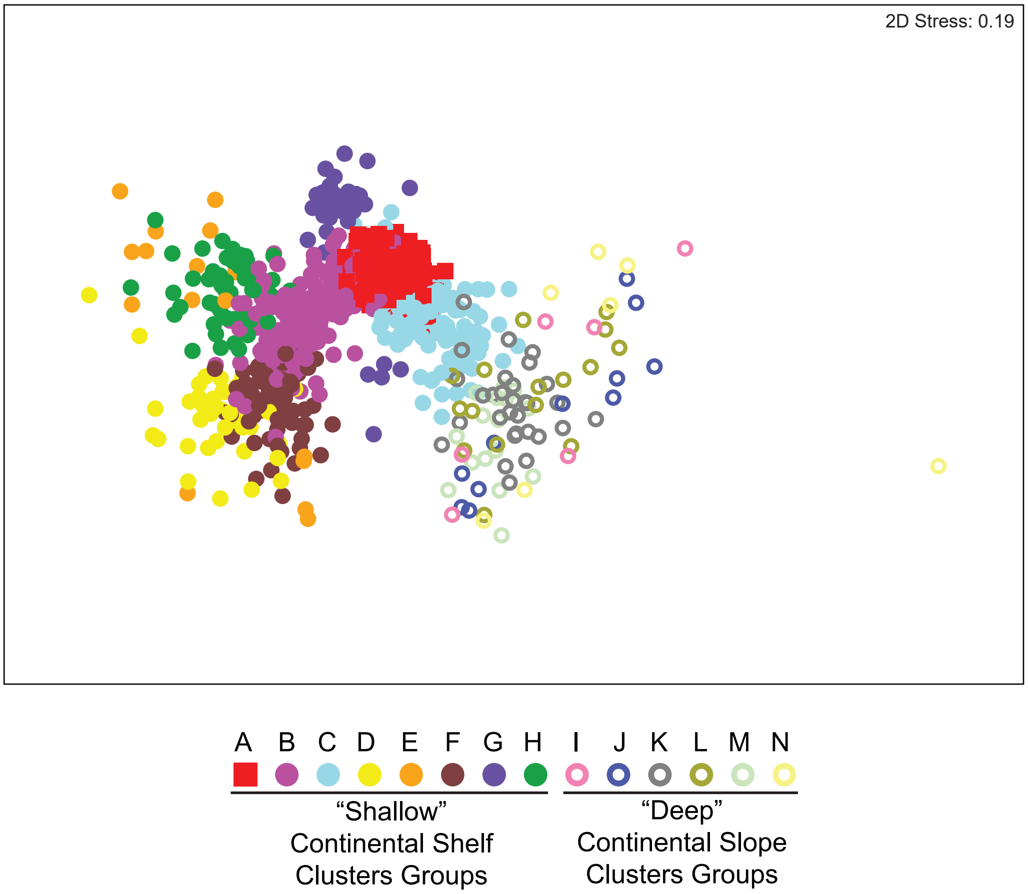



**FIGURE C2-1**
Results of ordination and cluster analysis of macrofauna data from 1,027 regional and special study grab samples collected off San Diego from 1994 through 2017. Results are presented as (A) nMDS ordination and (B) a map showing the distribution of cluster groups throughout the region. Cluster results are presented in Parnell et al. 2021. Data from cluster group A (red; excluding sites nearest the PLOO terminus) were used to calculate tolerance intervals. Data from cluster groups C, and I–N were used for the Deep Benthic Habitat Assessment Study (see Attachment C2.A).

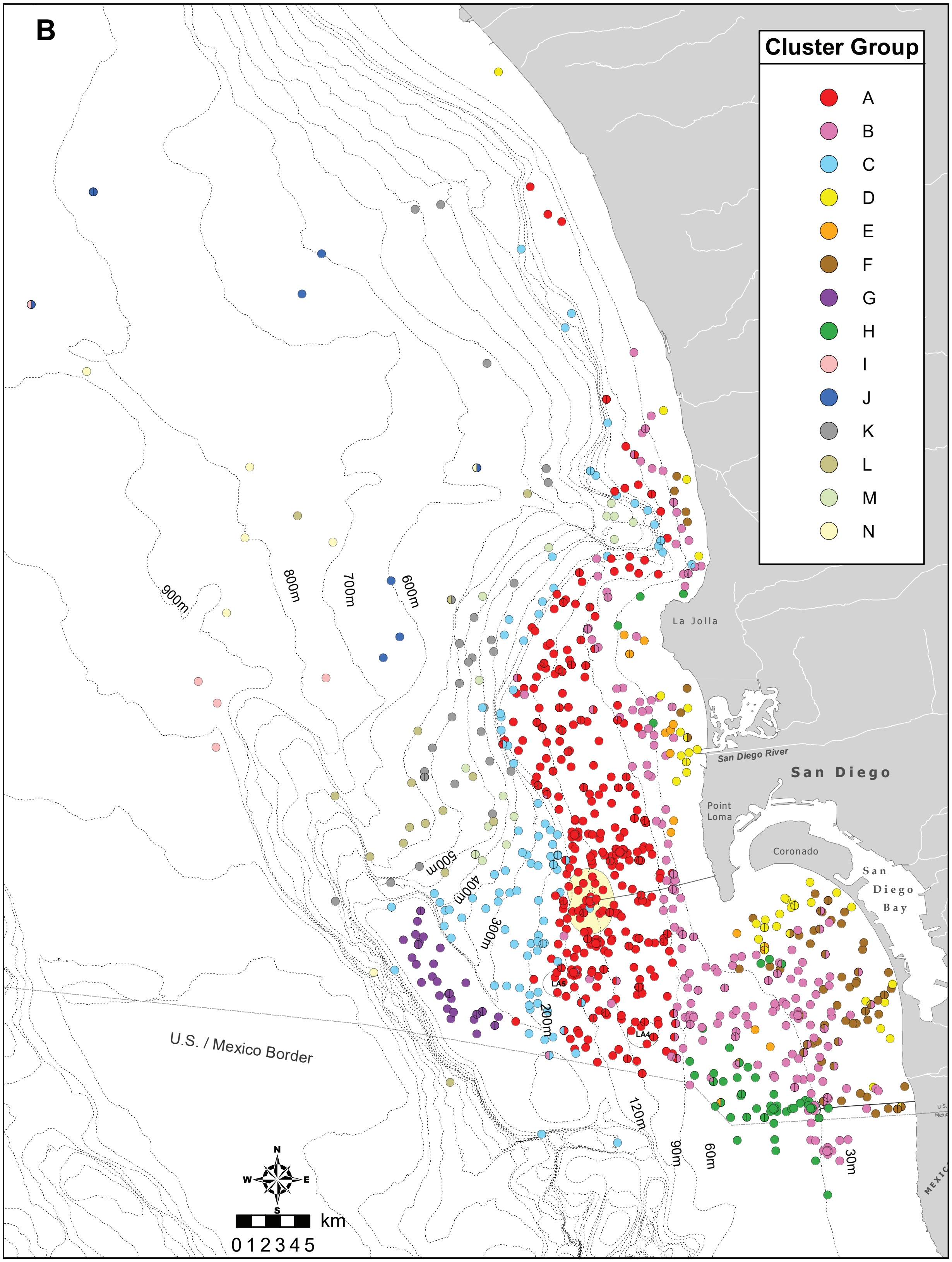



**FIGURE C2-1** *continued*

**TABLE C2-1**
Description of macrofauna cluster groups A–N defined in Figure C2-1 (see also Parnell et al. 2021). Community parameters are presented as means calculated over all stations within a cluster group (n); SR=species richness; Dom=dominance; BRI=Benthic Response Index (Smith et al. 2001).

| | Cluster Group | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** |
| n | 369 | 239 | 108 | 42 | 17 | 69 | 39 | 58 | 6 | 11 | 30 | 16 | 16 | 7 |
| Similarity (%) | 36 | 25 | 25 | 24 | 22 | 24 | 31 | 28 | 12 | 19 | 23 | 20 | 26 | 17 |
| *Depth (m)* | | | | | | | | | | | | | | |
| Minimum | 36 | 13 | 67 | 5 | 16 | 10 | 136 | 12 | 755 | 556 | 263 | 400 | 302 | 562 |
| Maximum | 203 | 138 | 430 | 19 | 49 | 31 | 197 | 59 | 1023 | 854 | 526 | 807 | 427 | 887 |
| Mean | 94 | 41 | 214 | 13 | 27 | 18 | 156 | 38 | 897 | 693 | 410 | 524 | 359 | 762 |
| *Community Parameters* | | | | | | | | | | | | | | |
| SR | 85 | 100 | 61 | 40 | 59 | 47 | 63 | 67 | 21 | 21 | 29 | 36 | 26 | 18 |
| Abundance | 347 | 424 | 211 | 191 | 386 | 137 | 193 | 306 | 52 | 33 | 77 | 123 | 65 | 27 |
| Diversity (H') | 3.5 | 3.7 | 3.5 | 2.8 | 3.1 | 3.3 | 3.5 | 3.2 | 2.6 | 2.8 | 2.8 | 3.0 | 2.7 | 2.7 |
| Evenness (J) | 0.80 | 0.82 | 0.86 | 0.78 | 0.77 | 0.87 | 0.86 | 0.76 | 0.90 | 0.95 | 0.85 | 0.88 | 0.84 | 0.95 |
| Swartz Dom | 26 | 31 | 23 | 13 | 14 | 20 | 24 | 19 | 10 | 14 | 12 | 15 | 12 | 12 |
| BRI | 9 | 20 | 18 | 9 | 12 | 20 | 3 | 12 | — | — | — | — | — | — |

**TABLE C2-2**
Particle size (%) summary for macrofauna cluster groups A–N (see **Figure** C2-1, **Table** C2-1, Parnell et al. 2021). Data are presented as means and standard deviations (SD) calculated over all stations within a cluster group (n).

| Particle Size | Cluster Group | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** |
| n | 369 | 239 | 108 | 42 | 17 | 69 | 39 | 58 | 6 | 11 | 30 | 16 | 16 | 7 |
| *Fines (%)* | | | | | | | | | | | | | | |
| Mean | 47.4 | 24.0 | 60.4 | 5.1 | 1.4 | 14.3 | 12.3 | 3.1 | 82.3 | 91.4 | 77.3 | 84.1 | 80.1 | 89.7 |
| SD | 11.8 | 14.2 | 17.8 | 6.1 | 2.2 | 9.8 | 9.0 | 4.2 | 24.0 | 3.0 | 12.8 | 6.0 | 7.5 | 4.1 |
| *Very Fine Sand (%)* | | | | | | | | | | | | | | |
| Mean | 34.0 | 36.7 | 23.4 | 26.6 | 0.7 | 43.9 | 6.3 | 3.7 | 6.8 | 6.3 | 16.7 | 11.4 | 15.6 | 7.3 |
| SD | 8.5 | 18.4 | 8.7 | 19.5 | 1.2 | 14.9 | 4.8 | 6.8 | 4.1 | 1.9 | 8.2 | 3.9 | 5.7 | 2.8 |
| *Fine Sand (%)* | | | | | | | | | | | | | | |
| Mean | 13.7 | 23.5 | 10.4 | 46.5 | 8.4 | 36.5 | 23.9 | 14.4 | 5.0 | 2.2 | 5.4 | 4.0 | 4.0 | 2.8 |
| SD | 7.6 | 13.6 | 8.7 | 18.3 | 12.0 | 15.5 | 13.7 | 12.0 | 7.2 | 1.1 | 5.3 | 2.3 | 2.1 | 1.3 |
| *Medium Sand (%)* | | | | | | | | | | | | | | |
| Mean | 2.9 | 9.1 | 2.8 | 15.1 | 27.8 | 4.3 | 38.2 | 38.3 | 3.8 | 0.1 | 0.6 | 0.4 | 0.2 | 0.2 |
| SD | 5.0 | 13.7 | 4.9 | 13.5 | 26.9 | 5.0 | 17.8 | 16.0 | 8.9 | 0.1 | 1.4 | 0.3 | 0.2 | 0.2 |
| *Coarse Sand (%)* | | | | | | | | | | | | | | |
| Mean | 1.2 | 4.7 | 1.3 | 6.3 | 40.5 | 1.0 | 16.2 | 36.1 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SD | 3.8 | 11.5 | 3.7 | 12.9 | 26.5 | 4.4 | 17.8 | 18.5 | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Larger Particles (%)* | | | | | | | | | | | | | | |
| Mean | 0.9 | 2.0 | 1.8 | 0.4 | 21.2 | 0.0 | 3.2 | 4.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SD | 3.3 | 7.0 | 8.3 | 1.1 | 19.8 | 0.1 | 4.1 | 3.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**TABLE C2-3**

Tolerance interval bounds for various sediment parameters using data from 342 (out of 369) regional and special study samples collected off San Diego from 1994 through 2017. Stations within 1.5 km of the PLOO wye structure were excluded. See text for details. P(norm) = the *p* value from a Shapiro-Wilk test for normality of the underlying data distribution. Parametric tolerance intervals computed for the 10th and 90th percentiles for indicators with p(norm) >0.15. Data were transformed when p(norm) for raw data were <0.15. Where transformation did not improve normality, non-parametric tolerance intervals for the 5th and 95th percentile were computed. Bolded values indicate thresholds for the direction of response predicted from environmental impact. Percent of samples from PLOO stations collected from 1991 through 2020 that fell outside of the tolerance interval bounds are included for near-ZID (E11, E14, and E17) and farfield (B12, B9, E26, E25, E23, E20, E9, E7, E5, E2) stations.

| | | | Tolerance Interval | | % Below Lower Bound | | % Above Upper Bound | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **p(norm)** | **Transformation** | **Lower Bound** | **Upper Bound** | **Near-ZID** | **Farfield** | **Near-ZID** | **Farfield** |
| *Particle Size (%)* | | | | | | | | |
| Fine Particles | <0.001* | — | 24 | **66** | 1.6 | 1.3 | 0.0 | 0.7 |
| Fine Sands | <0.001* | — | 31 | 67 | 0.4 | 1.0 | 3.7 | 1.7 |
| Med-Coarse Sands | <0.001* | — | 0 | 24 | 0.0 | 0.0 | 0.0 | 3.4 |
| Coarse Particles | <0.001* | — | 0 | 9 | 0.0 | 0.0 | 1.1 | 1.6 |
| *Organic Indicators* | | | | | | | | |
| TOC (%) | <0.001* | — | 0.36 | **1.50** | 3.4 | 2.7 | 0.0 | 4.5 |
| TN (%) | <0.001* | — | 0.02 | **0.10** | 1.1 | 2.7 | 0.0 | 0.3 |
| TVS (%) | <0.001* | — | 1.56 | **4.20** | 3.0 | 1.7 | 0.0 | 0.6 |
| BOD (ppm) | 0.309 | — | 220 | **440** | 3.8 | 14.6 | 3.4 | 4.6 |
| Sulfides (ppm) | <0.001* | — | 0.4 | **18.1** | 0.4 | 2.7 | 5.3 | 1.3 |
| *Metals (ppm)* | | | | | | | | |
| Aluminum | <0.001* | — | 6080 | **23,600** | 4.9 | 5.9 | 0.0 | 0.0 |
| Arsenic | <0.001* | — | 1.4 | **5.7** | 0.4 | 0.4 | 0.3 | 2.3 |
| Beryllium | <0.001* | — | 0.03 | **1.54** | 0.0 | 0.6 | 0.9 | 5.5 |
| Cadmium | <0.001* | — | 0.02 | **0.90** | 0.0 | 0.0 | 3.7 | 10.8 |
| Chromium | <0.001* | — | 11.7 | **31.6** | 3.4 | 3.5 | 0.1 | 0.7 |
| Copper | <0.001* | — | 3.8 | **25.8** | 2.6 | 5.7 | 0.0 | 0.1 |
| Iron | <0.001* | — | 8420 | **24,800** | 4.6 | 2.5 | 0.0 | 0.9 |
| Lead | <0.001* | — | 1.9 | **13.2** | 1.3 | 1.0 | 0.0 | 0.4 |

* Non-parametric tolerance interval bounds computed

**TABLE C2-3** *continued*

| Parameter | p(norm) | Transformation | Tolerance Interval | | % Below Lower Bound | | % Above Upper Bound | |
|---|---|---|---|---|---|---|---|---|
| | | | Lower Bound | Upper Bound | Near-ZID | Farfield | Near-ZID | Farfield |
| Manganese | <0.001* | — | 61.8 | **336.0** | 2.2 | 4.3 | 0.0 | 0.0 |
| Mercury | <0.001* | — | 0.009 | **0.107** | 0.6 | 1.7 | 0.0 | 0.0 |
| Nickel | 0.232 | — | 5.7 | **12.3** | 6.6 | 12.0 | 0.3 | 0.4 |
| Selenium | <0.001* | — | 0.1 | **0.7** | 0.9 | 2.2 | 0.0 | 0.9 |
| Silver | <0.001* | — | 0.01 | **6.07** | 0.0 | 0.0 | 1.0 | 0.0 |
| Zinc | <0.001* | — | 20.4 | **74.1** | 4.4 | 4.2 | 0.0 | 0.1 |
| Total DDT (ppt) | <0.001* | — | 130 | **17,000** | 1.2 | 1.5 | 0.0 | 0.9 |
| Total PCB (ppt) | 0.590 | ln | 59 | **12,430** | 6.0 | 8.3 | 0.0 | 1.2 |
| Total PCB Lim (ppt)** | 0.537 | ln | 58 | **11,790** | 6.0 | 8.4 | 0.0 | 1.2 |
| Total PAH (ppb) | <0.001* | — | 11 | **3640** | 4.5 | 9.0 | 0.0 | 0.0 |
| Total PAH Lim (ppb)** | <0.001* | — | 11 | **3640** | 0.0 | 9.2 | 0.0 | 0.0 |

* Non-parametric tolerance interval bounds computed
** Total PCB and total PAH calculated with all detected constituents, and limited to constituents analyzed consistently over all years (see Appendix C1)

**TABLE C2-4**

Tolerance interval bounds for various biological indicators using data from 342 (out of 369) regional and special study samples collected off San Diego from 1994 through 2017. Stations within 1.5 km of the PLOO wye structure were excluded. See text for details. p(norm) = the p value from a Shapiro-Wilk test for normality of the underlying data distribution. Parametric tolerance intervals computed for the 10th and 90th percentiles for indicators with p(norm) > 0.15. Data were transformed when p(norm) for raw data were <0.15. Where transformation did not improve normality, non-parametric tolerance intervals for the 5th and 95th percentile were computed. Bolded values indicate thresholds for the direction of response predicted from environmental impact. Percent of grabs from PLOO stations collected from 1991 through 2020 that fell outside of the tolerance interval bounds are included for near-ZID (E11, E14, and E17) and farfield (B12, B9, E26, E25, E23, E20, E9, E7, E5, E2) stations.

| | | | Tolerance Invertal | | % Below Lower Bound | | % Above Upper Bound | |
|---|---|---|---|---|---|---|---|---|
| **Indicator** | **p(norm)** | **Transformation** | **Lower Bound** | **Upper Bound** | **Near-ZID** | **Farfield** | **Near-ZID** | **Farfield** |
| Species Richness | 0.540 | ln | **61** | **113** | 3.0 | 5.8 | 1.8 | 3.4 |
| Abundance | <0.001* | — | **144** | **624** | 0.4 | 1.0 | 1.0 | 1.6 |
| BRI | 0.087* | — | 2 | **18** | 1.1 | 6.5 | 7.2 | 1.0 |
| Diversity | <0.001* | — | **2.5** | **4.3** | 0.0 | 0.4 | 0.1 | 1.0 |
| Evenness | <0.001* | — | **0.59** | **0.93** | 0.0 | 0.6 | 0.1 | 0.4 |
| Swartz Dominance | 0.001* | — | **7** | 48 | 0.0 | 0.3 | 0.0 | 0.4 |
| | | | | | | | | |
| *Amphiodia* spp | <0.001* | — | **2** | 191 | 2.8 | 0.1 | 0.0 | 0.0 |
| *Ampelisca* spp | <0.001* | — | **1** | 24 | 1.0 | 0.8 | 0.0 | 2.1 |
| *Proclea* sp A | <0.001* | — | **0** | 34 | 0.0 | 0.0 | 1.7 | 7.2 |
| *Rhepoxynius* spp | <0.001* | — | **0** | 12 | 0.0 | 0.0 | 3.4 | 4.2 |
| *Euphilomedes* spp | <0.001* | — | 0 | **28** | 0.0 | 0.0 | 9.3 | 12.2 |
| *Mediomastus* spp | <0.001* | — | 0 | **15** | 0.0 | 0.0 | 6.9 | 8.5 |
| *Parvilucina tenuisculpta* | <0.001* | — | 0 | **8** | 0.0 | 0.0 | 2.5 | 3.1 |
| *Solemya pervernicosa* | <0.001* | — | 0 | **<1** | 0.0 | 0.0 | 4.7 | 0.1 |
| *Capitella teleta* | <0.001* | — | 0 | **1** | 0.0 | 0.0 | 10.6 | 1.7 |

* Non-parametric tolerance interval bounds computed

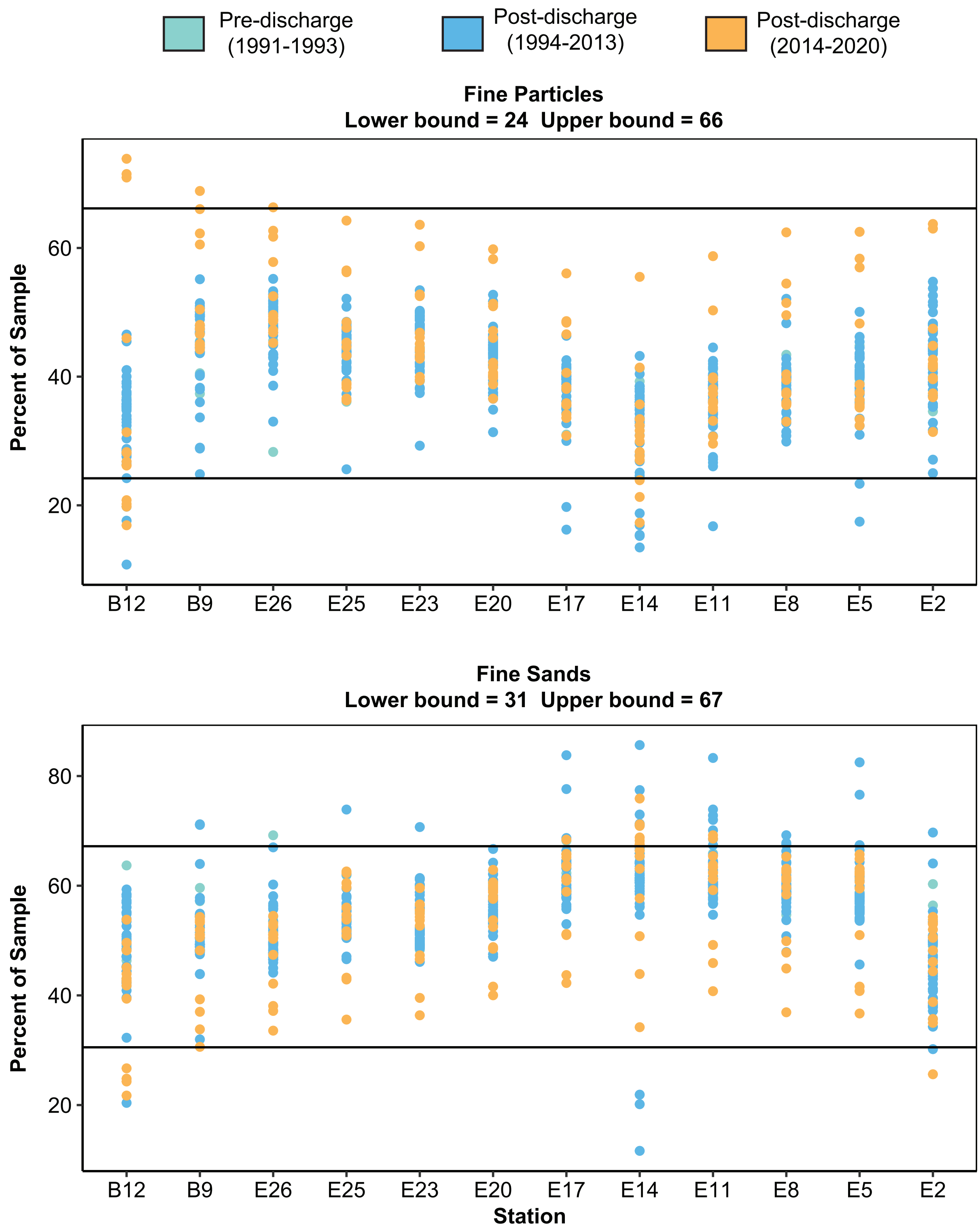



**FIGURE C2-2**
Particle sizes of sediments from PLOO primary core monitoring stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Horizontal lines indicate lower and upper tolerance intervals calculated from cluster group A regional and special study samples collected 1994–2017 (see text).

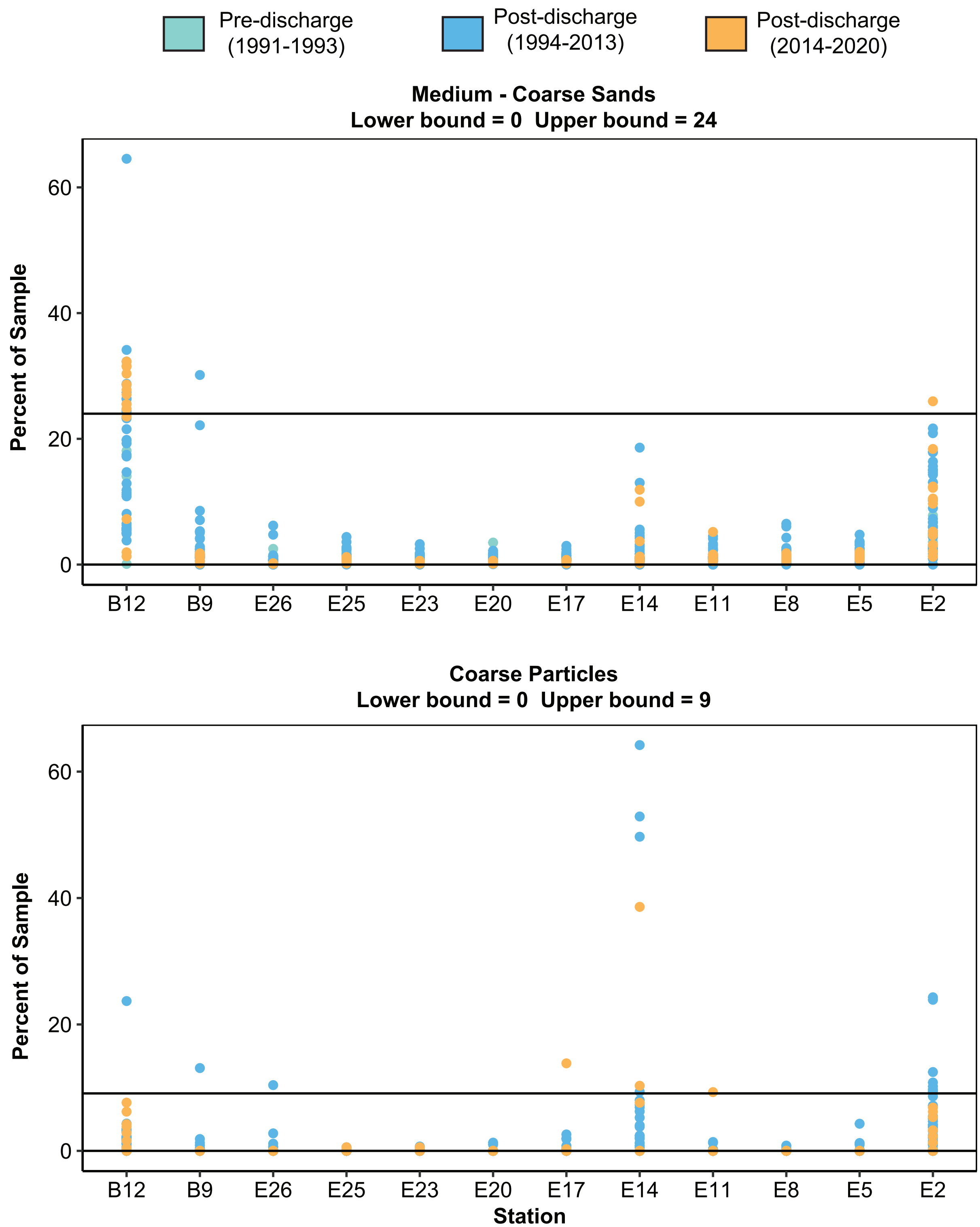



**FIGURE C2-2** *continued*

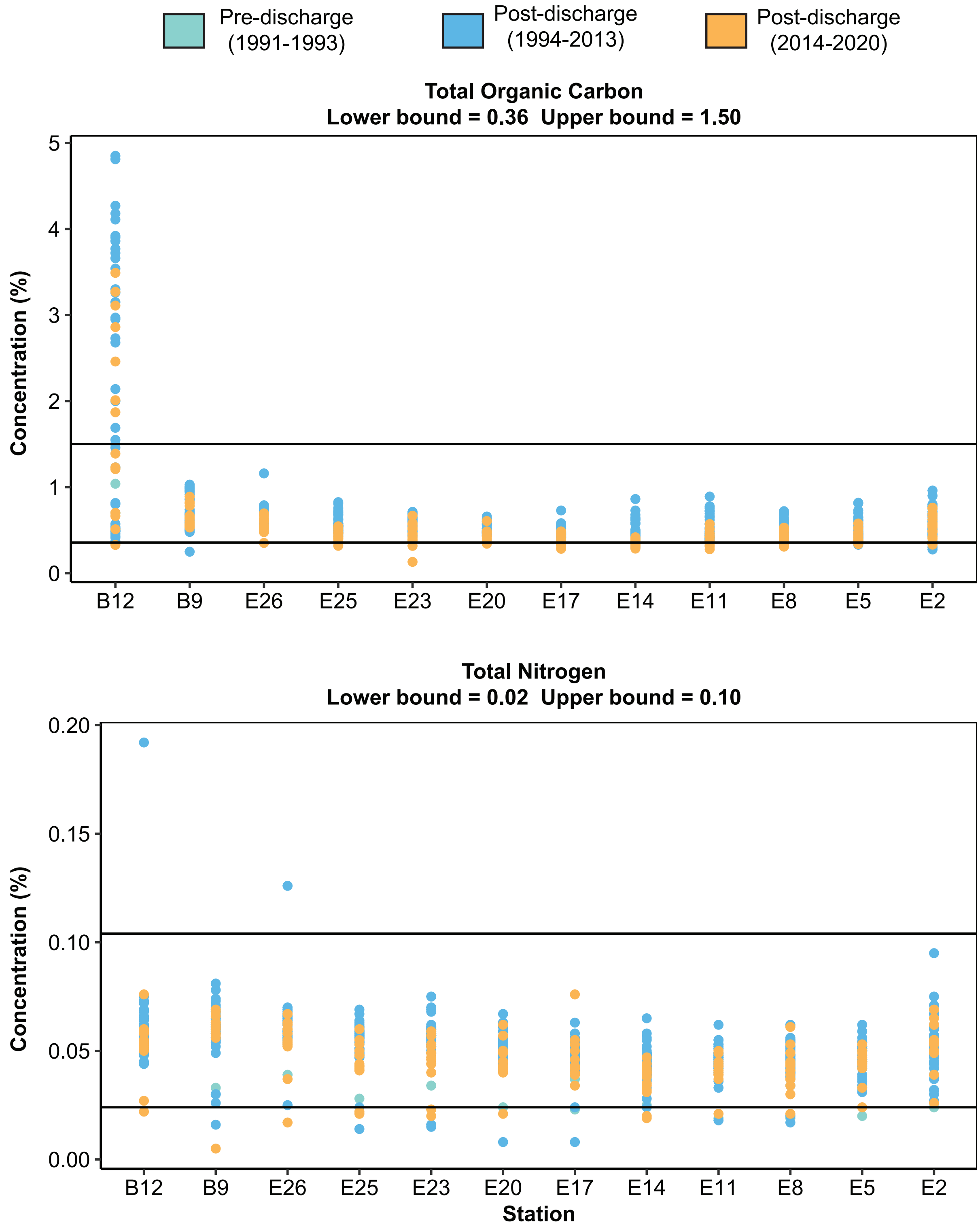



**FIGURE C2-3**
Organic indicators in sediments from PLOO primary core monitoring stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Horizontal lines indicate lower and upper tolerance intervals calculated from cluster group A regional and special study samples collected 1994–2017 (see text).

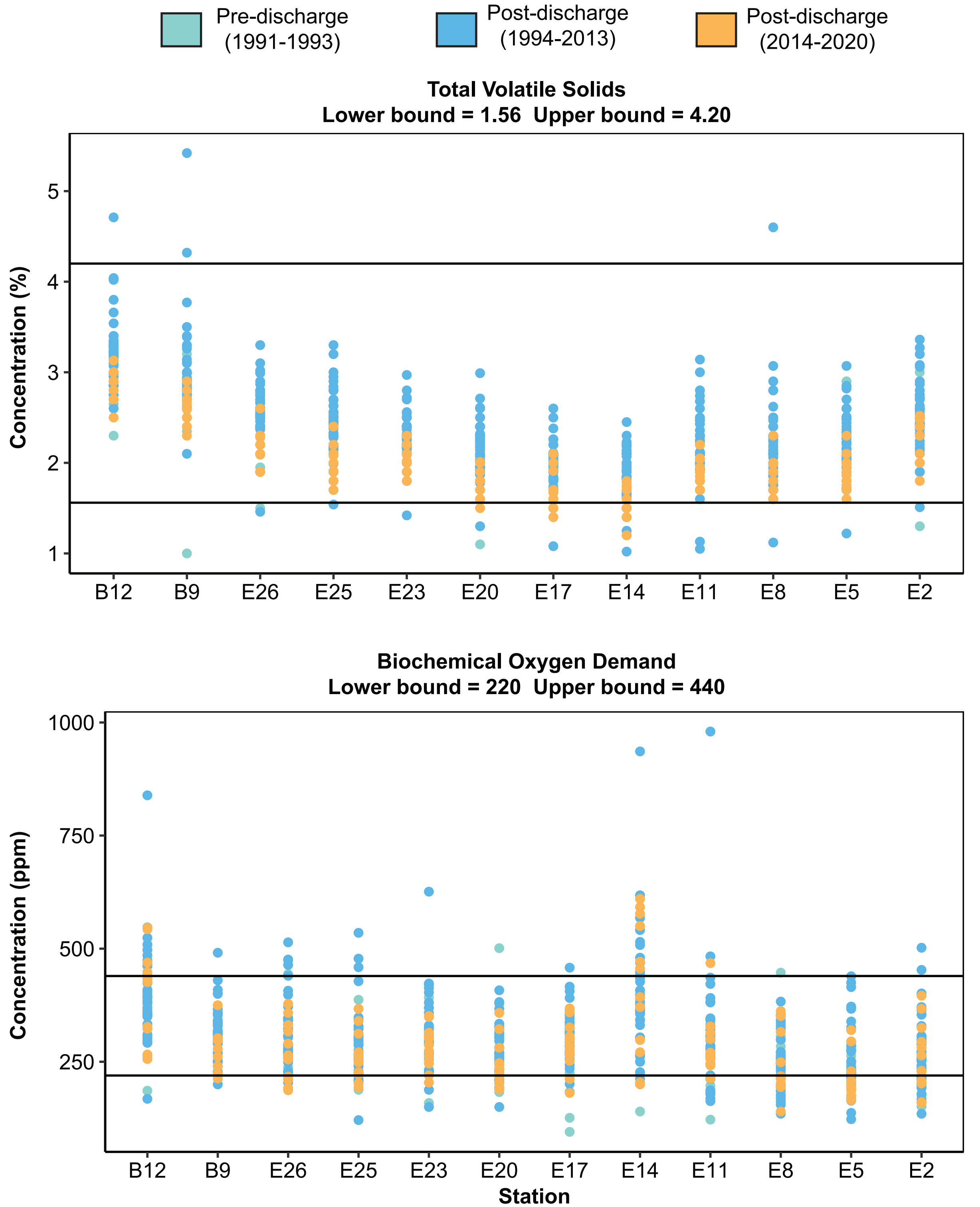



**FIGURE C2-3** *continued*

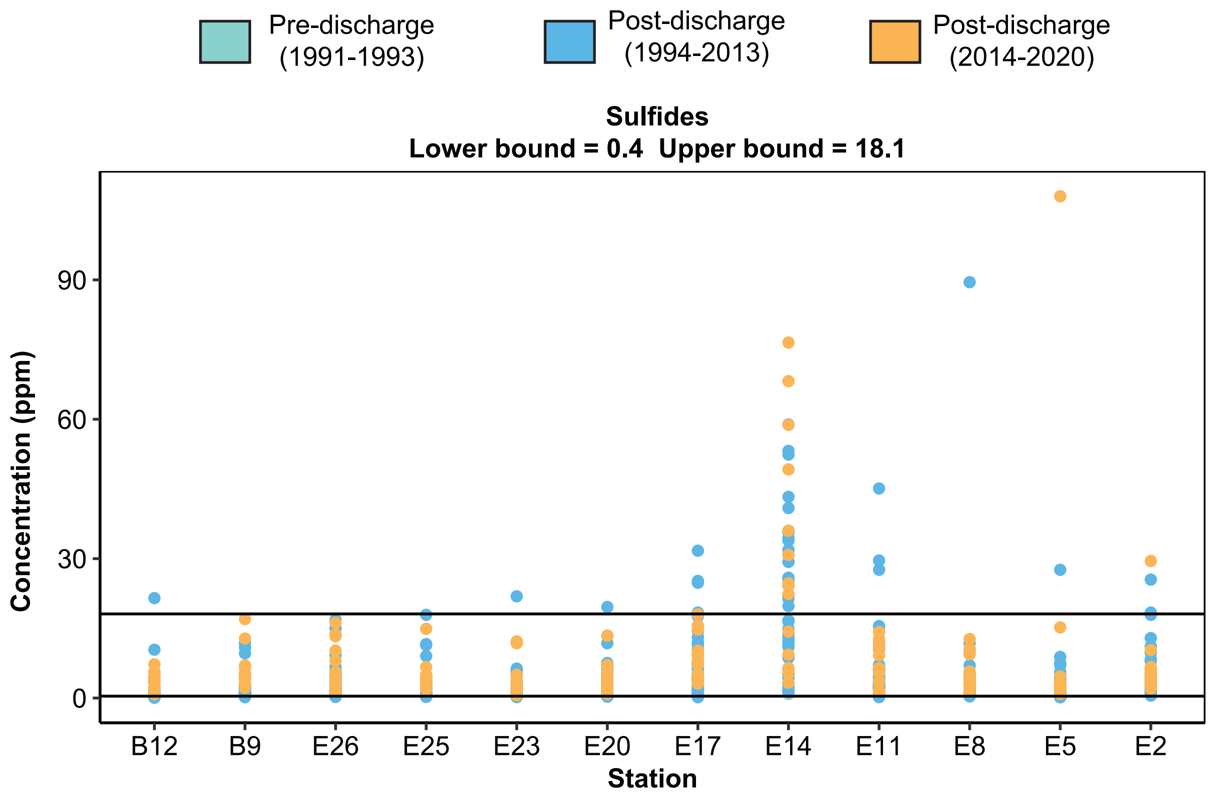



**FIGURE C2-3** *continued*

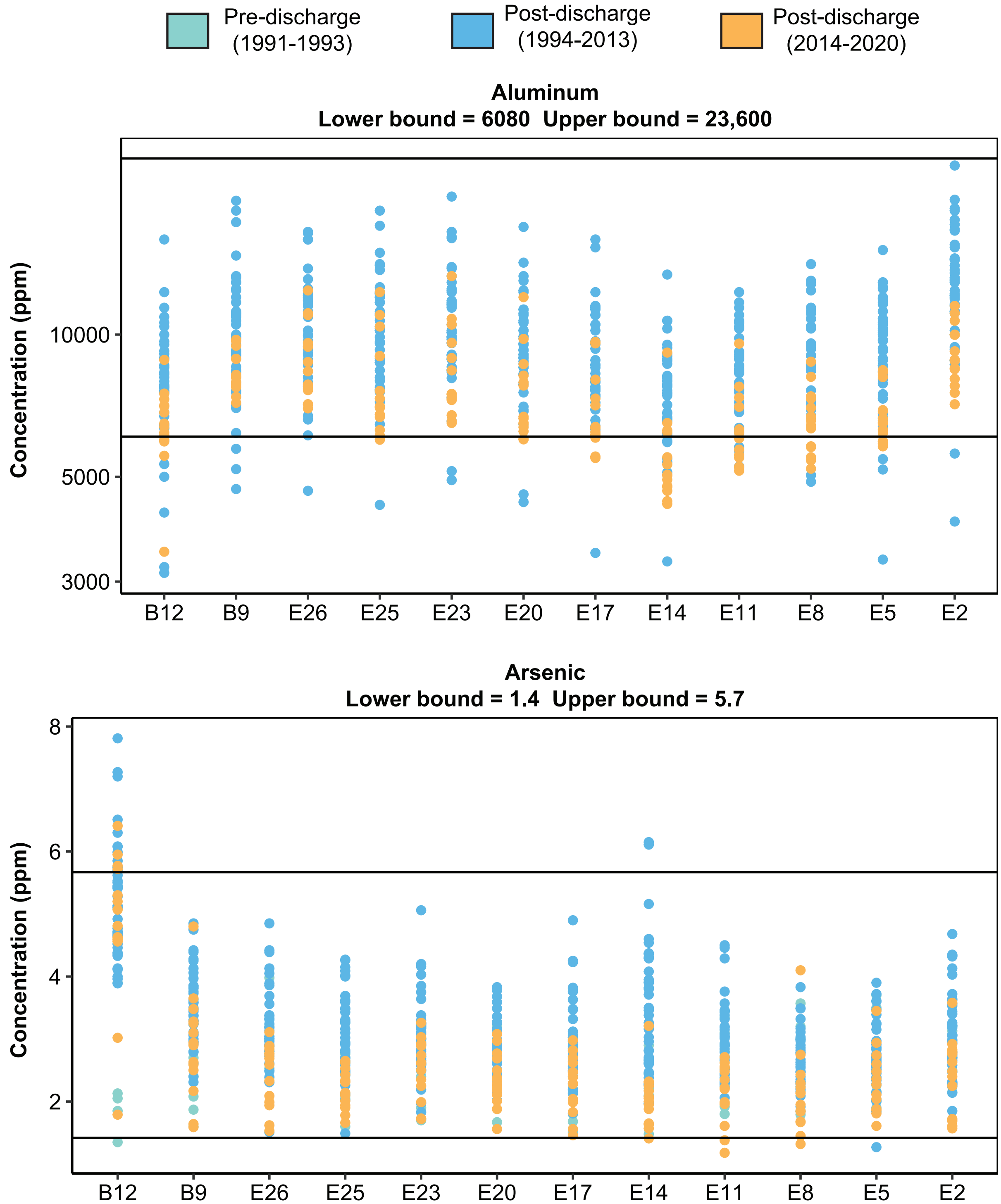



**FIGURE C2-4**

Metal concentrations in sediments from PLOO primary core monitoring stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Horizontal lines indicate lower and upper tolerance intervals calculated from cluster group A regional and special study samples collected 1994–2017 (see text).

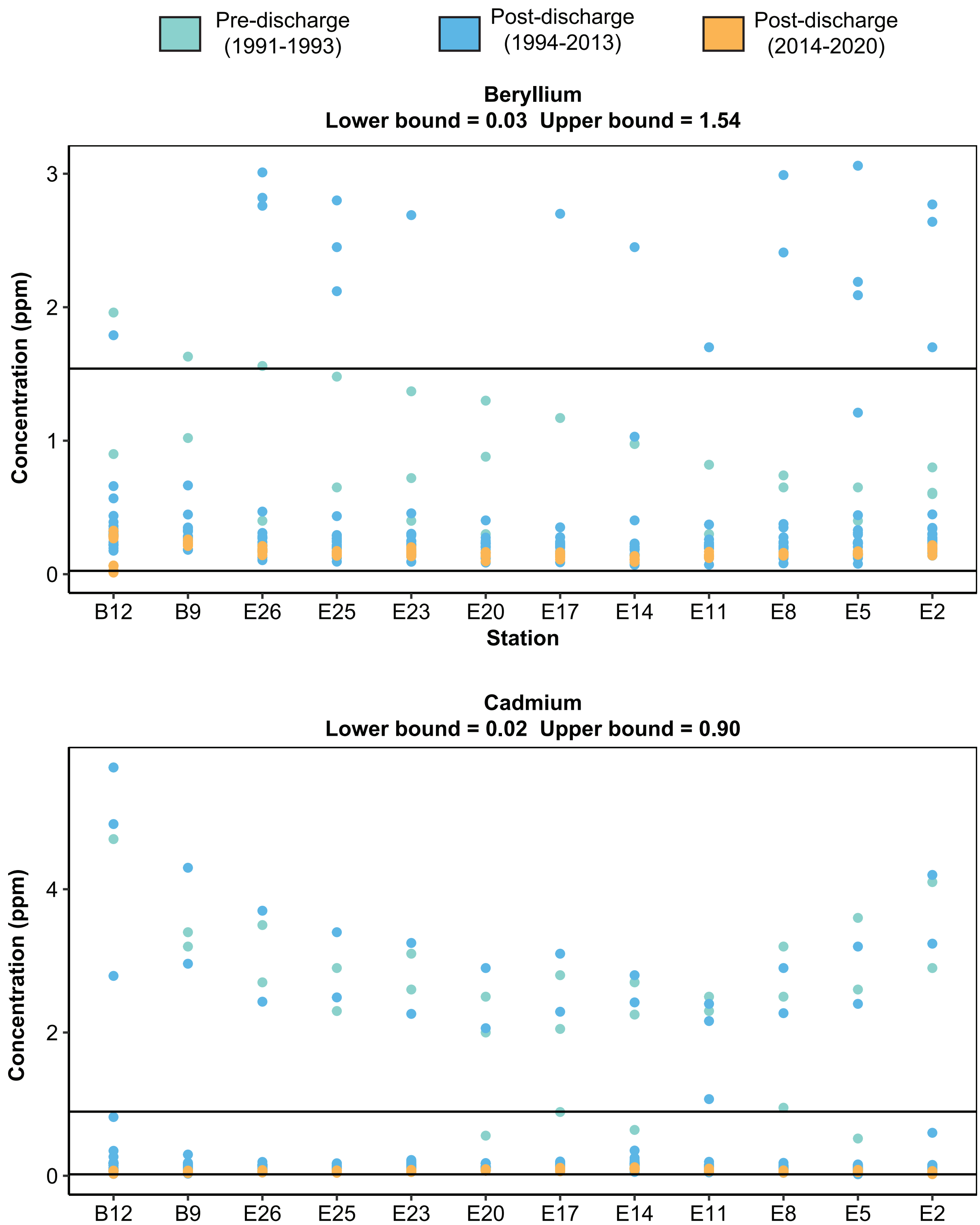



**FIGURE C2-4** *continued*

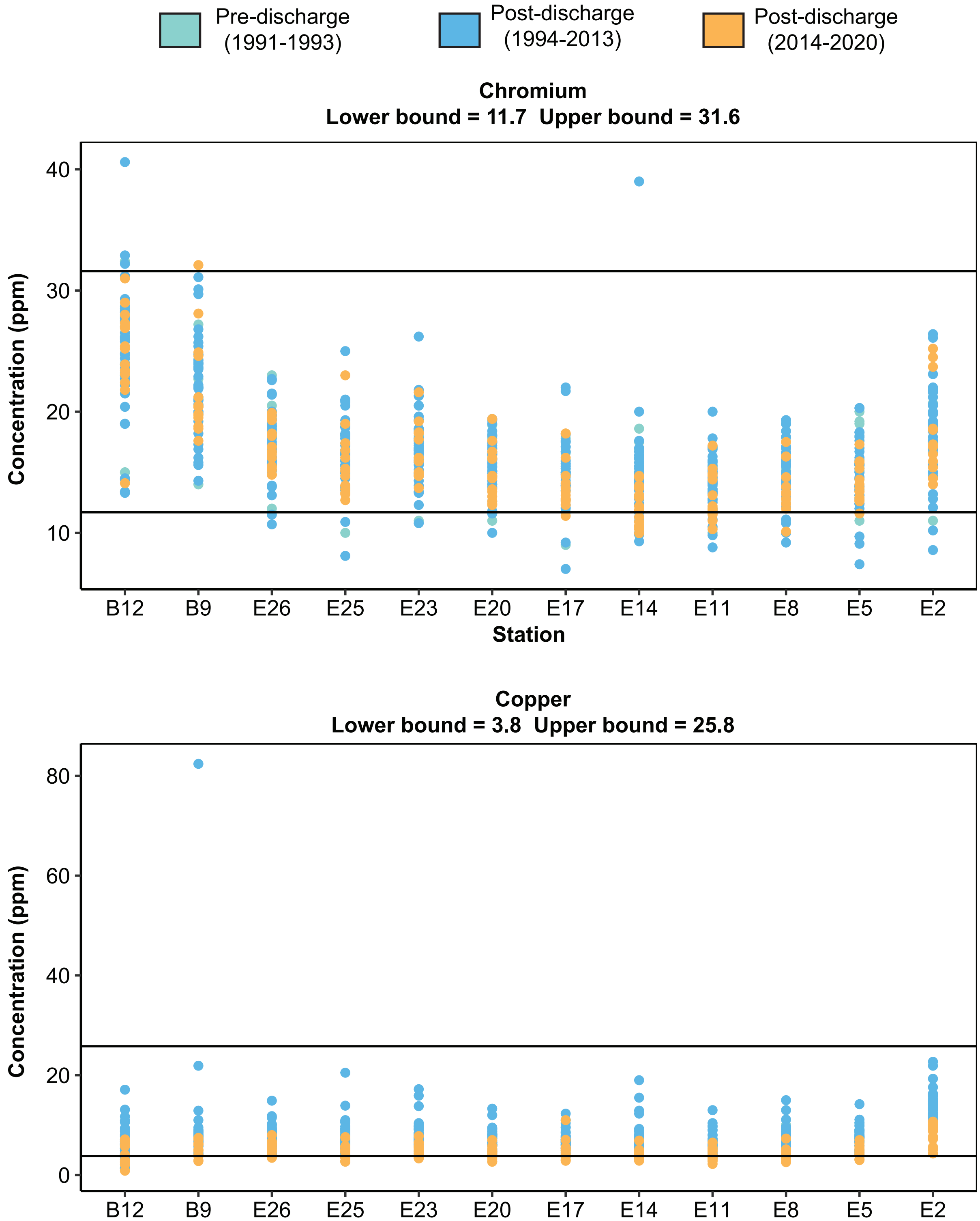



**FIGURE C2-4** *continued*

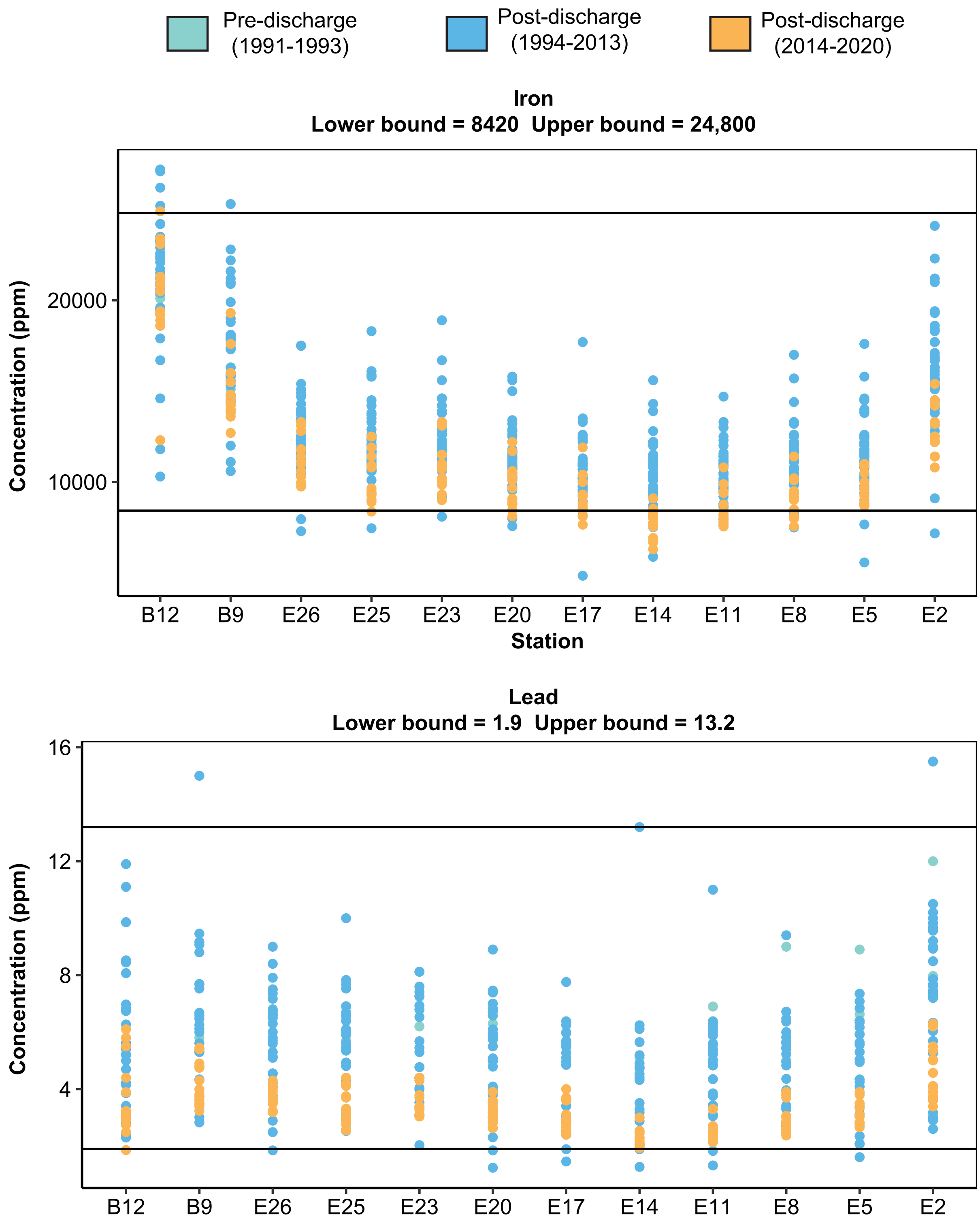



**FIGURE C2-4** *continued*

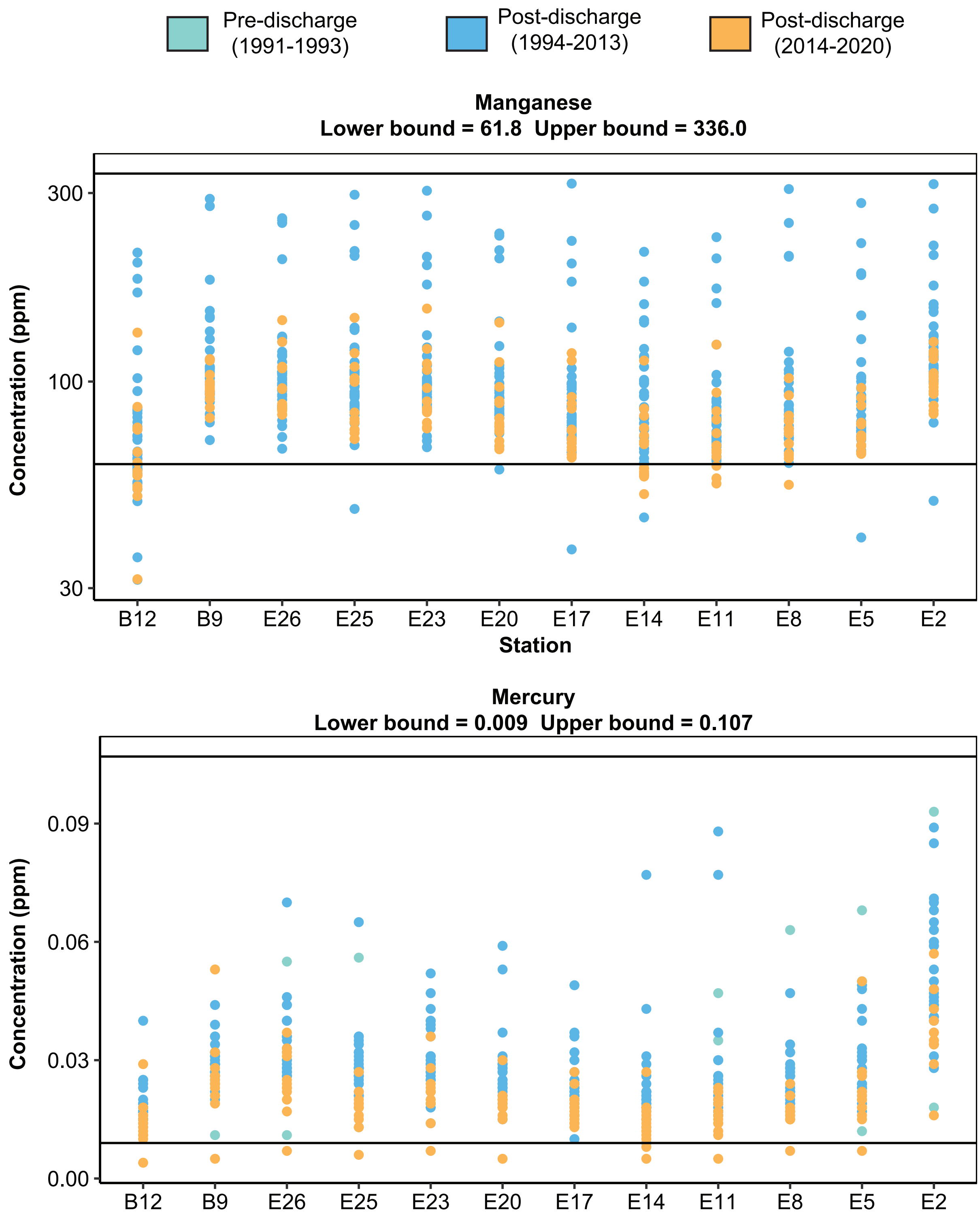



**FIGURE C2-4** *continued*

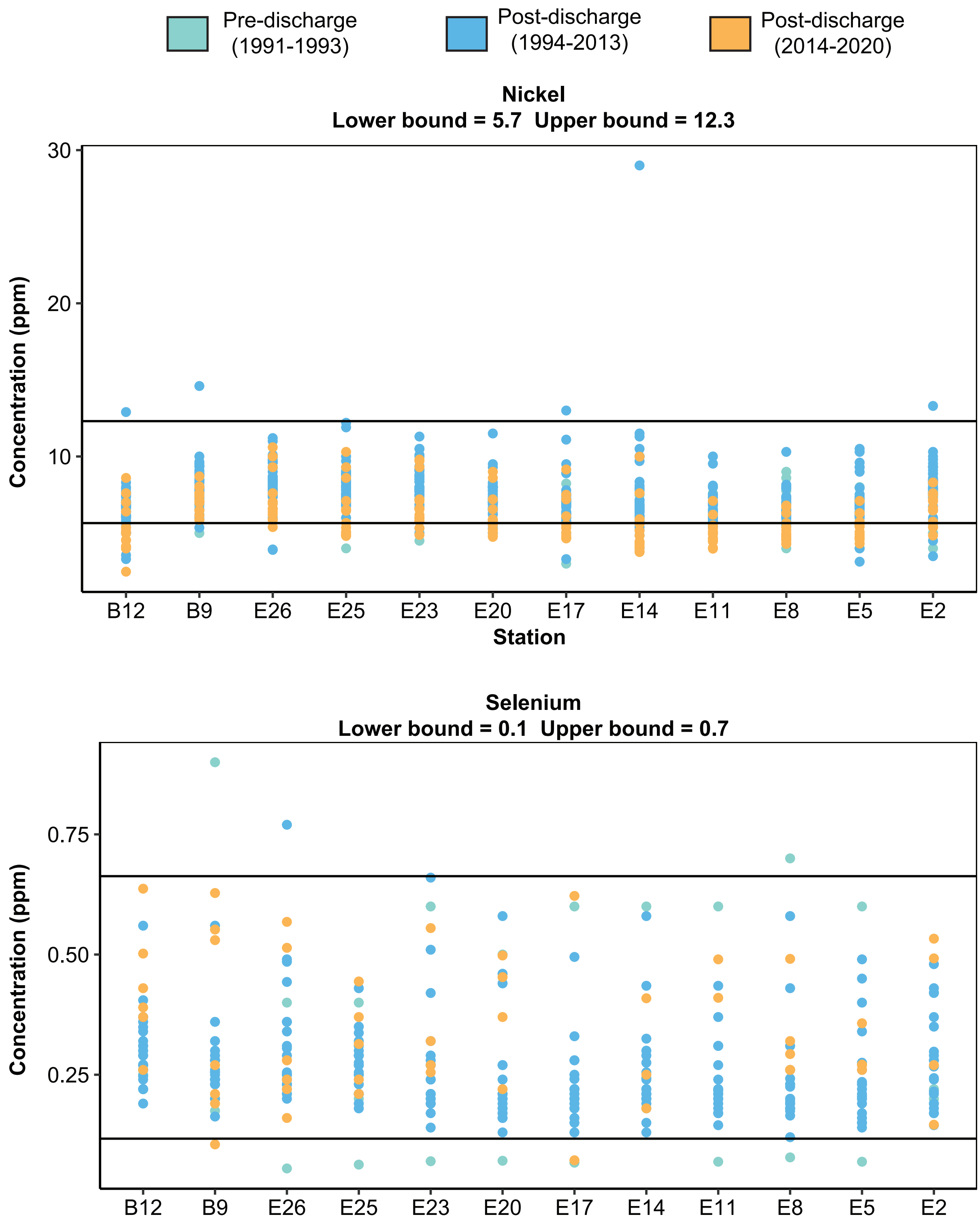



**FIGURE C2-4** *continued*

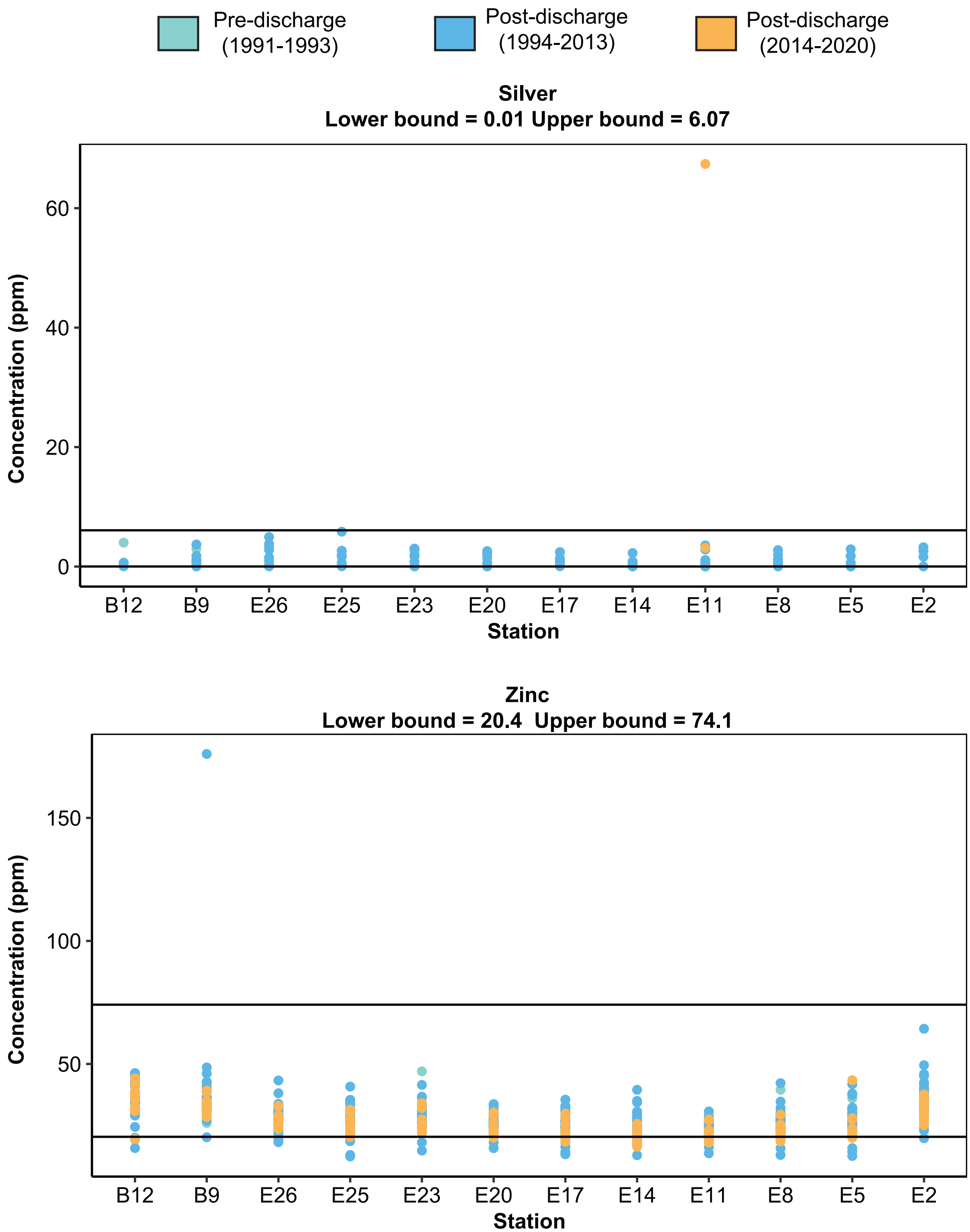



**FIGURE C2-4** *continued*

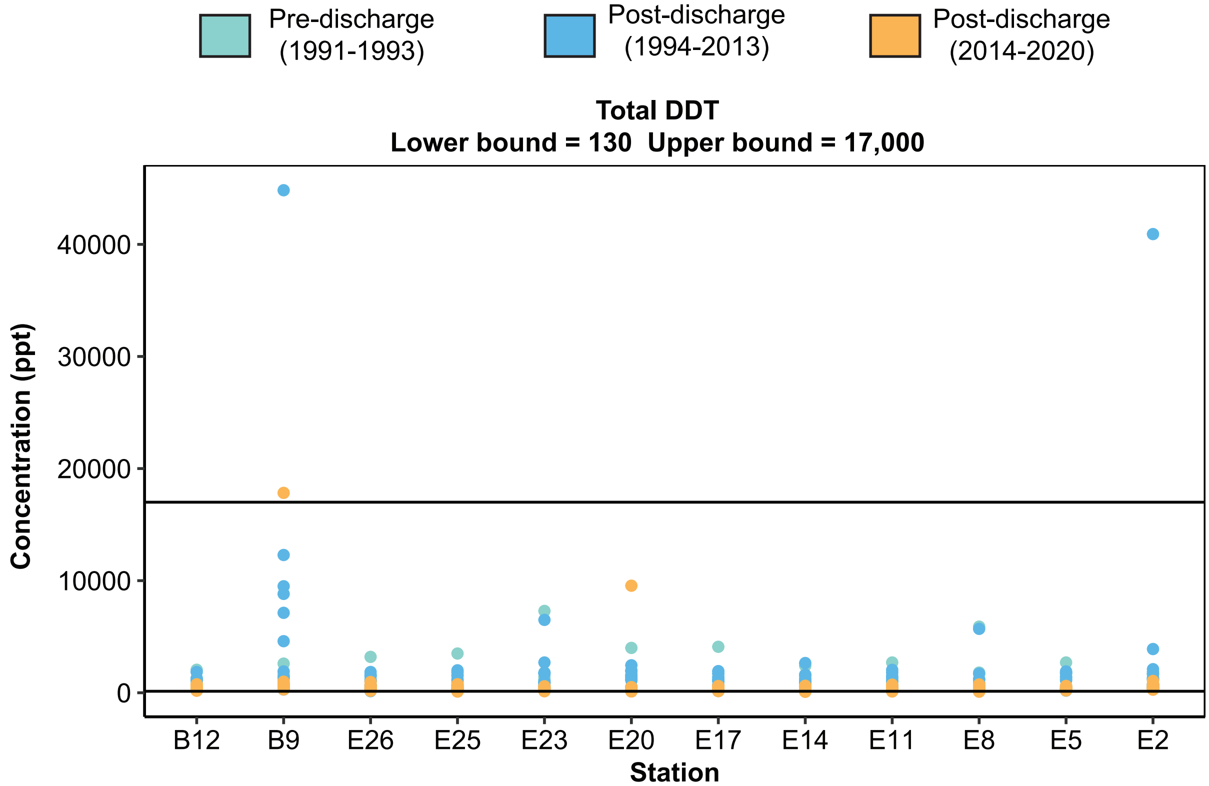



**FIGURE C2-5**
Total DDT in sediments from PLOO primary core monitoring stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Horizontal lines indicate lower and upper tolerance intervals calculated from cluster group A regional and special study samples collected 1994–2017 (see text).

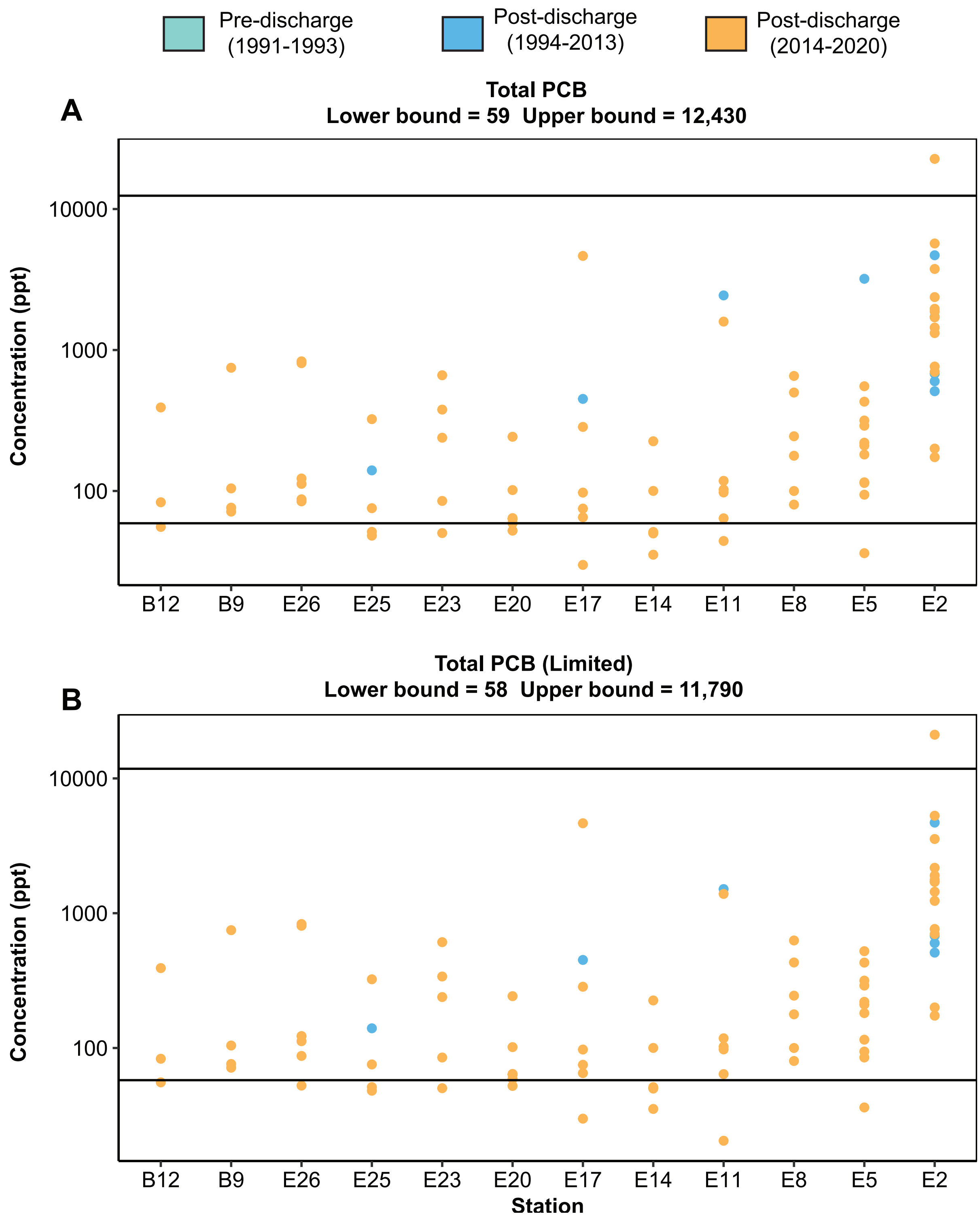



**FIGURE C2-6**

Total PCB with all detected congeners (A) and total PCB limited to congeners analyzed consistently over all years (B) (see Appendix C1) in sediments from PLOO primary core monitoring stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Horizontal lines indicate lower and upper tolerance intervals calculated from cluster group A regional and special study samples collected 1994–2017 (see text). PCBs were analyzed as arochlors prior to 1998.

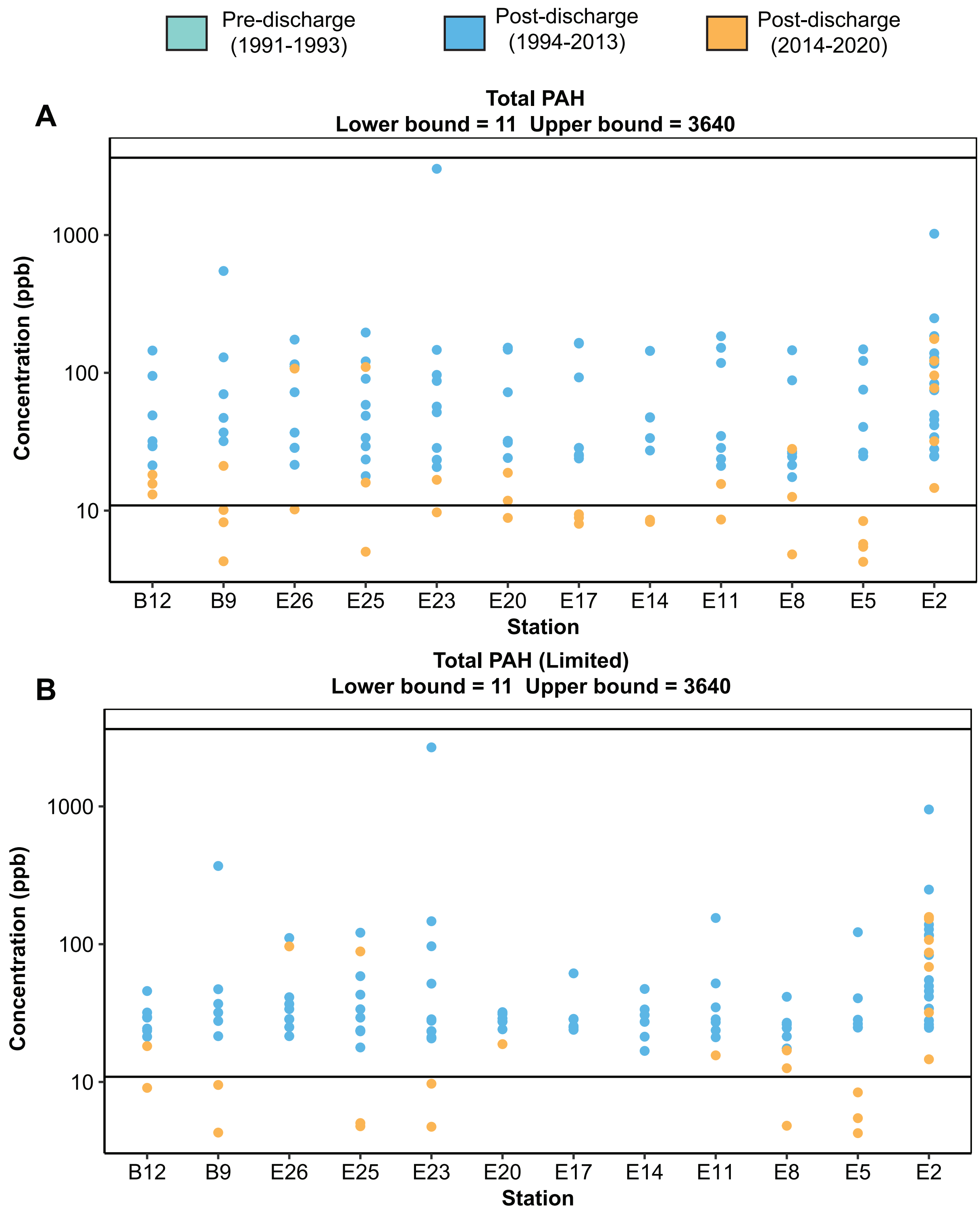



**FIGURE C2-7**
Total PAH with all detected constituents (A) and total PAH limited to constituents analyzed consistently over all years (B) (see Appendix C1) in sediments from PLOO primary core monitoring stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Horizontal lines indicate lower and upper tolerance intervals calculated from cluster group A regional and special study samples collected 1994–2017 (see text).

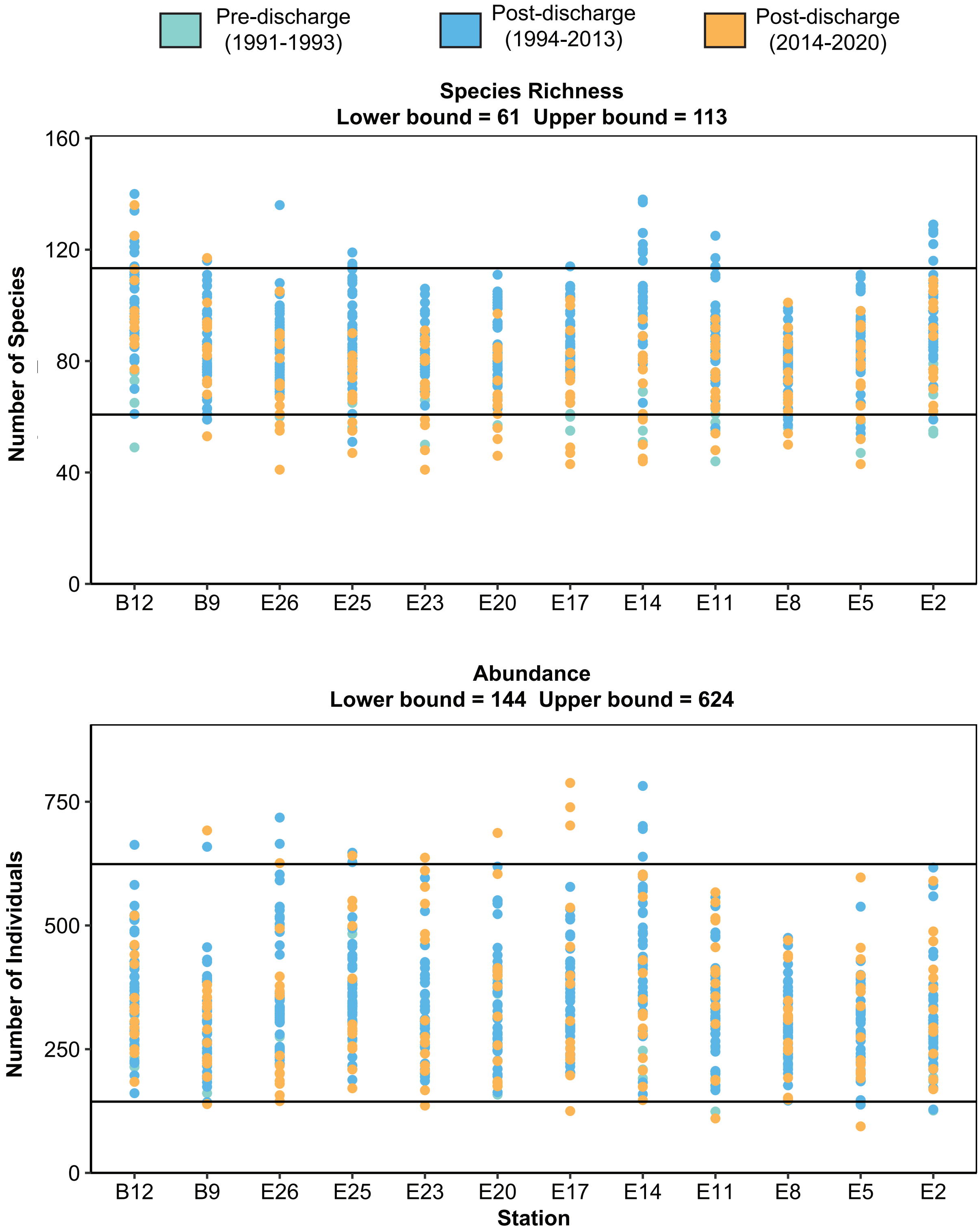



**FIGURE C2-8**
Biological Indicator values for PLOO primary core monitoring stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Horizontal lines indicate lower and upper tolerance intervals calculated from cluster group A regional and special study samples collected 1994–2017 (see text).

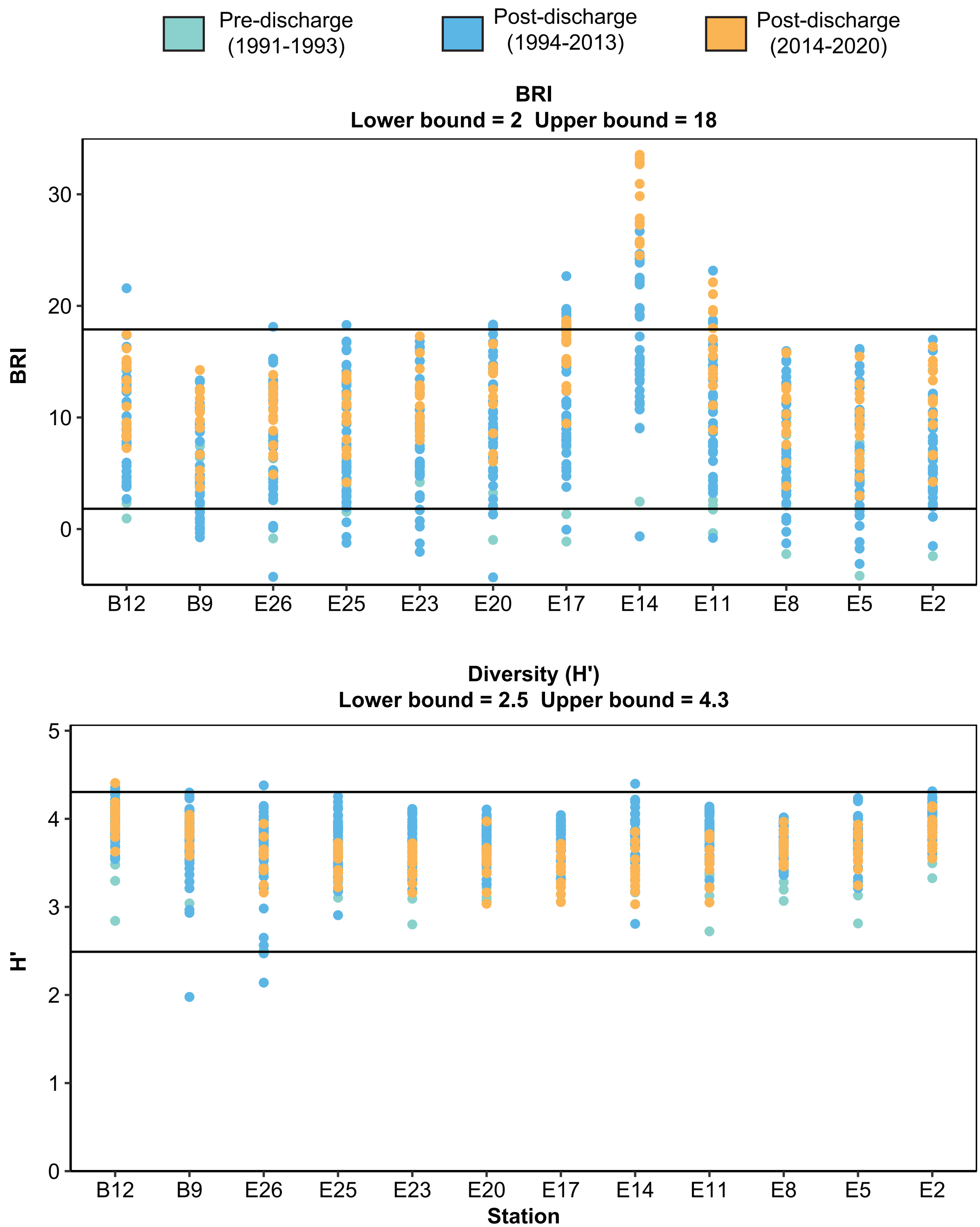



**FIGURE C2-8** *continued*

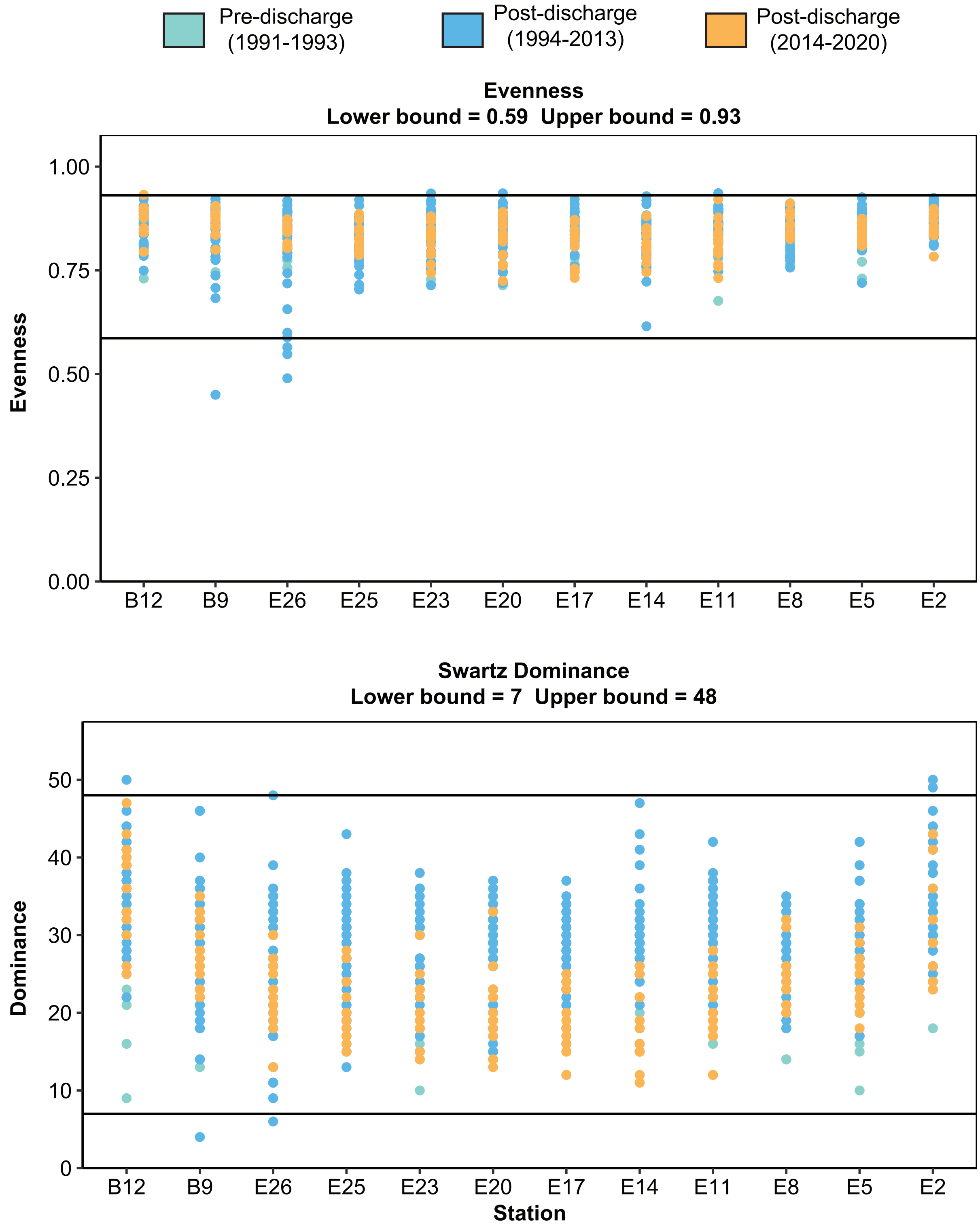



**FIGURE C2-8** *continued*

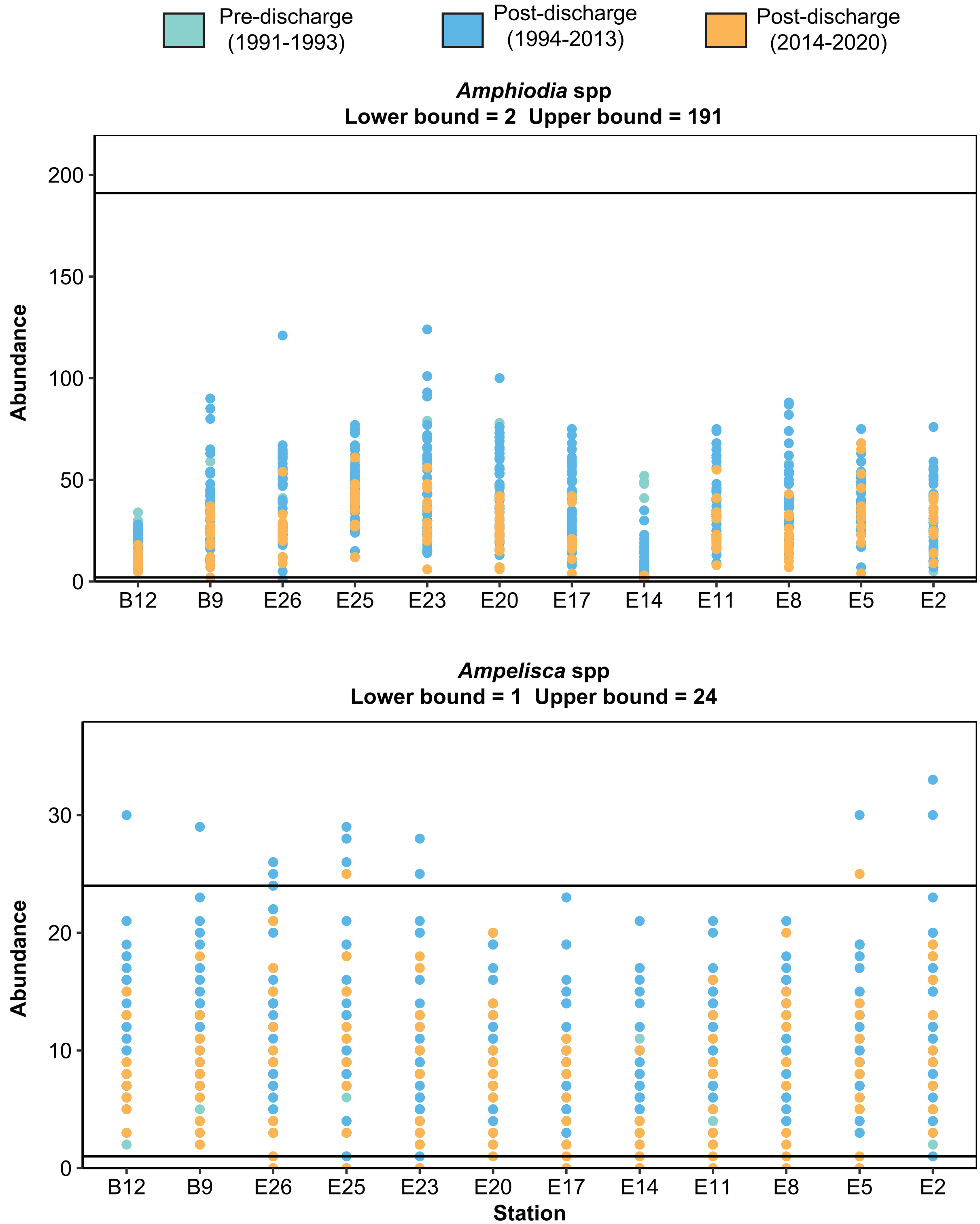



**FIGURE C2-8** *continued*

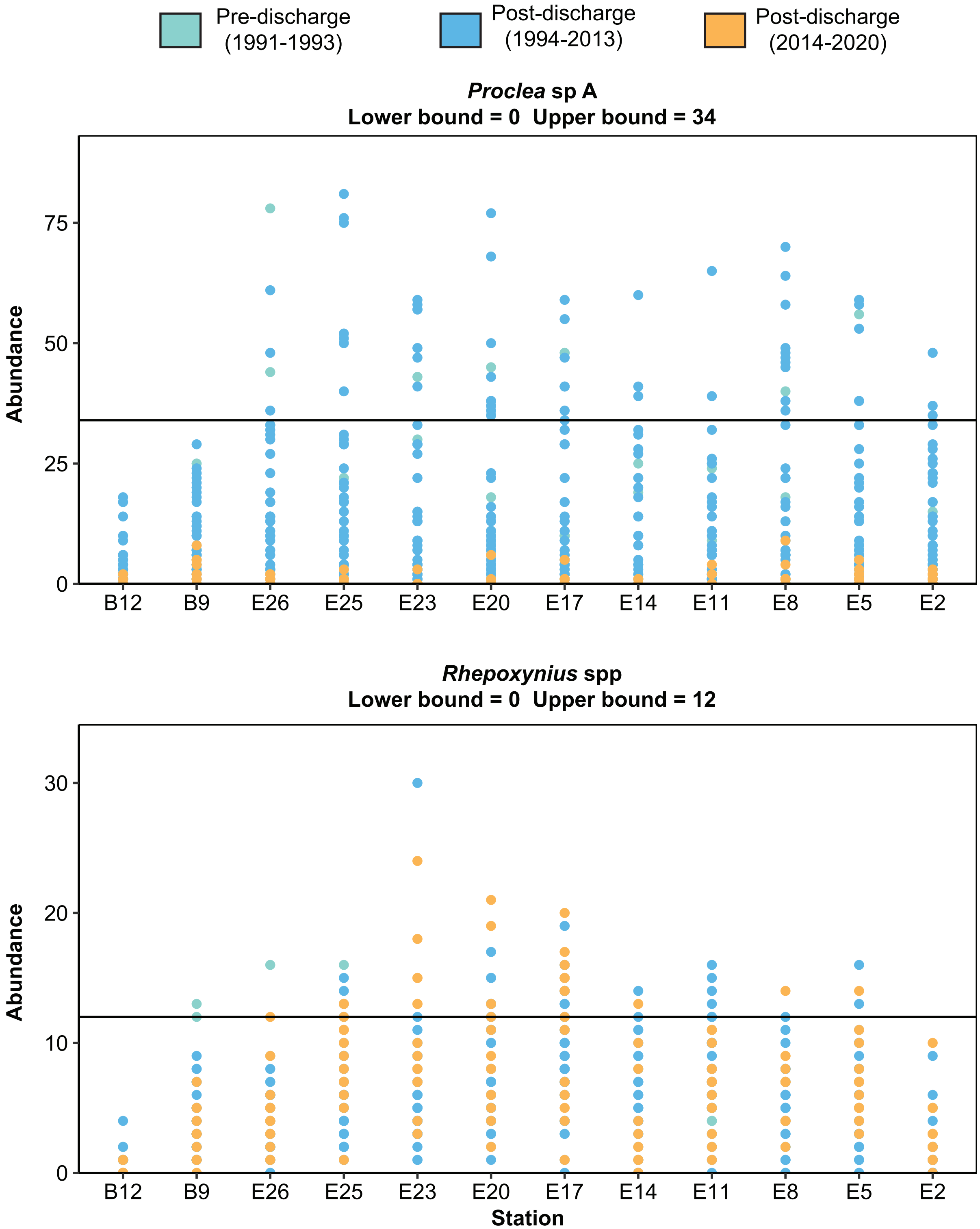



**FIGURE C2-8** *continued*

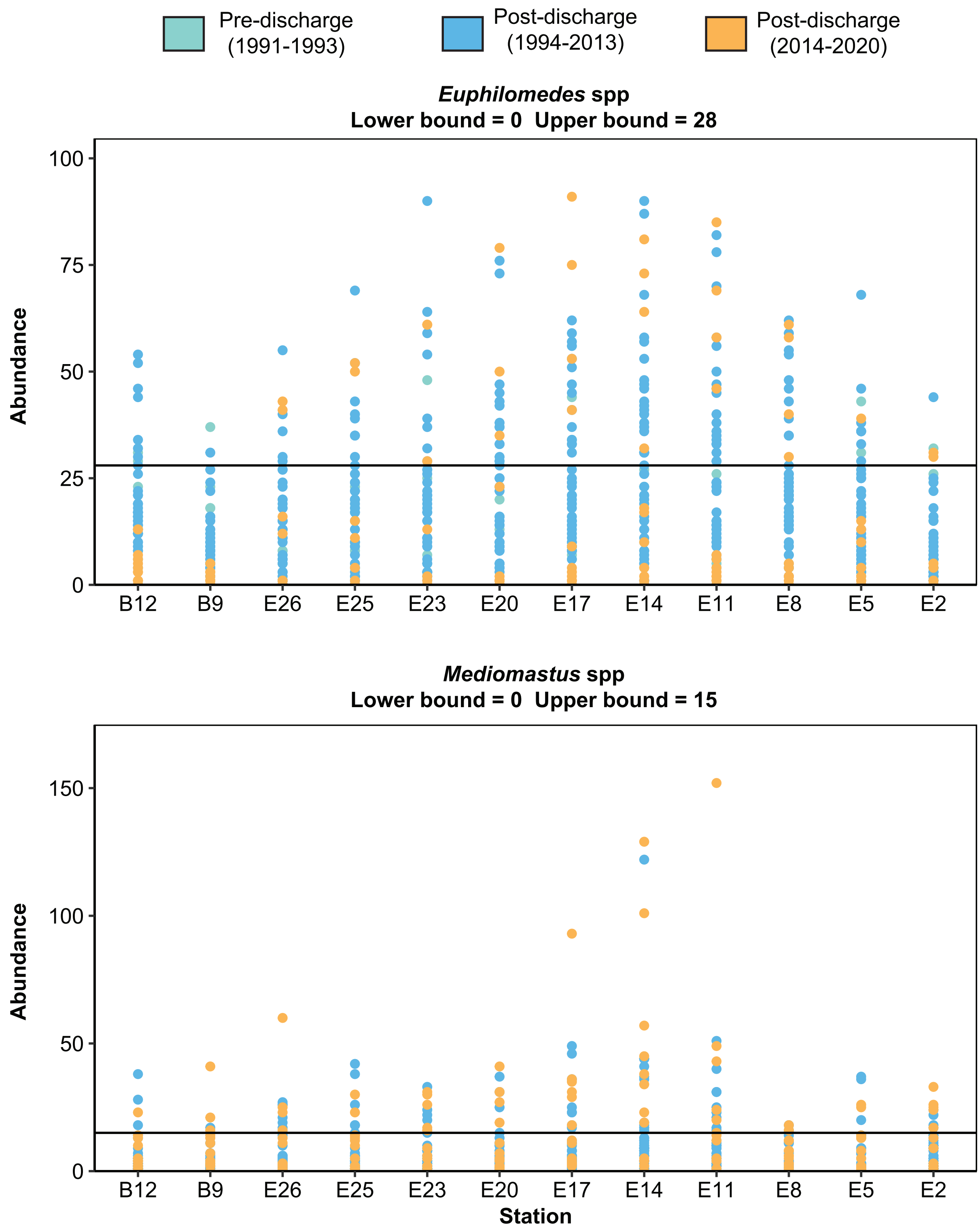



**FIGURE C2-8** *continued*

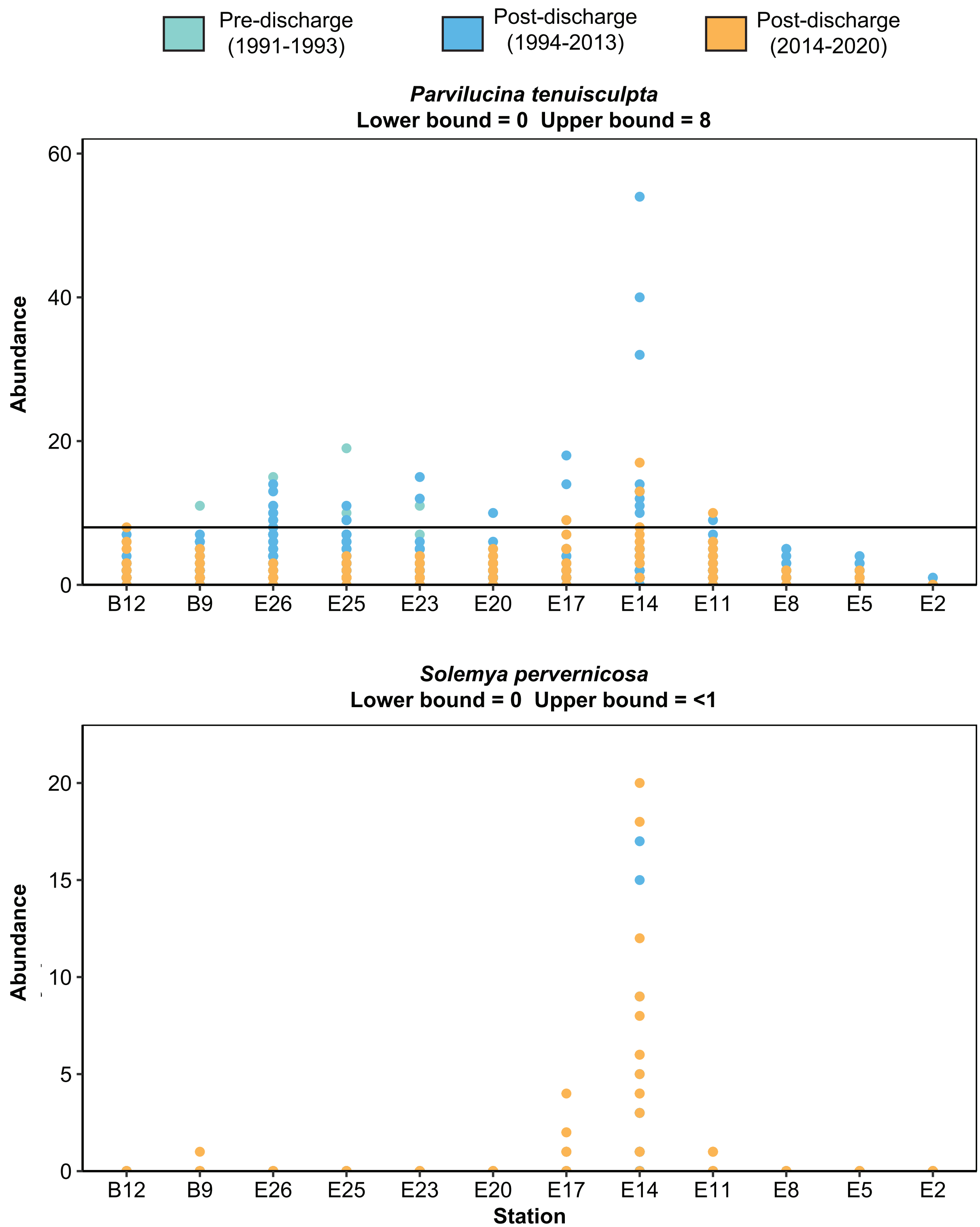



**FIGURE C2-8** *continued*

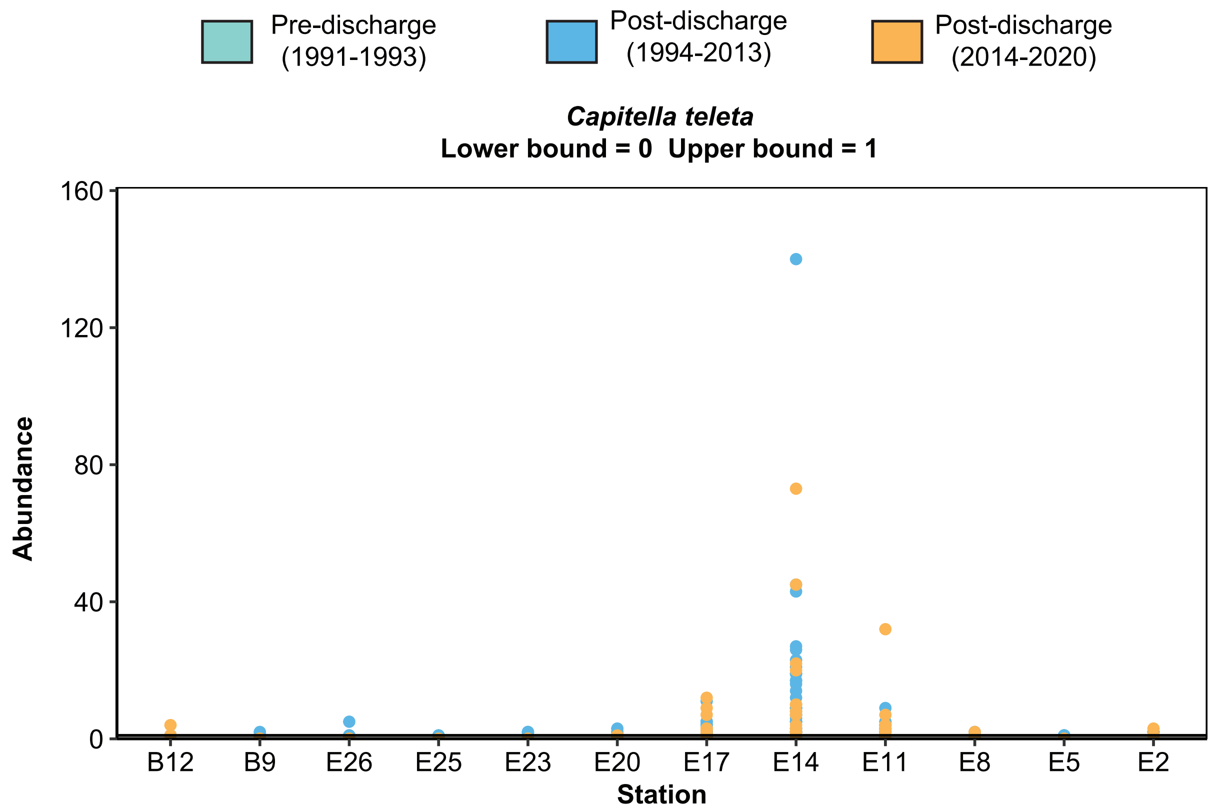



**FIGURE C2-8** *continued*

# APPENDIX C2

# ATTACHMENT A

# Deep Benthic Habitat Assessment Study

# ATTACHMENT C2.A

# Deep Benthic Habitat Assessment Study

## INTRODUCTION

The Scripps Institution of Oceanography (SIO) was hired by the City of San Diego (City) to assess the adequacy of the City's Ocean Monitoring Program in providing the data and scientific understanding necessary to answer relevant questions about the effects of the Point Loma Ocean Outfall on the marine environment off San Diego. This work, the Point Loma Outfall Project (PLOP), was performed by a team of SIO scientists who reviewed the City's existing monitoring efforts and capabilities and compared these to programs conducted elsewhere for similar ocean outfalls. The results of this scientific review were summarized in a peer-reviewed report (SIO 2004), which was submitted to the City in September 2004. This information was also conveyed to state and federal regulators and to other interested stakeholders, including the San Diego Regional Water Quality Control Board (SDRWQCB), the United States Environmental Protection Agency (USEPA), and local environmental organizations (i.e., Bay Council). The final PLOP report included a summary of major findings and a subsequent list of prioritized recommendations for enhanced environmental monitoring of the San Diego coastal region.

A primary recommendation of the PLOP report was that a special studies program should be developed and implemented to examine the need to extend the City's benthic monitoring program to additional areas where sediments may accumulate. It was also recommended that new target areas include deeper slope and submarine canyon habitats located further offshore of the Point Loma outfall, as well as the nearby LA-5 dredged materials disposal site (see Gardner et al. 1998). The Deep Benthic Pilot Study was designed to begin assessing the quality of deep benthic habitats that occur off Point Loma, San Diego, California. Specifically, the pilot study targeted sediment quality at depths greater than 200 meters (m) in the Loma Sea Valley located offshore of the regular Point Loma monitoring region. The general scope, direction and level of effort of the pilot study (e.g., sampling area, distribution and number of sites, biotic and abiotic parameters) were agreed upon during negotiations between the City, SIO, SDRWQCB, USEPA and Bay Council. The final study design, including the rationale for the specific location and selection of sampling sites, was developed collaboratively by representatives of the City and SIO (Stebbins and Parnell 2005) and a Phase 1 Summary Report for the San Diego Deep Benthic Pilot Study was included in the 301(h) modified permit application in 2007 (City of San Diego 2007).

The objective of the Deep Benthic Habitat Assessment Study, initially presented in the City's 301(h) modified permit application in 2015, was to build on the findings of the Deep Benthic Pilot Study by summarizing results from all stations sampled in deeper habitats along the upper slope (200–500 m) and lower slope (500-1000 m) as part of various surveys conducted from 2003 to 2005 and from 2007 to 2013 (see Appendix C.5, City of San Diego 2015). Subsequently, data from the Deep Benthic Habitat Assessment Study were incorporated as part of the San Diego Regional Benthic Condition Assessment Project. The first phase of this project involved analyzing 24 years (1994-2017) of benthic infauna and sediment particle size data from San Diego and Bight regional surveys, along with data from the initial phase of the *San Diego Sediment Mapping Study* (see Appendix C.4 of City of San Diego 2015). Results from this effort were used in this appendix to determine reference conditions for the PLOO core monitoring stations (see Section C2-3) and are presented in full in Parnell et al. (2021).

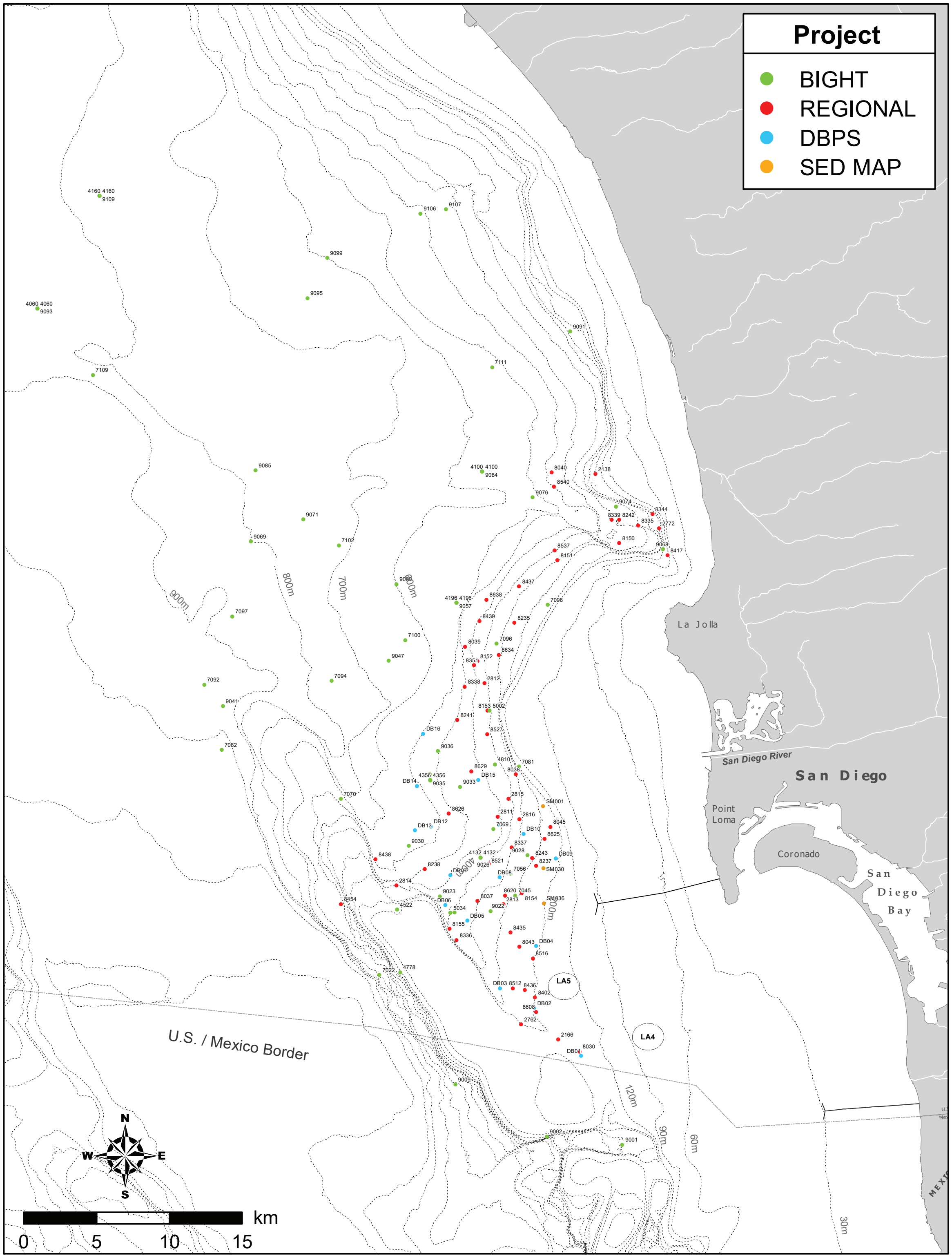
This attachment includes additional results from Parnell et al. (2021) focused just on benthic infauna communities located on the slope, as well as a brief summary of associated sediment particle size and sediment chemistry data, thus providing an update of the Deep Benthic Habitat Assessment Study through 2017. The area for this expanded study ranged from off Oceanside in northern San Diego County to just south of the US/Mexico border. One hundred and forty-one samples were collected from 135 sites ranging in depth from 199 to 1023 m during these 17 surveys (Attachments C2.A-1, C2.A-2). The majority of data come from the original pilot study conducted during 2005 (City of San Diego 2007) and three larger, multi-agency surveys of the entire Southern California Bight (SCB) conducted in 2003, 2008, and 2013 (Bight'13 CIA 2013, Ranasinghe et al. 2007, 2012). Additional data are from stations sampled during 12 San Diego "mini" regional surveys conducted in 2001-2002, 2006-2007, 2009-2012, and 2014-2017 (see Section C2-1), and the first phase of a special sediment mapping project conducted during 2004 (Stebbins et al. 2004). General methods for benthic sample collection and processing are included in Section C2-2; more specific details can be found in City of San Diego (2020) which is available online (City of San Diego 2021).

# SUMMARY

## Sediments

Sediment particle size and chemistry parameters are summarized across all deep benthic (slope) samples and by depth range in Attachment C2.A-3 and compared to shelf values in Attachment C2.A-4. Sediment composition averaged 76% fines, 22% fine sands, and only traces of medium-coarse sands or coarse particles (mean≤3% per sample). Detection rates were ≥99% for sulfides, total nitrogen (TN), total organic carbon (TOC), total volatile solids (TVS), aluminum, arsenic, barium, chromium, copper, iron, lead, manganese, mercury, nickel, tin, and zinc, while rates for antimony, beryllium, cadmium, selenium, total DDT, and total PAH ranged from 38 to 94% and rates for silver, thallium, and total PCB were ≤21% (Attachment C2.A-3).

Overall, concentrations of the various parameters were variable with very few exceedances of available Effects Range Low (ERL) and Effects Range Medium (ERM) thresholds (see Long et al. 1995). For example, lead, zinc and total PAH never exceeded their ERL or ERM, while exceedances for arsenic, cadmium, chromium, mercury, and total DDT were rare (i.e., ≤3% of




**ATTACHMENT C2.A-1**
Distribution of benthic stations included in the Deep Benthic Habitat Assessment Study. BIGHT = Southern California Bight surveys, REGIONAL = San Diego "mini" regional surveys, DBPS = Deep Benthic Pilot Study, SED MAP = San Diego Sediment Mapping Study Phase I.

**ATTACHMENT C2.A-2**
Summary by project for slope stations included in the Deep Benthic Habitat Assessment Study.

| | | | Depth (m) | |
|---|---|---|---|---|
| Year | Project | No. of Stations | Min | Max |
| 2001 | San Diego Regional Survey | 1 | 201 | 201 |
| 2002 | San Diego Regional Survey | 1 | 202 | 202 |
| 2003 | Southern California Bight Survey (Bight'03) | 11 | 252 | 850 |
| 2004 | Sediment Mapping Study Phase 1 | 3 | 203 | 224 |
| 2005 | Deep Benthic Pilot Study | 16 | 199 | 542 |
| 2006 | San Diego Regional Survey | 1 | 199 | 199 |
| 2007 | San Diego Regional Survey | 1 | 216 | 216 |
| 2008 | Southern California Bight Survey (Bight'08) | 23 | 203 | 1023 |
| 2009 | San Diego Regional Survey | 6 | 257 | 413 |
| 2010 | San Diego Regional Survey | 7 | 203 | 433 |
| 2011 | San Diego Regional Survey | 6 | 249 | 427 |
| 2012 | San Diego Regional Survey | 6 | 247 | 448 |
| 2013 | Southern California Bight Survey (Bight'13) | 31 | 244 | 942 |
| 2014 | San Diego Regional Survey | 7 | 208 | 449 |
| 2015 | San Diego Regional Survey | 8 | 199 | 530 |
| 2016 | San Diego Regional Survey | 6 | 200 | 437 |
| 2017 | San Diego Regional Survey | 7 | 205 | 469 |

the samples included in this study). Copper exceeded its ERL in 6% of the slope samples. Silver exceeded its ERL in 15% and 11% of all slope samples, respectively. Nickel exceeded its ERL and its ERM in 50% and 1% of all slope samples, respectively.

In this study, the mean proportion of fine particles was higher on the slope than the shelf (Attachment C2.A-4) and increased with increasing depth down the slope (Attachment C2.A-3). This trend was mirrored by sediment concentrations of TOC, TVS, TN, sulfides (upper slope only), aluminum, arsenic (upper slope only), barium, beryllium, cadmium, chromium, copper, iron, manganese, mercury (upper slope only), nickel, selenium, and zinc. The association between sediment particle size and the concentration of organics and trace metals is expected (see Eganhouse and Venkatesan 1993) and has been observed regionally off San Diego previously (e.g., City of San Diego 2013). In contrast, the highest mean concentrations of total DDT and total PCB were found on the middle shelf and inner shelf, respectively. Over the years, when sediment chemistry data from slope stations have been plotted with results from other regional and PLOO core benthic stations, no clear patterns relative to proximity to the Point Loma Ocean Outfall were observed (e.g., City of San Diego 2018, 2020).

## Benthic Infauna

As described in Section C2-3, cluster analysis and ordination of macrofauna data from 1,027 0.1-$m^2$ grab samples collected from 1994 through 2017 discriminated between 14 habitat-related benthic infauna assemblages off San Diego (cluster groups A–N in Figure C2-1, Tables C2-1, C2-2; Attachments C2.A-5; from Parnell et al. 2021). These groups were stratified along depth contours and sediment types associated with variations in seafloor topography, with very little temporal partitioning evident, and displayed no spatial patterns relative to point source inputs (Figure C2-1)., Eight of the 14 cluster groups were largely representative of assemblages found at shallower depths (mean depths ≤214 m) on the continental shelf (i.e., “shallow” clusters, groups A–H), while six were representative of assemblages found at deeper depths (mean depths ≥359 m) on the continental slope (i.e., “deep” clusters, groups I–N). Of the 141 Deep Benthic Habitat Assessment Study samples (i.e., with station depths ≥199 m) included in the analysis, assemblages from two grabs clustered with the main shelf group (cluster group A), 52 clustered with the shelf-break group (cluster group C), and 86 clustered into groups I–N. The species composition and main descriptive characteristics of cluster groups C, and I–N are described below.

Cluster group C comprised 108 grabs, including 6 from the mid-shelf, 53 from the outer shelf, and 49 from the upper slope. This cluster represented transitional assemblages located along the Continental shelf break, with higher species richness (mean=61 species per grab) and abundance (mean=211 individuals per grab) than groups I–N (overall mean=25 species and 63 individuals per grab). According to SIMPER, the five most characteristic species of group C were the spionid polychaetes *Spiophanes kimballi* and *Paraprionospio alata*, the capitellid polychaete *Mediomastus* sp, the maldanid polychaete *Maldane sarsi*, and the bivalve *Tellina carpenteri*. The sediments associated with these assemblages were also transitional, having proportions of fine particles (mean=60%) between the mid-shelf, “mud-belt” cluster (group A, mean=47%) and the “deep” clusters (groups I–N; overall mean=84%).

**ATTACHMENT C2.A-3**

Summary of particle sizes and chemistry concentrations in sediments from slope stations included in the Deep Benthic Habitat Assessment Study. Data include total number of samples (n), detection rate (DR), minimum, maximum, and mean detected values for all stations combined.

| | Slope | | | | | Depth (m) | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **n** | **DR** | **Min** | **Max** | **Mean** | **200-299** | **300-399** | **400-499** | **500+** |
| ***Particle Size (%)*** | | | | | | | | | |
| Fine Particles | 141 | 100 | 25 | 96 | 76 | 67 | 73 | 78 | 87 |
| Fine Sands | 141 | 100 | 4 | 72 | 22 | 31 | 25 | 20 | 12 |
| Med-Coarse Sands | 141 | 93 | 0 | 34 | 2 | 2 | 3 | 2 | 1 |
| Coarse Particles | 141 | 4 | 0 | 7 | 3 | 3 | 7 | 0 | 1 |
| ***Organic Indicators*** | | | | | | | | | |
| TotalOrganicCarbon | 141 | 100 | 0.16 | 5.30 | 2.30 | 1.79 | 1.91 | 2.20 | 3.31 |
| TotalVolatileSolids | 107 | 100 | 3.06 | 14.10 | 7.27 | 6.03 | 7.07 | 7.29 | 9.82 |
| TotalNitrogen | 141 | 100 | 0.01 | 0.50 | 0.20 | 0.14 | 0.16 | 0.18 | 0.31 |
| Sulfides | 73 | 99 | 0.0 | 444.0 | 31.8 | 21.5 | 44.0 | 39.6 | 7.5 |
| ***Metals (ppm)*** | | | | | | | | | |
| Aluminum | 141 | 100 | 4540 | 53700 | 23502 | 19535 | 20778 | 22859 | 31049 |
| Antimony | 141 | 75 | nd | 3.2 | 1.5 | 1.3 | 1.7 | 1.8 | 1.2 |
| Arsenic | 141 | 100 | 0.6 | 10.5 | 3.6 | 3.4 | 3.9 | 3.9 | 3.3 |
| Barium | 139 | 100 | 18.1 | 503.0 | 128.5 | 74.0 | 90.8 | 112.9 | 234.6 |
| Beryllium | 141 | 63 | nd | 1.7 | 0.4 | 0.3 | 0.4 | 0.5 | 0.5 |
| Cadmium | 141 | 94 | nd | 2.1 | 0.4 | 0.3 | 0.3 | 0.5 | 0.6 |
| Chromium | 141 | 100 | 12.5 | 98.2 | 41.1 | 33.2 | 36.8 | 44.0 | 52.0 |
| Copper | 141 | 100 | 5.0 | 51.3 | 21.4 | 17.5 | 18.8 | 19.5 | 29.7 |
| Iron | 141 | 100 | 9310 | 49900 | 23426 | 20495 | 21289 | 23626 | 28627 |
| Lead | 141 | 100 | 1.4 | 30.1 | 9.5 | 8.3 | 8.1 | 8.6 | 12.7 |
| Manganese | 140 | 100 | 28.1 | 394.0 | 201.7 | 182.2 | 180.4 | 195.2 | 250.3 |
| Mercury | 140 | 99 | nd | 0.425 | 0.060 | 0.067 | 0.064 | 0.052 | 0.055 |
| Nickel | 141 | 100 | 5.0 | 53.8 | 22.7 | 16.7 | 18.9 | 21.7 | 33.8 |
| Selenium | 141 | 87 | nd | 4.1 | 1.1 | 0.6 | 0.8 | 1.1 | 2.2 |
| Silver | 141 | 21 | nd | 7.0 | 3.3 | 1.6 | 1.9 | 3.5 | 4.1 |
| Thallium | 141 | 4 | nd | 0.9 | 0.6 | 0.7 | 0.5 | 0.7 | 0.2 |
| Tin | 140 | 99 | nd | 5.1 | 1.6 | 1.5 | 1.5 | 1.5 | 1.8 |
| Zinc | 141 | 100 | 16.9 | 138.0 | 61.9 | 49.4 | 54.8 | 62.3 | 82.3 |
| ***Total DDT (ppt)*** | 139 | 46 | n | 2051 | 681 | 579 | 783 | 712 | 699 |
| ***Total PCB (ppt)*** | 141 | 13 | n | 9858 | 1593 | 2203 | 865 | 369 | 1895 |
| ***Total PAH (ppb)*** | 117 | 38 | n | 457 | 115 | 75 | 146 | 96 | 172 |

**ATTACHMENT C2.A-4**

Summary of particle sizes and chemistry concentrations in sediments from 1,027 regional and special study samples collected off San Diego from 1994 through 2017. Data include total number of samples (n), detection rate (DR), minimum, maximum, and mean detected values by strata; nd = not detected.

| | Inner Shelf (n≤222) | | | | Middle Shelf (n≤521) | | | | Outer Shelf (n≤147) | | | | Upper Slope (n≤100) | | | | Lower Slope (n≤37) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **DR** | **Min** | **Max** | **Mean** | **DR** | **Min** | **Max** | **Mean** | **DR** | **Min** | **Max** | **Mean** | **DR** | **Min** | **Max** | **Mean** | **DR** | **Min** | **Max** | **Mean** |
| ***Particle Size (%)*** | | | | | | | | | | | | | | | | | | | | |
| FineParticles | 97 | 0 | 56 | 13 | 97 | 0 | 83 | 38 | 99 | 0 | 78 | 42 | 100 | 25 | 96 | 72 | 100 | 35 | 96 | 87 |
| FineSands | 99 | 0 | 99 | 72 | 100 | 0 | 92 | 45 | 100 | 0 | 68 | 39 | 100 | 4 | 72 | 26 | 100 | 4 | 31 | 12 |
| MedCoarseSands | 100 | 0 | 92 | 14 | 94 | 0 | 98 | 17 | 94 | 0 | 100 | 19 | 95 | 0 | 25 | 2 | 86 | 0 | 34 | 1 |
| CoarseParticles | 23 | 0 | 70 | 9 | 31 | 0 | 58 | 7 | 33 | 0 | 26 | 5 | 4 | 0 | 7 | 4 | 3 | 0 | 1 | 1 |
| ***Organic Indicators*** | | | | | | | | | | | | | | | | | | | | |
| TotalOrganicCarbon (%) | 98 | 0.00 | 3.24 | 0.21 | 100 | 0.00 | 4.55 | 0.59 | 99 | 0.00 | 9.02 | 1.55 | 100 | 0.16 | 3.55 | 1.95 | 100 | 0.44 | 5.30 | 3.31 |
| TotalVolatileSolids (%) | 100 | 0.40 | 38.50 | 1.19 | 100 | 0.29 | 8.62 | 2.32 | 100 | 1.15 | 6.85 | 3.54 | 100 | 3.06 | 9.39 | 6.77 | 100 | 3.51 | 14.10 | 9.82 |
| TotalNitrogen (%) | 94 | 0.00 | 0.17 | 0.02 | 99 | 0.00 | 0.27 | 0.05 | 99 | 0.00 | 0.23 | 0.08 | 100 | 0.01 | 0.32 | 0.16 | 100 | 0.05 | 0.50 | 0.31 |
| Sulfides (ppm) | 94 | 0.0 | 85.2 | 4.8 | 97 | 0.0 | 272.0 | 5.9 | 100 | 0.1 | 97.7 | 8.2 | 98 | 0.0 | 444.0 | 34.7 | 100 | 3.2 | 18.2 | 7.5 |
| ***Metals (ppm)*** | | | | | | | | | | | | | | | | | | | | |
| Aluminum | 100 | 809 | 19600 | 6292 | 100 | 791 | 32300 | 11113 | 100 | 2260 | 33200 | 12024 | 100 | 4540 | 43700 | 20928 | 100 | 14600 | 53700 | 31049 |
| Antimony | 38 | nd | 8.0 | 1.2 | 55 | nd | 15.2 | 1.4 | 61 | nd | 13.8 | 1.8 | 79 | nd | 3.2 | 1.5 | 62 | nd | 2.9 | 1.2 |
| Arsenic | 100 | 0.5 | 11.0 | 2.0 | 100 | nd | 26.7 | 3.6 | 100 | 1.0 | 9.0 | 3.5 | 100 | 1.0 | 10.5 | 3.7 | 100 | 0.6 | 7.5 | 3.3 |
| Barium | 100 | 1.7 | 94.4 | 30.0 | 100 | 1.9 | 230.0 | 45.0 | 100 | 9.2 | 213.0 | 52.3 | 100 | 18.1 | 200.0 | 90.7 | 100 | 84.5 | 503.0 | 234.6 |
| Beryllium | 50 | nd | 1.1 | 0.2 | 59 | nd | 3.7 | 0.3 | 53 | nd | 2.0 | 0.3 | 70 | nd | 1.7 | 0.4 | 49 | nd | 0.7 | 0.5 |
| Cadmium | 31 | nd | 1.1 | 0.2 | 45 | nd | 2.5 | 0.1 | 51 | nd | 2.6 | 0.3 | 92 | nd | 2.1 | 0.4 | 100 | 0.1 | 1.3 | 0.6 |
| Chromium | 99 | nd | 24.3 | 10.4 | 100 | 3.4 | 39.8 | 18.3 | 100 | 9.3 | 50.4 | 24.1 | 100 | 12.5 | 98.2 | 37.4 | 100 | 28.9 | 92.8 | 52.0 |
| Copper | 82 | nd | 22.2 | 3.8 | 94 | nd | 172.0 | 8.9 | 97 | nd | 78.0 | 12.2 | 100 | 5.0 | 31.8 | 18.6 | 100 | 8.7 | 51.3 | 29.7 |
| Iron | 100 | 2070 | 20900 | 7614 | 100 | 3170 | 39200 | 14000 | 100 | 5920 | 31900 | 15993 | 100 | 9310 | 40400 | 21649 | 100 | 19400 | 49900 | 28627 |
| Lead | 65 | nd | 24.4 | 2.9 | 74 | nd | 331.0 | 6.5 | 76 | nd | 534.0 | 11.5 | 100 | 1.4 | 25.8 | 8.3 | 100 | 1.7 | 30.1 | 12.7 |
| Manganese | 100 | nd | 600.0 | 104.6 | 100 | nd | 485.0 | 145.3 | 100 | 18.2 | 310.0 | 112.5 | 100 | 28.1 | 382.0 | 185.0 | 100 | 126.0 | 394.0 | 250.3 |
| Mercury | 45 | nd | 0.118 | 0.011 | 72 | nd | 0.212 | 0.035 | 79 | nd | 0.226 | 0.048 | 99 | nd | 0.425 | 0.061 | 100 | 0.019 | 0.102 | 0.055 |
| Nickel | 77 | nd | 18.8 | 3.5 | 93 | nd | 33.0 | 7.5 | 99 | nd | 21.4 | 9.4 | 100 | 5.0 | 34.2 | 18.9 | 100 | 12.7 | 53.8 | 33.8 |
| Selenium | 8 | nd | 0.4 | 0.2 | 35 | nd | 0.8 | 0.2 | 67 | nd | 0.8 | 0.4 | 91 | nd | 1.9 | 0.8 | 76 | nd | 4.1 | 2.2 |
| Silver | 17 | nd | 6.2 | 0.6 | 15 | nd | 8.4 | 1.1 | 7 | nd | 4.2 | 2.0 | 13 | nd | 6.0 | 2.4 | 43 | nd | 7.0 | 4.1 |
| Thallium | 10 | nd | 14.0 | 3.3 | 18 | nd | 18.0 | 2.1 | 9 | nd | 2.5 | 1.2 | 5 | nd | 0.9 | 0.6 | 3 | nd | 0.2 | 0.2 |
| Tin | 48 | nd | 2.7 | 1.0 | 63 | nd | 15.0 | 1.4 | 69 | nd | 81.8 | 2.1 | 98 | nd | 5.1 | 1.5 | 100 | 0.6 | 3.5 | 1.8 |
| Zinc | 99 | nd | 187.0 | 19.6 | 99 | nd | 908.0 | 34.3 | 100 | 10.0 | 408.0 | 41.1 | 100 | 16.9 | 114.0 | 55.1 | 100 | 33.7 | 138.0 | 82.3 |
| **Total DDT (ppt)** | 11 | nd | 3052 | 502 | 36 | nd | 75300 | 1619 | 40 | nd | 3470 | 775 | 51 | nd | 2051 | 684 | 30 | nd | 1400 | 699 |
| **Total PCB (ppt)** | 4 | nd | 66600 | 11764 | 10 | nd | 30230 | 2471 | 19 | nd | 50770 | 4449 | 15 | nd | 9858 | 1546 | 5 | nd | 3020 | 1895 |
| **Total PAH (ppb)** | 10 | nd | 420 | 54 | 24 | nd | 3640 | 111 | 29 | nd | 557 | 145 | 44 | nd | 457 | 105 | 19 | nd | 414 | 172 |

Cluster group I comprised 6 grabs collected from four sites located off the tip of the Coronado Bank and two sites located due west of Encinitas, all at depths of 755 to 1023 m along the lower slope. This group averaged 21 species and 52 individuals per grab, and was characterized by ophiuroids (Ophiuroidea) in the family Amphiuridae, the fauveliopsid polychaete *Fauveliopsis glabra*, nemertean worms in the family Lineidae, and the scaphopod *Gadila tolmiei*. Sediments associated with these assemblages had the highest proportions of medium sand (mean=4%), coarse sand (mean=2%) and coarse particles (mean=0.1%) among the "deep" clusters.

Cluster group J comprised 11 grabs collected at depths of 556 to 854 m along the lower slope around La Jolla/Scripps Canyon, and off Oceanside south to Bird Rock. This group averaged 21 species and 33 individuals per grab, and was characterized by the phoxocephalid amphipod *Harpiniopsis epistomata*, the ampeliscid amphipod *Byblis barbarensis*, the caprellid amphipod *Tritella tenuissima, Maldane sarsi*, and specimens of Ophiuroidea. Sediments associated with these assemblages had the highest proportion of fine particles (mean=91%) and the lowest proportion of medium sand (mean=0.1%) among all cluster groups (i.e., groups A–N). These sediments also had the lowest proportion of very fine sand (mean=6%) and fine sand (mean=2%) among the "deep" clusters.

Cluster group K was the largest "deep" cluster, comprising 30 grabs collected at depths of 263 to 526 m, primarily located along the upper slope from around the Coronado Bank up to just north of Encinitas. This group averaged 29 species and 77 individuals per grab, and was characterized by the bivalves *Nuculana conceptionis* and *Yoldiella nana*, the terebellid polychaete *Eclysippe trilobata*, *Maldane sarsi*, and *Fauveliopsis glabra*. Sediments associated with these assemblages had the lowest proportion of fine particles (mean=77%) and the highest proportions of very fine sand (mean=17%) and fine sand (5%) among the "deep" clusters. These sediments also had the second highest proportion of medium sand (mean=1%).

Cluster group L comprised 16 grabs collected at depths of 400 to 807 m. The distribution of group L assemblages overlapped with group K assemblages, representing the transition from the upper to the lower slope. Group L averaged 36 species and 123 individuals per grab, and was characterized by the cirratulid polychaete *Monticellina cryptica*, the nephtyid polychaete *Bipalponephtys cornuta*, *Fauveliopsis glabra*, *Maldane sarsi*, and *Eclysippe trilobata*. Sediments associated with these assemblages had the third highest proportion of fine particles among all cluster groups (mean=84%).

Cluster group M comprised 16 grabs collected at depths of 302 to 427 m along the upper slope of La Jolla/Scripps Canyon and south to the Coronado Bank. This group averaged 26 species and 65 individuals per grab, and was characterized by the bivalve *Macoma carlottensis*, the orbiniid polychaete *Leitoscoloplos* sp A, the scaphopod *Compressidens stearnsii*, *Nuculana conceptionis*, and *Paraprionospio alata*. Sediments associated with group M had the second highest proportion of very fine sand (mean=16%) and the second lowest proportion of fine particles (mean=80%) among the "deep" clusters.

Cluster group N comprised 7 grabs collected at depths of 562 to 887 m along the lower slope. This group averaged 18 species and 27 individuals per grab, and was characterized by the capitellid polychaete *Leiochrides hemipodus*, the maldanid polychaete *Sonatsa carinata*, the scutopod *Falcidens hartmanae*, the trichobranchid polychaete *Terebellides* sp SD1, and *Monticellina cryptica.*

**ATTACHMENT C2.A-5**

Mean abundance of characteristic species found in each macrofauna cluster group A–N (defined in Figure C2-1). Highlighted values indicate the top ten most characteristic species according to SIMPER analysis for groups with n >2, otherwise the top ten most abundant species are listed.

| | Cluster Group | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** |
| *Amphiodia urtica* | 51.0 | 20.8 | 3.1 | 0.0 | 1.0 | 4.3 | 0.0 | 1.9 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| *Amphiodia* sp | 18.7 | 6.2 | 2.0 | 1.6 | 1.8 | 1.3 | 2.0 | 2.7 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| *Spiophanes duplex* | 15.2 | 19.7 | 3.9 | 7.9 | 2.3 | 6.2 | 4.3 | 5.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Amphiuridae* | 14.5 | 3.9 | 3.5 | 1.6 | 1.7 | 1.8 | 3.1 | 5.3 | 6.8 | 3.0 | 3.4 | 6.0 | 1.3 | 0.0 |
| *Axinopsida serricata* | 10.3 | 6.1 | 7.4 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| *Rhepoxynius bicuspidatus* | 5.3 | 2.7 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Paradiopatra parva* | 4.9 | 4.3 | 6.9 | 4.3 | 0.0 | 0.0 | 1.8 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Sternaspis affinis* | 4.9 | 6.5 | 2.4 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 5.0 | 1.0 | 9.0 |
| *Prionospio (Prionospio) jubata* | 4.8 | 7.2 | 3.8 | 1.0 | 5.0 | 1.8 | 3.6 | 2.8 | 0.0 | 0.0 | 0.0 | 3.0 | 1.0 | 0.0 |
| *Prionospio (Prionospio) dubia* | 4.5 | 5.1 | 2.3 | 0.0 | 0.0 | 0.0 | 1.5 | 2.0 | 1.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 |
| *Spiophanes norrisi* | 1.5 | 58.9 | 6.7 | 12.2 | 16.5 | 9.7 | 1.0 | 86.6 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| *Monticellina siblina* | 3.3 | 23.3 | 5.9 | 1.5 | 1.0 | 5.0 | 9.2 | 4.9 | 0.0 | 1.0 | 1.0 | 4.0 | 0.0 | 0.0 |
| *Mediomastus* sp | 5.1 | 10.5 | 22.3 | 1.5 | 3.6 | 4.8 | 3.9 | 2.2 | 0.0 | 0.0 | 2.0 | 4.3 | 3.0 | 0.0 |
| *Euclymeninae* sp A | 3.5 | 7.1 | 3.1 | 1.0 | 1.0 | 2.7 | 1.7 | 4.6 | 0.0 | 0.0 | 1.3 | 1.0 | 0.0 | 0.0 |
| *Gadila aberrans* | 1.8 | 6.2 | 1.0 | 2.0 | 2.0 | 2.2 | 1.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Ampelisca brevisimulata* | 1.9 | 6.0 | 2.0 | 1.5 | 1.0 | 2.4 | 1.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Maldanidae | 3.4 | 4.7 | 4.3 | 1.7 | 3.2 | 2.3 | 1.0 | 4.6 | 3.0 | 2.3 | 1.4 | 2.8 | 6.0 | 0.0 |
| *Paraprionospio alata* | 3.2 | 3.5 | 6.5 | 2.4 | 1.0 | 3.3 | 1.6 | 2.0 | 0.0 | 0.0 | 1.4 | 7.0 | 2.8 | 0.0 |
| *Spiophanes kimballi* | 7.0 | 8.1 | 16.9 | 1.0 | 0.0 | 0.0 | 1.9 | 1.5 | 0.0 | 0.0 | 6.7 | 1.0 | 1.8 | 0.0 |
| *Tellina carpenteri* | 4.8 | 2.8 | 8.6 | 0.0 | 0.0 | 0.0 | 5.6 | 0.0 | 0.0 | 0.0 | 3.7 | 1.0 | 1.0 | 0.0 |
| *Melinna heterodonta* | 1.7 | 1.0 | 6.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 3.0 | 0.0 | 1.0 | 1.5 | 1.3 | 1.0 |
| *Maldane sarsi* | 1.8 | 1.8 | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 10.0 | 7.6 | 5.6 | 1.3 |
| *Parvilucina tenuisculpta* | 2.9 | 3.3 | 3.9 | 3.0 | 0.0 | 1.6 | 4.0 | 1.0 | 0.0 | 0.0 | 1.0 | 0.0 | 1.4 | 0.0 |
| *Scoletoma tetraura* Cmplx | 2.9 | 5.3 | 3.0 | 8.0 | 0.0 | 7.2 | 0.0 | 1.0 | 0.0 | 0.0 | 1.6 | 1.0 | 1.5 | 0.0 |
| *Aphelochaeta monilaris* | 3.1 | 3.3 | 3.3 | 1.3 | 0.0 | 2.0 | 1.9 | 1.2 | 2.5 | 3.0 | 1.7 | 1.0 | 2.6 | 1.5 |
| *Owenia collaris* | 1.4 | 2.9 | 2.0 | 63.0 | 4.3 | 25.2 | 1.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Photis macinerneyi* | 0.0 | 0.0 | 0.0 | 25.0 | 2.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Diastylopsis tenuis* | 0.0 | 3.1 | 0.0 | 9.2 | 0.0 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Gibberosus myersi* | 1.0 | 2.3 | 0.0 | 7.8 | 0.0 | 2.4 | 0.0 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Rhepoxynius abronius* | 0.0 | 10.5 | 0.0 | 7.4 | 0.0 | 2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Rhepoxynius menziesi* | 1.9 | 3.8 | 1.0 | 7.1 | 0.0 | 3.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Tellina modesta* | 1.0 | 5.1 | 0.0 | 6.0 | 0.0 | 5.7 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Anchicolurus occidentalis* | 0.0 | 1.3 | 0.0 | 5.9 | 4.0 | 2.6 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Carinoma mutabilis* | 1.2 | 3.1 | 1.0 | 4.6 | 0.0 | 3.4 | 1.7 | 6.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Hesionura coineaui difficilis* | 0.0 | 1.3 | 0.0 | 0.0 | 36.0 | 0.0 | 0.0 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**ATTACHMENT C2.A-5** *continued*

| | Cluster Group | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** |
| NEMATODA | 1.6 | 4.9 | 12.5 | 2.3 | 29.9 | 1.1 | 1.6 | 6.1 | 1.0 | 1.0 | 1.0 | 5.1 | 2.0 | 0.0 |
| *Pisione* sp | 0.0 | 1.0 | 0.0 | 0.0 | 25.0 | 0.0 | 0.0 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Protodorvillea gracilis* | 0.0 | 2.4 | 0.0 | 0.0 | 24.7 | 0.0 | 1.4 | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Halistylus pupoideus* | 0.0 | 0.0 | 0.0 | 0.0 | 18.7 | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Micranellum crebricinctum* | 4.8 | 18.2 | 15.3 | 1.0 | 17.3 | 0.0 | 12.0 | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Cnemidocarpa rhizopus* | 0.0 | 1.7 | 0.0 | 0.0 | 11.0 | 0.0 | 0.0 | 5.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Branchiostoma californiense* | 0.0 | 1.0 | 0.0 | 0.0 | 5.9 | 1.0 | 0.0 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Leptosynapta* sp | 1.9 | 2.1 | 3.0 | 1.3 | 4.4 | 1.0 | 1.0 | 2.3 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| *Ampharete labrops* | 1.0 | 6.7 | 1.0 | 3.4 | 2.3 | 7.1 | 1.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Goniada littorea* | 0.0 | 1.9 | 0.0 | 3.2 | 0.0 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Photis* sp OC1 | 1.0 | 3.4 | 0.0 | 3.5 | 1.0 | 3.2 | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Sigalion spinosus* | 1.5 | 3.3 | 0.0 | 2.5 | 1.3 | 2.6 | 1.8 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Aphelochaeta glandaria* Cmplx | 2.8 | 3.0 | 5.6 | 0.0 | 0.0 | 1.0 | 19.0 | 4.0 | 0.0 | 1.0 | 2.0 | 1.0 | 0.0 | 0.0 |
| *Leptochelia dubia* Cmplx | 3.7 | 4.9 | 2.4 | 1.0 | 5.2 | 1.7 | 8.6 | 6.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Huxleyia munita* | 4.1 | 1.5 | 3.3 | 0.0 | 0.0 | 0.0 | 8.2 | 0.0 | 0.0 | 0.0 | 32.0 | 0.0 | 0.0 | 0.0 |
| *Amphiodia digitata* | 3.2 | 2.6 | 3.8 | 1.7 | 0.0 | 1.5 | 5.9 | 1.3 | 0.0 | 0.0 | 2.8 | 0.0 | 0.0 | 0.0 |
| *Ampelisca careyi* | 2.5 | 2.5 | 2.3 | 0.0 | 0.0 | 1.2 | 5.6 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Euchone arenae* | 1.3 | 2.4 | 0.0 | 0.0 | 20.0 | 0.0 | 1.6 | 22.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Mooreonuphis* sp SD1 | 0.0 | 8.1 | 0.0 | 0.0 | 5.0 | 0.0 | 1.0 | 13.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Ampelisca cristata cristata* | 1.1 | 4.3 | 0.0 | 1.3 | 4.1 | 3.4 | 1.0 | 8.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Ophiuroconis bispinosa* | 2.5 | 3.2 | 1.0 | 0.0 | 2.5 | 1.0 | 1.0 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Polyschides quadrifissatus* | 2.7 | 3.2 | 2.5 | 1.2 | 2.7 | 1.0 | 2.3 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Spiochaetopterus costarum Cmplx* | 2.3 | 8.0 | 2.7 | 2.5 | 1.5 | 2.2 | 1.3 | 4.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| *Hemilamprops californicus* | 1.7 | 3.6 | 0.0 | 1.2 | 5.8 | 3.4 | 0.0 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Foxiphalus obtusidens* | 1.4 | 4.3 | 1.3 | 2.4 | 1.3 | 1.5 | 2.0 | 3.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 |
| *Fauveliopsis glabra* | 1.0 | 0.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.0 | 3.0 | 5.6 | 3.3 | 1.5 | 3.0 |
| Ophiuroidea | 1.5 | 1.6 | 2.7 | 1.0 | 0.0 | 1.0 | 1.0 | 1.0 | 8.0 | 1.9 | 2.3 | 2.4 | 1.0 | 0.0 |
| Lineidae | 1.6 | 2.5 | 1.7 | 2.0 | 2.1 | 1.4 | 1.1 | 1.6 | 1.0 | 1.4 | 1.0 | 1.0 | 1.0 | 1.5 |
| *Gadila tolmiei* | 1.0 | 0.0 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 2.4 | 1.8 | 2.2 | 1.0 |
| *Adontorhina cyclia* | 4.8 | 2.2 | 3.1 | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 1.0 | 1.2 | 1.8 | 1.6 | 1.0 | 0.0 |
| *Byblis barbarensis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 0.0 | 1.5 | 0.0 | 0.0 |
| *Tritella tenuissima* | 0.0 | 0.0 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.7 | 1.9 | 1.7 | 0.0 | 1.0 |
| *Harpiniopsis epistomata* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.3 | 2.3 | 2.4 | 0.0 | 1.0 |
| *Falcidens hartmanae* | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 1.7 | 1.8 | 1.0 | 2.0 |
| *Limifossor fratula* | 1.0 | 0.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 1.2 | 2.8 | 1.9 | 1.0 |
| *Yoldiella nana* | 0.0 | 0.0 | 12.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.0 | 1.2 | 8.3 | 2.4 | 11.3 | 1.0 |
| *Dacrydium pacificum* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.6 | 1.0 | 0.0 | 0.0 |

**ATTACHMENT C2.A-5** *continued*

| | Cluster Group | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** |
| *Eclysippe trilobata* | 4.0 | 3.5 | 6.0 | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 1.0 | 1.0 | 6.9 | 3.8 | 4.3 | 1.0 |
| *Nuculana conceptionis* | 0.0 | 0.0 | 4.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.4 | 5.8 | 6.1 | 0.0 |
| *Ampelisca unsocalae* | 1.5 | 0.0 | 3.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.1 | 1.9 | 2.3 | 0.0 |
| *Ennucula tenuis* | 2.7 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.8 | 2.0 | 2.3 | 0.0 |
| *Bipalponephtys cornuta* | 1.3 | 1.1 | 12.1 | 1.0 | 2.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 1.2 | 30.4 | 1.8 | 1.0 |
| *Araphura cuspirostris* | 1.3 | 1.0 | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 8.6 | 1.0 | 0.0 |
| *Monticellina cryptica* | 3.0 | 5.5 | 1.8 | 2.5 | 0.0 | 8.3 | 1.9 | 1.0 | 1.0 | 1.5 | 1.8 | 7.0 | 1.5 | 2.3 |
| *Sternaspis williamsae* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 3.0 | 1.8 | 0.0 | 0.0 |
| *Fauveliopsis* sp | 0.0 | 1.0 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 1.5 | 0.0 | 0.0 |
| *Leucon declivis* | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 1.0 | 1.1 | 3.0 | 4.0 |
| *Compressidens stearnsii* | 2.0 | 11.0 | 4.3 | 0.0 | 0.0 | 0.0 | 2.3 | 0.0 | 1.0 | 1.0 | 3.9 | 13.0 | 3.2 | 1.0 |
| *Macoma carlottensis* | 3.2 | 4.0 | 8.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.3 | 0.0 | 8.3 | 0.0 |
| *Ancistrosyllis groenlandica* | 0.0 | 1.2 | 1.8 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 | 1.0 | 4.5 | 3.1 | 0.0 |
| *Prionospio (Prionospio) ehlersi* | 0.0 | 0.0 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 1.0 | 3.1 | 1.0 |
| *Leitoscoloplos* sp A | 1.0 | 0.0 | 1.7 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 1.0 | 1.2 | 6.0 | 2.2 | 1.0 |
| *Amphioplus strongyloplax* | 1.4 | 2.8 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 1.3 | 1.6 | 0.0 |
| *Chaetozone* sp | 1.7 | 2.0 | 4.4 | 1.0 | 2.5 | 1.8 | 4.8 | 2.2 | 1.0 | 0.0 | 1.0 | 3.3 | 1.0 | 1.0 |
| *Leiochrides hemipodus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.3 | 1.0 | 3.0 | 0.0 | 1.5 |
| *Sonatsa carinata* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 3.0 | 0.0 | 1.6 |
| *Aricidea (Acmira) rubra* | 1.2 | 1.7 | 1.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.0 | 1.0 | 2.0 | 0.0 | 1.0 | 0.0 | 1.0 |
| *Terebellides* sp SD1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 |

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# APPENDIX C3

# SAN DIEGO SEDIMENT QUALITY ASSESSMENT

March 2022

# APPENDIX C3

# San Diego Sediment Quality Assessment

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# APPENDIX C3

## San Diego Sediment Quality Assessment

### SECTION C3-1 | INTRODUCTION

The requirement for toxicity testing of coastal offshore marine sediments for the Point Loma Ocean Outfall (PLOO) monitoring region off San Diego, California was added in 2017 to the receiving waters monitoring and reporting program for the Point Loma Wastewater Treatment Plant (PLWTP) with the implementation of Order R9-2017-0007, National Pollutant Discharge Elimination System (NPDES) permit CA0107409. This monitoring requirement was added as a result of recommendations from the City's Sediment Toxicity Monitoring Plan (STMP) (City of San Diego 2015), which was developed in consultation with staff of the San Diego Regional Water Quality Control Board (SDRWQCB), US Environmental Protection Agency (USEPA), Region IX, the Southern California Coastal Water Research Project (SCCWRP), and the International Boundary and Water Commission, US Section (USIBWC). The sediment toxicity plan was designed as a three-year pilot study with the goal of answering the following three primary questions: (1) what is the extent and magnitude of sediment toxicity in offshore marine sediments in the region; (2) how does the extent and magnitude of sediment toxicity off San Diego compare among different continental shelf strata (e.g., inner, mid, and outer shelf); (3) how does the extent and magnitude of sediment toxicity off San Diego compare to results from the Southern California Bight regional monitoring surveys. During the three-year STMP pilot study, no sediment toxicity was observed at any offshore monitoring sites in the San Diego region. Despite this, the City, in consultation with the aforementioned agencies, recommended continuation of annual sediment toxicity testing of the PLOO region to facilitate monitoring of any potential changes in PLOO discharge flows related to implementation of the City's Pure Water program. The sampling design for this ongoing monitoring was detailed in the final report (City of San Diego 2019) and included annual testing of a reduced number of samples alternating between permanent fixed monitoring sites and randomly selected sites during surveys conducted during the summers of 2019–2023.

This appendix summarizes the results and conclusions of all sediment toxicity testing conducted for the PLOO monitoring region during:

- the summers of 2016, 2017, and 2018 as previously documented in the pilot study final project report (City of San Diego 2019),
- the summer of 2019 as documented in the City's 2018-2019 Biennial Receiving Waters Monitoring and Assessment Report (City of San Diego 2020)
- the summer of 2020 as documented in the City's 2020 Interim Receiving Waters Monitoring Report (City of San Diego 2021)

Further, in an effort to provide a more comprehensive assessment of sediment quality in this region, sediment toxicity results have been integrated with other lines of evidence (LOEs), including sediment chemistry and benthic community structure. These LOEs were integrated using a framework adopted by the State of California to assess sediment quality within enclosed bays and estuaries (SWRCB 2009; see also Bay et al. 2013), but with the same modifications used for the coastal shelf as part of Southern California Bight (SCB) Regional Monitoring Program surveys (i.e., Bight regional surveys; see B13CIA 2017). These modifications included applying the results from the 10-day amphipod sediment toxicity test prescribed by the STMP (versus the two sediment toxicity tests available for embayments) and the benthic response index (BRI) that was developed specifically for evaluation of benthic macrofaunal (e.g., worms, crabs, clams, brittle stars, other small invertebrates) communities in offshore waters (Bergen et al. 2000, Smith et al. 2001). The same two sediment chemistry assessment indices developed for embayments were used, even though these indices have not been calibrated or validated for continental shelf sediments, as these are the best tools currently available (B13CIA 2017). The integration of each line of evidence using the State of California's sediment quality assessment framework resulted in the classification of each site into one of five potential categories: (1) unimpacted; (2) likely unimpacted; (3) possibly impacted; (4) likely impacted; (5) clearly impacted. The State Water Board considers the first two categories as healthy, or representative of conditions undisturbed by pollutants in sediment (SWRCB 2009, B13CIA 2017).

## SECTION C3-2 | GENERAL METHODOLGY

A total of 65 sediment samples from 53 stations were tested during the summers of 2016 through 2020 (Figure C3-1). These included 16 samples collected during 2016–2019 from the four stations located within 1,000 meters (m) of the PLOO and near the zone of initial dilution (ZID) (i.e., stations E11, E14, E17, E15), and 49 randomly selected regional stations, including 20 stations from the 2016 San Diego "mini" regional survey, 21 stations from the Bight'18 survey, and 8 stations from the 2020 San Diego "mini" regional survey (see Appendix C2 in this application for more details on San Diego "mini" regional and Bight surveys). All sampling methodologies followed guidelines established by the USEPA (USEPA 1987) and utilized during various Bight surveys (e.g., SCCWRP 2018). Samples were collected using a double 0.1-$m^2$ Van Veen grab, with one grab per cast used for benthic community analysis, one grab per cast used for sediment quality analysis, and all subsequent casts used for sediment toxicity testing.

Specific details regarding benthic sample processing and the 10-day amphipod sediment toxicity test methods can be found in City of San Diego (2020) which is available online (City of San Diego 2021). All identifications followed nomenclatural standards established by the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT 2018). Sediment particle size and sediment chemistry analytical protocols may be obtained from the City of San Diego's Environmental Chemistry Services Laboratory. Briefly, sediments were analyzed on a dry weight basis for trace metals, chlorinated pesticides, polychlorinated biphenyl compounds (PCBs), and polycyclic aromatic hydrocarbons (PAHs). A review of recommended protocols in Bay et al. 2013 by City chemists confirmed that the data included herein were the result of comparable methods. A comparison of method detection limits (MDLs), which equate to reporting limits (RLs) for the

City, to the recommended maximum RLs in Bay et al (2013), found that the MDLs for cadmium were slightly higher than recommended RLs during 2016 and 2017, as were MDLs for PAHs during 2016 (Attachment C3-A). The PCB congeners PCB 8 and PCB 195 were only analyzed for samples collected during the Bight'18 survey. Excluding these from the remaining samples was determined to have minimal impact on the results for the following reasons: (1) for the 25 samples collected off San Diego during Bight'18, the detection rate for PCB 8 was 8% (n=2, max value = 0.6 ppb); (2) the detection rate for PCB 195 was 12% (n=3, max value = 6.4 ppb); (3) maximum values of both PCB 8 and PCB 195 were detected in one sample from Bight'18 station 8703 that was found to have low exposure overall. These findings are consistent with overall low PCB detection rates and low PCB concentrations across the Point Loma region (City of San Diego 2020). Additionally, this station was located directly south of the LA-5 dredge spoils dumpsite where higher PCB concentrations associated with short dumps of contaminated sediments from San Diego Bay are known to occur (Parnell et al. 2008). In contrast to Appendices C1 and C2 (this application), one half of the MDL value was substituted for non-detects. This approach was recommended by Bay et al. (2013) to address errors generated by calculating the log of zero values. Also, in contrast to Appendices C1 and C2, concentrations that fell below MDLs were included herein as estimated values, if the presence of a specific constituent was verified by mass-spectrometry.

Following instructions provided in Bay et al. (2013), all available benthic macrofauna, sediment toxicity, and sediment chemistry data were analyzed to determine relevant condition categories (Figure C3-2). The benthic community LOE was determined by assigning condition categories to each sample collected at acceptable depths as follows: BRI values <25 = reference conditions, 25-33 = low disturbance (defined as minor deviation from reference conditions in Smith et al. 2001), 34-43 = moderate disturbance, 44-71 = high disturbance (defined as loss in community function in Smith et al. 2001), and >72 = defaunation. Due to limitations in the validation dataset, BRI values are not calculated for samples collected at depths <10 m or >200 m (Smith et al. 2001). The sediment toxicity LOE was determined by assigning scores to samples using the following thresholds: percent control ≥90% = nontoxic, ≥82% = low toxicity, and ≥59% = moderate toxicity, <59% = high toxicity. The sediment chemistry LOE was determined by using the California Logistic Regression Model Index (LRM) and the Chemical Score Index (CSI) to calculate scores for each sample with sufficient parameters analyzed (i.e., all but PCB 8 and PCB 195, see above and Attachment C3-A), calculating the mean score as (LRM + CSI)/2, and assigning the overall integrated chemistry category LOE as follows: mean score ≤1.0 = minimal exposure, 1.1-2.0 = low exposure, 2.1-3.0 = moderate exposure, and 3.1-4.0 = high exposure.

After the scores were converted to LOE categories, they were combined using the integration framework defined in Bay et al (2013). This framework is based on a conceptual approach that addresses two key elements: (1) is there biological degradation at the site, and (2) is chemical exposure at the site high enough to potentially result in a biological response? (see SWRCB 2009, Bay and Weisberg 2012). Station assessment (site condition) categories were assigned using benthic community condition as determined by the BRI (reference, or low, moderate, high disturbance), sediment toxicity (non-toxic, or low, moderate, high toxicity), and sediment chemistry exposure (minimal, low, moderate, high) according to Table 6.1 in Bay et al (2013). For example, if a sample had a benthic community in reference condition, the sediments were found to be nontoxic, and the sediment chemistry exposure was minimal, then the station assessment (site condition) was deemed unimpacted. There is a total of 64 combinations resulting in the five categories: (1) unimpacted; (2) likely unimpacted; (3) possibly impacted; (4) likely impacted; (5) clearly impacted. The station assessment could also be inconclusive (e.g., reference benthic conditions plus moderate sediment toxicity exposure plus high sediment chemistry exposure).

## SECTION C3-3 | RESULTS

Of the 65 samples collected from 2016 through 2020 and analyzed herein, 15 were collected on the inner shelf at depths ranging from 5 to 30 m, 37 were collected on the mid-shelf at depths ranging from 34 to 116 m, 9 were collected on the outer shelf at depths ranging from 130 to 195 m, and 4 were collected on the upper slope at depths from 240 to 350 m (Table C3-1). Sediment particle sizes were highly variable, with fine particles ranging from 2-54% on the inner shelf, 2-63% on the middle shelf, 32-68% on the outer shelf, and 56-80% on the upper slope.

Overall, benthic community condition was very good off San Diego based on this study, as 85% (n=51) of samples collected where BRI could be applied (n=60) were considered in reference condition (Table C3-1, Figure C3-3). Another 13% of samples (n=8) were considered to have minor deviation from reference condition (i.e., low disturbance), and only 2% (n=1) had a BRI value indicative of moderate disturbance. Of the 16 samples collected at near-ZID stations, all of the samples from stations E11, E15 and E17 were found to be in reference condition. Three of the four samples from station E14 were indicative of low disturbance, and one was indicative of moderate disturbance. These results are consistent with BRI values recorded for the PLOO near-ZID stations over the past 30 years (see Appendices C1 and C2, this application).

Sediment toxicity was absent from all 65 samples, and sediment quality objective (SQO) chemistry scores were indicative of minimal exposure in 95% (n=60) of the 63 samples for which scores could be calculated (Table C3-1, Figure C3-3). The remaining 5% of samples (n=3) had SQO scores indicative of low exposure. One of these three samples was collected at station 8745 in 2018, located at a depth of 13 m just south of the entrance to San Diego Bay (Figure C3-1). This sample had lead value of 33.7 parts per million (ppm), which was relatively high compared to most samples collected in the SCB (see Tables C1-2 and C1-4 in Appendix C1, this application), but lower than the Effects Range Low (ERL) threshold of 46.7 ppm (Long et al 1995). Another of the three samples was collected at station 8703 in 2018, located at a depth of 182 m due south from the LA-5 dredge spoils dumpsite. This sample had a relatively high total PCB value, a finding not surprising considering the proximity of the site to the LA-5 dredge spoils dumpsite (Parnell et al. 2008). No ERLs exist for PCBs measured as congeners. The third sample was collected at station 8916 in 2020, located at a depth of 189 m to the northwest of the LA-5 dredge spoils dumpsite. This sample had relatively a high total dichloro-diphenyl-trichloroethane (DDT) value of 1555 parts per trillion (ppt), also possibly related to proximity to the dumpsite. This value was just below the ERL for total DDT of 1580 ppt (Long et al. 1995).

Based on the integration framework presented in Bay et al (2013) (Figure C3-4), 98% of the 58 samples that had all LOEs available (i.e., not too shallow or deep for the BRI and at least 96% of chemistry parameters analyzed) were deemed unimpacted (Table C3-2). The single exception was collected from near-ZID station E14 during summer 2017. Despite having a BRI value indicative of moderate disturbance (37), sediments from this sample were deemed likely unimpacted, as they were found to be nontoxic with minimal exposure to pollutants. California's State Water Resource Control Board (SWRCB) considers both unimpacted and likely unimpacted categories as healthy, or representative of conditions undisturbed by pollutants in sediment (SWRCB 2009, B13CIA 2017). These findings support previous conclusions that changes in benthic communities at station E14 may reflect a habitat with coarser sediment particle size composition, versus being impacted by wastewater contamination (see Appendices C1, C2, C4, this application; see also City of San Diego 2020).

## SECTION C3-4 | SUMMARY

Utilizing the State of California sediment quality assessment framework, benthic habitats and associated macrofaunal communities found on the continental shelf off San Diego from 2016 through 2020 were determined to be healthy, or representative of conditions undisturbed by pollutants in sediment (SWRCB 2009, Bay et al. 2013, B13CIA 2017). Overall, this integrated assessment, based on benthic community condition, sediment toxicity, and sediment chemistry exposure, is consistent with findings from 30 years of monitoring at the core PLOO stations (see Appendices C1, C2, and C4, this application; City of San Diego 2020), and is similar to findings from Bight'08 and Bight'13 that found 95% - 100% of the area on the SCB continental shelf classified as healthy (B08CEC 2012, B13CIA 2017).

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# APPENDIX C3

## San Diego Sediment Quality Assessment

### FIGURES & TABLES

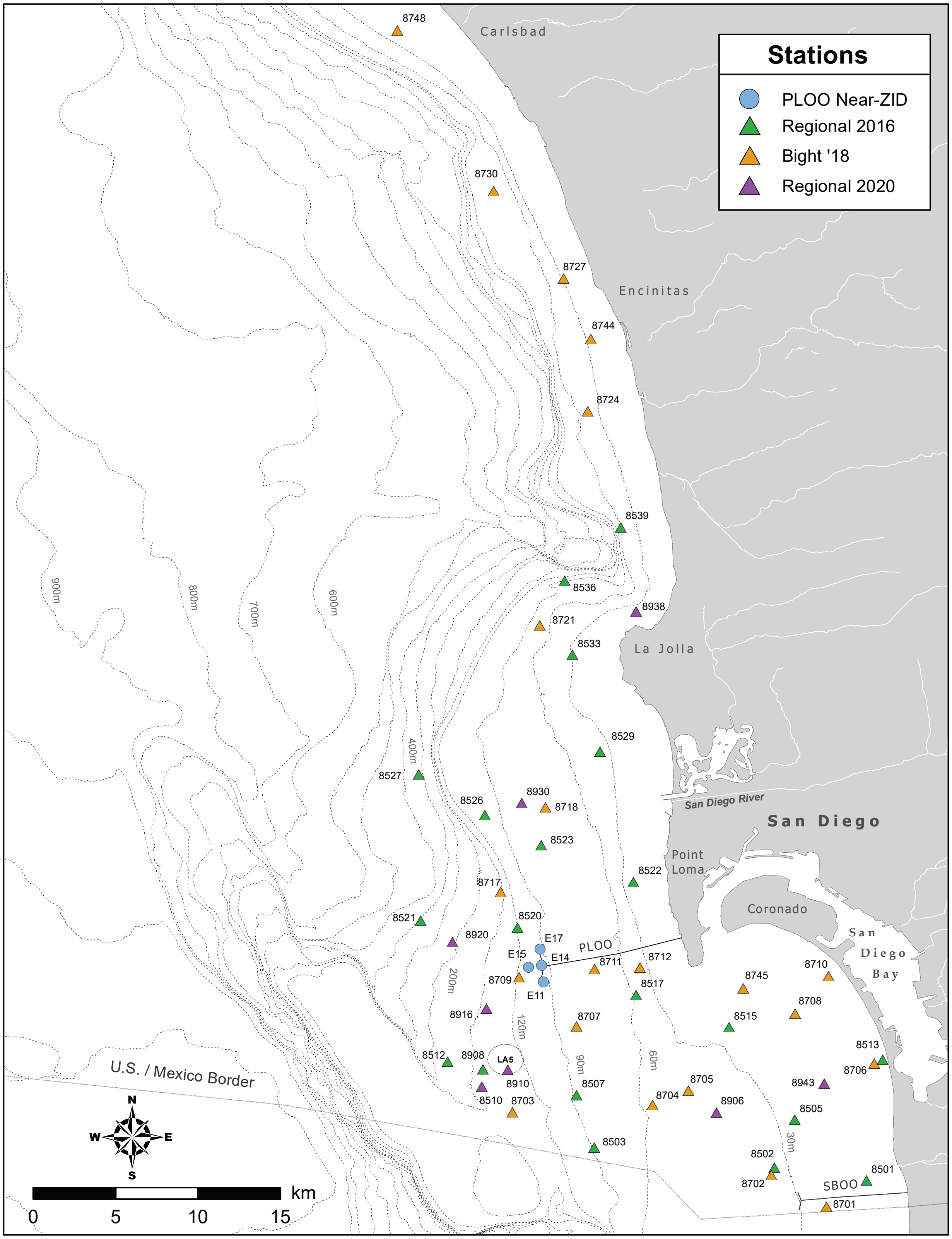


**FIGURE C3-1**
Distribution of benthic stations selected for sediment toxicity testing off San Diego from 2016 through 2020.

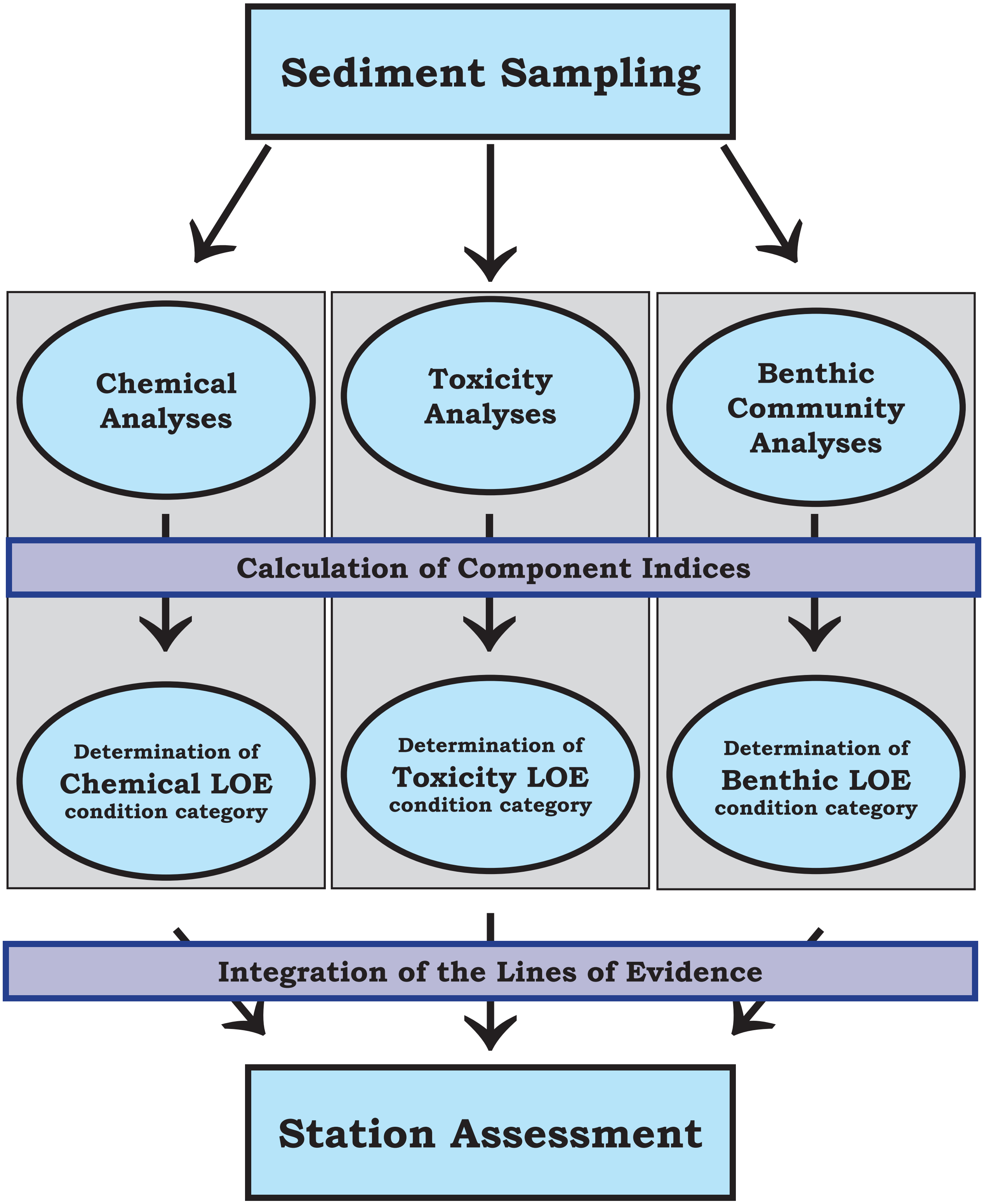


**FIGURE C3-2**
Overview of the station assessment process for the State of California's sediment quality assessment framework. After Figure 1.1 from Bay et al. 2013.

**TABLE C3-1**
Results for the benthic response index (BRI), sediment toxicity, and sediment quality objective (SQO) lines of evidence. Cond = condition; TR = test result; TC = test control; %C = percent control; LRM = logistic regression model; CSI = chemical score index; Ref = reference; Low Dist = low disturbance (defined as minor deviation from reference conditions in Smith et al. 2001); Mod Dist = moderate disturbance; NT = nontoxic; ME = minimal exposure; Low = low exposure.

| | | Depth | Fines | BRI | | Sediment Toxicity | | | | SQOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey | Station | (m) | (%) | Value | Cond | TR | TC | %C | Cond | LRM | CSI | Cond |
| 2016 | 8501 | 17 | 22 | 23.0 | Ref | 100 | 99 | 101 | NT | 0.10 | 1.00 | ME |
| 2016 | 8502 | 35 | 28 | 22.0 | Ref | 99 | 100 | 99 | NT | 0.11 | 1.00 | ME |
| 2016 | 8503 | 92 | 34 | 4.0 | Ref | 100 | 99 | 101 | NT | 0.11 | 1.06 | ME |
| 2016 | 8505 | 26 | 17 | 23.0 | Ref | 100 | 100 | 100 | NT | 0.10 | 1.00 | ME |
| 2016 | 8507 | 91 | 38 | 3.0 | Ref | 99 | 99 | 100 | NT | 0.18 | 1.26 | ME |
| 2016 | 8510 | 195 | 68 | 15.0 | Ref | 98 | 99 | 99 | NT | 0.31 | 1.06 | ME |
| 2016 | 8512[a] | 240 | 76 | — | — | 100 | 99 | 101 | NT | 0.31 | 1.06 | ME |
| 2016 | 8513[a] | 5 | 2 | — | — | 100 | 100 | 100 | NT | 0.09 | 1.00 | ME |
| 2016 | 8515 | 20 | 3 | 23.0 | Ref | 98 | 100 | 98 | NT | 0.07 | 1.00 | ME |
| 2016 | 8517[b] | 57 | 34 | 14.0 | Ref | 100 | 99 | 101 | NT | — | — | — |
| 2016 | 8520 | 138 | 47 | 17.0 | Ref | 99 | 99 | 100 | NT | 0.18 | 1.06 | ME |
| 2016 | 8521[a] | 340 | 80 | — | — | 99 | 99 | 100 | NT | 0.32 | 1.06 | ME |
| 2016 | 8522 | 22 | 2 | -3.0 | Ref | 96 | 99 | 97 | NT | 0.06 | 1.00 | ME |
| 2016 | 8523 | 81 | 59 | 8.0 | Ref | 96 | 99 | 97 | NT | 0.22 | 1.06 | ME |
| 2016 | 8526 | 101 | 50 | 11.0 | Ref | 100 | 99 | 101 | NT | 0.18 | 1.06 | ME |
| 2016 | 8527[a] | 350 | 61 | — | — | 100 | 99 | 101 | NT | 0.28 | 1.06 | ME |
| 2016 | 8529 | 45 | 28 | 20.0 | Ref | 100 | 99 | 101 | NT | 0.17 | 1.00 | ME |
| 2016 | 8533 | 36 | 2 | 4.0 | Ref | 100 | 99 | 101 | NT | 0.14 | 1.00 | ME |
| 2016 | 8536 | 135 | 32 | 16.0 | Ref | 99 | 99 | 100 | NT | 0.15 | 1.00 | ME |
| 2016 | 8539 | 112 | 38 | 23.0 | Ref | 99 | 99 | 100 | NT | 0.24 | 1.06 | ME |
| 2016 | E11 | 98 | 35 | 12.8 | Ref | 98 | 100 | 98 | NT | 0.12 | 1.00 | ME |
| 2016 | E14 | 98 | 27 | 27.8 | Low Dist | 98 | 100 | 98 | NT | 0.13 | 1.00 | ME |
| 2016 | E15 | 116 | 40 | 7.0 | Ref | 97 | 100 | 97 | NT | 0.13 | 1.00 | ME |
| 2016 | E17[b] | 98 | 34 | 15.3 | Ref | 100 | 99 | 101 | NT | — | — | — |
| 2017 | E11 | 98 | 33 | 19.4 | Ref | 99 | 97 | 102 | NT | 0.14 | 1.00 | ME |
| 2017 | E14 | 98 | 21 | 37.4 | Mod Dist | 100 | 97 | 103 | NT | 0.12 | 1.00 | ME |
| 2017 | E15 | 116 | 30 | 16.0 | Ref | 97 | 97 | 100 | NT | 0.12 | 1.00 | ME |
| 2017 | E17 | 98 | 34 | 18.7 | Ref | 98 | 97 | 101 | NT | 0.12 | 1.00 | ME |
| 2018 | 8701 | 23 | 10 | 16.0 | Ref | 98 | 98 | 100 | NT | 0.08 | 1.00 | ME |
| 2018 | 8702 | 34 | 27 | 26.8 | Low Dist | 99 | 98 | 101 | NT | 0.13 | 1.06 | ME |
| 2018 | 8703 | 182 | 53 | 19.9 | Ref | 99 | 98 | 101 | NT | 0.65 | 1.31 | LE |
| 2018 | 8704 | 57 | 20 | 14.3 | Ref | 98 | 98 | 100 | NT | 0.07 | 1.00 | ME |
| 2018 | 8705 | 47 | 19 | 16.7 | Ref | 95 | 96 | 99 | NT | 0.07 | 1.00 | ME |
| 2018 | 8706 | 13 | 48 | 23.3 | Ref | 97 | 98 | 99 | NT | 0.21 | 1.00 | ME |

**TABLE C3-1** *continued*

| | | | | BRI | | Sediment Toxicity | | | | SQOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey | Station | Depth (m) | Fines (%) | Value | Cond | TR | TC | %C | Cond | LRM | CSI | Cond |
| 2018 | 8707 | 87 | 51 | 9.6 | Ref | 95 | 96 | 99 | NT | 0.17 | 1.00 | ME |
| 2018 | 8708 | 20 | 20 | 24.8 | Ref | 97 | 100 | 97 | NT | 0.15 | 1.10 | ME |
| 2018 | 8709 | 130 | 39 | 14.3 | Ref | 99 | 96 | 103 | NT | 0.15 | 1.00 | ME |
| 2018 | 8710 | 11 | 21 | 27.9 | Low Dist | 100 | 98 | 102 | NT | 0.13 | 1.00 | ME |
| 2018 | 8711 | 77 | 57 | 15.0 | Ref | 99 | 98 | 101 | NT | 0.21 | 1.01 | ME |
| 2018 | 8712 | 49 | 37 | 25.1 | Low Dist | 100 | 98 | 102 | NT | 0.18 | 1.00 | ME |
| 2018 | 8717 | 185 | 61 | 20.8 | Ref | 99 | 98 | 101 | NT | 0.20 | 1.00 | ME |
| 2018 | 8718 | 76 | 63 | 11.5 | Ref | 98 | 98 | 100 | NT | 0.20 | 1.00 | ME |
| 2018 | 8721 | 70 | 41 | 11.9 | Ref | 100 | 98 | 102 | NT | 0.15 | 1.00 | ME |
| 2018 | 8724 | 50 | 40 | 17.3 | Ref | 97 | 98 | 99 | NT | 0.19 | 1.00 | ME |
| 2018 | 8727 | 30 | 11 | 22.4 | Ref | 97 | 98 | 99 | NT | 0.12 | 1.00 | ME |
| 2018 | 8730 | 74 | 61 | 10.3 | Ref | 98 | 98 | 100 | NT | 0.21 | 1.00 | ME |
| 2018 | 8744 | 27 | 9 | 18.0 | Ref | 99 | 100 | 99 | NT | 0.03 | 1.00 | ME |
| 2018 | 8745 | 13 | 2 | 14.3 | Ref | 100 | 96 | 104 | NT | 0.41 | 1.16 | LE |
| 2018 | 8748 | 24 | 24 | 22.2 | Ref | 99 | 100 | 99 | NT | 0.18 | 1.00 | ME |
| 2018 | E11 | 98 | 31 | 19.6 | Ref | 99 | 96 | 103 | NT | 0.12 | 1.00 | ME |
| 2018 | E14 | 98 | 24 | 27.3 | Low Dist | 94 | 96 | 98 | NT | 0.10 | 1.00 | ME |
| 2018 | E15 | 116 | 29 | 14.0 | Ref | 98 | 96 | 102 | NT | 0.11 | 1.00 | ME |
| 2018 | E17 | 98 | 36 | 18.5 | Ref | 92 | 96 | 96 | NT | 0.12 | 1.00 | ME |
| 2019 | E11 | 98 | 59 | 13.9 | Ref | 97 | 99 | 98 | NT | 0.12 | 1.00 | ME |
| 2019 | E14 | 98 | 56 | 32.7 | Low Dist | 100 | 99 | 101 | NT | 0.11 | 1.00 | ME |
| 2019 | E15 | 116 | 56 | 16.0 | Ref | 97 | 99 | 98 | NT | 0.11 | 1.00 | ME |
| 2019 | E17 | 98 | 47 | 12.4 | Ref | 96 | 99 | 97 | NT | 0.13 | 1.00 | ME |
| 2020 | 8906 | 41 | 14 | 16.0 | Ref | 96 | 95 | 101 | NT | 0.05 | 1.00 | ME |
| 2020 | 8908 | 194 | 51 | 16.0 | Ref | 92 | 95 | 97 | NT | 0.23 | 1.06 | ME |
| 2020 | 8910 | 169 | 52 | 22.0 | Ref | 93 | 95 | 98 | NT | 0.29 | 1.03 | ME |
| 2020 | 8916 | 189 | 53 | 25.0 | Low Dist | 96 | 95 | 101 | NT | 0.37 | 1.11 | LE |
| 2020 | 8920[a] | 270 | 56 | — | — | 97 | 95 | 102 | NT | 0.26 | 1.06 | ME |
| 2020 | 8930 | 83 | 55 | 8.0 | Ref | 98 | 95 | 103 | NT | 0.21 | 1.06 | ME |
| 2020 | 8938 | 28 | 54 | 27.0 | Low Dist | 99 | 95 | 104 | NT | 0.06 | 1.00 | ME |
| 2020 | 8943 | 19 | 37 | 19.0 | Ref | 98 | 95 | 103 | NT | 0.05 | 1.00 | ME |

[a] Sample collected outside of depth range for BRI

[b] SQOs not calculated due to missing parameters

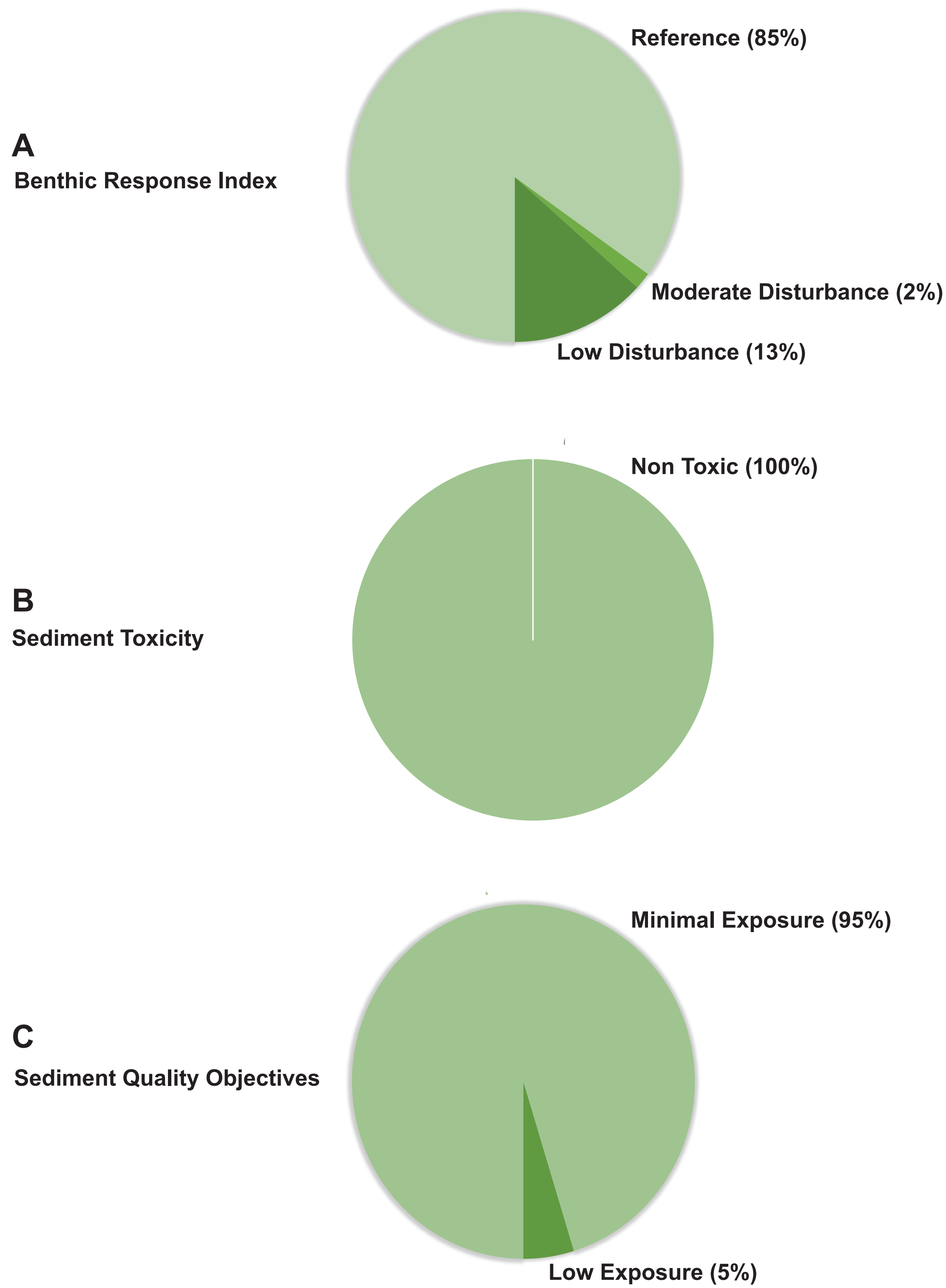


**FIGURE C3-3**
Proportion of samples that fall within condition categories for (A) the benthic response index (BRI), (B) sediment toxicity tests, and (C) sediment quality objectives.

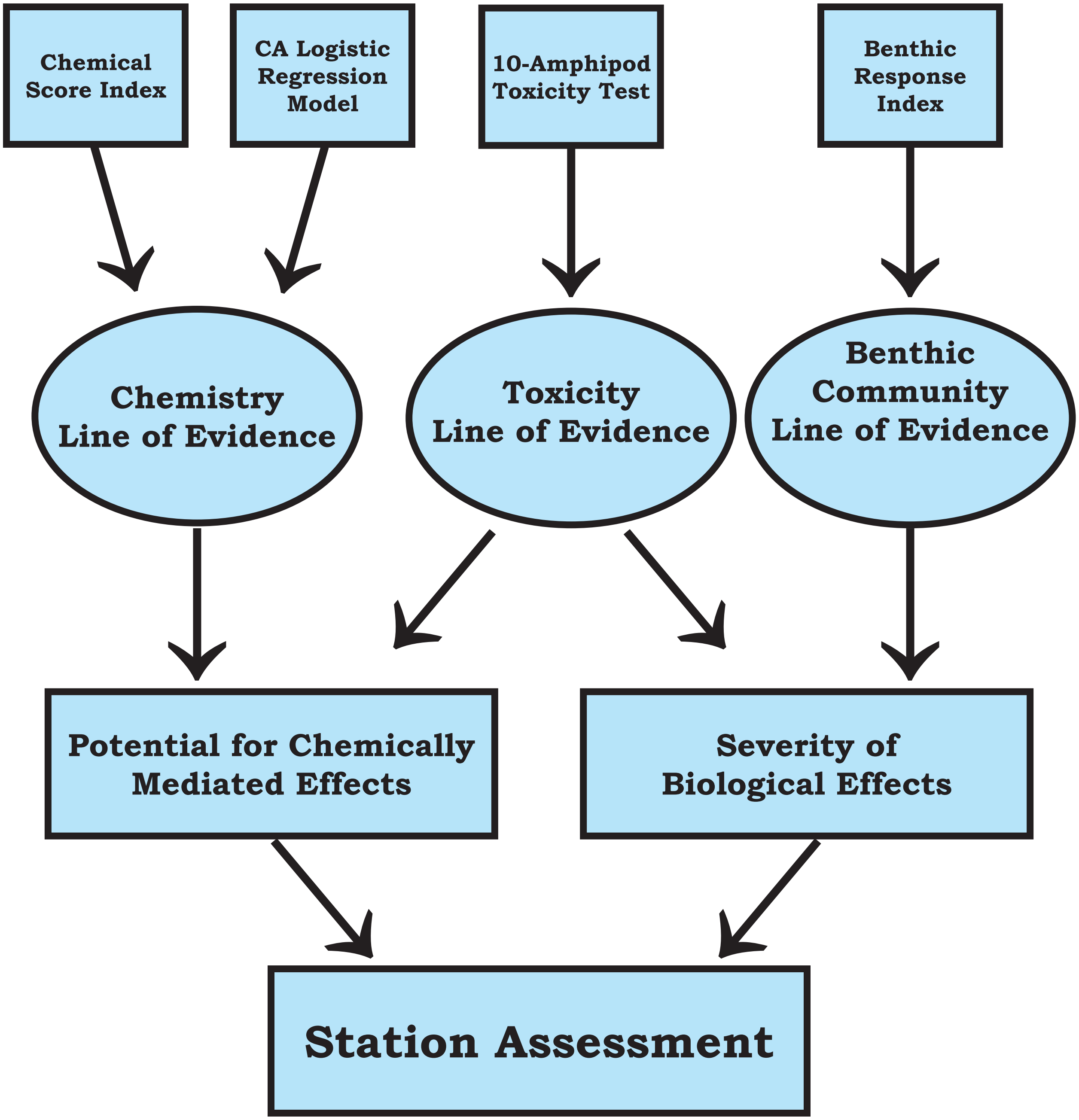


**FIGURE C3-4**
Stages of sediment quality assessment within the State of California's sediment quality assessment framework. After Figure 6.1 from Bay et al. 2013.

**TABLE C3-2**
Summary of benthic community condition (Benthic Response Index; BRI), sediment toxicty (Sed Tox), sediment chemistry exposure (SCE), station assessment and overall condition for each sample with all lines of evidence available (see text).

| | | | Threshold | | | | |
|---|---|---|---|---|---|---|---|
| Survey | Station | Depth Stratum | BRI | Sed Tox | SCE | Station Assessment | Condition |
| 2016 | 8501 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8502 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8503 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8505 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8507 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8510 | Outer Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8515 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8520 | Outer Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8522 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8523 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8526 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8529 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8533 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8536 | Outer Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | 8539 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | E11 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | E14 | Middle Shelf | Low Disturb | Non-toxic | Minimal | Unimpacted | Healthy |
| 2016 | E15 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2017 | E11 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2017 | E14 | Middle Shelf | Mod Disturb | Non-toxic | Minimal | Likely Unimp | Healthy |
| 2017 | E15 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2017 | E17 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8701 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8702 | Middle Shelf | Low Disturb | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8703 | Outer Shelf | Reference | Non-toxic | Low | Unimpacted | Healthy |
| 2018 | 8704 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8705 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8706 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8707 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8708 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8709 | Outer Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8710 | Inner Shelf | Low Disturb | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8711 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8712 | Middle Shelf | Low Disturb | Non-toxic | Minimal | Unimpacted | Healthy |

**TABLE C3-2** *continued*

| | | | Threshold | | | | |
|---|---|---|---|---|---|---|---|
| **Survey** | **Station** | **Middle Shelf** | **Inner Shelf** | **Sed Tox** | **SCE** | **Station Assessment** | **Condition** |
| 2018 | 8717 | Outer Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8718 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8721 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8724 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8727 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8730 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8744 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | 8745 | Inner Shelf | Reference | Non-toxic | Low | Unimpacted | Healthy |
| 2018 | 8748 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | E11 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | E14 | Middle Shelf | Low Disturb | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | E15 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2018 | E17 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2019 | E11 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2019 | E14 | Middle Shelf | Low Disturb | Non-toxic | Minimal | Unimpacted | Healthy |
| 2019 | E15 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2019 | E17 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2020 | 8906 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2020 | 8908 | Outer Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2020 | 8910 | Outer Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2020 | 8916 | Outer Shelf | Reference | Non-toxic | Low | Unimpacted | Healthy |
| 2020 | 8930 | Middle Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |
| 2020 | 8938 | Inner Shelf | Low Disturb | Non-toxic | Minimal | Unimpacted | Healthy |
| 2020 | 8943 | Inner Shelf | Reference | Non-toxic | Minimal | Unimpacted | Healthy |

# APPENDIX C3

# San Diego Sediment Quality Assessment

# ATTACHMENT

**ATTACHMENT C3-A**

Constituents analyzed for sediment chemistry index determination within the California sediment quality assessment framework, with City of San Diego method detection limits (CSD MDL) and corresponding recommended maximum reporting limits (RL) (Bay et al. 2013).

| | | CSD MDL | | | | CSD MDL | |
|---|---|---|---|---|---|---|---|
| **Target Analytes** | **Max RL** | **Min** | **Max** | **Target Analytes** | **Max RL** | **Min** | **Max** |
| **Metals (mg/kg):** | | | | | | | |
| Cadmium | 0.09 | 0.02 | 0.13 | Mercury | 0.09 | 0.003 | 0.004 |
| Copper | 52.8 | 0.7 | 1.2 | Zinc | 60 | 0.38 | 1.45 |
| Lead | 25 | 0.10 | 0.30 | | | | |
| **Polycyclic Aromatic Hydrocarbons (PAHs, μg/kg):** | | | | | | | |
| ***Low Molecular Weight*** | | | | | | | |
| 1-methylnaphthalene | 20 | 6.5 | 14.1 | Anthracene | 20 | 8.0 | 16.2 |
| 1-methylphenanthrene | 20 | 5.6 | 22.5 | Biphenyl | 20 | 8.8 | 21.3 |
| 2,6-dimethylnaphthalene | 20 | 7.6 | 20.2 | Fluorene | 20 | 10.6 | 17.9 |
| 2-methylnaphthalene | 20 | 6.0 | 23.2 | Naphthalene | 20 | 5.6 | 32.9 |
| Acenaphthene | 20 | 7.5 | 15.7 | Phenanthrene | 20 | 4.5 | 14.3 |
| ***High Molecular Weight*** | | | | | | | |
| Benzo(a)anthracene | 80 | 4.8 | 13.5 | Dibenz(a,h)anthracene | 80 | 1.8 | 12.0 |
| Benzo(a)pyrene | 80 | 3.5 | 12.5 | Fluoranthene | 80 | 3.2 | 13.6 |
| Benzo(e)pyrene | 80 | 4.4 | 11.4 | Perylene | 80 | 3.3 | 14.6 |
| Chrysene | 80 | 4.7 | 14.8 | Pyrene | 80 | 5.9 | 15.4 |
| **Organochlorine Pesticides (μg/kg)** | | | | | | | |
| o,p’-DDD | 0.5 | 0.03 | 0.10 | Alpha Chlordane | 0.5 | 0.04 | 0.10 |
| o,p’-DDE | 0.5 | 0.02 | 0.07 | Gamma Chlordane | 0.54 | 0.03 | 0.10 |
| o,p’-DDT | 0.5 | 0.04 | 0.07 | Trans Nonachlor | 4.6 | 0.03 | 0.12 |
| p,p’-DDD | 0.5 | 0.03 | 0.07 | Dieldrin | 2.5 | 0.03 | 0.28 |
| p,p’-DDE | 0.5 | 0.02 | 0.08 | | | | |
| p,p’-DDT | 0.5 | 0.02 | 0.07 | | | | |

**ATTACHMENT C3-A** *continued*

| Target Analytes | Max RL | CSD MDL Min | CSD MDL Max | Target Analytes | Max RL | CSD MDL Min | CSD MDL Max |
|---|---|---|---|---|---|---|---|
| **Polychlorinated Biphenyls (PCB Congeners, µg/kg)** | | | | | | | |
| PCB 8 | 3 | 0.04 | 0.06 | PCB 110 | 3 | 0.04 | 0.10 |
| PCB 18 | 3 | 0.03 | 0.11 | PCB 118 | 3 | 0.02 | 0.09 |
| PCB 28 | 3 | 0.03 | 0.07 | PCB 128 | 3 | 0.02 | 0.08 |
| PCB 44 | 3 | 0.03 | 0.09 | PCB 138 | 3 | 0.04 | 0.10 |
| PCB 52 | 3 | 0.03 | 0.09 | PCB 153 | 3 | 0.04 | 0.24 |
| PCB 66 | 3 | 0.02 | 0.08 | PCB 180 | 3 | 0.03 | 0.07 |
| PCB 101 | 3 | 0.03 | 0.08 | PCB 187 | 3 | 0.03 | 0.06 |
| PCB 105 | 3 | 0.02 | 0.12 | PCB 195 | 3 | 0.03 | 0.05 |

# APPENDIX C4

# ASSESSMENT OF MACROBENTHIC COMMUNITIES OFF POINT LOMA

March 2022

# APPENDIX C4

# Assessment of Macrobenthic Communities off Point Loma

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# APPENDIX C4

# Assessment of Macrobenthic Communities off Point Loma

## SECTION C4-1 | INTRODUCTION

The City of San Diego (City) conducts extensive monitoring of soft-bottom marine macrobenthic communities at permanent (core) monitoring sites surrounding the Point Loma Ocean Outfall (PLOO). Benthic macrofauna (e.g., worms, crabs, clams, brittle stars, other small invertebrates) are targeted when monitoring seafloor habitats because such organisms play important ecological roles in coastal marine ecosystems off southern California, and throughout the world (e.g., Fauchald and Jones 1979, Thompson et al. 1993a, Snelgrove et al. 1997). As many macrobenthic species live relatively long and stationary lives, they may exhibit effects of pollution, or other disturbances, over time (Hartley 1982, Bilyard 1987). The response of many of these species to environmental stressors is also well documented, and thus monitoring changes in discrete populations, or more complex communities, can help identify areas impacted by anthropogenic inputs (Pearson and Rosenberg 1978, Bilyard 1987, Warwick 1993, Smith et al. 2001). For example, pollution-tolerant species are often opportunistic, successfully colonizing impacted areas, and can therefore displace more sensitive species. In contrast, populations of pollution-sensitive species will typically decrease in response to contamination, oxygen depletion, nutrient loading, or other forms of environmental degradation (Gray 1979). For these reasons, the assessment of benthic community structure has become a major component of many ocean monitoring programs.

The assessment of benthic community structure requires tools that are capable of handling multiple measurement variables (i.e., distinct species within a sample) recorded from each grab sample, resulting in species-by-sample arrays that become quite large when evaluating many samples collected over time at multiple locations. Multivariate techniques such as ordination and cluster analyses are adept at handling the challenges of ecological data such as over-dispersion, zero-inflation, and the occurrence of rare species, while also providing compositional information (e.g., the turnover in identities of species), without having to meet the same assumptions required by classical parametric statistical testing (see Clarke et al. 2014). These methods are founded on similarity indices calculated between every pair of samples that measure the extent to which two (or more) samples share particular species at comparable levels of abundance. These indices then facilitate a classification, or clustering, of samples into groups which are mutually similar (i.e., cluster analysis). Ordination plots are a useful visualization tool in which the samples are “mapped” in two or three dimensions in such a way that the distances between pairs of samples reflect their relative dissimilarity of species composition.

The main objective of this appendix is to assess temporal trends in benthic macrofaunal communities at permanent (core) monitoring sites surrounding the PLOO over the past 30 years. Ordination and cluster analyses were used to evaluate changes in macrobenthic community structure within the PLOO region without *a priori* assignment of stations near the Zone of Initial Dilution (near-ZID) versus farfield location, or pre- and post-discharge time periods. Preliminary results from a component of the multi-phase San Diego Regional Benthic Condition Assessment Project (see City of San Diego 2020) are presented herein, and are intended to supplement results presented earlier in this application for the regular fixed-grid monitoring sites surrounding the PLOO (see Appendices C1 and C2 in this application).

## SECTION C4-2 | GENERAL METHODOLOGY

The benthic samples analyzed for this study were collected from the 12 PLOO primary core stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020, thus matching the datasets analyzed in both Appendices C1 and C2, this application. As described in Appendix C1, three of the 12 primary core stations, E14, E11 and E17, are located within about 100–300 meters (m) of the outfall diffuser legs (i.e., within 200 m of the ZID) and are considered nearfield or near-ZID sites (Figure C4-1). Station E14 is nearest the outfall, located adjacent to the ZID boundary about 103 m west of the center of the outfall wye. This station is the site most likely to be impacted by wastewater discharge. Stations E11 and E17 are located a little farther away off the ends of the southern and northern diffuser legs, respectively. Station E11 is located about 149 m south of the southern ZID boundary, while E17 is located about 197 m north of the northern ZID boundary. The remaining seven "E" stations are considered farfield sites. The two "B" stations are located >11 km north of the discharge area and were originally selected to represent reference or control sites.

Samples for benthic analyses were collected using a single or double 0.1-$m^2$ Van Veen grab, with one grab used for sediment quality analysis and one grab used for benthic community analysis. Criteria established by the U.S. Environmental Protection Agency (USEPA) to ensure consistency of these types of samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All identifications followed nomenclatural standards established by the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT 2018). Herein, "species" were calculated as distinct taxa, which may or may not be identified at the species level.

Particle size data were limited to samples collected winter 1992 through summer 2020, because previous methods were not compatible. Over the years, analyses were performed using various models of Horiba laser scattering particle analyzers, or a set of nested sieves. The Horiba measures particles ranging in size from 0.5 to 2000 micrometers (µm). Coarser sediments were removed and quantified prior to laser analysis by screening samples through a 2000 µm mesh sieve. These data were later combined with the Horiba results to obtain a complete distribution of particle sizes totaling 100%, and then classified into 11 sub-fractions and four main size fractions, based on the Wentworth scale (Folk 1980) (see Attachment C4-A). When a sample contained substantial amounts of coarse sand, gravel, or shell hash that could damage the Horiba analyzer, and/or where the general distribution of sediments would be poorly represented by laser analysis, a set of nested sieves with mesh sizes of 2000 µm, 1000 µm, 500 µm, 250 µm, 125 µm, 75 µm, and 63 µm was used to divide the samples into seven sub-fractions.

Multivariate analyses were performed using PRIMER v7 software to examine temporal patterns in the particle size and macrofaunal datasets described above (Clarke et al. 2008, 2014). These included ordination and hierarchical agglomerative clustering (cluster analysis) with group-average linking and similarity profile analysis (SIMPROF) to confirm the non-random structure of the resultant cluster dendrograms. Prior to these analyses, proportions of silt and clay sub-fractions were combined as fine particles and particles >1000 µm were combined as coarse particles to accommodate differences in analytical methods over the years. Macrofaunal abundance data were square-root transformed to lessen the influence of overly abundant species and increase the importance (or presence) of rare species. Measures of dissimilarity/similarity used as the basis for clustering included Euclidean distance for particle size data and the Bray-Curtis measure of similarity for macrofaunal data. Major ecologically-relevant clusters receiving SIMPROF support were retained, and similarity percentages analysis (SIMPER) was used to determine which species were responsible for the greatest contributions to within-group similarity (i.e., characteristic species) and between-group dissimilarity (i.e., distinguishing species) for retained macrofauna clusters.

PRIMER's BEST test, using the BVSTEP procedure, was conducted to determine which subset of sediment sub-fractions or species best described patterns within the dendrograms resulting from each of the above cluster analyses. An additional BEST test, using the BIO-ENV procedure, was conducted to determine which subsets of sediment sub-fractions were the best explanatory variables for similarity between the particle size and macrofaunal resemblance matrices. To determine whether macrofaunal communities varied by sediment particle size sub-fractions, a RELATE test was used to compare patterns in the macrofauna Bray-Curtis resemblance matrix with patterns in the particle size Euclidean distance matrix.

# SECTION C4-3 | RESULTS & DISCUSSION

## Distribution of Sediments

Ordination and cluster analyses of sediment particle size data collected 1992–2020 from PLOO primary core stations resulted in five ecologically-relevant SIMPROF-supported sediment clusters (groups 1 – 5) (Figure C4-2, Table C4-1). According to BEST/BVSTEP results ($\rho = 0.976$, $p \leq 0.001$, number of permutations = 999), these five clusters were primarily distinguished by differing proportions of very fine sand and fine particles. With Euclidean distance dissimilarity set at 30%, patterns related to pre- versus post-discharge periods were not apparent in the distribution of sediment cluster groups. However, the occurrence of coarser sediments at northern reference station B12, southern farfield station E2, and near-ZID station E14 described in Appendix C1 and Appendix C2 was evident (i.e., sediment cluster groups 1 – 4 versus group 5).

Sediment cluster group 1 comprised a single sample from station B12 collected in summer 2001 that had the lowest proportion of fine particles (11%) and very fine sand (13%), the second highest proportion of medium sand (10%), and the highest proportion of coarse sand (54.5%) relative to the other groups (Figure C4-2, Table C4-1). Group 2 comprised four samples from station E14 that had the lowest proportion of fine sand (mean=2%), the second lowest proportion of fine particles (mean=16%), the second highest proportion of coarse sand (mean=9%), and the highest proportion by far of coarse particles (mean=51%). Group 3 comprised 29 samples, 86% of which were collected from station B12. Samples in this group had the highest proportion of fine sand (mean=22%) and medium sand (mean=18%). Group 4 comprised 17 samples, including eight from farfield stations B9, E2, E5, E8, and E25, and nine from near-ZID stations E11, E14 and E17. Samples in this group had the second highest proportion of fine particles (mean=29%), the highest proportion of very fine sand (mean=63%), the lowest proportion of medium sand (mean=0.2%), and the second lowest proportion of coarse sand (mean=0.5%) and coarse particles (mean=2%). Group 5 comprised 93% (n=644) of all samples collected at PLOO primary core stations from 1992 through 2020. Sediments represented by group 5 had the highest proportion of fine particles (mean=42%), the second highest proportion of very fine sand (mean=39%) and fine sand (mean=16%), and the lowest proportion of coarse sand (mean=0.4%) and coarse particles (mean=0.5%). It is likely that this sediment cluster group represents background conditions in the Point Loma region (also referred to as “mud-belt” shelf habitats) that correspond to the Amphiodia “mega-community” described by Barnard and Ziesenhenne (1961) that is known to be common off San Diego (e.g., City of San Diego 2020, Appendix C2), as well as other parts of the southern California mainland shelf (e.g., Jones 1969, Fauchald and Jones 1979, Thompson et al. 1987, 1993; Zmarzly et al. 1994, Diener and Fuller 1995, and Bergen et al. 1998, 2000, 2001).

## Distribution of Macrobenthic Communities

Ordination and cluster analyses of the macrofaunal data collected 1991–2020 from PLOO primary core stations resulted in 15 ecologically-relevant SIMPROF-supported macrofauna clusters (groups A–O) (Figure C4-3). With the Bray-Curtis measure of similarity set at 40%, patterns related to pre- versus post-discharge periods were not apparent in the distribution of macrofauna cluster groups, and near-ZID versus farfield station differences were minimal (Figure C4-3C). Instead, macrofauna clusters J, K, and M accounted for 96% of the grab samples from 11 of the 12 PLOO primary core stations, split into three periods: (1) group K spanned surveys conducted from summer 1991 through summer 2006; (2) group M spanned surveys conducted from winter 2007 through summer 2015; (3) group J spanned surveys from winter 2016 through summer 2020. Additionally, macrofaunal communities at northern farfield station B12 remained distinct during all surveys (i.e., macrofauna cluster groups F, G, H), while communities at southern farfield station E2 and near-ZID station E14 sporadically grouped apart from other stations (e.g., macrofauna cluster groups B, D, E, O).

Because sediments within the “mud-belt” region off Point Loma are so consistent (see above and Appendix C2 in this application), a comparison of the similarity matrices used to generate cluster dendrograms based on matched macrofauna and sediment particle size samples were only 33% correlated (RELATE $\rho = 0.33$, $p \leq 0.001$, number of permutations = 999). The sediment sub-fractions that were most highly correlated with the macrofaunal communities included coarse particles, medium sand, fine sand, and very fine sand (BEST/BIOENV $\rho = 0.36$, $p \leq 0.001$, number of permutations = 999).

The composition of each cluster group varied in terms of the specific taxa present and their relative abundance. According to BEST/BVSTEP ($\rho = 0.948$, $p \leq 0.001$, number of permutations = 999), a total of 65 species (taxa) best described the overall pattern (gradient) of the cluster dendrogram (Attachment C4-B). Out of the 65 species, 28 of these species were strongly characteristic of one or more cluster groups according to SIMPER (see Table C4-3, Attachment C4-B, and group descriptions below), while 13 are considered environmental indicator species (see Appendices C1 and C2 in this application), including individuals of ophiuroids in the family Amphiuridae, the genus *Amphiodia* sp, and identified as *A. urtica* or *A. digitata*, as well as the ampeliscid amphipods A*mpelisca pacifica*, *A. brevisimulata*, and *A. careyi*, the phoxocephalid amphipod *Rhepoxynius bicuspidatus*, the philomedid ostracods *Euphilomedes producta* and *E. carcharodonta*, the capitellid polychaetes *Capitella teleta* and *Mediomastus* sp, and the bivalve *Parvilucina tenuisculpta*. The main characteristics and distribution of each macrofauna cluster group are described below.

### S*mall "Outlier" Assemblages*

Macrofauna clusters A – E, I, L, N and O represented small "outlier" groups with 1-13 grabs each (Figures C4-3–C4-5, Tables C4-2–C4-4). Community parameters for each of these groups averaged from 43 to 126 species per grab for species richness, 94 to 494 individuals per grab for abundance, 3.2 to 4.2 units per grab for Shannon diversity (H'), 0.84 to 0.93 units per grab for Pielou's evenness (J'), and 14 to 42 taxa per grab for Swartz dominance. For grabs in all but one of these groups, benthic response index (BRI) values were ≤24.3. BRI values below 25 are considered indicative of reference conditions, while values above 34 represent increasing levels of disturbance or environmental degradation (Smith et al. 2001). This finding indicates that the outlier groups were not necessarily indicative of degraded conditions.

Macrofauna cluster group A represented a unique macrofaunal assemblage present at southern farfield station E5 in winter 1995 that had a BRI value of 3.1. The species with the five highest abundances in this grab were the bivalve *Keenaea centifilosum*, the ischyrocerid amphipod *Ericthonius brasiliensis*, the ophiuroid *Amphichondrius granulatus*, the onuphid polychaete *Paradiopatra parva*, the cirratulid polychaete *Chaetozone hartmanae*, the ampharetid polychaete *Eclysippe trilobata*, the terebellid polychaete *Proclea* sp A, *Ampelisca careyi*, and *Amphiodia urtica* (no SIMPER results available for groups with n<2). This was the only sample in which *E. brasiliensis* occurred, and it had the highest numbers of *K. centifilosum* and *A. granulatus* (15 and 8 individuals, respectively). Among cluster groups, sediments associated with this assemblage had the highest proportion of fine particles (46%, along with groups L and J), second highest proportion of very fine sand (45%), and moderate amounts of fine sand (9%). No medium sand, coarse sand, or coarse particles were present in this sample.

Macrofauna cluster group B comprised four grabs collected from station E14 during winter 2016 through summer 2017. Assemblages represented by this group had the highest mean BRI (33.8, range=27.8–37.4), likely associated with the highest recorded mean abundance (along with Group M) of the bivalve *Solemya pervernicosa* (mean=7 individuals). Group B also had the highest mean abundance of the bivalve *Tellina carpenteri* (mean=15 individuals). According to SIMPER results, the three other most characteristic species for group B included the bivalves *Axinopsida serricata* and *Parvilucina tenuisculpta*, and the capitellid polychaete *Notomastus hemipodus*. Sediments associated with these assemblages had the highest proportion of very fine sand (mean=53%), relatively low proportions of fine particles (mean=27%), relatively low proportions of fine sand (mean=9%), and less than 5% medium sand, coarse sand, or coarse particles per sample.

Macrofauna cluster group C comprised two grabs collected during winter 1992, one each from near-ZID station E11 and southern farfield station E2. Assemblages represented by this group had BRI values <3.4 per grab, moderate numbers of *Amphiodia urtica*, and were also characterized by *Euphilomedes producta*, the pectinariid polychaete *Pectinaria californiensis*, the spionid polychaete *Spiophanes duplex*, and the bivalve *Huxleyia munita*. Sediments associated with group C had moderate proportions of fine particles (mean=34%) and very fine sand (mean=41%), with relatively high proportions of fine sand (mean=22%), and less than 5% medium sand, coarse sand, or coarse particles per sample.

Macrofauna cluster group D represented a unique assemblage present at station E14 during summer 2006 that had a BRI of 22.5, and the highest numbers of the spionid polychaete *Prionospio jubata*, (48 individuals), the photid amphipod *Photis californica*, (22 individuals), and the glycerid polychaete *Glycera nana* (14 individuals). The capitellid polychaete *Decamastus gracilis*, and the bivalve *Nuculana* sp A were also among the most abundant species in this grab. Sediments associated with this assemblage had the highest proportion of coarse sand (12%) and coarse particles (50%), and the lowest proportion of fine particles (15%) and fine sand (0.6%).

Macrofauna cluster group E comprised two grabs from station E14, one collected during winter and one collected during summer 2010. Assemblages represented by this group had BRI values <24.3 per grab and were characterized by the highest mean abundances of *Notomastus hemipodus* and *Decamastus gracilis* (23 and 21 individuals, respsectively), and maldanid polychaetes within the subfamily of Euclymeninae. The two other most characteristic species were *Parvilucina tenuisculpta* and *Chaetozone hartmanae*. Similarly to group D, sediments associated with group E assemblages had some of the highest proportions of coarse sand (mean=8.5%) and coarse particles (mean=26.5%), and relatively low proportions of fine particles (mean=28%) and very fine sand (mean=28%).

Macrofauna cluster group I represented a unique assemblage present at station E5 during winter 2016 that had a BRI of 5.7, the highest numbers of *Ampelisca brevisimulata* (4 individuals), and the third highest numbers of *Amphiodia urtica*. The leptocheliid tanaid *Chondrochelia dubia* Cmplx, the terebellid polychaete *Phisidia sanctaemariae*, the orbiniid polychaete *Scoloplos armiger* Cmplx, *Nuculana* sp A, *Rhepoxynius bicuspidatus*, and *Chaetozone hartmanae* were also among the most abundant species in this grab. Sediments associated with this assemblage had moderate proportions of fine particles (37.5%), relatively high proportions of very fine sand (44.3%), and less than 1.2% medium sand, coarse sand, or coarse particles.

Macrofauna cluster group L comprised two grabs from station B9, one collected during summer 2015 and one collected during summer 2016. Assemblages represented by this group had BRI values <12.3 per grab, and were characterized by the highest mean abundance of *Chaetozone hartmanae* and *Nuculana* sp A (24 and 20 individuals, respectively), the second highest mean abundance of the amphinomid polychaete *Chloeia pinnata* (with group O), and was also characterized by the spionid polychaete *Prionospio dubia* and the maldanid polychaete *Praxillella pacifica*. Sediments associated with group L assemblages had the highest proportion of fine particles (mean=46%, along with groups A and J), along with moderate proportions of very fine and fine sand (means=38 and 14%, respectively), and less than 1.5% medium sand, coarse sand, or coarse particles.

Macrofauna cluster group N comprised two grabs from station E2, one collected during winter 1995 and one collected during winter 1997. Assemblages represented by this group had BRI values <5.3 per grab and were characterized by moderate to low mean abundances of *Amphiodia urtica*, *Euphilomedes producta*, *Proclea* sp A, *Chaetozone hartmanae*, and *Spiophanes duplex*. Sediments associated with group N assemblages had some of the highest proportions of fine particles (mean=45%), relatively high fine sand (mean=23%), along with relatively low proportions of very fine sand (mean=26%), and less than 5% medium sand, coarse sand, or coarse particles.

Macrofauna cluster group O comprised 13 grabs overall, including one collected at northern farfield station E26 in summer 1995, four collected at station E14 in the summers of 1993, 1994, and 1995, and the winter of 1997, and eight collected at station E2 from summer 1993 through summer 1994, summer 1995, and from summer 1998 through winter 2001. Assemblages represented by group O had BRI values <19.8 per sample, the highest mean abundance of *Paradiopatra parva* (mean=10 individuals), *Proclea* sp A (mean=23 individuals), *Pectinaria californiensis* (mean=17 individuals), and *Phisidia sanctaemariae* (mean=21 individuals), as well as the third highest mean abundance of *Spiophanes duplex*. Sediments associated with these assemblages had moderate proportions of fine particles (mean=37%), very fine sand (mean=32%), fine sand (mean=17%), and medium sand (mean=4%), along with the third highest proportion of coarse particles (mean=8%).

### *Assemblages at Farfield Station B12*

Station B12 is located farthest to the north of the PLOO and is known to have distinct macrofaunal communities present (see Appendices C1, and C2 in this application, and City of San Diego 2020). Results from the analyses presented herein also demonstrated that assemblages encountered at station B12 were distinct from the 11 other PLOO primary core stations (Figures C4-3–C4-5, Tables C4-2–C4-4). Mean community parameter values for each of these groups were similar, ranging from 93 to 103 species per grab for species richness, 339 to 376 individuals per grab for abundance, 3.7 to 4.0 units per grab for Shannon diversity (H’), 0.83 to 0.87 units per grab for Pielou’s evenness (J’), and 27 to 38 taxa per grab for Swartz dominance. All grabs collected from station B12 had BRI values <12.2 per grab.

While assemblages represented by groups F, G, and H were fairly similar overall in terms of community parameters and sediments, they did differ in terms of the most characteristic species. Assemblages present at station B12 from summer 1991 to summer 2000, represented by group H, had the highest mean abundance of *Huxleyia munita*, *Caecum crebricinctum*, and *Amphiodia digitata* (means=32, 35, and 16, respectively), the second highest mean abundance *Pectinaria californiensis* (with group C), and the third highest mean abundance of *Euphilomedes producta*. Assemblages present at station B12 from winter 2001 to winter 2016, represented by group G, had the second highest mean abundance of the gastropod *Caecum crebricinctum*, *Amphiodia digitata*, and *Euphilomedes producta*, the third highest mean abundance of *Prionospio jubata*, and moderate numbers of *Euphilomedes carcharodonta*. Assemblages present at station B12 from summer 2016 to summer 2020, represented by group F, had the highest mean abundances of *Eclysippe trilobata* (mean=27 individuals) and the fauveliopsid polychaete *Fauveliopsis* sp SD1 (mean=23 individuals), among the highest abundances of *Spiophanes duplex* and *Prionospio jubata*, and moderate numbers of *Nuculana* sp A.

According to SIMPER, several of the above species also distinguished groups F, G, and H from assemblages represented by groups J, K and M (Figure C4-4). For example, relative abundances of *Amphiodia digitata*, *Caecum crebricinctum*, *Chloeia pinnata*, *Eclysippe trilobata*, *Fauveliopsis* sp SD1, *Huxleyia munita*, and *Phisidia sanctaemariae* were higher at station B12 than other stations during one or more of the time periods described above, while relative abundances of *Amphiodia urtica*, *Axinopsida serricata*, *Euphilomedes producta*, *Myriochele striolata*, and *Proclea* sp A were lower. *Spiophanes duplex* had lower relative abundance at station B12, but only during 2016-2020 (group F verses group J).

When compared to all other cluster groups, sediments associated with groups F, G, and H had moderate to high proportions of fine particles (means=30-42%) and coarse particles (means=1-3%), and relatively low proportions of very fine sand (means=21-23%). Groups G and H had the highest proportions of fine sand (means=24.5-26%), while groups F and H had the highest proportions of medium sand (mean=15%) and coarse sand after Groups D and E (means=4-6%).

### *Background "Mud-belt" Assemblages*

Macrofauna cluster groups J, K and M comprised 620 grabs, or 96% of all grabs collected from 11 of 12 PLOO core stations from 1991 through 2020 (i.e., excluding station B12) (Figures C4-3–C4-5, Tables C4-2 – C4-4). As with sediment cluster group 1 described in the previous section, it is likely that assemblages represented by these groups denote background conditions in the Point Loma region (also referred to as "mud-belt" shelf habitats) that correspond to the *Amphiodia* "mega-community" described by Barnard and Ziesenhenne (1961) that is known to be common off San Diego (e.g., City of San Diego 2020, Appendix C2) as well as other parts of the southern California mainland shelf (e.g., Jones 1969, Fauchald and Jones 1979, Thompson et al. 1987, 1993; Zmarzly et al. 1994, Diener and Fuller 1995, and Bergen et al. 1998, 2000, 2001).

Mean community parameter values for each of these groups were similar, ranging from 74 to 86 species per grab for species richness, 304 to 378 individuals per grab for abundance, 3.5 to 3.8 units per grab for Shannon diversity (H'), 0.82 to 0.87 units per grab for Pielou's evenness (J'), 21 to 30 taxa per grab for Swartz dominance, and 5.8 to 14.2 per grab for BRI (range across groups= -4.3–33.5 per grab). When compared to all other cluster groups, sediments associated with Groups J, K, and M were also very similar, each having relatively high proportions of fine particles (means=40–45.5%) and moderate proportions of very fine sand (means=40–41%), fine sand (means=12.5–17%) and medium sand (means=1–2%), with <1% coarse sand or coarse particles per sample, on average.

The "mud-belt" assemblages were split into three periods that were slightly offset from those described above for station B12. The most characteristic species for assemblages present from 1991 to 2006, represented by group K (n=320 grabs), were *Amphiodia urtica*, *Proclea* sp A, *Spiophanes duplex*, *Euphilomedes producta*, and *Phisidia sanctaemariae*. These assemblages had the highest mean abundance of *A. urtica* (mean=33 individuals), the second highest mean abundance of *Proclea* sp A, and moderate numbers of the other three characteristic species. While not one of the strongly characteristic species, higher relative abundances of *Myriochele striolata* helped distinguish group K from group M. Characteristic species for assemblages present from 2007 to 2015, represented by group M (n=197 grabs), were *A. urtica*, *E. producta*, *Chaetozone hartmanae*, *Euphilomedes carcharodonta*, and *Prionospio jubata*. These assemblages had the highest mean abundance of *E. producta* and *E. carcharodonta* (means=16 and 15 individuals, respectively), the second highest mean abundance of *A. urtica*, and moderate numbers of the other two characteristic species. Characteristic species for assemblages present from 2016 through 2020, represented by group J (n=103 grabs), were *S. duplex*, *A. urtica*, *P. jubata*, *Axinopsida serricata*, and *Eclysippe trilobata*. These assemblages had the highest mean abundance of *A. serricata* and *S. duplex* (means=35 and 40, respectively), the second highest mean abundance of *E. trilobata*, and moderate numbers of the other two characteristic species. While not one of the strongly characteristic species, higher relative abundances of *Mediomastus* sp helped distinguish group J from group K.

## SECTION C4-4 | SUMMARY

Multivariate analyses of macrofaunal data collected from PLOO primary stations over the past 30 years suggest that wastewater discharged through the PLOO has not affected macrobenthic communities in the region other than a minor deviation from reference conditions that may be occurring at near-ZID station E14 (see also Appendices C1 and C2 in this application). Sediments from 93% of the samples collected from 1992 through 2020, and assemblages from 88% of macrofaunal grabs (96% with northern reference station B12 excluded) collected from 1991 through 2020 were representative of background conditions typical for this portion of the southern California coast (Emery 1960, Barnard 1963, Jones 1969, Thompson et al. 1987, 1993a,b, MBC-ES 1988, Mikel et al. 2007), and consistent with results of regional surveys off San Diego (e.g., Appendix C2 , City of San Diego 2008–2015b, 2016, 2018, 2020), and other areas of the Southern California Bight (Bergen et al. 1998, 2001, Schiff and Gossett 1998, Noblet et al. 2002, Schiff et al. 2006, 2011, Maruya and Schiff 2009, Ranasinghe et al. 2003, 2007, 2010, 2012, Dodder et al. 2016, Gillett et al. 2017, SCCWRP 2018).

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# APPENDIX C4

## Assessment of Macrobenthic Communities off Point Loma

### FIGURES & TABLES

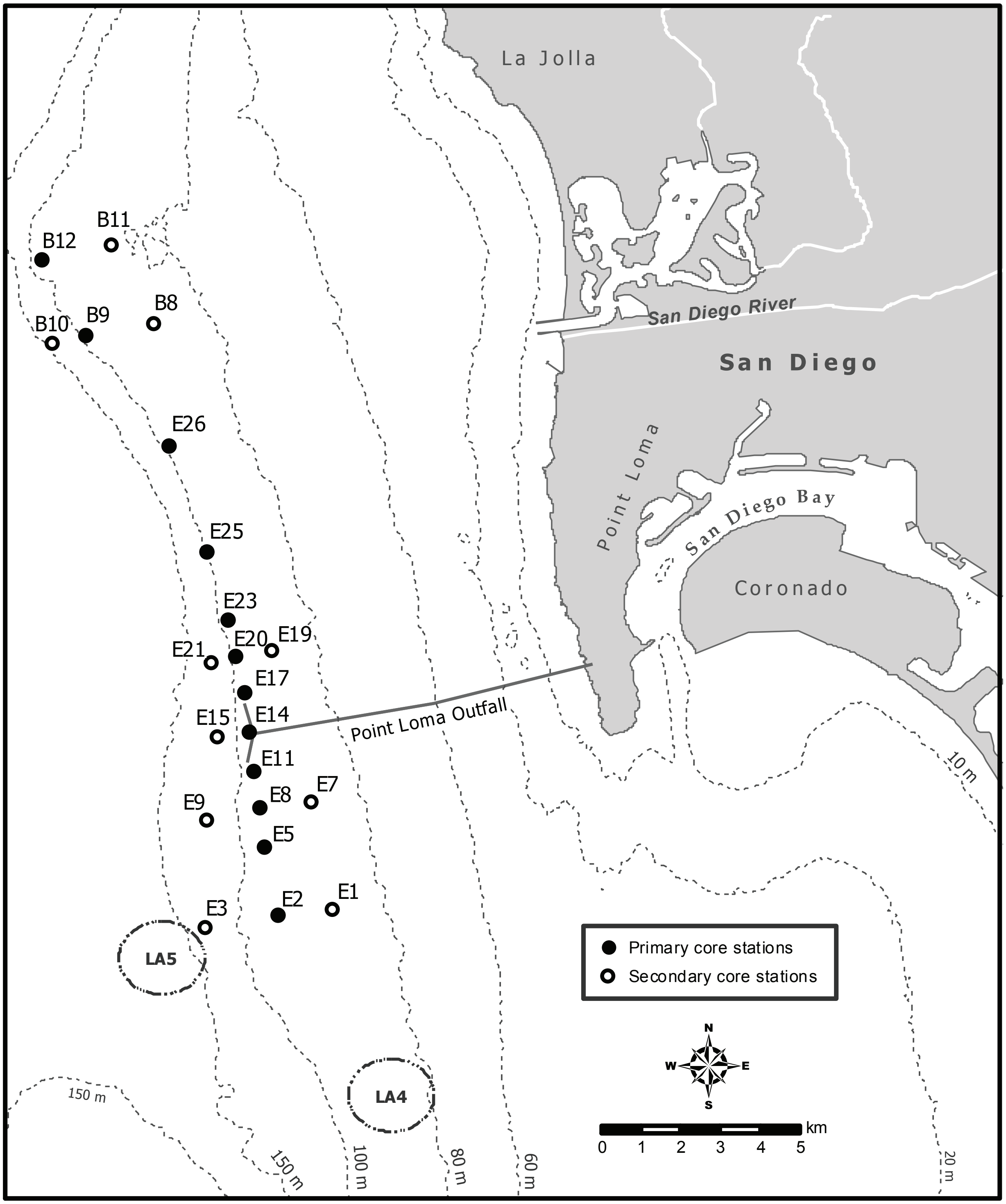



**FIGURE C4-1**

Benthic station locations sampled around the PLOO as part of the City of San Diego's Ocean Monitoring Program. Primary core stations (●) = 12 monitoring sites located along the 98-m outfall discharge depth contour that are the focus of the analyses presented in this 301(h) modified permit application. Secondary core stations (**o**) = five sites along the 88-m depth contour and five sites along the 116-m depth contour. LA-4 and LA-5 = USEPA designated dredged materials disposal sites.

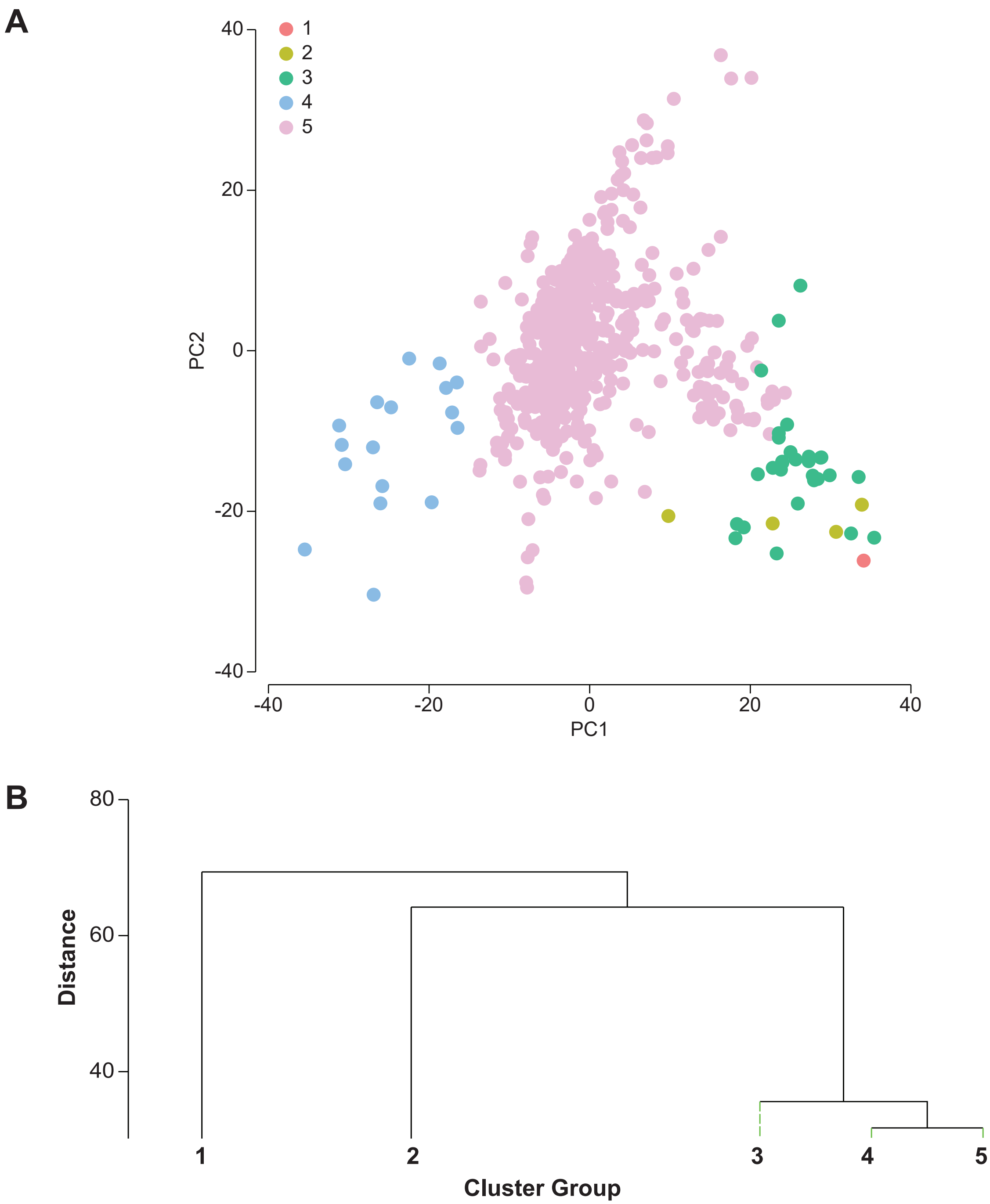



**FIGURE C4-2**
Results of ordination and cluster analysis of particle size sub-fraction data from the 12 PLOO primary core stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Results are presented as (A) two-dimensional Principal Components Analysis ordination; (B) a dendrogram of main cluster groups; (C) a matrix showing distribution of cluster groups over time; ns = no sample.

C

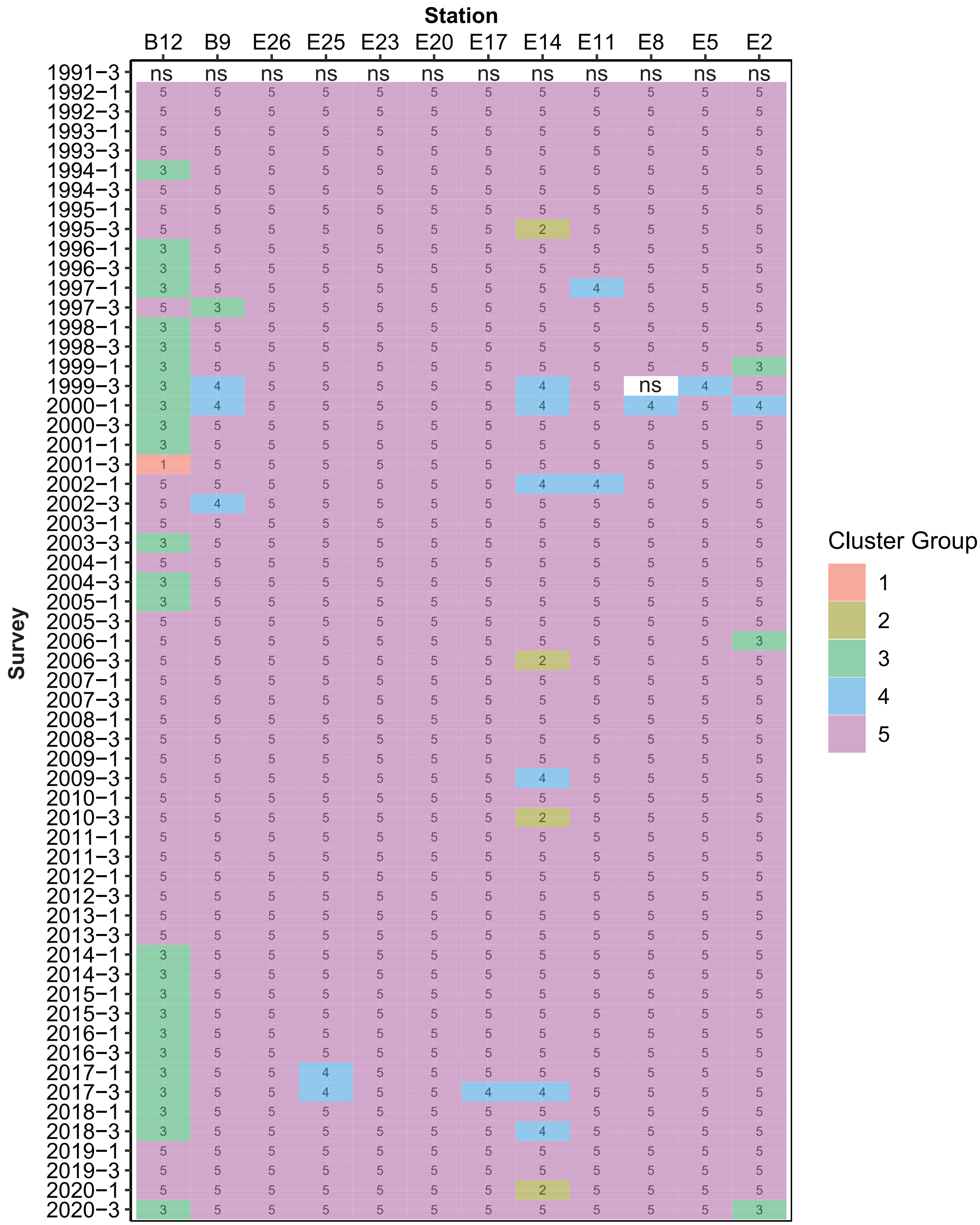
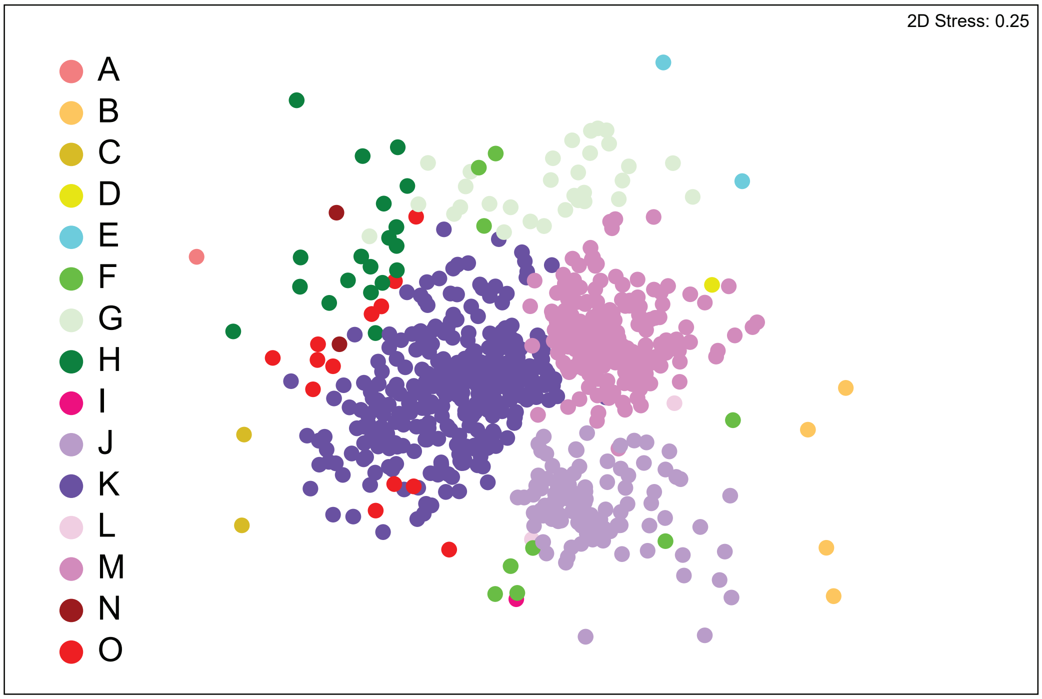



**FIGURE C4-2** *Continued*

**TABLE C4-1**
Particle size summary for each particle size cluster group 1–5 (defined in Figure C4-2). Data are presented as means (ranges) calculated over all stations within a cluster group (n); VF = very fine; F = fine; M = medium; C = coarse.

| | | Particle Size (%) | | | | | |
|---|---|---|---|---|---|---|---|
| **Cluster Group** | **n** | **Fines** | **VF Sand** | **F Sand** | **M Sand** | **C Sand** | **C Particles** |
| 1 | 1 | 10.8 | 12.7 | 7.7 | 10.1 | 54.5 | 4.2 |
| 2 | 4 | 16.2<br>(15.2-17.3) | 19.8<br>(10.6-33.2) | 2.2<br>(0.6-6.2) | 1.2<br>(0.4-1.6) | 9.4<br>(0-17) | 51.4<br>(38.6-64.2) |
| 3 | 29 | 27.4<br>(16.9-46) | 19.6<br>(12.2-28.3) | 22.0<br>(8.5-30.4) | 18.4<br>(4.1-27.2) | 7.8<br>(0.3-17) | 4.9<br>(0-24.3) |
| 4 | 17 | 29.1<br>(13.5-38.6) | 63.1<br>(54.5-75.7) | 5.6<br>(0.1-17.1) | 0.2<br>(0-1.1) | 0.5<br>(0-4.5) | 1.6<br>(0-8) |
| 5 | 644 | 42.1<br>(16.2-73.9) | 39.0<br>(14.6-53.8) | 16.3<br>(2.1-34.9) | 1.8<br>(0-16.4) | 0.4<br>(0-12.9) | 0.5<br>(0-13.8) |

A




B

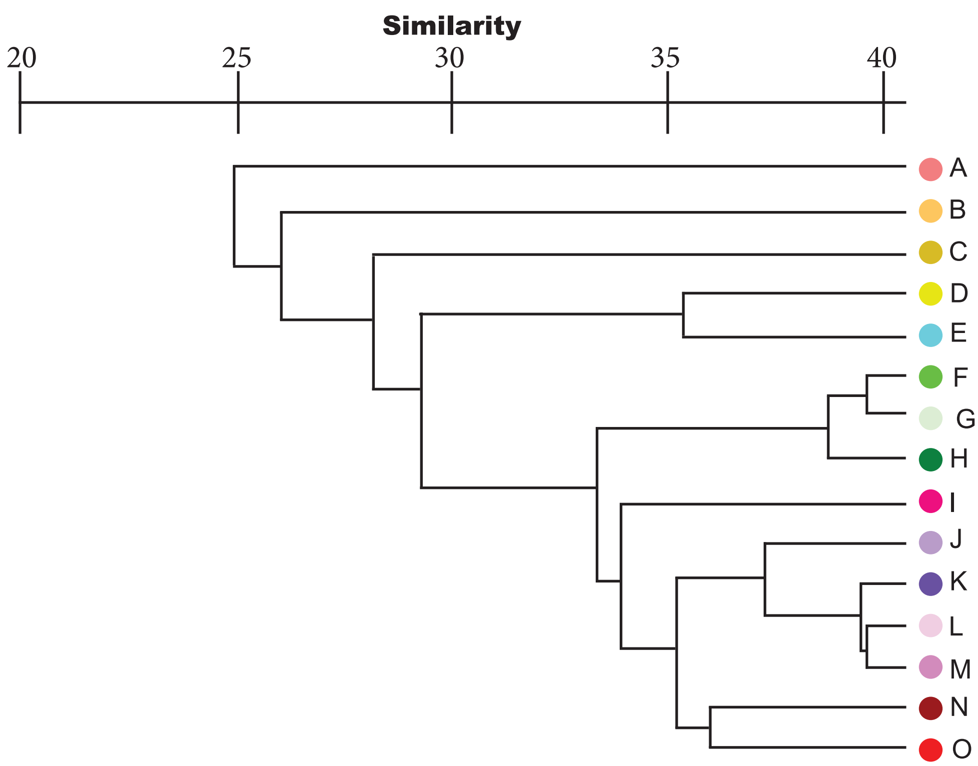



**FIGURE C4-3**
Results of ordination and cluster analysis of macrofauna data from the 12 PLOO primary core stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Results are presented as (A) non-metric multi-dimensional scaling ordination; (B) a dendrogram of main cluster groups; (C) a matrix showing distribution of cluster groups over time; ns = no sample.

**C**

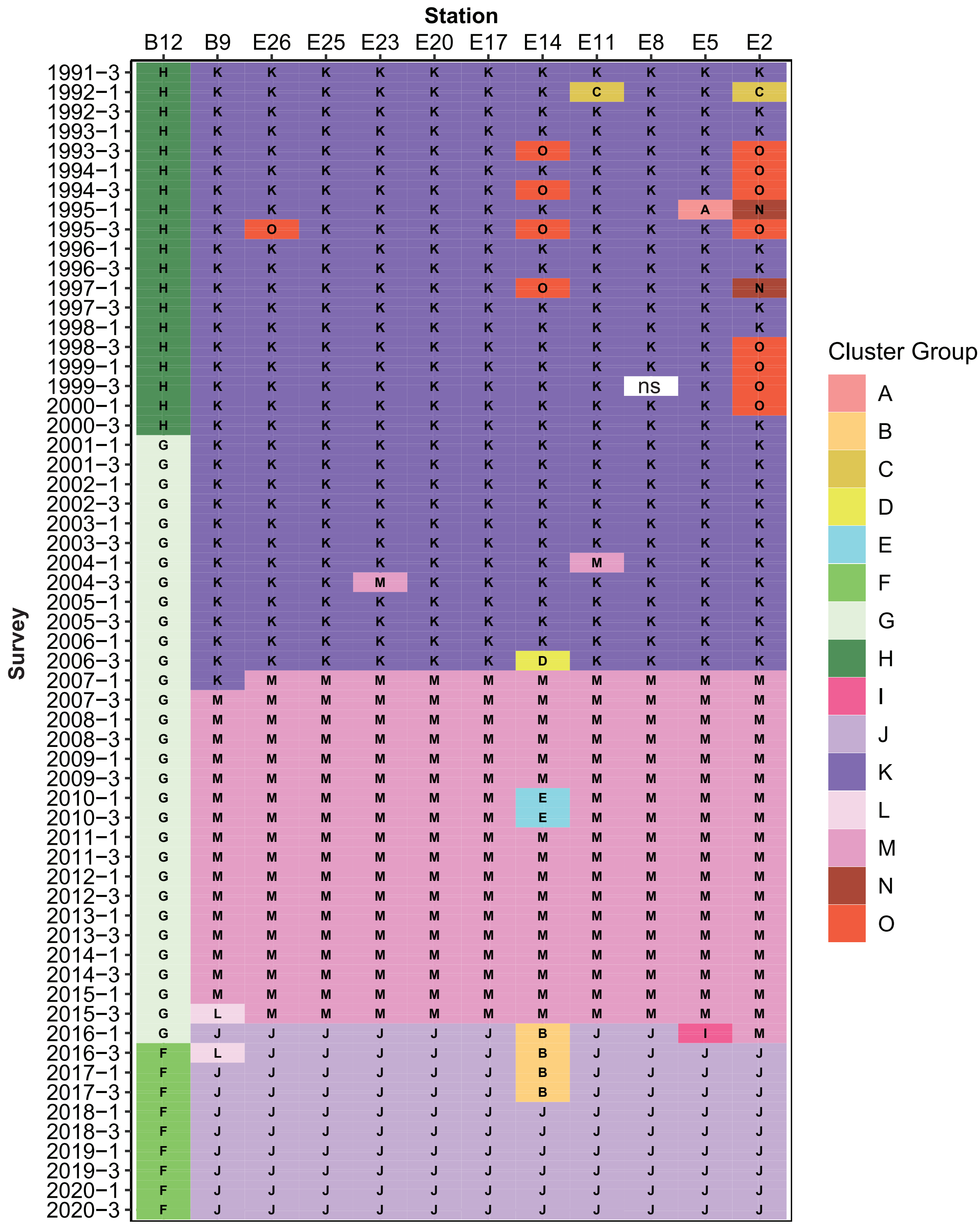



**FIGURE C4-3** *Continued*

**TABLE C4-2**
Community parameter summary for each macrofauna cluster group A–O (defined in Figure C4-3). Data are presented as means (ranges) calculated over all stations within a cluster group (n). SR = species richness; Abund = abundance; H' = Shannon diversity index; J' = Pielou's evenness; Dom = Swartz dominance; BRI = benthic response index.

| Cluster Group | n | Community Parameter | | | | | |
|---|---|---|---|---|---|---|---|
| | | SR | Abund | H | J | Dom | BRI |
| A | 1 | 65 | 138 | 3.9 | 0.93 | 31 | -3.1 |
| B | 4 | 47 | 190 | 3.2 | 0.84 | 14 | 33.8 |
| | | (44-50) | (147-232) | (3.0-3.4) | (0.80 -0.88 ) | (11-19) | (27.8 -37.4 ) |
| C | 2 | 49 | 125 | 3.4 | 0.88 | 20 | 2.8 |
| | | (44-54) | (124-126) | (3.2-3.6) | (0.86-0.91) | (17-23) | (2.1-3.4) |
| D | 1 | 105 | 428 | 4.1 | 0.87 | 34 | 22.5 |
| E | 2 | 126 | 494 | 4.2 | 0.87 | 42 | 21.8 |
| | | (126-126) | (418-570) | (4.0-4.4) | (0.84-0.91) | (36-47) | (19.2-24.32) |
| F | 9 | 102 | 375 | 4.0 | 0.86 | 35 | 11.3 |
| | | (86-136) | (242-520) | (3.6-4.2) | (0.79 -0.90) | (25-43) | (8.22-14.8) |
| G | 31 | 103 | 339 | 4.0 | 0.87 | 38 | 12.2 |
| | | (70-140) | (184-582) | (3.5-4.4) | (0.75-0.93) | (26-50) | (3.8-21.6) |
| H | 19 | 93 | 376 | 3.7 | 0.83 | 27 | 5.7 |
| | | (49-121) | (161-663) | (2.8-4.1) | (0.73 -0.87 ) | (9-37) | (0.95-11.2) |
| I | 1 | 43 | 94 | 3.2 | 0.86 | 20 | 5.7 |
| J | 103 | 74 | 378 | 3.5 | 0.83 | 21 | 12.5 |
| | | (41-117) | (110-788) | (3.0-4.1) | (0.72 -0.92 ) | (12-36) | (3.0-33.5) |
| K | 320 | 84 | 345 | 3.6 | 0.82 | 25 | 5.8 |
| | | (47-125) | (147-782) | (2.0-4.3) | (0.45 -0.93) | (4-46) | (-4.3-19.0 ) |
| L | 2 | 84 | 245 | 3.8 | 0.87 | 31 | 8.8 |
| | | (73-94) | (226-263) | (3.7-4.0) | (0.86-0.88) | (27-35) | (5.3-12.3 ) |
| M | 197 | 86 | 304 | 3.8 | 0.87 | 30 | 14.2 |
| | | (55-129) | (143-701) | (3.3-4.3) | (0.78-0.95) | (15-50) | (3.3-29.8) |
| N | 2 | 72 | 150 | 3.9 | 0.92 | 35 | 3.7 |
| | | (59-84) | (128-172) | (3.7 -4.1) | (0.91-0.92 ) | (28-42) | (2.0-5.3) |
| O | 13 | 114 | 454 | 4.0 | 0.86 | 36 | 8.2 |
| | | (72-138) | (239-617) | (3.6-4.38) | (0.80 -0.89 ) | (20-48) | (1.1-19.8 ) |

**TABLE C4-3**
Mean abundance of characteristic species found in each macrofauna cluster group A–O (defined in Figure C4-3). Highlighted values indicate the top five most characteristic species according to SIMPER analysis for groups with n >2, otherwise the top five most abundant species are listed.

| | Cluster Group | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** | **O** |
| *Keenaea centifilosum* | 15 | 0 | 4 | 0 | 1 | 2 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 0 | 5 |
| *Ericthonius brasiliensis* | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphichondrius granulatus* | 6 | 0 | 2 | 0 | 4 | 1 | 1 | 1 | 0 | 2 | 2 | 1 | 2 | 5 | 3 |
| *Paradiopatra parva* | 6 | 0 | 2 | 9 | 4 | 14 | 6 | 7 | 0 | 9 | 6 | 0 | 2 | 6 | 10 |
| *Ampelisca careyi* | 4 | 1 | 2 | 0 | 0 | 4 | 4 | 4 | 0 | 3 | 3 | 2 | 3 | 1 | 3 |
| *Amphiodia urtica* | 4 | 0 | 14 | 0 | 0 | 1 | 2 | 3 | 23 | 19 | 33 | 10 | 24 | 16 | 8 |
| *Chaetozone hartmanae* | 3 | 5 | 3 | 11 | 16 | 5 | 5 | 1 | 6 | 5 | 9 | 24 | 10 | 5 | 14 |
| *Eclysippe trilobata* | 3 | 2 | 0 | 1 | 0 | 27 | 2 | 6 | 1 | 16 | 5 | 6 | 2 | 1 | 9 |
| *Proclea* sp A | 3 | 0 | 5 | 0 | 1 | 2 | 3 | 6 | 1 | 3 | 21 | 5 | 3 | 7 | 23 |
| *Axinopsida serricata* | 0 | 25 | 0 | 3 | 12 | 2 | 3 | 0 | 0 | 35 | 3 | 5 | 9 | 0 | 1 |
| *Tellina carpenteri* | 0 | 15 | 1 | 13 | 1 | 7 | 5 | 2 | 2 | 6 | 3 | 1 | 5 | 0 | 4 |
| *Notomastus hemipodus* | 0 | 15 | 0 | 5 | 23 | 1 | 2 | 2 | 0 | 4 | 1 | 0 | 4 | 0 | 2 |
| *Parvilucina tenuisculpta* | 0 | 8 | 0 | 5 | 13 | 2 | 3 | 2 | 0 | 3 | 5 | 3 | 2 | 0 | 9 |
| *Solemya pervernicosa* | 0 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 7 | 0 | 0 |
| *Euphilomedes producta* | 0 | 5 | 11 | 0 | 0 | 4 | 13 | 12 | 0 | 2 | 10 | 1 | 16 | 4 | 5 |
| *Pectinaria californiensis* | 0 | 14 | 10 | 3 | 1 | 1 | 3 | 10 | 0 | 4 | 9 | 0 | 2 | 3 | 17 |
| *Spiophanes duplex* | 2 | 4 | 9 | 12 | 0 | 33 | 6 | 14 | 1 | 40 | 18 | 5 | 2 | 4 | 23 |
| *Huxleyia munita* | 0 | 0 | 5 | 2 | 1 | 2 | 8 | 32 | 1 | 2 | 4 | 0 | 2 | 1 | 7 |
| *Prionospio jubata* | 0 | 4 | 3 | 48 | 1 | 19 | 16 | 3 | 1 | 11 | 6 | 3 | 11 | 1 | 6 |
| *Photis californica* | 1 | 0 | 0 | 22 | 10 | 4 | 5 | 5 | 0 | 1 | 4 | 0 | 3 | 0 | 6 |
| *Decamastus gracilis* | 0 | 4 | 0 | 15 | 21 | 2 | 5 | 5 | 0 | 2 | 3 | 0 | 3 | 2 | 5 |
| *Nuculana* sp A | 0 | 9 | 1 | 14 | 5 | 8 | 4 | 1 | 5 | 9 | 2 | 20 | 6 | 0 | 2 |
| *Glycera nana* | 2 | 1 | 0 | 14 | 7 | 2 | 3 | 1 | 0 | 3 | 2 | 2 | 3 | 2 | 5 |
| Euclymeninae | 0 | 4 | 0 | 0 | 19 | 1 | 3 | 0 | 0 | 3 | 1 | 9 | 2 | 0 | 0 |
| *Fauveliopsis* sp SD1 | 0 | 0 | 0 | 0 | 3 | 23 | 8 | 7 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Caecum crebricinctum* | 0 | 0 | 0 | 0 | 0 | 4 | 15 | 35 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Amphiodia digitata* | 0 | 1 | 7 | 0 | 0 | 6 | 10 | 16 | 2 | 1 | 3 | 1 | 2 | 1 | 2 |
| *Euphilomedes carcharodonta* | 0 | 8 | 3 | 6 | 1 | 2 | 6 | 8 | 1 | 2 | 10 | 0 | 15 | 0 | 6 |
| *Ampelisca brevisimulata* | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 4 | 2 | 2 | 2 | 2 | 1 | 1 |
| *Phisidia sanctaemariae* | 2 | 1 | 4 | 0 | 1 | 6 | 3 | 23 | 3 | 17 | 17 | 11 | 3 | 3 | 21 |
| *Chondrochelia dubia* Cmplx | 1 | 0 | 0 | 6 | 3 | 2 | 5 | 6 | 3 | 2 | 3 | 2 | 3 | 0 | 4 |
| *Scoloplos armiger* Cmplx | 0 | 1 | 0 | 8 | 0 | 3 | 4 | 2 | 3 | 7 | 3 | 4 | 5 | 0 | 1 |
| *Rhepoxynius bicuspidatus* | 0 | 1 | 4 | 0 | 0 | 1 | 1 | 1 | 3 | 6 | 5 | 1 | 5 | 0 | 1 |
| *Chloeia pinnata* | 0 | 0 | 1 | 11 | 27 | 8 | 16 | 11 | 0 | 2 | 7 | 19 | 11 | 0 | 19 |
| *Praxillella pacifica* | 0 | 2 | 0 | 1 | 9 | 4 | 3 | 7 | 2 | 10 | 5 | 5 | 5 | 2 | 4 |
| *Prionospio dubia* | 0 | 3 | 0 | 5 | 4 | 7 | 4 | 3 | 2 | 6 | 4 | 6 | 5 | 2 | 8 |

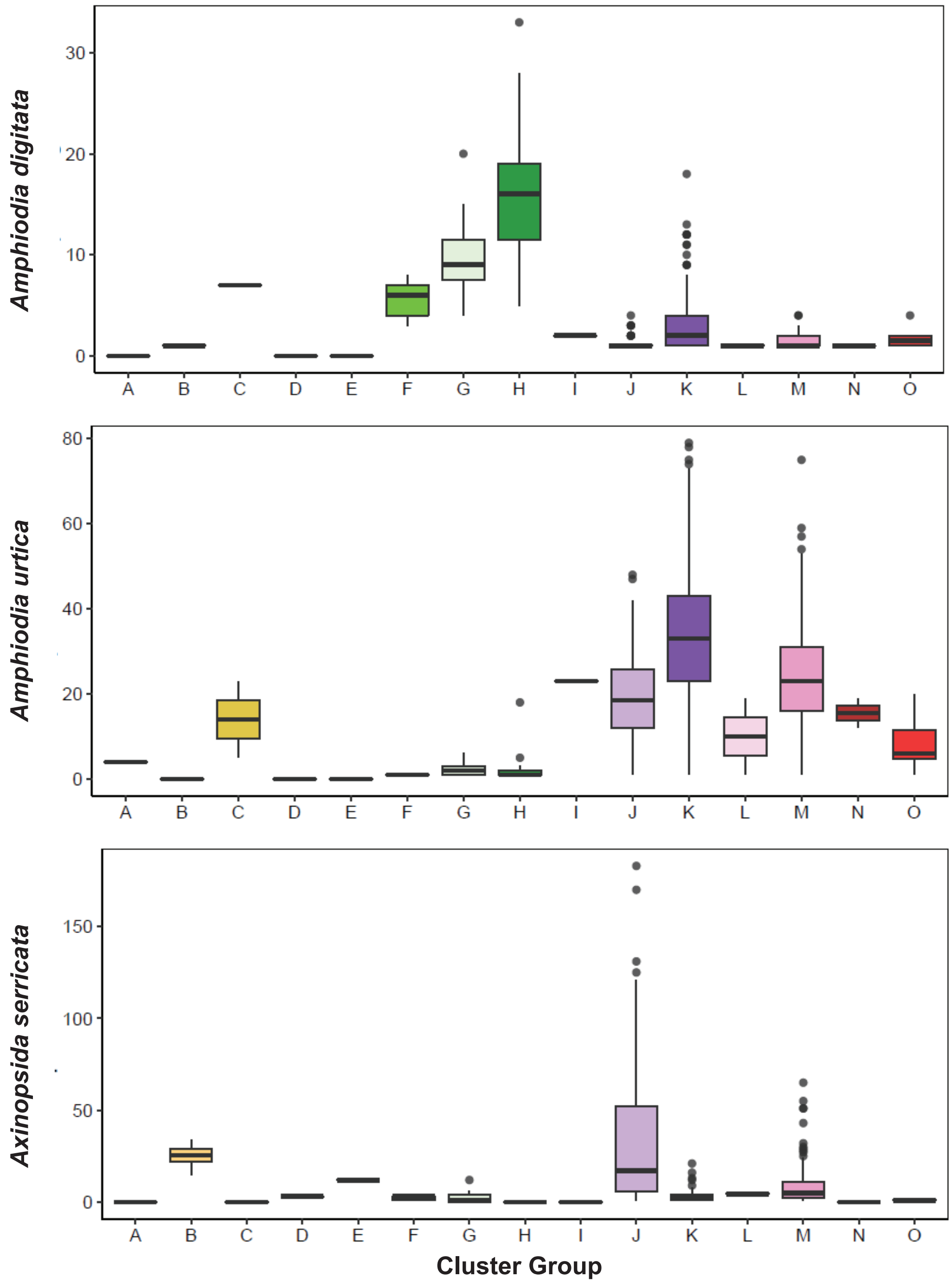



**FIGURE C4-4**
Abundances of select species summarized for macrofauna cluster groups A–O (see Figure C4-3). Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

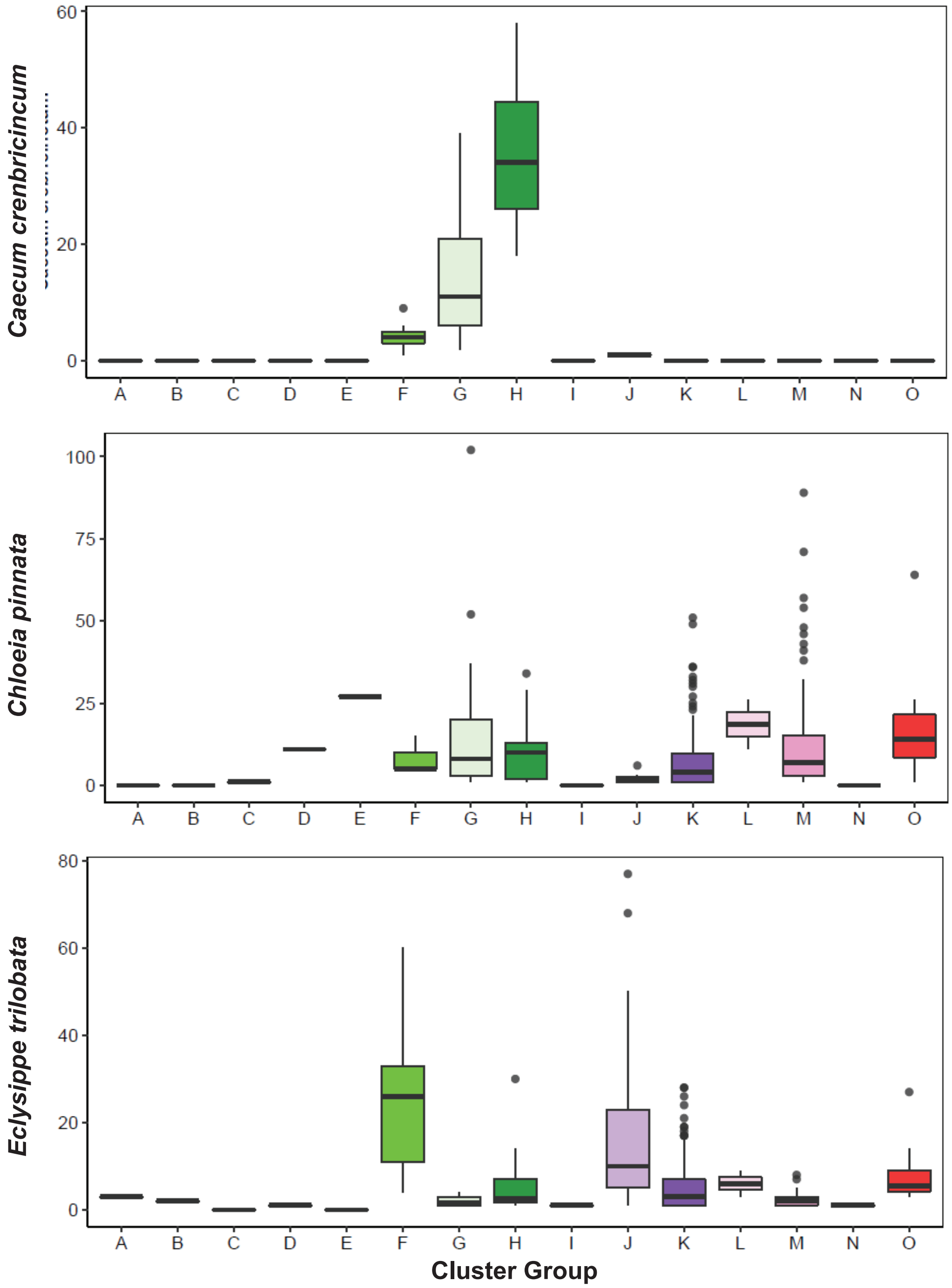



**FIGURE C4-4** *Continued*

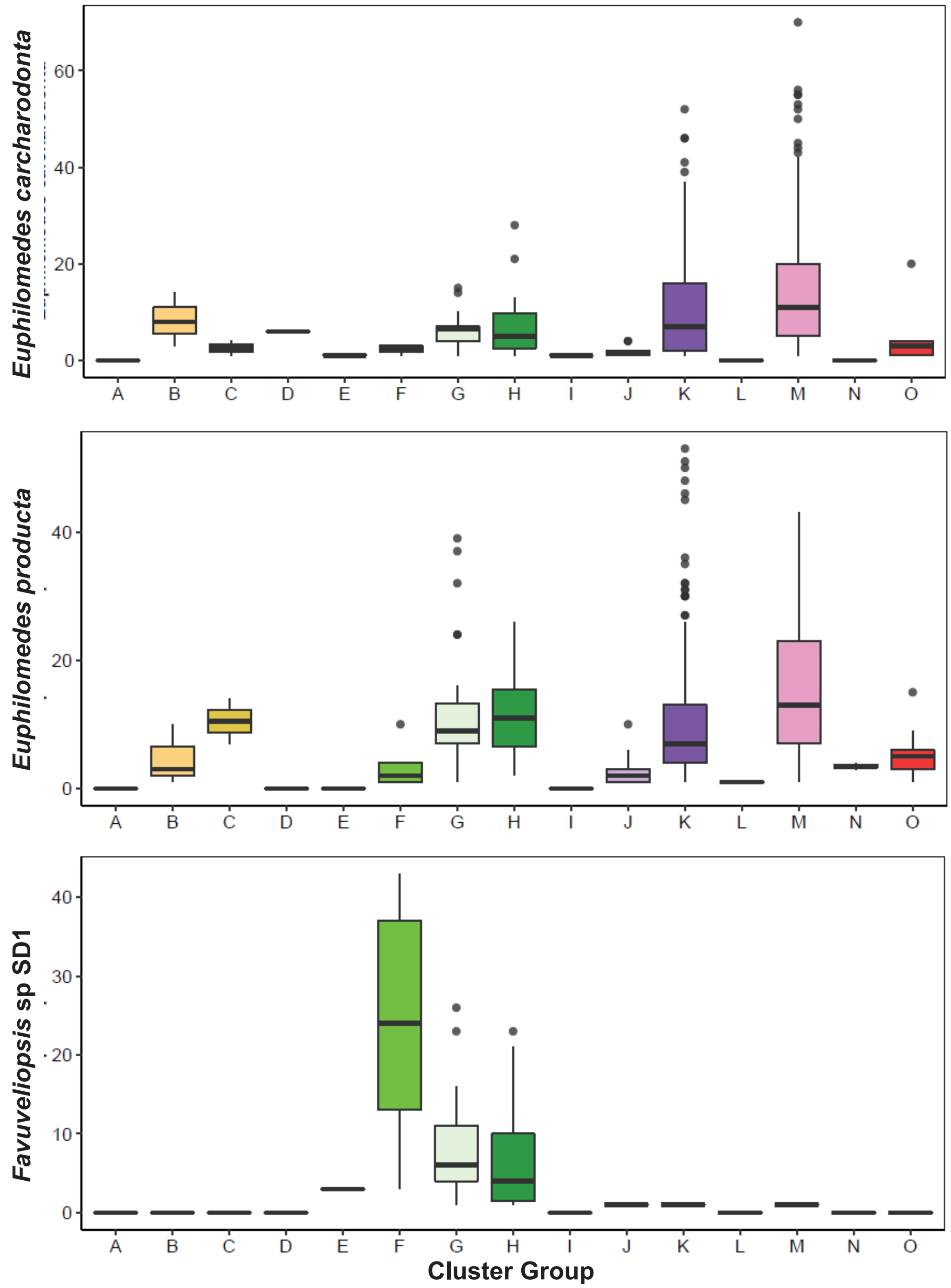



**FIGURE C4-4** *Continued*

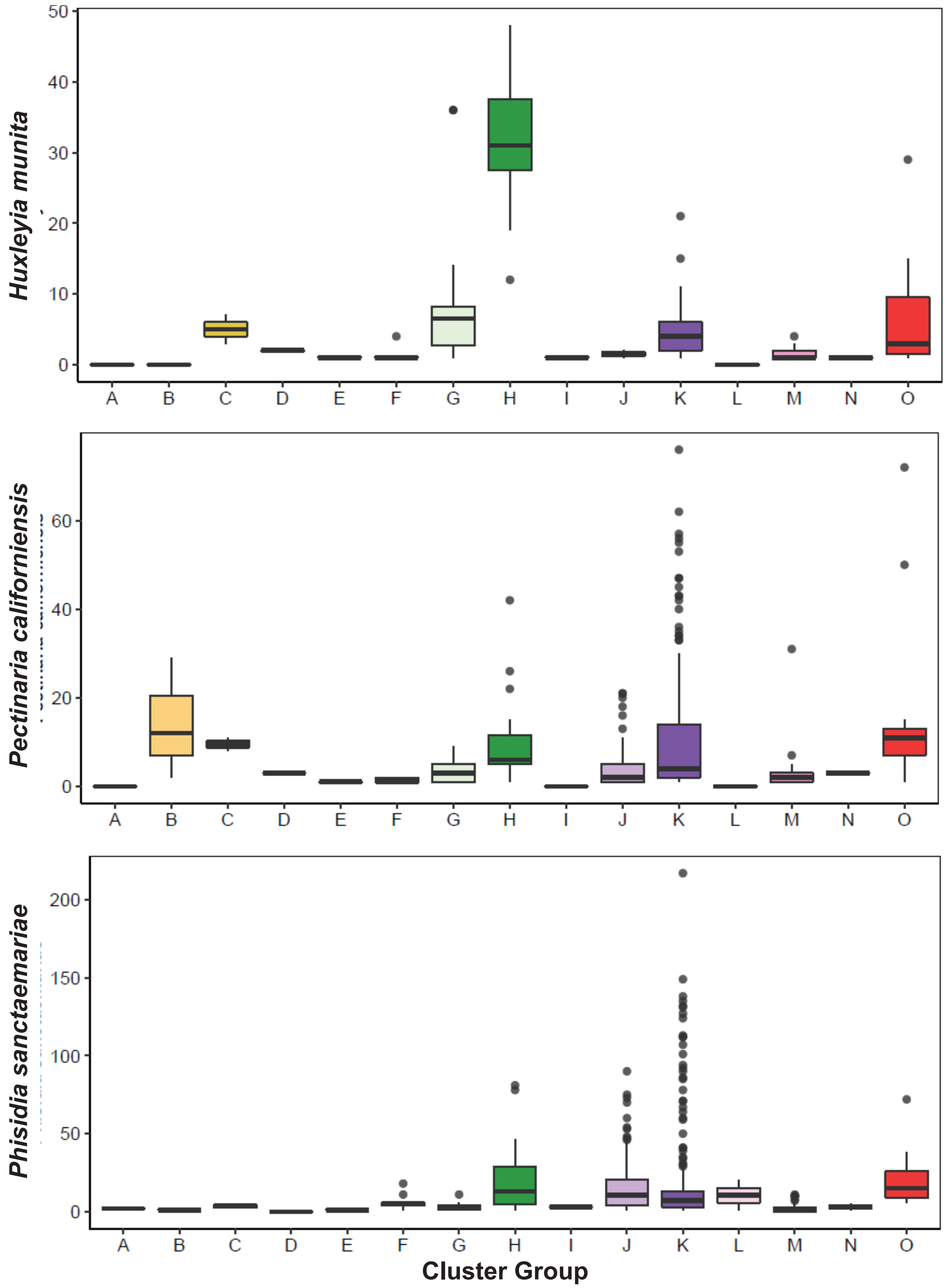



**FIGURE C4-4** *Continued*

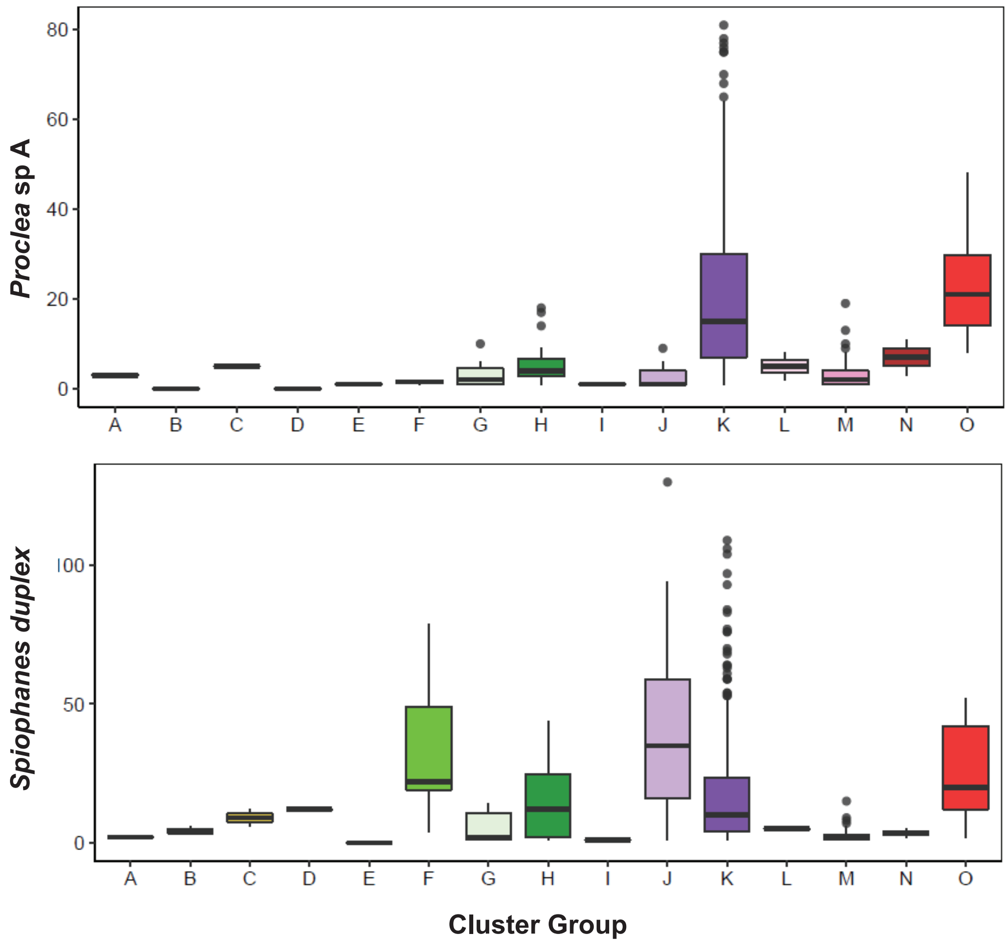



**FIGURE C4-4** *Continued*

**TABLE C4-4**
Particle size summary for each macrofauna cluster group A–O (defined in Figure C4-3). Data are presented as means (ranges) calculated over all stations within a cluster group (n); VF = very fine; F = fine; M = medium; C = coarse.

| | | Particle Size (%) | | | | | |
|---|---|---|---|---|---|---|---|
| Cluster Group | n | Fines | VF Sand | F Sand | M Sand | C Sand | C Particles |
| A | 1 | 46.2 | 45.1 | 8.8 | 0.0 | 0.0 | 0.0 |
| B | 4 | 26.6 | 52.8 | 11.7 | 1.3 | 3.1 | 4.5 |
| | | (21.3-29.9) | (40.2-66.1) | (1.3-17.5) | (0.6-2.6) | (0-9.3) | (0-10.3) |
| C | 2 | 33.7 | 41.4 | 21.7 | 2.9 | 0.5 | 0.0 |
| | | (32.7-34.6) | (41.2-41.6) | (19.1-24.3) | (1.5-4.2) | (0-1.0) | (0-0) |
| D | 1 | 15.4 | 21.3 | 0.6 | 1.4 | 11.6 | 49.7 |
| E | 2 | 27.7 | 27.8 | 8.4 | 1.3 | 8.5 | 26.5 |
| | | (16.9-38.5) | (10.6-44.9) | (1.0-15.8) | (0.9-1.6) | (0-17.0) | (0-52.9) |
| F | 9 | 41.6 | 20.7 | 15.7 | 14.5 | 4.7 | 2.8 |
| | | (16.9-73.9) | (13.9-28) | (7.1-23.4) | (1.3-25.9) | (0-14.0) | (0-7.6) |
| G | 31 | 34.1 | 23.4 | 26.0 | 11.2 | 4.3 | 1.1 |
| | | (10.8-46.5) | (12.7-28.3) | (7.7-33.4) | (3.8-27.2) | (0-54.5) | (0-4.3) |
| H | 18 | 29.7 | 21.8 | 24.5 | 15.1 | 6.1 | 2.8 |
| | | (17.6-36.8) | (12.2-47.6) | (16.1-30.4) | (0.1-23.4) | (0-10.7) | (0-23.7) |
| I | 1 | 37.5 | 44.3 | 17.0 | 1.2 | 0.0 | 0.0 |
| J | 103 | 45.5 | 39.8 | 12.5 | 1.0 | 0.4 | 0.8 |
| | | (17.3-68.9) | (17.1-64.2) | (1.0-20.2) | (0.1-9) | (0-17) | (0-38.6) |
| K | 309 | 39.8 | 40.7 | 17.1 | 1.6 | 0.4 | 0.6 |
| | | (13.5-53.7) | (12.9-75.7) | (0.1-34.9) | (0-20.9) | (0-12.9) | (0-23.9) |
| L | 2 | 46.3 | 38.1 | 14.2 | 1.5 | 0.0 | 0.0 |
| | | (45.1-47.4) | (37.4-38.8) | (13.7-14.6) | (1.5-1.5) | (0-0) | (0-0) |
| M | 197 | 43.4 | 40.0 | 14.4 | 1.5 | 0.3 | 0.5 |
| | | (29.7-55.2) | (22.8-55.6) | (1.1-20.4) | (0.2-10) | (0-9.2) | (0-12.5) |
| N | 2 | 44.6 | 25.9 | 23.1 | 4.3 | 0.2 | 2.1 |
| | | (44.1-45) | (25.3-26.5) | (22.7-23.5) | (2.9-5.6) | (0-0.3) | (0-4.1) |
| O | 13 | 37.4 | 32.3 | 17.2 | 3.9 | 0.8 | 8.4 |
| | | (15.2-48.2) | (13.9-62.7) | (1.4-27.8) | (0-10.5) | (0-4.1) | (0-64.2) |

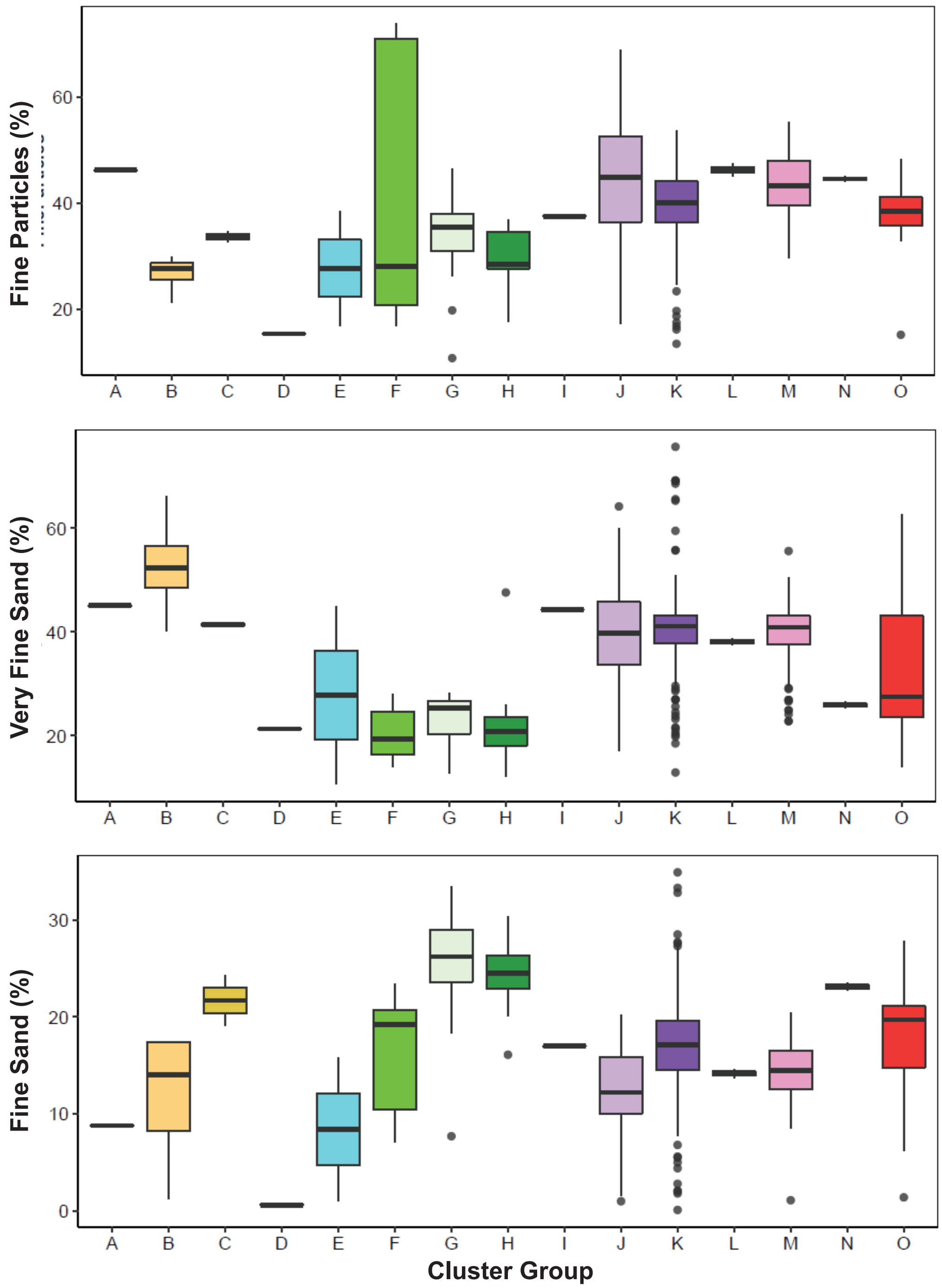



**FIGURE C4-5**
Sediment particle size parameters summarized for macrofauna cluster groups A–O (see Figure C4-3). Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

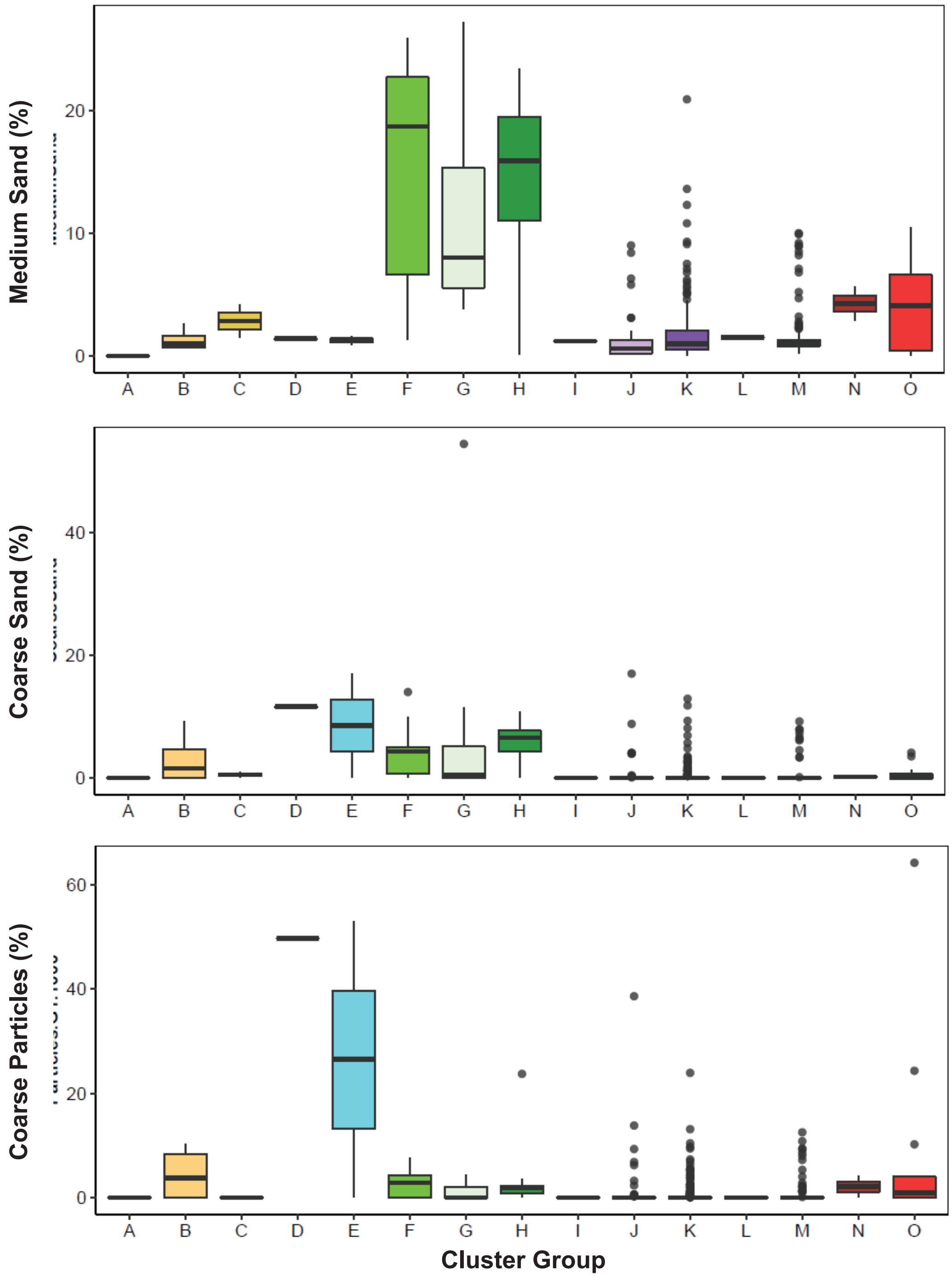



**FIGURE C4-5** *Continued*

# APPENDIX C4

# Assessment of Macrobenthic Communities off Point Loma

# ATTACHMENTS

**ATTACHMENT C4-A**

Particle size classification schemes (based on Folk 1980) used in the analysis of sediments from 1992 through 2020. Included is a subset of the Wentworth scale presented as “phi” categories with corresponding Horiba channels, sieve sizes, and size fractions.

**Wentworth Scale**

| | Horiba[a] | | | | |
|---|---|---|---|---|---|
| **Phi size** | **Min µm** | **Max µm** | **Sieve Size** | **Sub-Fraction** | **Fraction** |
| -1 | — | — | SIEVE_2000 | Granules | Coarse Particles |
| 0 | 1100 | 2000 | SIEVE_1000 | Very coarse sand | Coarse Particles |
| 1 | 590 | 1000 | SIEVE_500 | Coarse sand | Med-Coarse Sands |
| 2 | 300 | 500 | SIEVE_250 | Medium sand | Med-Coarse Sands |
| 3 | 149 | 250 | SIEVE_125 | Fine sand | Fine Sands |
| 4 | 64 | 125 | SIEVE_63 | Very fine sand | Fine Sands |
| 5 | 32 | 62.5 | SIEVE_0[b] | Coarse silt | Fine Particles[c] |
| 6 | 16 | 31 | — | Medium silt | Fine Particles[c] |
| 7 | 8 | 15.6 | — | Fine silt | Fine Particles[c] |
| 8 | 4 | 7.8 | — | Very fine silt | Fine Particles[c] |
| 9 | ≤ | 3.9 | — | Clay | Fine Particles[c] |

[a] Values correspond to Horiba channels; particles > 2000 µm measured by sieve

[b] SIEVE_0 = sum of all silt and clay, which cannot be distinguished for samples processed by nested sieves

[c] Fine particles also referred to as percent fines

**ATTACHMENT C4-B**

Summary of species that influenced macrofaunal assesmblages at the 12 PLOO primary core stations located at outfall depths and sampled during winter and summer surveys from 1991 through 2020. Abund = total abundance (number of individuals) collected; BEST = species (taxa) that best described the overall pattern (gradient) of the cluster dendrogram; CHAR = species that are among the top five most characteristic species for one or more cluster groups according to SIMPER; DIST = species that are among the top five species that distinguish between two or more cluster groups according to SIMPER; Indicator = species that are considered as environmental indicators (see Appendices C1 and C2).

| Species | Taxonomic Classification | Abund | BEST | CHAR | DIST | Indicator |
|---|---|---|---|---|---|---|
| *Amphiodia urtica* | Echinodermata: Ophiuroidea | 17409 | √ | √ | √ | √ |
| *Spiophanes duplex* | Polychaeta: Spionidae | 10509 | √ | √ | √ | |
| *Phisidia sanctaemariae* | Polychaeta: Terebellidae | 7277 | √ | √ | √ | |
| *Proclea* sp A | Polychaeta: Terebellidae | 7262 | √ | √ | √ | |
| *Euphilomedes producta* | Ostracoda: Philomedidae | 6836 | √ | √ | √ | √ |
| *Myriochele striolata* | Polychaeta: Oweniidae | 6212 | √ | | √ | |
| *Prionospio jubata* | Polychaeta: Spionidae | 5692 | √ | √ | | |
| *Mediomastus* sp | Polychaeta: Capitellidae | 5658 | √ | | √ | √ |
| *Euphilomedes carcharodonta* | Ostracoda: Philomedidae | 5573 | √ | √ | √ | √ |
| *Chaetozone hartmanae* | Polychaeta: Cirratulidae | 5461 | √ | √ | | |
| *Axinopsida serricata* | Mollusca: Bivalvia | 5347 | √ | √ | √ | |
| *Amphiodia* sp | Echinodermata: Ophiuroidea | 4847 | √ | | | √ |
| Amphiuridae | Echinodermata: Ophiuroidea | 4073 | √ | | | √ |
| *Pectinaria californiensis* | Polychaeta: Pectinariidae | 3715 | √ | √ | √ | |
| *Eclysippe trilobata* | Polychaeta: Ampharetidae | 3681 | √ | √ | √ | |
| *Chloeia pinnata* | Polychaeta: Amphinomidae | 3432 | √ | √ | √ | |
| *Praxillella pacifica* | Polychaeta: Maldanidae | 3258 | √ | √ | | |
| *Paradiopatra parva* | Polychaeta: Onuphidae | 3204 | √ | √ | | |
| *Rhepoxynius bicuspidatus* | Amphipoda: Phoxocephalidae | 3125 | √ | √ | | √ |
| *Prionospio dubia* | Polychaeta: Spionidae | 2976 | | √ | | |
| *Polycirrus* sp A | Polychaeta: Terebellidae | 2954 | √ | | | |
| *Sternaspis affinis* | Polychaeta: Sternaspidae | 2937 | √ | | | |
| *Aricidea (Acmira) catherinae* | Polychaeta: Paraonidae | 2381 | √ | | | |
| *Nuculana* sp A | Mollusca: Bivalvia | 2328 | √ | √ | | |
| *Spiophanes berkeleyorum* | Polychaeta: Spionidae | 2303 | √ | | | |
| *Tellina carpenteri* | Mollusca: Bivalvia | 2244 | √ | √ | | |
| *Scoloplos armiger* Cmplx | Polychaeta: Orbiniidae | 2239 | √ | √ | | |
| *Aphelochaeta glandaria* Cmplx | Polychaeta: Cirratulidae | 2205 | √ | | | |
| *Spiophanes kimballi* | Polychaeta: Spionidae | 2202 | √ | | | |
| *Myriochele gracilis* | Polychaeta: Oweniidae | 2194 | √ | | | |
| *Clymenura gracilis* | Polychaeta: Maldanidae | 2075 | √ | | | |
| *Ampelisca pacifica* | Amphipoda: Ampeliscidae | 1956 | √ | | | √ |
| Maldanidae | Polychaeta: Maldanidae | 1908 | √ | | | |
| *Lanassa venusta venusta* | Polychaeta: Terebellidae | 1829 | √ | | | |
| *Ampelisca careyi* | Amphipoda: Ampeliscidae | 1804 | √ | √ | | √ |

**ATTACHMENT C4-B** *continued*

| Species | Taxonomic Classification | Abund | BEST | CHAR | DIST | Indicator |
|---|---|---|---|---|---|---|
| *Lumbrineris* sp Group I | Polychaeta: Lumbrineridae | 1731 | √ | | | |
| Euclymeninae sp A | Polychaeta: Maldanidae | 1702 | √ | | | |
| *Parvilucina tenuisculpta* | Mollusca: Bivalvia | 1653 | √ | √ | | √ |
| *Huxleyia munita* | Mollusca: Bivalvia | 1490 | √ | √ | √ | |
| *Terebellides californica* | Polychaeta: Trichobranchidae | 1472 | √ | | | |
| *Lysippe* sp B | Polychaeta: Ampharetidae | 1455 | √ | | | |
| *Paraprionospio alata* | Polychaeta: Spionidae | 1404 | √ | | | |
| *Lumbrineris cruzensis* | Polychaeta: Lumbrineridae | 1390 | √ | | | |
| *Glycera nana* | Polychaeta: Glyceridae | 1375 | √ | √ | | |
| *Amphiodia digitata* | Echinodermata: Ophiuroidea | 1370 | √ | √ | √ | √ |
| *Lysippe* sp A | Polychaeta: Ampharetidae | 1273 | √ | | | |
| *Chondrochelia dubia* Cmplx | Tanaidacea: Leptocheliidae | 1267 | √ | √ | | |
| *Ennucula tenuis* | Mollusca: Bivalvia | 1205 | √ | | | |
| *Caecognathia crenulatifrons* | Isopoda: Gnathiidae | 1154 | √ | | | |
| *Caecum crebricinctum* | Mollusca: Gastropod | 1138 | √ | √ | √ | |
| *Aricidea (Acmira) simplex* | Polychaeta: Paraonidae | 1111 | √ | | | |
| *Travisia brevis* | Polychaeta: Travisiidae | 1095 | √ | | | |
| *Decamastus gracilis* | Polychaeta: Capitellidae | 1084 | | √ | | |
| *Heterophoxus oculatus* | Amphipoda: Phoxocephalidae | 1082 | √ | | | |
| *Capitella teleta* | Polychaeta: Capitellidae | 977 | √ | | | √ |
| *Pholoe glabra* | Polychaeta: Pholoidae | 897 | √ | | | |
| *Nephtys ferruginea* | Polychaeta: Nephtydae | 849 | √ | | | |
| *Ampelisca brevisimulata* | Amphipoda: Ampeliscidae | 812 | √ | √ | | √ |
| *Notomastus hemipodus* | Polychaeta: Capitellidae | 811 | | √ | | |
| *Sthenelanella uniformis* | Polychaeta: Sigalionidae | 793 | √ | | | |
| *Kirkegaardia siblina* | Polychaeta: Cirratulidae | 759 | √ | | | |
| *Eyakia robusta* | Amphipoda: Phoxocephalidae | 743 | √ | | | |
| *Polyschides quadrifissatus* | Mollusca: Scaphopoda | 718 | √ | | | |
| *Maldane sarsi* | Polychaeta: Maldanidae | 681 | √ | | | |
| *Fauveliopsis* sp SD1 | Polychaeta: Fauveliopsidae | 563 | √ | √ | √ | |
| *Keenaea centifilosum* | Mollusca: Bivalvia | 466 | | √ | | |
| *Amphichondrius granulatus* | | 462 | | √ | | |
| *Urothoe elegans* Cmplx | Amphipoda: Urothoidae | 447 | √ | | | |
| Euclymeninae | Polychaeta: Maldanidae | 433 | | √ | | |
| *Photis californica* | Amphipoda: Photidae | 298 | √ | √ | | |
| *Solemya pervernicosa* | Mollusca: Bivalvia | 169 | | √ | | √ |
| *Laonice nuchala* | Polychaeta: Spionidae | 163 | √ | | | |
| *Ericthonius brasiliensis* | Amphipoda: Ischyroceridae | 8 | | √ | | |

# APPENDIX C5

## BIOACCUMULATION ASSESSMENT

March 2022

# APPENDIX C5

## Bioaccumulation Assessment

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# APPENDIX C5
# Bioaccumulation Assessment

## SECTION C5.1 | INTRODUCTION

Bioaccumulation is the process of biological uptake and retention of chemical contaminants from various exposure pathways (USEPA 2000). Marine organisms can accumulate pollutants through adsorption or absorption of dissolved chemical constituents from the surrounding water or from the ingestion and assimilation of pollutants from different food sources (Rand 1995). Because of their proximity to seafloor sediments, demersal fish and other bottom dwelling organisms can also be exposed to pollutants through ingestion of suspended particulates and the subsequent assimilation of chemicals into body tissues. Once a contaminant becomes incorporated into an organism's tissues, it may resist normal metabolic excretion and accumulate (Walker et al. 1996). In addition, higher trophic level organisms may feed on contaminated prey and further concentrate pollutants in their tissues (Suedel et al. 1994). This food web magnification may lead to tissue burdens in fish that have both ecological and human health implications (USEPA 1997).

The City of San Diego's (City's) Ocean Monitoring Program includes extensive sampling to detect any effects on demersal fish communities associated with wastewater discharge from the Point Loma Ocean Outfall (PLOO). The bioaccumulation portion of the program presently consists of two components, including: (1) analysis of liver tissues from trawl-caught fishes; (2) analysis of muscle tissues from fishes collected by rig fishing. Fishes collected from trawling activities are considered representative of the general demersal fish community that dominates the region, and certain species are targeted based on their ecological significance. Chemical analyses are performed using livers of these fishes because this is the organ where contaminants typically concentrate. In contrast, fishes targeted for collection at rig fishing sites represent species from a typical sport fisher's catch and are therefore of recreational and commercial importance. Muscle tissue is analyzed from these fish because it is the tissue most often consumed by humans, and therefore the results have implications concerning seafood safety issues and public health.

This appendix includes bioaccumulation analyses for fishes collected from the Point Loma outfall region over the past 26 years (1995-2020), thus providing an update of the assessment presented in the City's previous 301(h) modified permit application in 2015, which addressed monitoring data collected from 1995 through 2013 (City of San Diego 2015). The primary goals of this appendix are to document levels of contaminant loading in local fishes and determine if the discharge of wastewater via the PLOO has caused abnormal body burdens of any toxic pollutants known to have adverse effects on marine fishes or their consumers.

# SECTION C5.2 | GENERAL METHODOLOGY

The fishes analyzed herein were collected from a total of four trawl and two rig fishing zones that span the PLOO monitoring region (Figure C5-1). Each trawl zone represents an area within a 1-kilometer (km) radius centered on one or two trawl stations, as follows: Trawl Zone 1 represents the nearfield zone and includes trawls from stations SD10 and SD12, which are located just south and just north of the PLOO, respectively; Trawl Zone 2 is considered the northern farfield zone, and includes trawls from stations SD13 and SD14; Trawl Zone 3 includes trawls from station SD8 and represents a farfield zone near the LA-5 dredged materials disposal site where contaminated sediments dredged from San Diego Bay are deposited (SAIC 1990, Gardner et al. 1998, Steinberger et al. 2003); Trawl Zone 4 is considered the southernmost farfield zone, and includes trawls from station SD7. Each rig fishing zone represents the areas within a 1-km radius of the nominal coordinates for stations RF1 and RF2. Station RF1 represents the nearfield zone and is located within 1 km of the PLOO discharge site, while station RF2 is located approximately 11 km northwest of the PLOO and is considered a farfield zone.

All fishes were collected, measured, and weighed following guidelines described in the Quality Assurance Plan for Coastal Receiving Waters Monitoring (City of San Diego 2020b) and applicable standard operating procedures. Efforts to collect target species by trawl were generally limited to five 10-minute (bottom time) trawls per site, while rig fishing effort was limited to five hours at each station. Occasionally, insufficient numbers of target species are obtained despite this effort; at times this has resulted in inadequate amounts of tissue to complete three full composite samples, or inadequate amounts of tissue to complete a full suite of analyses (see Attachment C5-A).

Table C5-1 lists the common and scientific names of the different flatfishes and rockfishes used for the assessment of contaminant bioaccumulation herein. For all samples, only fish greater than 11 cm standard length were retained for tissue analyses. Composite samples were typically made up of a single species, with a minimum of three individuals comprising each composite; the only exceptions occurred when multiple species of a single genus were required to obtain the minimum number of fish for a sample. The species caught at each station or zone in sufficient quantity to make up adequate tissue samples are indicated in Attachment C5-A.

A detailed description of the analytical protocols may be obtained from the City of San Diego's Environmental Chemistry Services Laboratory. Briefly, tissue samples (liver and muscle) were analyzed on a wet weight basis for trace metals, chlorinated pesticides, and polychlorinated biphenyl compounds (PCBs). Data presented in this report were summarized using detected values only, with no substitutions made for analyte concentrations that fall below method detection limits (MDLs) for each parameter (Attachment C5-B). Limiting analyses to detected values (i.e., excluding non-detects) is considered a conservative way of handling contaminant concentrations as it creates a strong upward bias in the data and respective summary statistics, and therefore may represent a worst-case scenario (e.g., see Helsel 2005a, b, 2006 for discussions of non-detect data).

For the sake of continuity between the various permit periods, all analyses were limited as follows: (1) excluded data collected prior to 1995 due to non-comparable analytical methods; (2) included only the first three replicate samples collected from current stations/zones during October surveys; (3) included only liver tissue data from trawl zones; (4) included only muscle tissue data from rig fishing stations; (5) excluded estimated values that fell below method detection limits, but were confirmed by mass-spectrometry. Estimated values were treated as non-detects for this report. Individual trawl stations sampled prior to October 2003 were assigned to their corresponding zone. All excluded data have been reported previously (City of San Diego 1995, 2001a,b, 2007, 2015, 2020a, 2021).

To address continuity issues like changes in the constituents analyzed, and non-reportable data (see Attachments C5-A, C5-B) for total dichloro-diphenyl-trichloroethane (DDT), total DDT was calculated without 2,2-bis(4-chlorophenyl)-1-chloroethylene (p,p-DDMU), and nine samples from 2019 and 2020 with missing parameters were excluded from analyses. Total PCB was calculated two ways, with all congeners detected (excluding 13 samples from 2019 with missing parameters), and with just the congeners analyzed overall years (PCB 77, PCB 87, PCB 101, PCB 105, PCB 118, PCB 126, PCB 128, PCB 138, PCB 153/PCB153-168, PCB 170, PCB 180, PCB 187). Total chlordane was calculated with all available data for comparison to muscle tissue thresholds. Individual DDT, PCB, and chlordane constituents are also summarized.

To highlight conditions over the past five years, spatial analyses included data summarized by trawl zone and rig fishing station for three post-discharge periods: (1) 1995–2008; (2) 2009–2013; (3) 2013–2020. Both spatial and temporal analyses of the trawl-caught fishes were limited to samples from Pacific, Longfin and Mixed Sanddabs. These species were considered collectively as a "sanddab feeding guild" after Allen et al. (2002), forming the best basis for assessment because of the sample size and coverage in both space and time. Spatial and temporal analyses for the rig fishing stations were limited to muscle tissues from various rockfish species.

# SECTION C5.3 | RESULTS & DISCUSSION

## Metals

### *Mercury*

Mercury is a common trace element in ocean waters and sediments and has a wide variety of natural and anthropogenic sources (Mearns et al. 1991). It may be injected into the atmosphere by volcanism, transported into coastal waters by rain and runoff, or released directly into the ocean through geothermal springs. Man-made sources include the use of mercury in fungicides, plastics, medical preparations, and in smelting and mining processes, while electrochemical industries also generate mercury waste. Although elemental mercury is moderately toxic, organic mercury compounds (e.g., methylmercury) are highly toxic. Additionally, organic mercury readily penetrates biological membranes and may bioaccumulate in the tissues of organisms at higher trophic levels due to its chemical stability and lipid solubility.

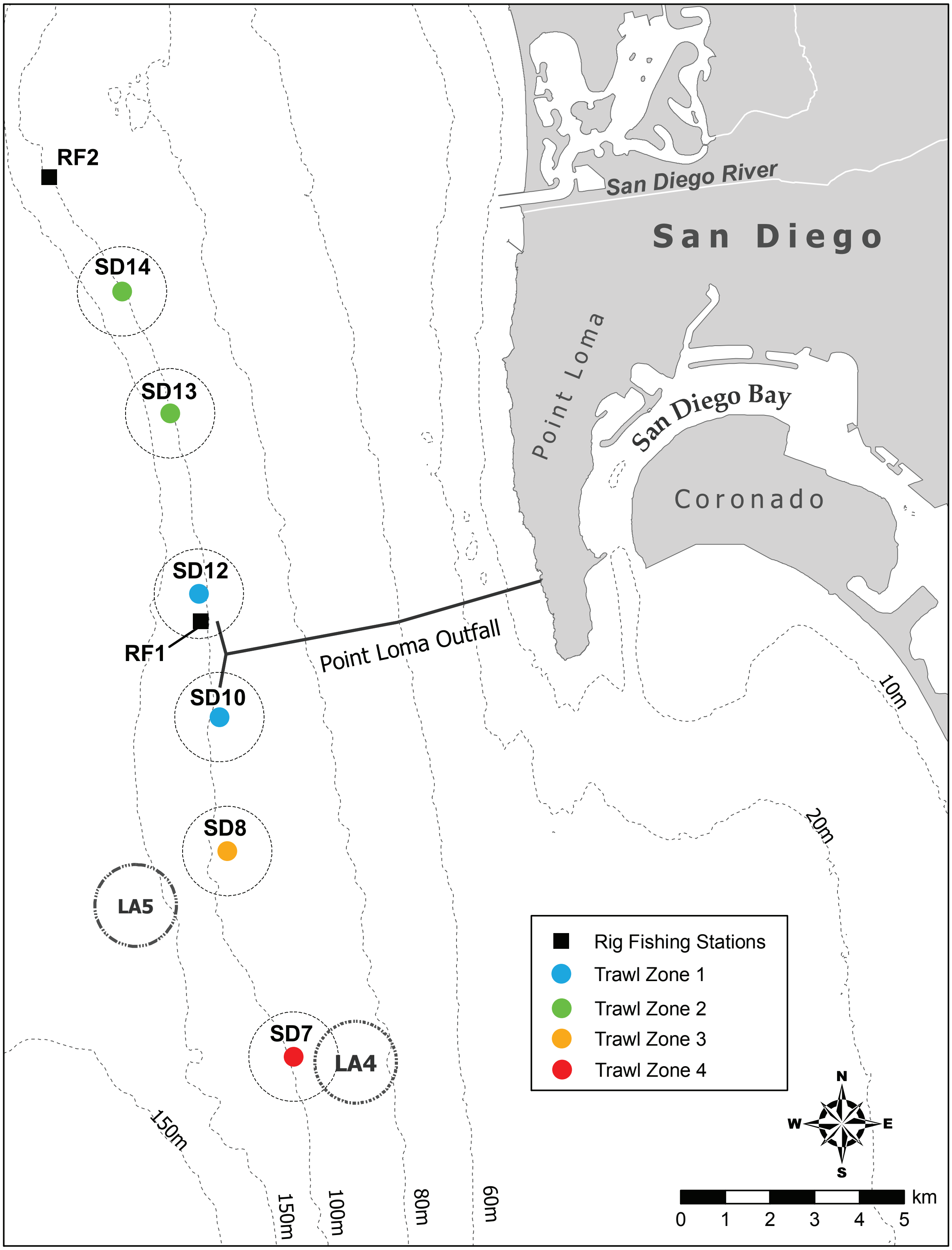



**FIGURE C5-1**
Otter trawl and rig fishing monitoring stations and fish collection zones surrounding the City of San Diego's Point Loma Ocean Outfall. LA-4 and LA-5 are EPA designated dredge materials disposal sites.

**TABLE C5-1**
Common and scientific names of fishes collected during October surveys as part of the City of San Diego's Ocean Monitoring Program from 1995 through 2020.

| Common Name | Scientific Name |
|---|---|
| ***TRAWL-CAUGHT*** | |
| Dover Sole | *Microstomus pacificus* |
| English Sole | *Parophrys vetulus* |
| Hornyhead Turbot | *Pleuronichthys verticalis* |
| Longfin Sanddab | *Citharichthys xanthostigma* |
| Pacific Sanddab | *Citharichthys sordidus* |
| | |
| California Scorpionfish | *Scorpaena guttata* |
| Flag Rockfish | *Sebastes rubrivinctus* |
| Greenblotched Rockfish | *Sebastes rosenblatti* |
| Greenspotted Rockfish | *Sebastes chlorostictus* |
| Halfbanded Rockfish | *Sebastes semicinctus* |
| Mixed Rockfish | *Sebastes* sp |
| ***HOOK and LINE CAUGHT*** | |
| California Scorpionfish | *Scorpaena guttata* |
| Canary Rockfish | *Sebastes pinniger* |
| Chilipepper | *Sebastes goodei* |
| Copper Rockfish | *Sebastes caurinus* |
| Flag Rockfish | *Sebastes rubrivinctus* |
| Greenblotched Rockfish | *Sebastes rosenblatti* |
| Greenspotted Rockfish | *Sebastes chlorostictus* |
| Greenstriped Rockfish | *Sebastes elongatus* |
| Rosethorn Rockfish | *Sebastes helvomaculatus* |
| Speckled Rockfish | *Sebastes ovalis* |
| Squarespot Rockfish | *Sebastes hopkinsi* |
| Starry Rockfish | *Sebastes constellatus* |
| Vermilion Rockfish | *Sebastes miniatus* |
| Yellowtail Rockfish | *Sebastes flavidus* |
| Mixed Rockfish | *Sebastes* sp |

Mercury is probably the metal with the greatest potential for bioaccumulation in Southern California Bight (SCB) marine organisms (Mearns et al. 1991). Although typically found in low concentrations in southern California invertebrates, concentrations of total mercury reach their highest levels at the top of the food web. For example, one of the highest mercury concentrations (~8.2 parts per million, or ppm) in a southern California marine animal was found in the muscle tissue of a white shark captured near Santa Catalina Island (Schafer et al. 1982). Elevated levels of mercury have also been reported in muscle tissues of other carnivorous fish, with swordfish having the highest reported value of 2.6 ppm for the bony fish (Mearns et al. 1991).

Studies in the SCB over the last 35 years have shown no relationship between elevated concentrations of mercury in marine organisms and point sources of contamination. Eganhouse and Young (1978) found that in spite of elevated mercury levels in Palos Verdes sediments, resident animals had low tissue concentrations of both total and organic mercury. In addition, mercury levels in edible tissues of seafood organisms collected near a major point source of contamination were comparable to samples from offshore islands and coastal control sites (see Young et al. 1981). Other investigations also indicate that mercury levels in southern California fish have not increased with exposure to contaminated sediments (Mearns et al. 1991).

For reference purposes, annual average mercury concentrations in Point Loma effluent ranged from 0.007 to 0.015 parts per billion (ppb) from 2016 through 2020. Mean concentrations of mercury in outfall depth sediments off Point Loma were 0.01 and 0.02 ppm during the pre- and post-discharge periods, respectively, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (0.02 – 0.10 ppm; see Table C1-2 in Appendix C1, this application).

Tissue concentrations of mercury in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-2 and by zone/station in Table C5-3 and Figures C5-2, C5-3. Mercury was detected in 89% of liver tissue samples from trawl-caught fishes, at concentrations of 0.02 to 0.58 ppm, and in 95% of muscle tissue samples from rig fishing stations, at concentrations of 0.02 to 0.79 ppm (Table C5-2). Mean detected concentrations of mercury in sanddab liver tissues ranged from 0.08 to 0.11 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 0.17 ppm at station RF1 and 0.15 ppm at station RF2 (Table C5-3). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild or between rig fishing stations for rockfish in terms of mercury concentrations over surveys combined for the three post-discharge periods (Figures C5-2A, C5-3A) or over time (Figures C5-2B, C5-3B). Although some relatively high mercury values (>0.5 ppm) were recorded at station RF1, these were limited to five rockfish muscle samples collected over just three years (2002–2004).

Many years ago, the United States Federal Drug Administration (USFDA) and the California Department of Health Services (CDHS) set action limits for mercury in seafood sold for human consumption at 1.0 ppm and 0.5 ppm, respectively (Hayes and Phillips 1987, Mearns et al. 1991,

**TABLE C5-2**
Summary of mercury concentrations (ppm) in liver and muscle tissue samples for each fish species collected from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 27 | 87 | 0.04 | 0.16 | 0.42 | 0.19 |
| Dover Sole | 2 | 2 | 100 | 0.06 | 0.10 | 0.14 | 0.10 |
| English Sole | 20 | 16 | 80 | 0.03 | 0.06 | 0.13 | 0.06 |
| Flag Rockfish | 2 | 2 | 100 | 0.14 | 0.15 | 0.16 | 0.15 |
| Greenblotched Rockfish | 2 | 1 | 50 | 0.15 | 0.15 | 0.15 | 0.15 |
| Greenspotted Rockfish | 2 | 2 | 100 | 0.05 | 0.20 | 0.35 | 0.20 |
| Halfbanded Rockfish | 2 | 2 | 100 | 0.09 | 0.11 | 0.13 | 0.11 |
| Hornyhead Turbot | 1 | 1 | 100 | 0.12 | 0.12 | 0.12 | 0.12 |
| Longfin Sanddab | 67 | 52 | 78 | 0.02 | 0.09 | 0.24 | 0.10 |
| Mixed Rockfish | 2 | 2 | 100 | 0.30 | 0.35 | 0.41 | 0.35 |
| Pacific Sanddab | 208 | 194 | 93 | 0.02 | 0.08 | 0.58 | 0.10 |
| ALL SPECIES | 339 | 301 | 89 | 0.02 | 0.09 | 0.58 | 0.11 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 7 | 70 | 0.08 | 0.11 | 0.34 | 0.16 |
| Canary Rockfish | 1 | 1 | 100 | 0.06 | 0.06 | 0.06 | 0.06 |
| Chilipepper | 2 | 2 | 100 | 0.06 | 0.08 | 0.09 | 0.08 |
| Copper Rockfish | 18 | 18 | 100 | 0.08 | 0.19 | 0.79 | 0.28 |
| Flag Rockfish | 2 | 2 | 100 | 0.13 | 0.39 | 0.65 | 0.39 |
| Greenblotched Rockfish | 3 | 3 | 100 | 0.11 | 0.19 | 0.28 | 0.20 |
| Greenspotted Rockfish | 2 | 2 | 100 | 0.27 | 0.28 | 0.29 | 0.28 |
| Greenstriped Rockfish | 1 | 1 | 100 | 0.18 | 0.18 | 0.18 | 0.18 |
| Mixed Rockfish | 34 | 32 | 94 | 0.04 | 0.13 | 0.60 | 0.18 |
| Rosethorn Rockfish | 1 | 1 | 100 | 0.11 | 0.11 | 0.11 | 0.11 |
| Speckled Rockfish | 15 | 15 | 100 | 0.06 | 0.09 | 0.39 | 0.14 |
| Squarespot Rockfish | 3 | 3 | 100 | 0.15 | 0.21 | 0.26 | 0.21 |
| Starry Rockfish | 9 | 9 | 100 | 0.11 | 0.19 | 0.24 | 0.18 |
| Vermilion Rockfish | 43 | 40 | 93 | 0.02 | 0.05 | 0.22 | 0.07 |
| Yellowtail Rockfish | 2 | 2 | 100 | 0.07 | 0.08 | 0.08 | 0.08 |
| ALL SPECIES | 146 | 138 | 95 | 0.02 | 0.11 | 0.79 | 0.16 |

**TABLE C5-3**
Summary of mercury concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 | Zone 4 | RF1 | RF2 |
| Total | 62 | 77 | 66 | 70 | 66 | 70 |
| Detected | 59 | 63 | 62 | 62 | 62 | 69 |
| Frequency | 95 | 82 | 94 | 89 | 94 | 99 |
| Minimum | 0.020 | 0.018 | 0.034 | 0.028 | 0.027 | 0.020 |
| Median | 0.085 | 0.062 | 0.090 | 0.098 | 0.085 | 0.122 |
| Maximum | 0.579 | 0.377 | 0.473 | 0.314 | 0.790 | 0.648 |
| Mean | 0.106 | 0.079 | 0.104 | 0.110 | 0.166 | 0.149 |
| 95% CI | 0.021 | 0.014 | 0.016 | 0.015 | 0.047 | 0.024 |

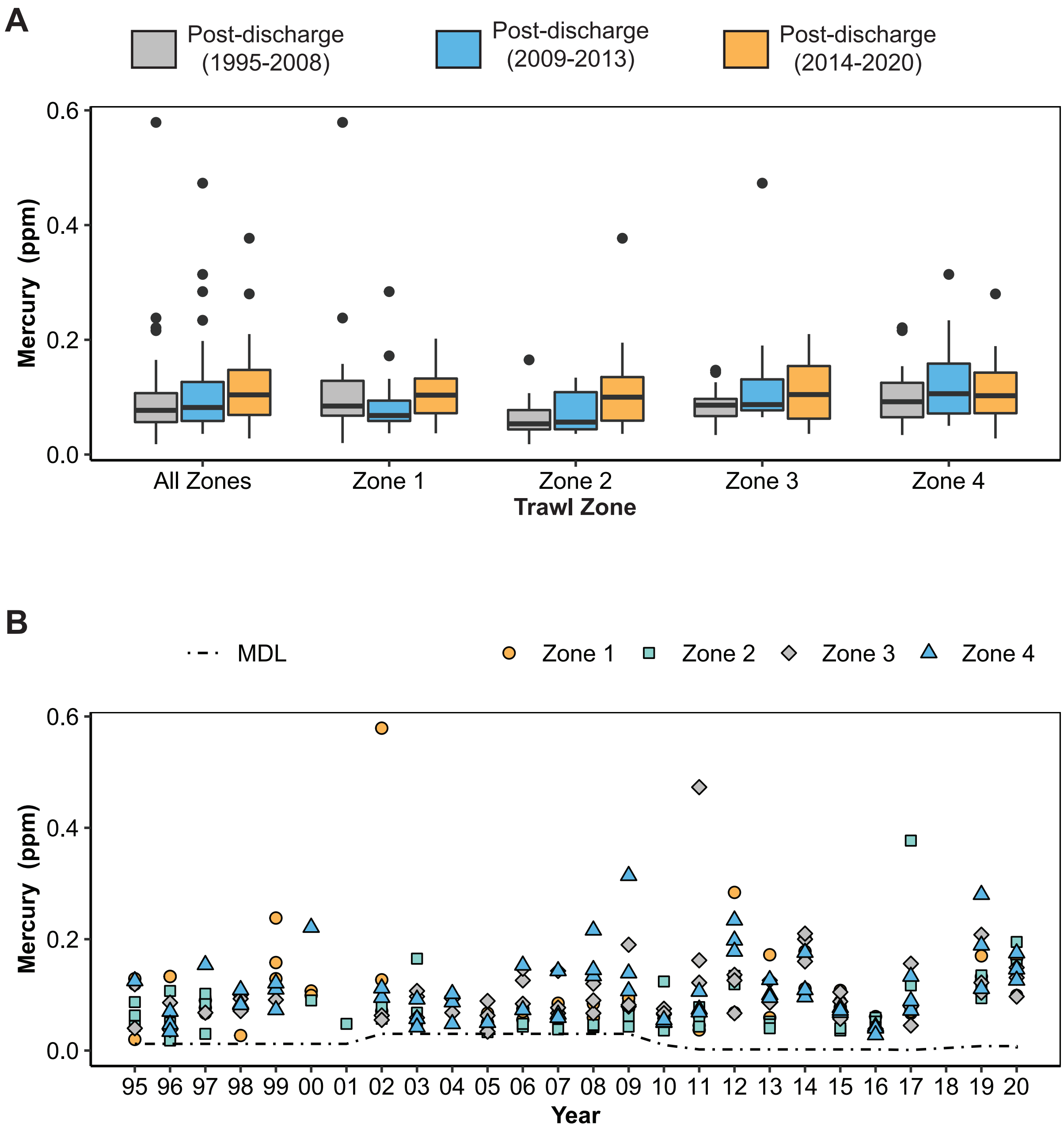



**FIGURE C5-2**
Mercury concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

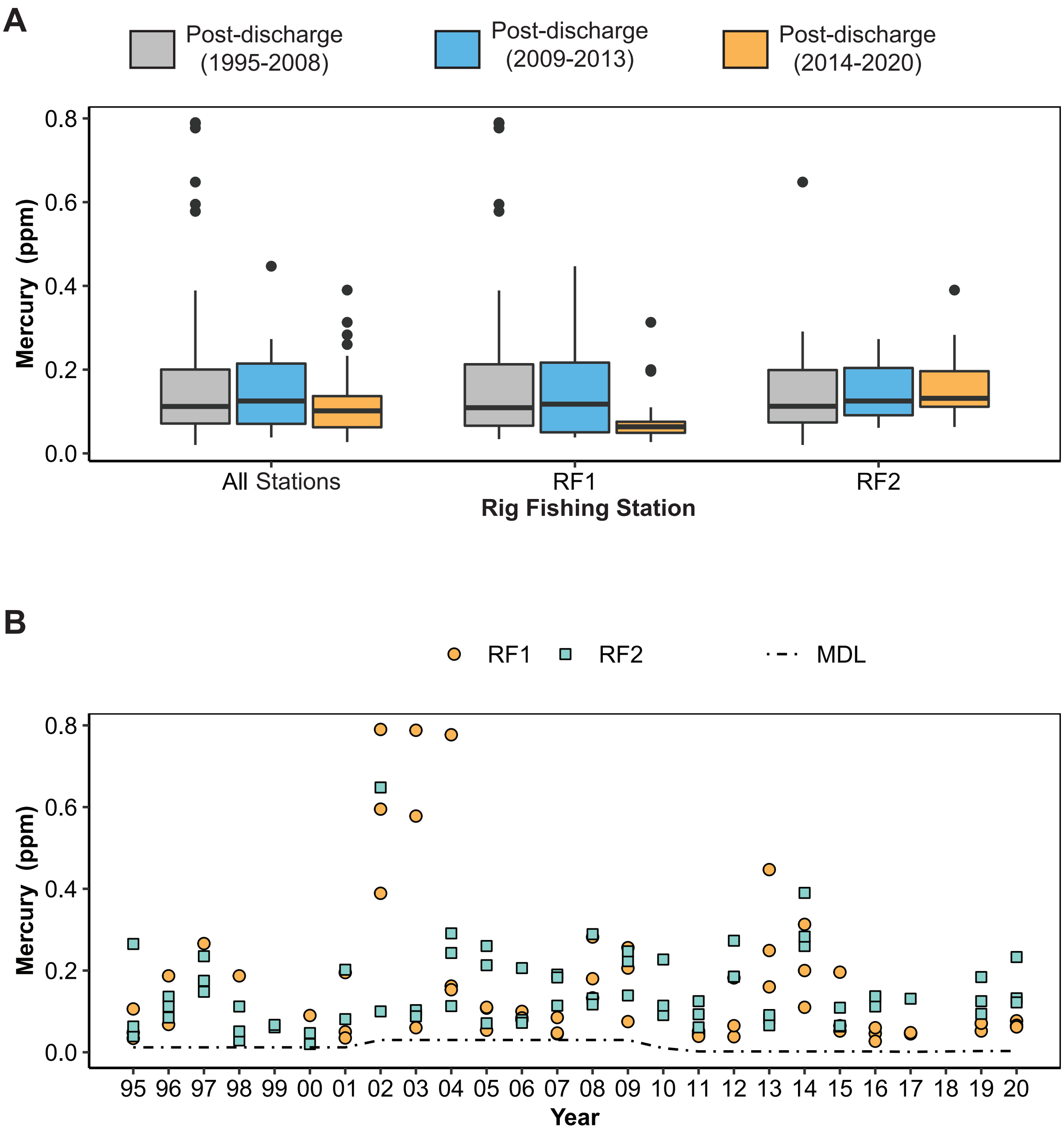



**FIGURE C5-3**
Mercury concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

**TABLE C5-4**
Maximum concentrations of various metals (ppm), pesticides (ppb), and total PCB (ppb) in muscle tissue samples of California Scorpionfish and each rockfish species collected from rig fishing stations. Data are summarized over all samples collected during October surveys from 1995 through 2020; tChlor = total chlordane; na=not available; nd=not detected.

| Species | Arsenic | Cadmium | Chromium | Copper | Lead | Mercury | Selenium | Tin | Zinc | tChlor | tDDT | tPCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| California Scorpionfish | 5.60 | nd | 0.14 | 1.63 | nd | 0.339 | 0.40 | nd | 6.91 | nd | 30.1 | 9.0 |
| Canary Rockfish | nd | nd | nd | nd | nd | 0.063 | 0.25 | nd | 3.82 | nd | 14.0 | 15.0 |
| Chilipepper | 0.93 | nd | nd | 0.36 | nd | 0.093 | 0.53 | 0.24 | 3.72 | nd | 6.7 | 2.2 |
| Copper Rockfish | 4.11 | 0.18 | 0.53 | 4.79 | nd | 0.790 | 0.72 | 1.77 | 5.90 | nd | 217.3 | 64.5 |
| Flag Rockfish | 2.15 | nd | nd | 1.20 | nd | 0.648 | 0.54 | 0.28 | 4.38 | nd | 69.7 | 25.5 |
| Greenblotched Rockfish | 5.75 | 0.08 | 0.31 | 0.77 | nd | 0.282 | 0.38 | 2.01 | 5.09 | nd | 9.7 | nd |
| Greenspotted Rockfish | 2.25 | nd | 0.20 | 0.14 | nd | 0.291 | 0.37 | 0.24 | 3.88 | nd | 13.0 | 0.6 |
| Greenstriped Rockfish | 4.31 | 0.05 | 0.06 | 0.50 | nd | 0.184 | 0.45 | 0.88 | 3.18 | nd | 2.9 | nd |
| Rockfish Unidentified | 6.10 | 0.06 | 1.78 | 8.96 | nd | 0.595 | 0.88 | 2.02 | 5.72 | 0.4 | 60.0 | 69.0 |
| Rosethorn Rockfish | 2.49 | nd | nd | 0.76 | nd | 0.108 | 0.37 | nd | 2.91 | nd | 2.2 | nd |
| Speckled Rockfish | 3.10 | 0.02 | 0.30 | 0.88 | 0.34 | 0.390 | 0.52 | 1.08 | 4.50 | nd | 16.0 | 3.3 |
| Squarespot Rockfish | 2.54 | nd | 0.09 | 0.46 | 0.42 | 0.260 | 0.44 | nd | 3.37 | nd | 20.0 | 3.4 |
| Starry Rockfish | 1.60 | 0.16 | 0.42 | 5.88 | nd | 0.235 | 0.70 | 1.55 | 4.35 | 2.4 | 117.3 | 44.1 |
| Vermilion Rockfish | 13.50 | 0.10 | 0.80 | 4.56 | 0.07 | 0.223 | 0.82 | 2.12 | 5.80 | nd | 24.0 | 28.0 |
| Yellowtail Rockfish | 0.46 | 0.16 | 0.47 | 0.45 | nd | 0.079 | 0.35 | 1.71 | 4.28 | nd | 6.3 | nd |
| ALL SPECIES | 13.50 | 0.18 | 1.78 | 8.96 | 0.42 | 0.790 | 0.88 | 2.12 | 6.91 | 2.4 | 217.3 | 69.0 |
| OEHHA[a] | na | na | na | na | na | 0.220 | 7.40 | na | na | 5.6 | 21.0 | 3.6 |
| USFDA Action Limit[b] | na | na | na | na | na | 1.000 | na | na | na | 300.0 | 5000.0 | na |
| CDHS Advisory Level[b] | na | na | na | na | na | 0.500 | na | na | na | na | na | na |
| Median IS[b] | 1.40 | 1.00 | 1.00 | 20.00 | 2.00 | 0.500 | 0.30 | 175 | 70 | 100.0 | 5000.0 | na |

[a] Klasing and Brodberg 2008

[b] Mearns et al. 1991

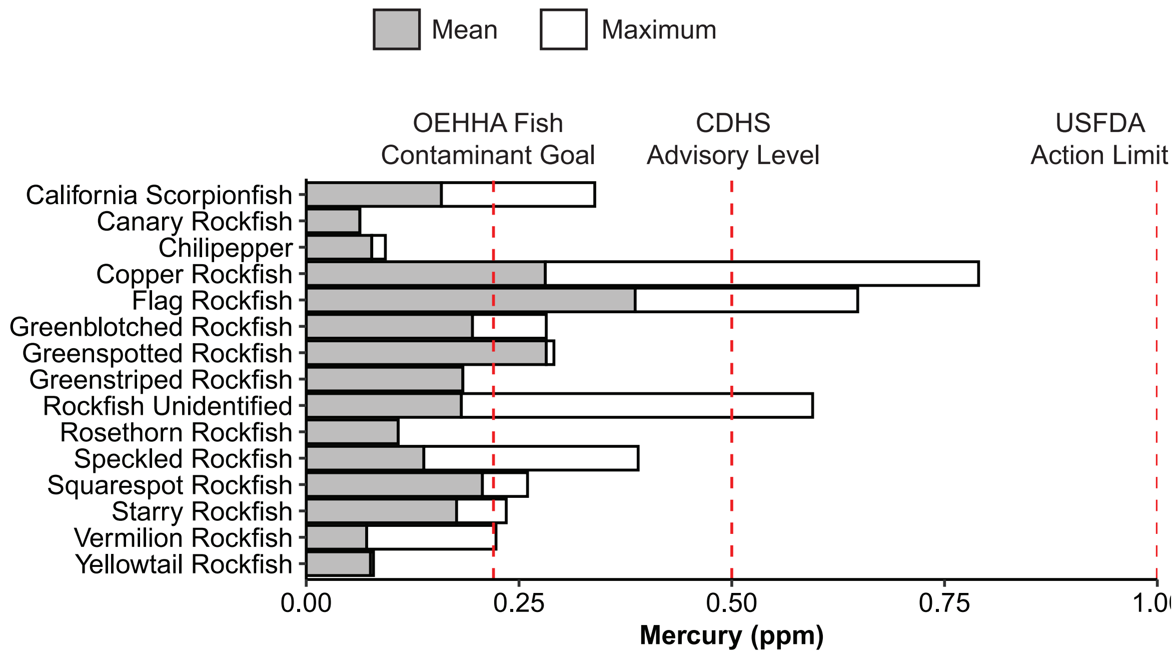



**FIGURE C5-4**

Mean and maximum concentrations of mercury in muscle tissues of all fishes collected off San Diego at rig fishing stations compared to the USFDA action limit (Mearns et al. 1991, USEPA 1997), the CDHS advisory level (Hayes and Phillips 1987, Mearns et al. 1991) and the OEHHA fish contaminant goal (Klasing and Brodberg 2008). See Table C5-2 for sample sizes.

USEPA 1997). These limits were legal devices, and not risk-based standards. Subsequently, the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) set a risk-based fish contaminant goal for mercury of 0.22 ppm (Klasing and Brodberg 2008). Table C5-4 and Figure C5-4 compare these thresholds to maximum mercury values in muscle tissues for all species collected at rig fishing stations from October 1995 through October 2020. Figure C5-4 also presents mean mercury concentrations per species collected off San Diego. Over the past 26 years, mercury concentrations have frequently exceeded the OEHHA goal in rockfish muscle tissues at both rig fishing stations (e.g., Figure C5-3B), resulting in 10 species with maximum values over this threshold (Table C5-4, Figure C5-4). Maximum values in Copper Rockfish, Flag Rockfish, and Mixed Rockfish have also exceeded the CDHS advisory level. In the history of the monitoring program, only a single Vermilion Rockfish sample exceeded the USFDA action limit (City of San Diego 2015). Because data have been limited to October surveys, this value is not included in this report. However, on average, no species had mercury concentrations that exceeded either the CDHS or USFDA limits, while only three (Copper, Flag, and Greenspotted Rockfish) exceeded the OEHHA fish contaminant goal (Figure C5-4). These results suggest that the occurrence of mercury values above the CDHS and USFDA limits is sporadic and may be due to the capture of relatively large and therefore older fishes. Additionally, elevated levels of mercury are not uncommon in sport fish from other areas of the San Diego region. For example, muscle tissue samples from fishes collected since 1995 in the South Bay outfall survey area, including the Coronado Islands, have occasionally had concentrations of mercury that exceeded the OEHHA fish contaminant goal (City of San Diego 2020a, McLaughlin et al. 2020).

### *Arsenic*

Arsenic is a common trace element, well known for its toxic effects. It occurs naturally in seawater and is used in herbicides, insecticides, wood preservatives, and in a variety of industrial applications (Mearns et al. 1991). In organisms, it is detoxified via production of organic forms of arsenic which are less toxic and more readily excreted. Southern California marine coastal waters have a significant natural source of arsenic originating from the Punta Banda submarine hot springs in Baja California. These hot springs discharge water containing up to 420,500 ppb arsenic compared to 3 ppb that naturally occur in seawater.

For reference purposes, annual average arsenic concentrations in Point Loma effluent ranged from 0.51 to 1.36 ppb from 2014 through 2020. Mean concentrations of arsenic in outfall depth sediments off Point Loma were 2.4 and 3.1 ppm during the pre- and post-discharge periods, respectively, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (2.7 – 6.1 ppm; see Table C1-2, Appendix C1).

Tissue concentrations of arsenic in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-5 and by zone/station in Table C5-6 and Figures C5-5 and C5-6. Arsenic was detected in 85% of liver tissue samples from trawl-caught fishes, at concentrations of 0.06 to 18.50 ppm, and in 86% of muscle tissue samples from rig fishing stations, at concentrations of 0.40 to 13.50 ppm

(Table C5-5). Mean detected concentrations of arsenic in sanddab liver tissues ranged from 4.09 to 5.19 ppm across trawl zones, while concentrations in rockfish muscle tissues averaged 2.94 ppm at station RF1 and 2.31 at station RF2 (Table C5-6). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or between rig fishing stations for rockfish in terms of arsenic concentrations over surveys combined for the three post-discharge periods (Figures C5-5A, C5-6A) or over time (Figures C5-5B, C5-6B). Regionally, arsenic levels have been highly variable over the years, with the highest values reported from 1996-2003 and again from 2015-2020 in trawl zones, and from 1998-2002 and again from 2015-2020 at rig fishing stations.

There are no USFDA, CDHS, or OEHHA standards for arsenic in food. However, arsenic concentrations in fishes caught off Point Loma are high relative to the Median International Standard (MIS) of 1.4 ppm applied to shellfish and to the sale of seafood for human consumption in some countries (Table C5-4 and Figure C5-7). Mearns et al. (1991) reviewed studies conducted in the SCB and concluded that (a) there is no correspondence between point sources of arsenic and arsenic concentrations in the tissues of marine animals, and (b) arsenic tissue concentrations generally decrease with trophic level. Consequently, high levels of arsenic in regional fishes are probably due to elevated levels that occur in the natural environment rather than exposure to anthropogenic sources and subsequent food web magnification. Additionally, as with mercury, elevated levels of arsenic have been detected in sport fish from other areas of the San Diego region, including the Coronado Islands (City of San Diego 2020a, McLaughlin et al. 2020).

***Cadmium***

Cadmium is widely used in electroplating, as a pigment in paints, in batteries, and as a plastic stabilizer. It has been one of the metals targeted for source control in the San Diego pretreatment program resulting in a significant decline in effluent concentrations over time. For reference purposes, annual average cadmium concentrations in Point Loma effluent ranged from not detected to 0.11 ppb from 2014 through 2020. Mean concentrations of cadmium in outfall depth sediments off Point Loma were 1.3 and 0.2 ppm during the pre- and post-discharge periods, respectively, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (0.1 – 0.7 ppm; see Table C1-2, Appendix C1).

Tissue concentrations of cadmium in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-7 and by zone/station in Table C5-8, and Figures C5-8 and C5-9. Cadmium was detected in 92% of liver tissue samples from trawl-caught fishes, at concentrations of 0.36 to 19.20 ppm but was detected in just 22% of muscle tissue samples from rig fishing stations, at concentrations of 0.01 to 0.18 ppm (Table C5-7). Mean detected concentrations of cadmium in sanddab liver tissues ranged from 3.26 to 5.32 ppm per trawl zone, while the mean concentration in rockfish muscle tissues was 0.07 ppm for both rig fishing stations (Table C5-8).

The cadmium data summarized in Table C5-8 and Figures C5-8 and C5-9 show no consistent differences in the bioaccumulation of this metal between fishes captured at the nearfield and

**TABLE C5-5**
Summary of arsenic concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 17 | 55 | 1.40 | 2.70 | 14.10 | 3.26 |
| Dover Sole | 2 | 1 | 50 | 0.08 | 0.08 | 0.08 | 0.08 |
| English Sole | 20 | 18 | 90 | 1.80 | 5.49 | 13.30 | 5.73 |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 2 | 1 | 50 | 1.55 | 1.55 | 1.55 | 1.55 |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Halfbanded Rockfish | 2 | 1 | 50 | 3.83 | 3.83 | 3.83 | 3.83 |
| Longfin Sanddab | 65 | 49 | 75 | 0.06 | 5.91 | 18.50 | 7.14 |
| Mixed Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Pacific Sanddab | 208 | 197 | 95 | 0.06 | 3.45 | 15.40 | 4.01 |
| ALL SPECIES | 336 | 284 | 85 | 0.06 | 3.65 | 18.50 | 4.59 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 10 | 100 | 1.06 | 2.65 | 5.60 | 2.82 |
| Canary Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Chilipepper | 2 | 2 | 100 | 0.71 | 0.82 | 0.93 | 0.82 |
| Copper Rockfish | 18 | 14 | 78 | 0.68 | 1.70 | 4.11 | 1.85 |
| Flag Rockfish | 2 | 2 | 100 | 0.73 | 1.44 | 2.15 | 1.44 |
| Greenblotched Rockfish | 3 | 3 | 100 | 1.41 | 1.78 | 5.75 | 2.98 |
| Greenspotted Rockfish | 2 | 2 | 100 | 1.94 | 2.10 | 2.25 | 2.10 |
| Greenstriped Rockfish | 1 | 1 | 100 | 4.31 | 4.31 | 4.31 | 4.31 |
| Mixed Rockfish | 34 | 30 | 88 | 0.40 | 2.22 | 6.10 | 2.42 |
| Rosethorn Rockfish | 1 | 1 | 100 | 2.49 | 2.49 | 2.49 | 2.49 |
| Speckled Rockfish | 15 | 12 | 80 | 0.40 | 0.97 | 3.10 | 1.34 |
| Squarespot Rockfish | 3 | 3 | 100 | 1.84 | 2.16 | 2.54 | 2.18 |
| Starry Rockfish | 9 | 6 | 67 | 0.55 | 1.07 | 1.60 | 1.10 |
| Vermilion Rockfish | 45 | 40 | 89 | 0.96 | 2.47 | 13.50 | 3.85 |
| Yellowtail Rockfish | 2 | 1 | 50 | 0.46 | 0.46 | 0.46 | 0.46 |
| ALL SPECIES | 148 | 127 | 86 | 0.40 | 2.01 | 13.50 | 2.64 |

**TABLE C5-6**
Summary of arsenic concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 | Zone 4 | RF1 | RF2 |
| Total | 62 | 76 | 65 | 70 | 66 | 72 |
| Detected | 55 | 64 | 61 | 66 | 57 | 60 |
| Frequency | 89 | 84 | 94 | 94 | 86 | 83 |
| Minimum | 0.06 | 0.06 | 0.07 | 0.31 | 0.40 | 0.40 |
| Median | 4.00 | 3.78 | 3.45 | 3.75 | 2.33 | 1.66 |
| Maximum | 15.40 | 18.50 | 12.20 | 13.30 | 13.50 | 11.40 |
| Mean | 4.92 | 5.19 | 4.09 | 4.36 | 2.94 | 2.31 |
| 95% CI | 0.83 | 0.92 | 0.68 | 0.65 | 0.60 | 0.57 |

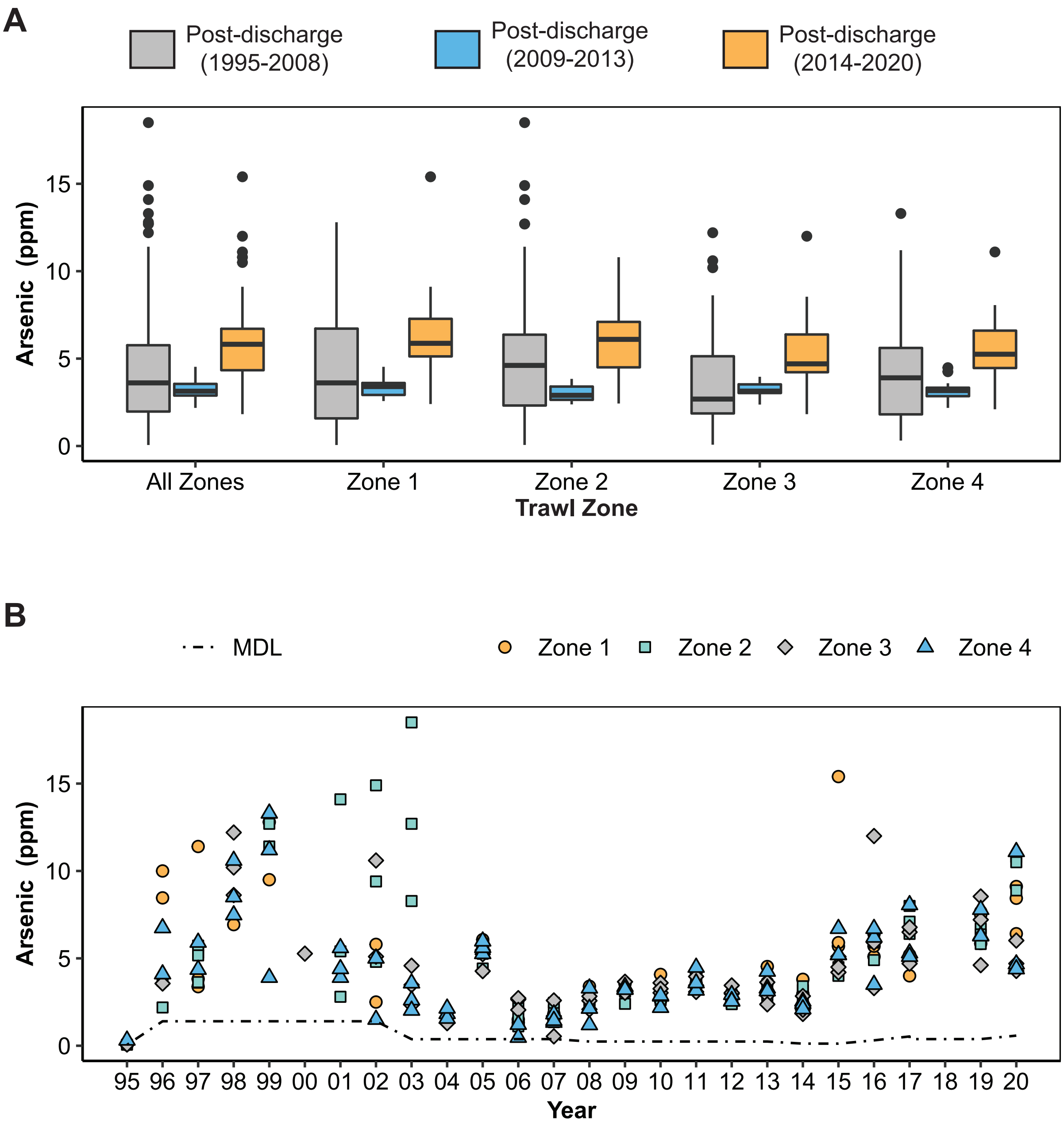



**FIGURE C5-5**
Arsenic concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

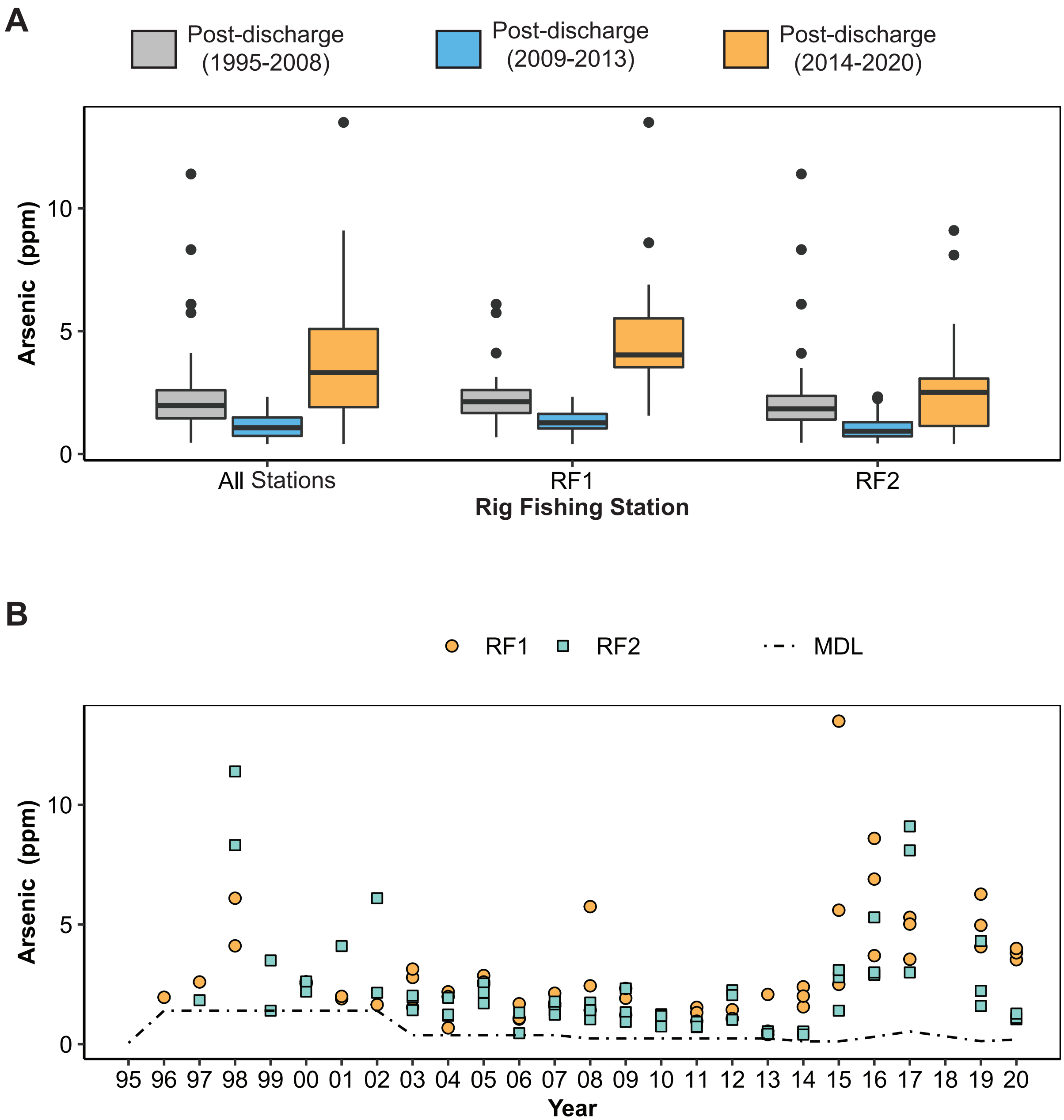



**FIGURE C5-6**

Arsenic concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

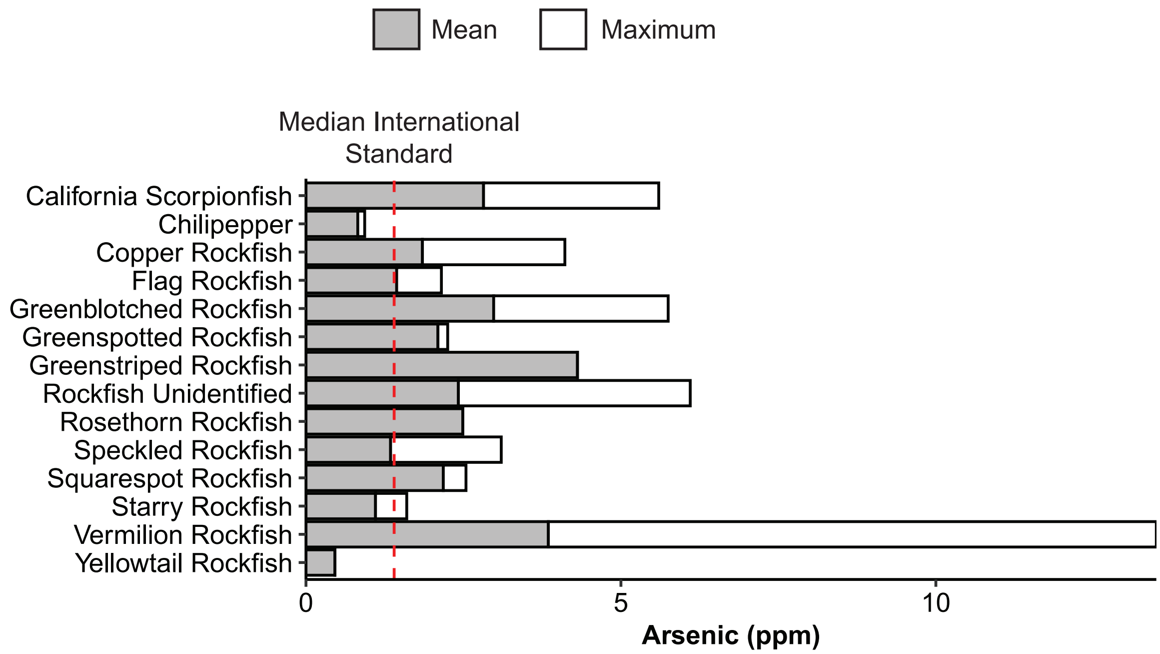



**FIGURE C5-7**
Mean and maximum concentrations of arsenic in muscle tissues of all fishes collected off San Diego at rig fishing stations compared to the median international standard (from Mearns et al. 1991). See Table C5-2 for sample sizes.

**TABLE C5-7**
Summary of cadmium concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd = not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 30 | 97 | 0.82 | 3.51 | 6.51 | 3.51 |
| Dover Sole | 2 | 0 | 0 | nd | nd | nd | nd |
| English Sole | 20 | 15 | 75 | 0.36 | 0.68 | 1.07 | 0.70 |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 2 | 2 | 100 | 0.46 | 0.66 | 0.86 | 0.66 |
| Greenspotted Rockfish | 2 | 2 | 100 | 1.77 | 1.88 | 1.99 | 1.88 |
| Halfbanded Rockfish | 2 | 2 | 100 | 1.09 | 1.16 | 1.22 | 1.16 |
| Longfin Sanddab | 65 | 52 | 80 | 0.38 | 1.75 | 4.79 | 1.82 |
| Mixed Rockfish | 2 | 2 | 100 | 2.05 | 4.82 | 7.59 | 4.82 |
| Pacific Sanddab | 208 | 205 | 99 | 0.38 | 4.27 | 19.20 | 4.96 |
| ALL SPECIES | 336 | 310 | 92 | 0.36 | 3.15 | 19.20 | 4.02 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 0 | 0 | nd | nd | nd | nd |
| Canary Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Chilipepper | 2 | 0 | 0 | nd | nd | nd | nd |
| Copper Rockfish | 18 | 5 | 28 | 0.04 | 0.15 | 0.18 | 0.12 |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 3 | 3 | 100 | 0.05 | 0.06 | 0.08 | 0.07 |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenstriped Rockfish | 1 | 1 | 100 | 0.05 | 0.05 | 0.05 | 0.05 |
| Mixed Rockfish | 34 | 3 | 9 | 0.03 | 0.03 | 0.06 | 0.04 |
| Rosethorn Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Speckled Rockfish | 15 | 3 | 20 | 0.01 | 0.01 | 0.02 | 0.01 |
| Squarespot Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Starry Rockfish | 9 | 2 | 22 | 0.02 | 0.09 | 0.16 | 0.09 |
| Vermilion Rockfish | 45 | 13 | 29 | 0.02 | 0.05 | 0.10 | 0.05 |
| Yellowtail Rockfish | 2 | 2 | 100 | 0.14 | 0.15 | 0.16 | 0.15 |
| ALL SPECIES | 148 | 32 | 22 | 0.01 | 0.05 | 0.18 | 0.07 |

**TABLE C5-8**
Summary of cadmium concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 | Zone 4 | RF1 | RF2 |
| Total | 62 | 76 | 65 | 70 | 66 | 72 |
| Detected | 59 | 74 | 61 | 63 | 17 | 15 |
| Frequency | 95 | 97 | 94 | 90 | 26 | 21 |
| Minimum | 0.38 | 0.38 | 0.58 | 0.80 | 0.02 | 0.01 |
| Median | 3.47 | 3.00 | 4.33 | 4.74 | 0.05 | 0.05 |
| Maximum | 18.10 | 10.90 | 19.20 | 12.10 | 0.18 | 0.16 |
| Mean | 4.02 | 3.26 | 4.91 | 5.32 | 0.07 | 0.07 |
| 95% CI | 0.83 | 0.51 | 1.00 | 0.82 | 0.02 | 0.03 |

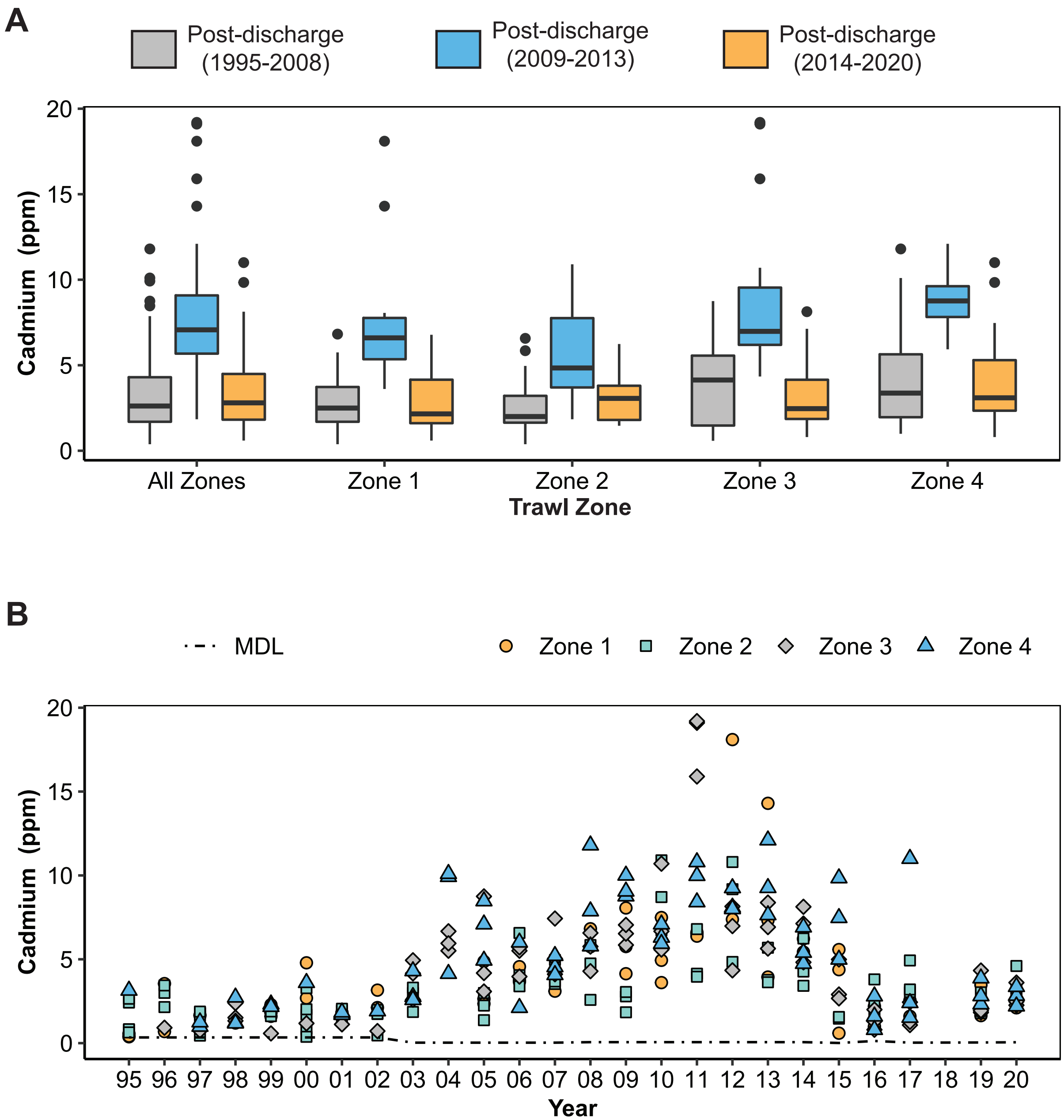
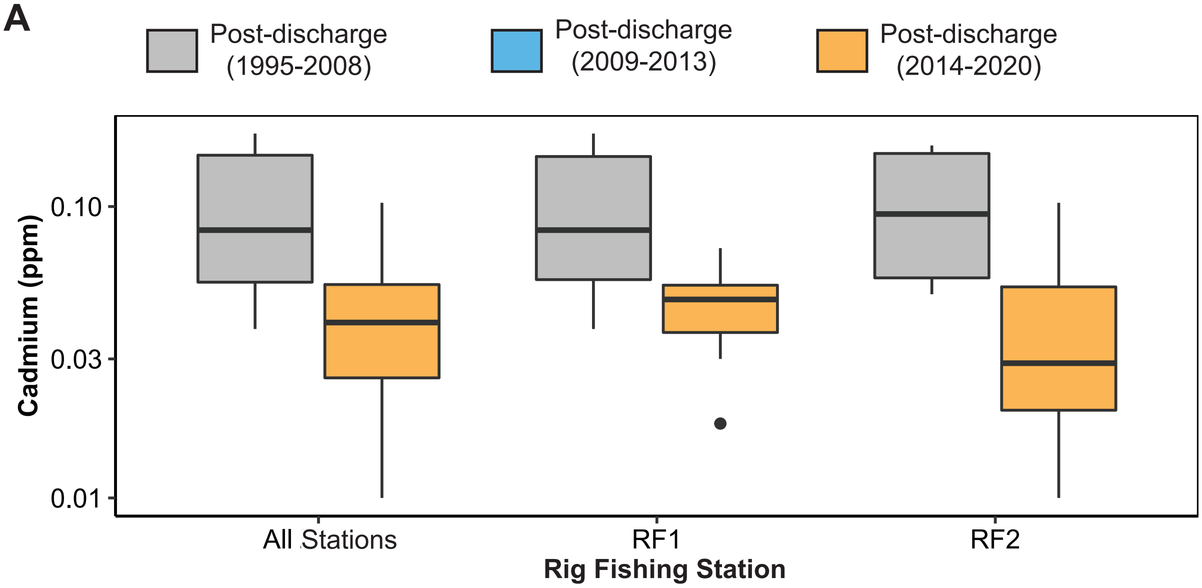



**FIGURE C5-8**
Cadmium concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

A




B

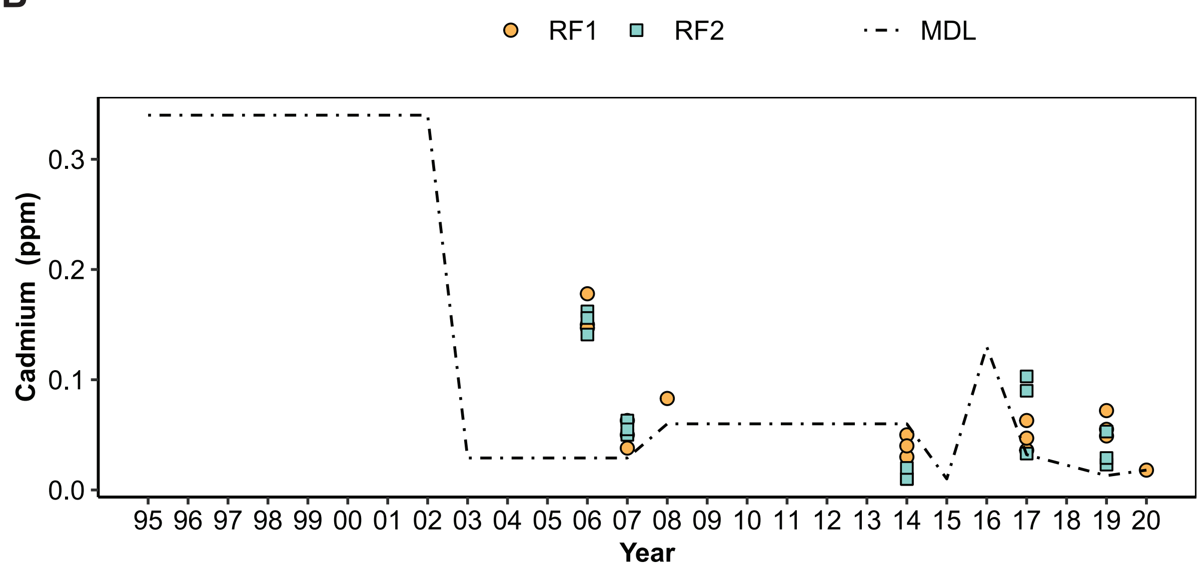



**FIGURE C5-9**
Cadmium concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

farfield trawl zones, or between the two rig fishing sites. However, cadmium concentrations in sanddab livers were substantially higher from 2004 through 2015 than previous or subsequent years, across all zones (Figure C5-8B). In contrast to sanddab liver tissues, the detection of cadmium in rockfish muscle tissues was sporadic, being limited to samples collected at both rig fishing stations during 2006, 2007, 2008, 2014, 2017, 2019, and 2020 (Figure C5-9B), all of which had concentrations below the MIS of 1.00 ppm (Table C5-4).

### *Chromium*

Chromium has also been a target of source control efforts for the San Diego metal plating industry. For reference purposes, annual average chromium concentrations in Point Loma effluent ranged from 0.77 to 3.00 ppb from 2014 through 2020. Mean concentrations of chromium in outfall depth sediments off Point Loma were 17 ppm during both the pre- and post-discharge periods, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (18 – 39 ppm; see Table C1-2, Appendix C1).

Tissue concentrations of chromium in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-9 and by zone/station in Table C5-10, and Figures C5-10 and C5-11. Chromium was detected in 59% of liver tissue samples from trawl-caught fishes, at concentrations of 0.05 to 22.80 ppm and was detected in 50% of muscle tissue samples from rig fishing stations, at concentrations of 0.04 to 1.78 ppm (Table C5-9). Mean detected concentrations of chromium in sanddab liver tissues ranged from 0.47 to 0.98 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 0.24 ppm at station RF1 and 0.26 at station RF2 (Table C5-10). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of chromium concentrations over surveys combined for the three post-discharge periods (Figures C5-10A, C5-11A) or over time (Figures C5-10B, C5-11B). A single relatively high value (>20 ppm) was reported from Zone 1 in 2020, otherwise chromium levels were < 5 ppm all trawl zones. As with cadmium, chromium was detected sporadically in rockfishes from the rig fishing stations. All but two of these muscle samples had values less than the MIS for chromium (Table C5-4). These included a Mixed Rockfish sample from RF1 and RF2 in 2000.

### *Copper*

Copper is typically the metal that occurs in the second highest concentrations in Point Loma effluent due to its widespread use in industrial commercial and household products and applications (i.e., zinc occurs in higher concentrations; see below). For example, copper is leached from many materials that are part of the sewage flow entering the treatment plant, and it also originates from copper water pipes. For reference purposes, annual average copper concentrations in Point Loma effluent ranged from 10.7 to 19.7 ppb from 2014 through 2020. Mean concentrations of copper in outfall depth sediments off Point Loma were 7 ppm during both the pre- and post-discharge periods, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (7 – 15 ppm; see Table C1-2, Appendix C1).

**TABLE C5-9**
Summary of chromium concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 10 | 32 | 0.41 | 1.23 | 4.29 | 1.58 |
| Dover Sole | 2 | 0 | 0 | nd | nd | nd | nd |
| English Sole | 20 | 16 | 80 | 0.10 | 0.31 | 1.14 | 0.34 |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 2 | 1 | 50 | 1.14 | 1.14 | 1.14 | 1.14 |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Halfbanded Rockfish | 2 | 1 | 50 | 1.23 | 1.23 | 1.23 | 1.23 |
| Longfin Sanddab | 65 | 27 | 42 | 0.29 | 0.66 | 22.80 | 1.87 |
| Mixed Rockfish | 2 | 1 | 50 | 1.00 | 1.00 | 1.00 | 1.00 |
| Pacific Sanddab | 208 | 141 | 68 | 0.05 | 0.28 | 4.48 | 0.40 |
| ALL SPECIES | 336 | 197 | 59 | 0.05 | 0.33 | 22.80 | 0.66 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 1 | 10 | 0.14 | 0.14 | 0.14 | 0.14 |
| Canary Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Chilipepper | 2 | 0 | 0 | nd | nd | nd | nd |
| Copper Rockfish | 18 | 10 | 56 | 0.11 | 0.27 | 0.53 | 0.29 |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 3 | 3 | 100 | 0.21 | 0.29 | 0.31 | 0.27 |
| Greenspotted Rockfish | 2 | 2 | 100 | 0.19 | 0.20 | 0.20 | 0.20 |
| Greenstriped Rockfish | 1 | 1 | 100 | 0.06 | 0.06 | 0.06 | 0.06 |
| Mixed Rockfish | 34 | 18 | 53 | 0.05 | 0.17 | 1.78 | 0.30 |
| Rosethorn Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Speckled Rockfish | 15 | 6 | 40 | 0.10 | 0.17 | 0.30 | 0.18 |
| Squarespot Rockfish | 3 | 1 | 33 | 0.09 | 0.09 | 0.09 | 0.09 |
| Starry Rockfish | 9 | 5 | 56 | 0.11 | 0.20 | 0.42 | 0.24 |
| Vermilion Rockfish | 45 | 25 | 56 | 0.04 | 0.17 | 0.80 | 0.22 |
| Yellowtail Rockfish | 2 | 2 | 100 | 0.36 | 0.42 | 0.47 | 0.42 |
| ALL SPECIES | 148 | 74 | 50 | 0.04 | 0.19 | 1.78 | 0.25 |

**TABLE C5-10**

Summary of chromium concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | **Zone 1** | **Zone 2** | **Zone 3** | **Zone 4** | **RF1** | **RF2** |
| Total | 62 | 76 | 65 | 70 | 66 | 72 |
| Detected | 37 | 47 | 39 | 45 | 36 | 37 |
| Frequency | 60 | 62 | 60 | 64 | 55 | 51 |
| Minimum | 0.05 | 0.06 | 0.13 | 0.09 | 0.04 | 0.05 |
| Median | 0.29 | 0.33 | 0.30 | 0.34 | 0.19 | 0.17 |
| Maximum | 22.80 | 4.33 | 4.48 | 2.06 | 1.06 | 1.78 |
| Mean | 0.98 | 0.56 | 0.57 | 0.47 | 0.24 | 0.26 |
| 95% CI | 1.23 | 0.25 | 0.27 | 0.12 | 0.06 | 0.10 |

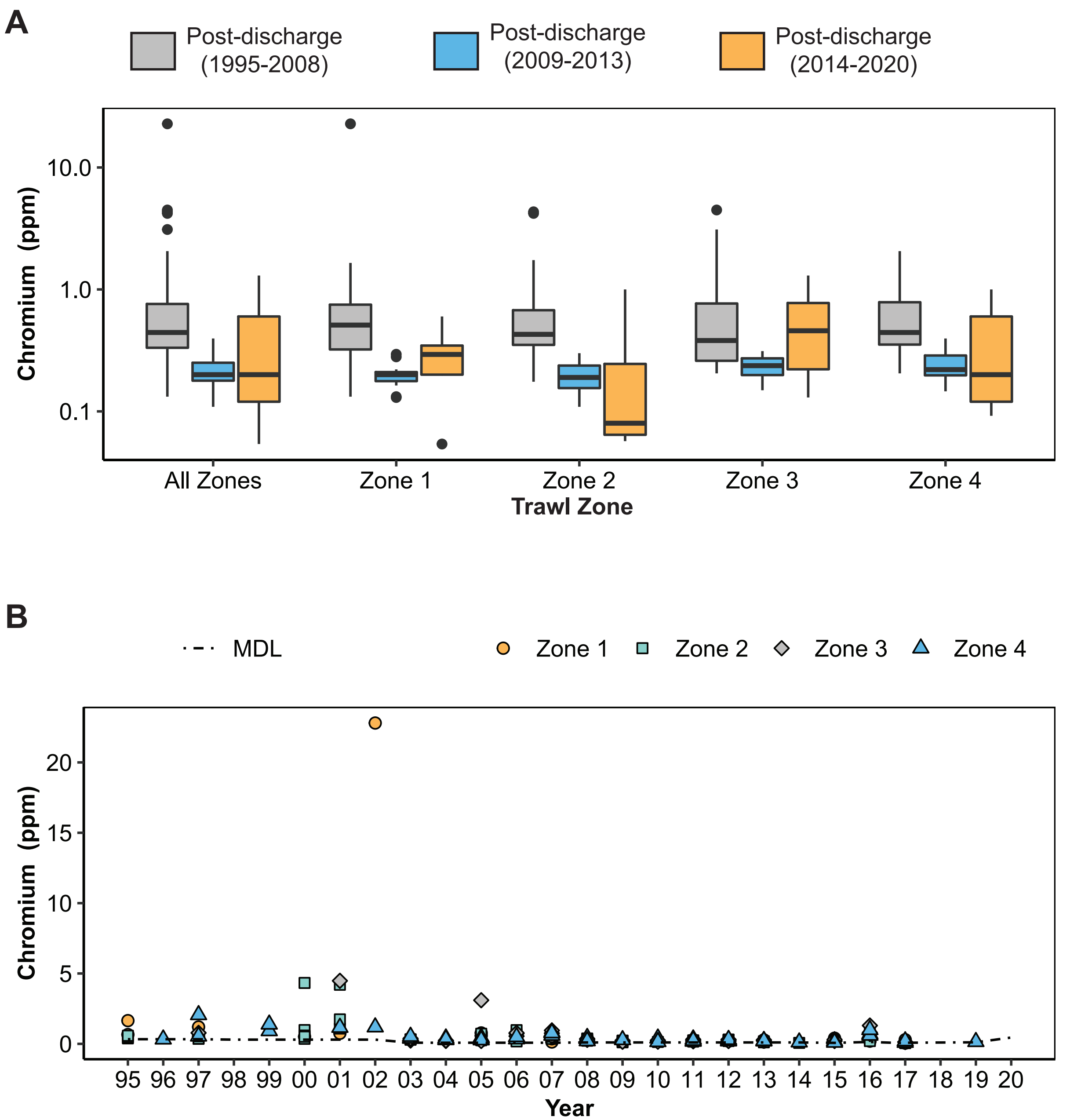



**FIGURE C5-10**
Chromium concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

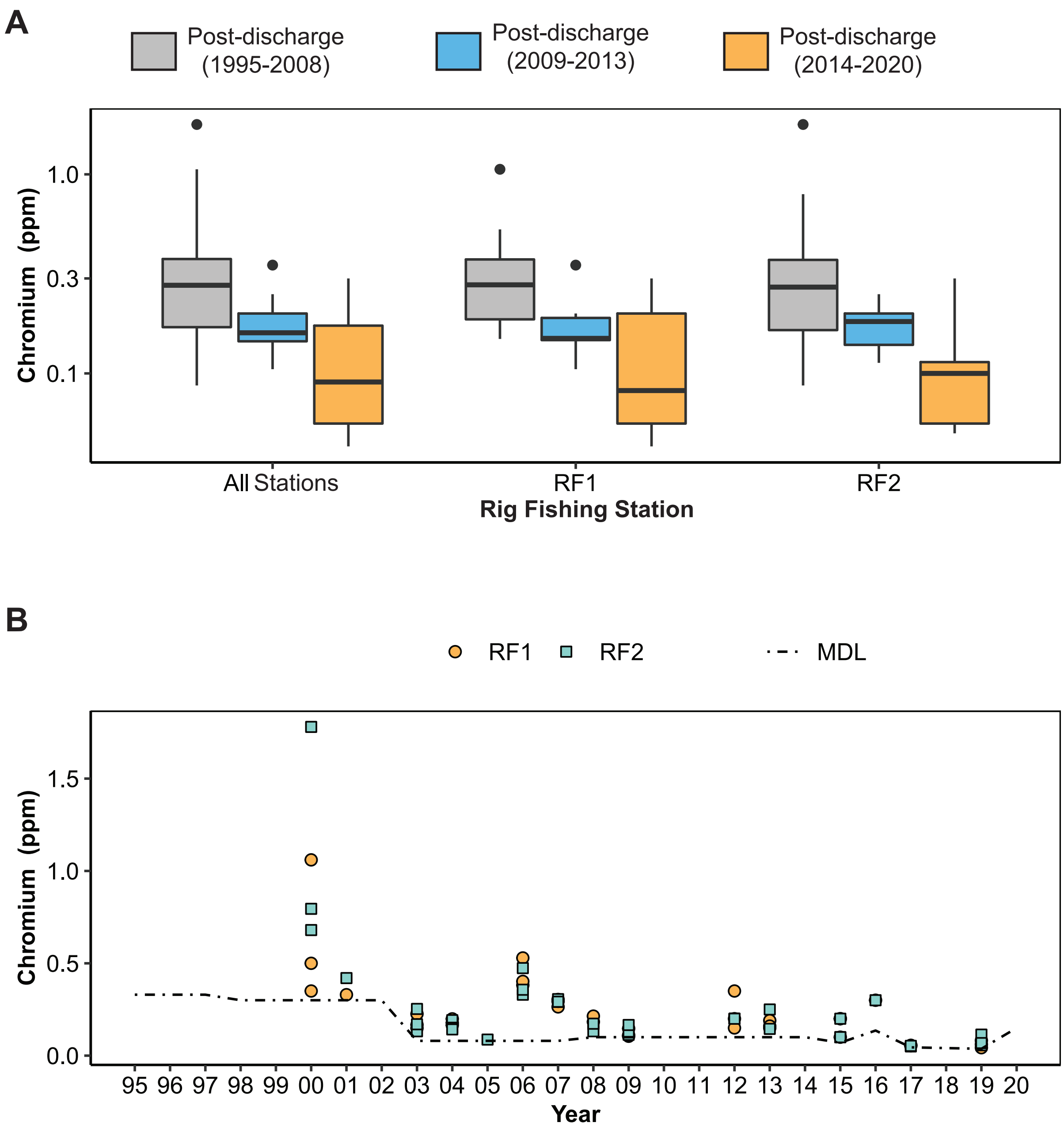



**FIGURE C5-11**
Chromium concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

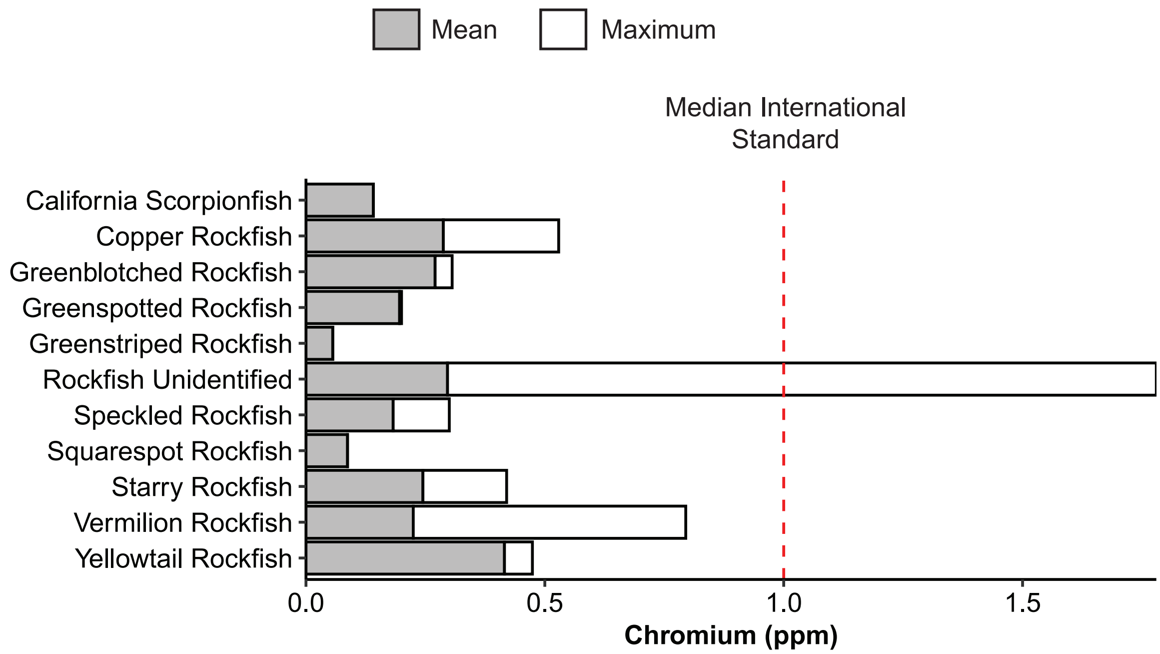


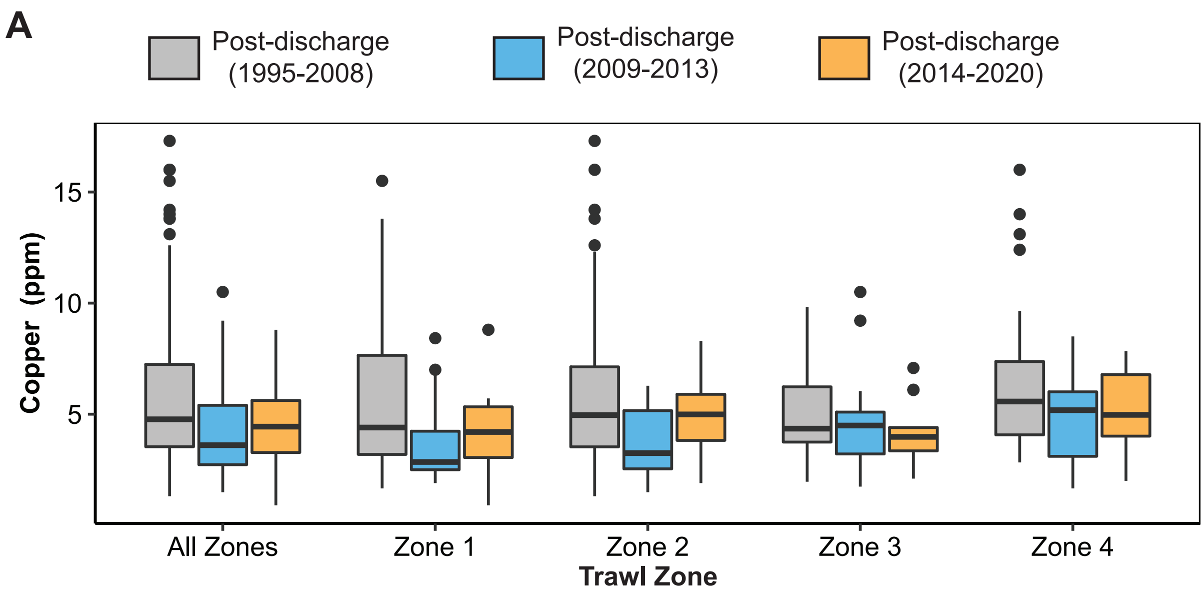

**FIGURE C5-12**
Mean and maximum concentrations of chromium in muscle tissues of all fishes collected off San Diego at rig fishing stations compared to the median international standard (from Mearns et al. 1991). See Table C5-2 for sample sizes.

**TABLE C5-11**
Summary of copper concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 31 | 100 | 6.42 | 27.80 | 67.00 | 30.31 |
| Dover Sole | 2 | 2 | 100 | 3.37 | 3.84 | 4.30 | 3.84 |
| English Sole | 20 | 20 | 100 | 0.86 | 5.00 | 15.80 | 5.20 |
| Flag Rockfish | 2 | 2 | 100 | 42.60 | 104.30 | 166.00 | 104.30 |
| Greenblotched Rockfish | 2 | 2 | 100 | 3.87 | 4.49 | 5.10 | 4.49 |
| Greenspotted Rockfish | 2 | 2 | 100 | 11.70 | 14.05 | 16.40 | 14.05 |
| Halfbanded Rockfish | 2 | 2 | 100 | 2.01 | 6.71 | 11.40 | 6.71 |
| Longfin Sanddab | 65 | 65 | 100 | 1.31 | 6.45 | 17.30 | 6.92 |
| Mixed Rockfish | 2 | 2 | 100 | 12.10 | 16.20 | 20.30 | 16.20 |
| Pacific Sanddab | 200 | 200 | 100 | 0.90 | 4.09 | 14.20 | 4.60 |
| ALL SPECIES | 328 | 328 | 100 | 0.86 | 4.89 | 166.00 | 8.27 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 6 | 60 | 0.21 | 1.02 | 1.63 | 0.94 |
| Canary Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Chilipepper | 2 | 2 | 100 | 0.33 | 0.34 | 0.36 | 0.34 |
| Copper Rockfish | 18 | 12 | 67 | 0.10 | 0.38 | 4.79 | 0.71 |
| Flag Rockfish | 2 | 2 | 100 | 0.34 | 0.77 | 1.20 | 0.77 |
| Greenblotched Rockfish | 3 | 3 | 100 | 0.51 | 0.59 | 0.77 | 0.63 |
| Greenspotted Rockfish | 2 | 1 | 50 | 0.14 | 0.14 | 0.14 | 0.14 |
| Greenstriped Rockfish | 1 | 1 | 100 | 0.50 | 0.50 | 0.50 | 0.50 |
| Mixed Rockfish | 34 | 20 | 59 | 0.05 | 0.39 | 8.96 | 1.19 |
| Rosethorn Rockfish | 1 | 1 | 100 | 0.76 | 0.76 | 0.76 | 0.76 |
| Speckled Rockfish | 15 | 6 | 40 | 0.17 | 0.22 | 0.88 | 0.41 |
| Squarespot Rockfish | 3 | 2 | 67 | 0.25 | 0.36 | 0.46 | 0.36 |
| Starry Rockfish | 9 | 5 | 56 | 0.21 | 0.30 | 5.88 | 1.40 |
| Vermilion Rockfish | 45 | 28 | 62 | 0.10 | 0.45 | 4.56 | 1.12 |
| Yellowtail Rockfish | 2 | 2 | 100 | 0.39 | 0.42 | 0.45 | 0.42 |
| ALL SPECIES | 148 | 91 | 61 | 0.05 | 0.42 | 8.96 | 0.94 |

**TABLE C5-12**
Summary of copper concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 | Zone 4 | RF1 | RF2 |
| Total | 59 | 74 | 64 | 68 | 66 | 72 |
| Detected | 59 | 74 | 64 | 68 | 42 | 43 |
| Frequency | 100 | 100 | 100 | 100 | 64 | 60 |
| Minimum | 0.90 | 1.31 | 1.74 | 1.66 | 0.05 | 0.14 |
| Median | 3.88 | 4.70 | 4.09 | 5.29 | 0.46 | 0.39 |
| Maximum | 15.50 | 17.30 | 10.50 | 16.00 | 8.96 | 5.88 |
| Mean | 4.75 | 5.36 | 4.75 | 5.71 | 1.05 | 0.84 |
| 95% CI | 0.74 | 0.76 | 0.51 | 0.68 | 0.54 | 0.41 |



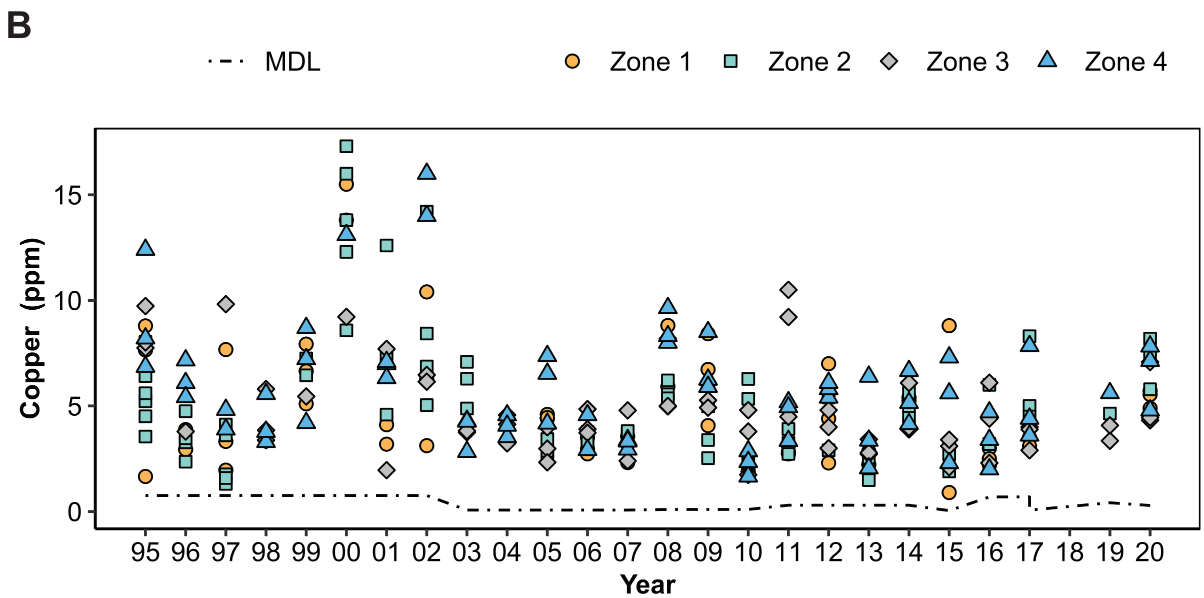




**FIGURE C5-13**
Copper concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

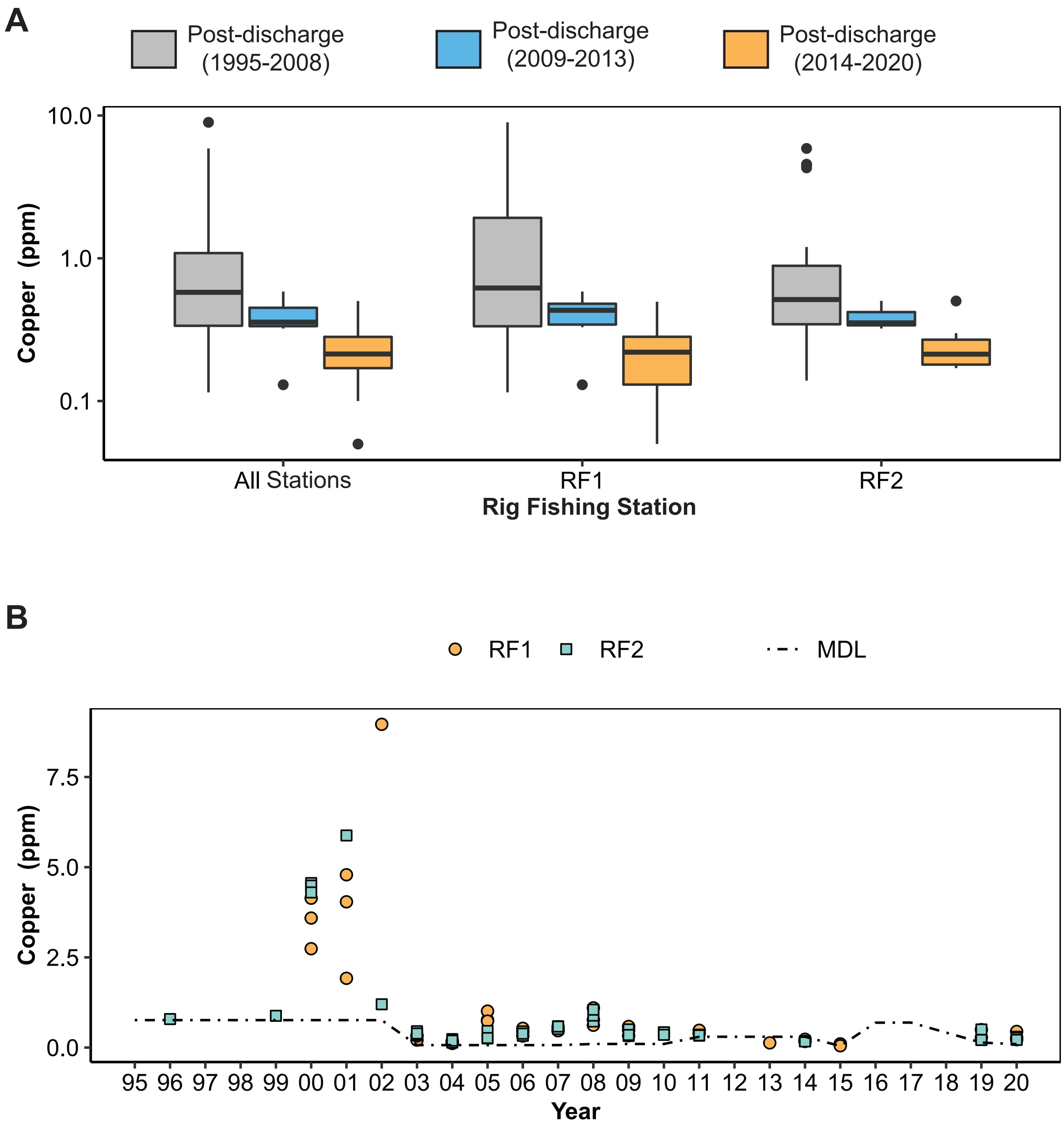



**FIGURE C5-14**
Copper concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

Tissue concentrations of copper in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-11 and by zone/station in Table C5-12, and Figures C5-13 and C5-14. Copper was detected in 100% of liver tissue samples from trawl-caught fishes, at concentrations of 0.86 to 166.00 ppm, and was detected in 61% of muscle tissue samples from rig fishing stations, at concentrations of 0.05 to 8.96 ppm (Table C5-11). Mean detected concentrations of copper in sanddab liver tissues ranged from 4.75 to 5.71 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 1.05 ppm at station RF1 and 0.84 at station RF2 (Table C5-12). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of copper concentrations over surveys combined for the three post-discharge periods (Figures C5-13A, C5-14A) or over time (Figures C5-13B, C5-14B). Regionally, copper levels have been highly variable over the years, with the highest values reported from 1995, 2000-2002 at trawl zones, and during 2000-2001 at rig fishing stations. While the highest reported muscle tissue concentration of copper was from station RF1 in 2002, all values were well below the MIS of 20 ppm.

### *Lead*

Lead is widely distributed in the environment as a result of its prior use in gasoline and paints. Lead in wastewater has its origin in various industrial uses and lead solder in water piping systems. Lead levels in wastewater have been declining over the years and are now mostly below detection levels in the Point Loma effluent. For reference purposes, annual average lead concentrations in Point Loma effluent ranged from not detected to 0.8 ppb from 2014 through 2020. Mean concentrations of lead in outfall depth sediments off Point Loma were 2 and 3 ppm during the pre- and post-discharge periods, respectively, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (5 – 12 ppm; see Table C1-2, Appendix C1).

Tissue concentrations of lead in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-13 and by zone/station in Table C5-14, and Figures C5-15 and C5-16. Lead was detected in just 19% of liver tissue samples from trawl-caught fishes, at concentrations of 0.07 to 8.80 ppm, and was detected in only 3% of muscle tissue samples from rig fishing stations, at concentrations of 0.07 to 0.42 ppm (Table C5-13). Mean detected concentrations of lead in sanddab liver tissues ranged from 0.60 to 1.17 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 0.07 ppm at station RF1 and 0.36 at station RF2 (Table C5-14). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of lead concentrations over surveys combined for the three post-discharge periods (Figures C5-15A, C5-16A) or over time (Figures C5-15B, C5-16B). Lead was found sporadically in fishes from trawl zones, with the highest levels (> 5 ppm) reported from Zone 2, Zone 4, and Zone 1 during 1996, 1997, and 2002, respectively. Additionally, lead was detected in just four rockfish muscle tissue samples, three of which were collected in 2005 at RF2, and one was collected in 2014 from station RF1. All four had concentrations below the MIS of 2 ppm (Table C5-4).

**TABLE C5-13**
Summary of lead concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 3 | 10 | 2.60 | 3.10 | 3.50 | 3.07 |
| Dover Sole | 2 | 0 | 0 | nd | nd | nd | nd |
| English Sole | 20 | 10 | 50 | 0.41 | 0.79 | 2.58 | 1.03 |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Halfbanded Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Longfin Sanddab | 65 | 2 | 3 | 2.60 | 4.15 | 5.70 | 4.15 |
| Mixed Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Pacific Sanddab | 208 | 50 | 24 | 0.07 | 0.30 | 8.80 | 0.75 |
| ALL SPECIES | 336 | 65 | 19 | 0.07 | 0.40 | 8.80 | 1.00 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 0 | 0 | nd | nd | nd | nd |
| Canary Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Chilipepper | 2 | 0 | 0 | nd | nd | nd | nd |
| Copper Rockfish | 18 | 0 | 0 | nd | nd | nd | nd |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenstriped Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Mixed Rockfish | 34 | 0 | 0 | nd | nd | nd | nd |
| Rosethorn Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Speckled Rockfish | 15 | 1 | 7 | 0.34 | 0.34 | 0.34 | 0.34 |
| Squarespot Rockfish | 3 | 2 | 67 | 0.32 | 0.37 | 0.42 | 0.37 |
| Starry Rockfish | 9 | 0 | 0 | nd | nd | nd | nd |
| Vermilion Rockfish | 45 | 1 | 2 | 0.07 | 0.07 | 0.07 | 0.07 |
| Yellowtail Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| ALL SPECIES | 148 | 4 | 3 | 0.07 | 0.33 | 0.42 | 0.29 |

**TABLE C5-14**
Summary of lead concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 | Zone 4 | RF1 | RF2 |
| Total | 62 | 76 | 65 | 70 | 66 | 72 |
| Detected | 12 | 16 | 12 | 12 | 1 | 3 |
| Frequency | 19 | 21 | 18 | 17 | 2 | 4 |
| Minimum | 0.07 | 0.10 | 0.10 | 0.13 | 0.07 | 0.32 |
| Median | 0.35 | 0.30 | 0.31 | 0.27 | 0.07 | 0.34 |
| Maximum | 5.60 | 8.80 | 1.55 | 5.70 | 0.07 | 0.42 |
| Mean | 0.81 | 1.17 | 0.60 | 0.83 | 0.07 | 0.36 |
| 95% CI | 0.98 | 1.18 | 0.35 | 0.99 | 0 | 0.13 |

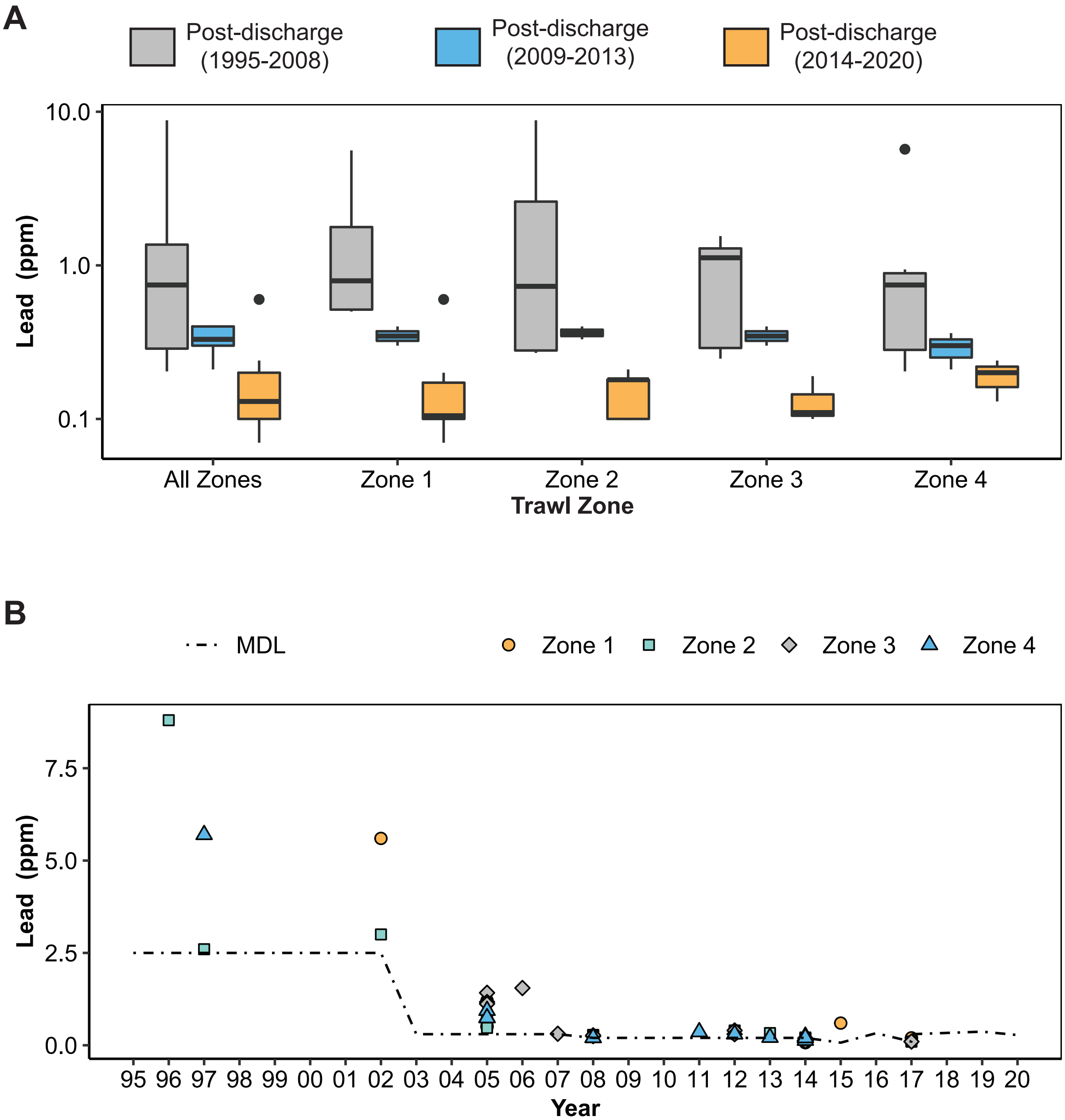



**FIGURE C5-15**

Lead concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

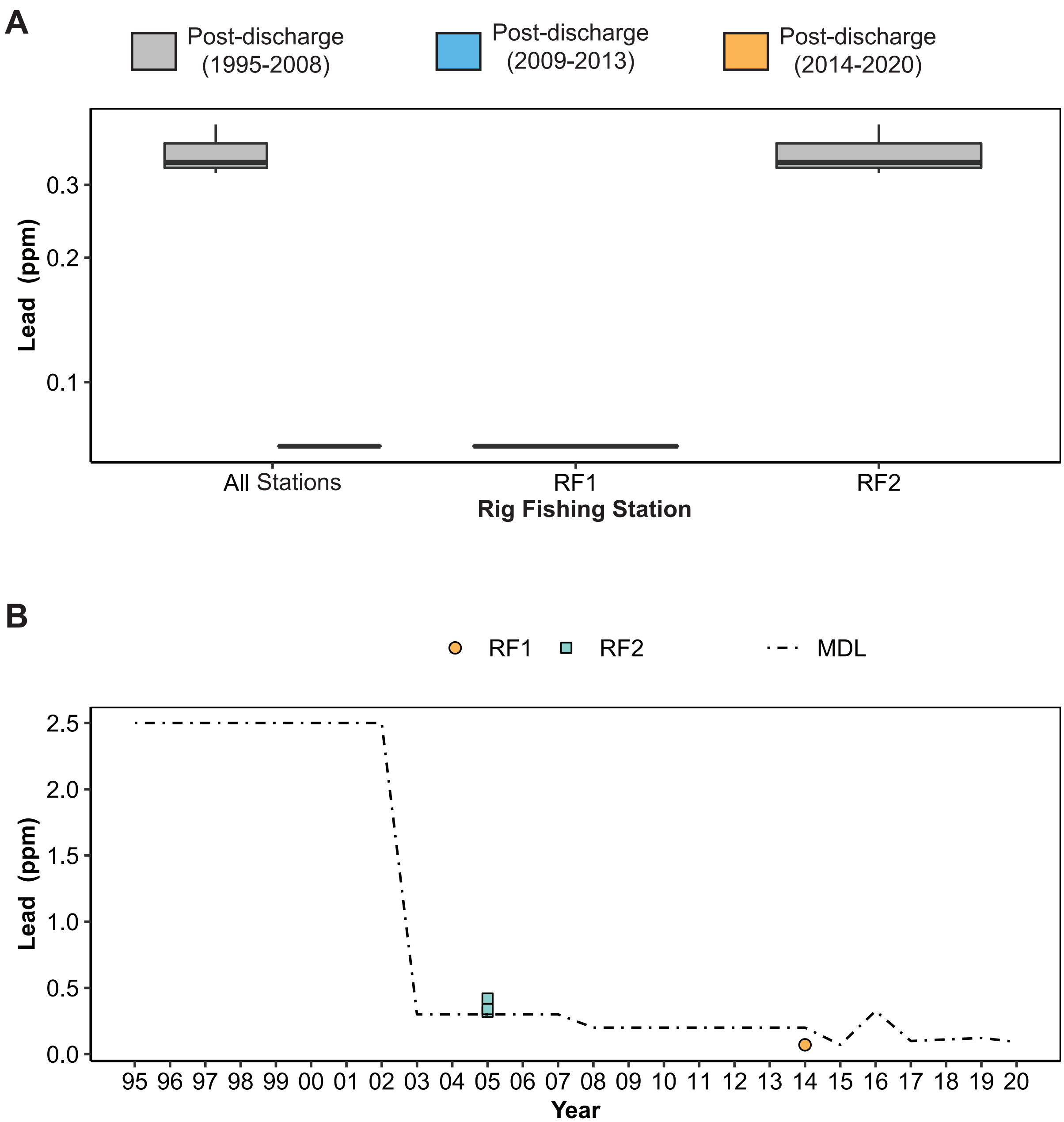



**FIGURE C5-16**

Lead concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

### *Nickel*

Nickel also has broad industrial applications and has become widespread in the environment. For reference purposes, annual average nickel concentrations in Point Loma effluent ranged from 3.85 to 5.86 ppb from 2014 through 2020. Mean concentrations of nickel in outfall depth sediments off Point Loma were 7 ppm during both the pre- and post-discharge periods, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (7 – 23 ppm; see Table C1-2, Appendix C1).

Tissue concentrations of nickel in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-15 and by zone/station in Table C5-16, and Figures C5-17 and C5-18. Nickel was detected in just 17% of liver tissue samples from trawl-caught fishes, at concentrations of 0.08 to 18.90 ppm, and was detected in only 10% of muscle tissue samples from rig fishing stations, at concentrations of 0.03 to 0.38 ppm (Table C5-15). Mean detected concentrations of lead in sanddab liver tissues ranged from 0.26 to 2.31 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 0.18 ppm at station RF1 and 0.11 at station RF2 (Table C5-16). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of nickel concentrations over surveys combined for the three post-discharge periods (Figures C5-17A, C5-18A) or over time (Figures C5-17B, C5-18B). Nickel was detected sporadically across the entire region since monitoring began, at both trawl and rig fishing sites. The high mean value reported for Zone 1 (Table C5-16) was driven by a single value of 18.90 ppm from a Longfin Sanddab sample collected in 2002 (Figure C5-17B). Otherwise, all sanddab liver values were below 5 ppm. Nickel was only detected in muscle tissues during 2006, 2007, and 2019 (Figure C5-19B). There are no U.S. or international standards for concentrations of nickel in seafood.

### *Selenium*

Natural weathering of rocks and soils accounts for most of the selenium in the environment although it also has agricultural and industrial uses. Considered an essential biological element, selenium has anti-carcinogenic properties and appears to protect against toxic effects of other metals such as arsenic, cadmium, copper, mercury, silver, and thallium (Mearns et al. 1991). At high concentrations, however, selenium itself has considerable toxicity and can adversely affect species of fish and birds. For example, selenium, concentrated by evaporation of agricultural water in the Kesterson Wildlife Refuge (San Joaquin Valley, California), was found to cause wildlife mortalities and reproductive deformities (Burau 1985).

For reference purposes, annual average selenium concentrations in Point Loma effluent ranged from 0.67 to 1.70 ppb from 2014 through 2020. Mean concentrations of selenium in outfall depth sediments off Point Loma were 0.2 and 0.1 ppm during the pre- and post-discharge periods, respectively, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (0.1 – 1.2 ppm; see Table C1-2, Appendix C1).

Tissue concentrations of selenium in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-17

**TABLE C5-15**
Summary of nickel concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 1 | 3 | 0.97 | 0.97 | 0.97 | 0.97 |
| Dover Sole | 2 | 0 | 0 | nd | nd | nd | nd |
| English Sole | 20 | 6 | 30 | 0.18 | 0.21 | 3.64 | 0.78 |
| Flag Rockfish | 2 | 1 | 50 | 0.91 | 0.91 | 0.91 | 0.91 |
| Greenblotched Rockfish | 2 | 1 | 50 | 2.46 | 2.46 | 2.46 | 2.46 |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Halfbanded Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Longfin Sanddab | 65 | 5 | 8 | 0.17 | 0.18 | 18.90 | 4.30 |
| Mixed Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Pacific Sanddab | 208 | 44 | 21 | 0.08 | 0.26 | 2.26 | 0.36 |
| ALL SPECIES | 336 | 58 | 17 | 0.08 | 0.26 | 18.90 | 0.80 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 0 | 0 | nd | nd | nd | nd |
| Canary Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Chilipepper | 2 | 0 | 0 | nd | nd | nd | nd |
| Copper Rockfish | 18 | 4 | 22 | 0.15 | 0.19 | 0.38 | 0.22 |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 3 | 2 | 67 | 0.12 | 0.13 | 0.15 | 0.13 |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenstriped Rockfish | 1 | 1 | 100 | 0.03 | 0.03 | 0.03 | 0.03 |
| Mixed Rockfish | 34 | 1 | 3 | 0.13 | 0.13 | 0.13 | 0.13 |
| Rosethorn Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Speckled Rockfish | 15 | 0 | 0 | nd | nd | nd | nd |
| Squarespot Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Starry Rockfish | 9 | 2 | 22 | 0.04 | 0.09 | 0.14 | 0.09 |
| Vermilion Rockfish | 45 | 3 | 7 | 0.05 | 0.16 | 0.17 | 0.13 |
| Yellowtail Rockfish | 2 | 2 | 100 | 0.15 | 0.16 | 0.16 | 0.16 |
| ALL SPECIES | 148 | 15 | 10 | 0.03 | 0.15 | 0.38 | 0.15 |

**TABLE C5-16**
Summary of nickel concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | **Zone 1** | **Zone 2** | **Zone 3** | **Zone 4** | **RF1** | **RF2** |
| Total | 62 | 76 | 65 | 70 | 66 | 72 |
| Detected | 10 | 13 | 15 | 11 | 7 | 8 |
| Frequency | 16 | 17 | 23 | 16 | 11 | 11 |
| Minimum | 0.08 | 0.12 | 0.10 | 0.14 | 0.05 | 0.03 |
| Median | 0.33 | 0.22 | 0.25 | 0.26 | 0.17 | 0.14 |
| Maximum | 18.90 | 0.55 | 2.26 | 0.75 | 0.38 | 0.16 |
| Mean | 2.31 | 0.26 | 0.51 | 0.31 | 0.18 | 0.11 |
| 95% CI | 4.19 | 0.07 | 0.32 | 0.12 | 0.09 | 0.04 |

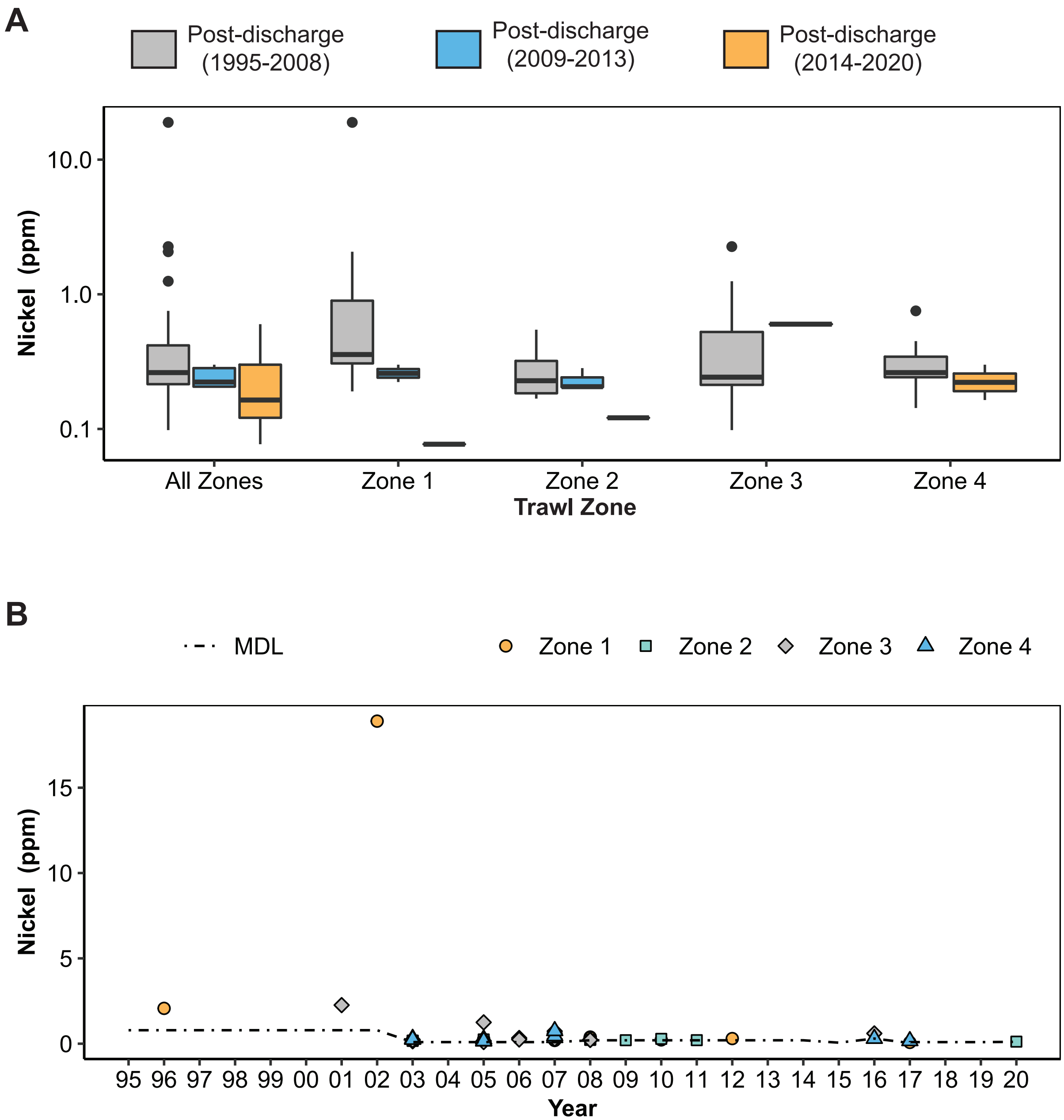



**FIGURE C5-17**
Nickel concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

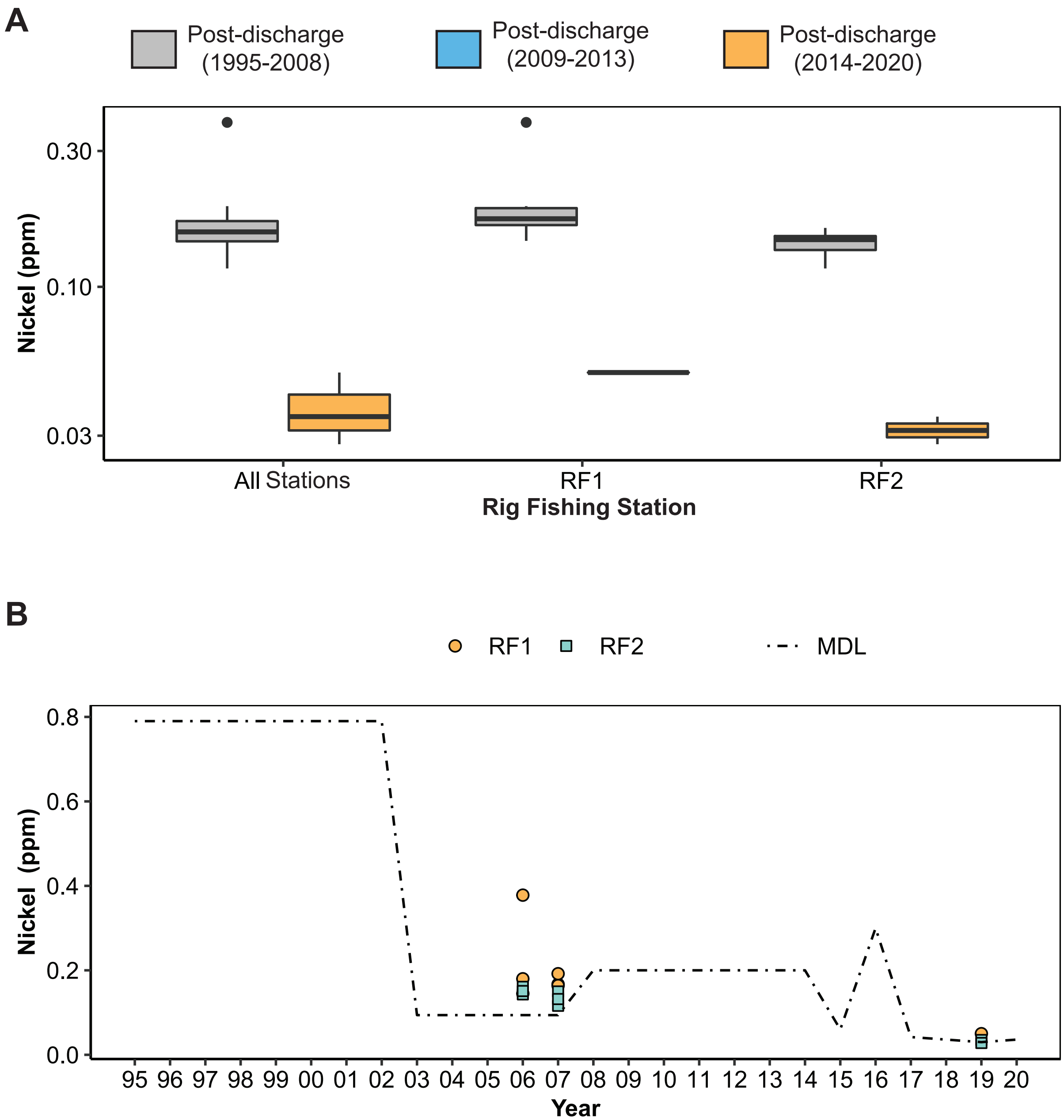



**FIGURE C5-18**

Nickel concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Box-plots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

**TABLE C5-17**
Summary of selenium concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 31 | 100 | 0.59 | 0.84 | 2.29 | 0.89 |
| Dover Sole | 2 | 2 | 100 | 0.72 | 1.75 | 2.77 | 1.75 |
| English Sole | 20 | 20 | 100 | 0.99 | 2.21 | 3.24 | 2.13 |
| Flag Rockfish | 2 | 2 | 100 | 1.42 | 2.00 | 2.58 | 2.00 |
| Greenblotched Rockfish | 2 | 2 | 100 | 1.03 | 2.04 | 3.05 | 2.04 |
| Greenspotted Rockfish | 2 | 2 | 100 | 2.37 | 2.62 | 2.87 | 2.62 |
| Halfbanded Rockfish | 2 | 2 | 100 | 1.69 | 2.65 | 3.61 | 2.65 |
| Longfin Sanddab | 66 | 65 | 98 | 0.61 | 1.48 | 3.68 | 1.60 |
| Mixed Rockfish | 2 | 2 | 100 | 1.95 | 2.07 | 2.19 | 2.07 |
| Pacific Sanddab | 208 | 202 | 97 | 0.18 | 0.87 | 3.20 | 0.92 |
| ALL SPECIES | 337 | 330 | 98 | 0.18 | 0.99 | 3.68 | 1.17 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 10 | 100 | 0.14 | 0.27 | 0.40 | 0.27 |
| Canary Rockfish | 1 | 1 | 100 | 0.25 | 0.25 | 0.25 | 0.25 |
| Chilipepper | 2 | 2 | 100 | 0.43 | 0.48 | 0.53 | 0.48 |
| Copper Rockfish | 18 | 18 | 100 | 0.25 | 0.49 | 0.72 | 0.50 |
| Flag Rockfish | 2 | 2 | 100 | 0.32 | 0.43 | 0.54 | 0.43 |
| Greenblotched Rockfish | 3 | 3 | 100 | 0.33 | 0.34 | 0.38 | 0.35 |
| Greenspotted Rockfish | 2 | 2 | 100 | 0.20 | 0.29 | 0.37 | 0.29 |
| Greenstriped Rockfish | 1 | 1 | 100 | 0.45 | 0.45 | 0.45 | 0.45 |
| Mixed Rockfish | 34 | 33 | 97 | 0.17 | 0.45 | 0.88 | 0.43 |
| Rosethorn Rockfish | 1 | 1 | 100 | 0.37 | 0.37 | 0.37 | 0.37 |
| Speckled Rockfish | 15 | 15 | 100 | 0.21 | 0.36 | 0.52 | 0.37 |
| Squarespot Rockfish | 3 | 3 | 100 | 0.28 | 0.36 | 0.44 | 0.36 |
| Starry Rockfish | 9 | 7 | 78 | 0.30 | 0.37 | 0.70 | 0.41 |
| Vermilion Rockfish | 45 | 43 | 96 | 0.14 | 0.37 | 0.82 | 0.37 |
| Yellowtail Rockfish | 2 | 2 | 100 | 0.30 | 0.33 | 0.35 | 0.33 |
| ALL SPECIES | 148 | 143 | 97 | 0.14 | 0.38 | 0.88 | 0.39 |

**TABLE C5-18**

Summary of selenium concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | **Zone 1** | **Zone 2** | **Zone 3** | **Zone 4** | **RF1** | **RF2** |
| Total | 62 | 76 | 66 | 70 | 66 | 72 |
| Detected | 60 | 75 | 65 | 67 | 63 | 70 |
| Frequency | 97 | 99 | 98 | 96 | 95 | 97 |
| Minimum | 0.26 | 0.44 | 0.39 | 0.18 | 0.18 | 0.14 |
| Median | 0.92 | 0.99 | 0.95 | 0.97 | 0.43 | 0.37 |
| Maximum | 3.20 | 3.68 | 2.88 | 2.68 | 0.82 | 0.88 |
| Mean | 1.03 | 1.16 | 1.05 | 1.08 | 0.43 | 0.38 |
| 95% CI | 0.13 | 0.15 | 0.12 | 0.12 | 0.04 | 0.03 |

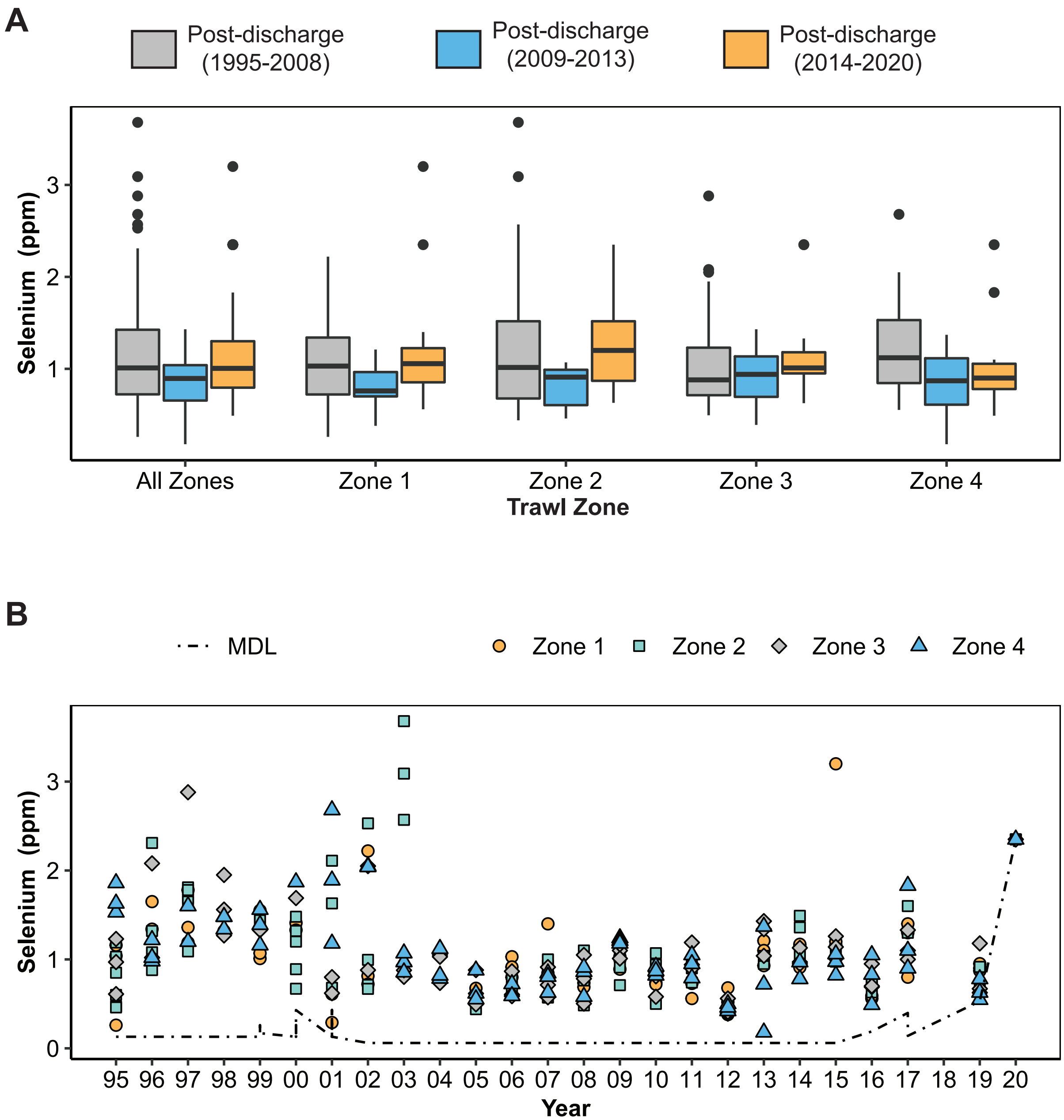



**FIGURE C5-19**
Selenium concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

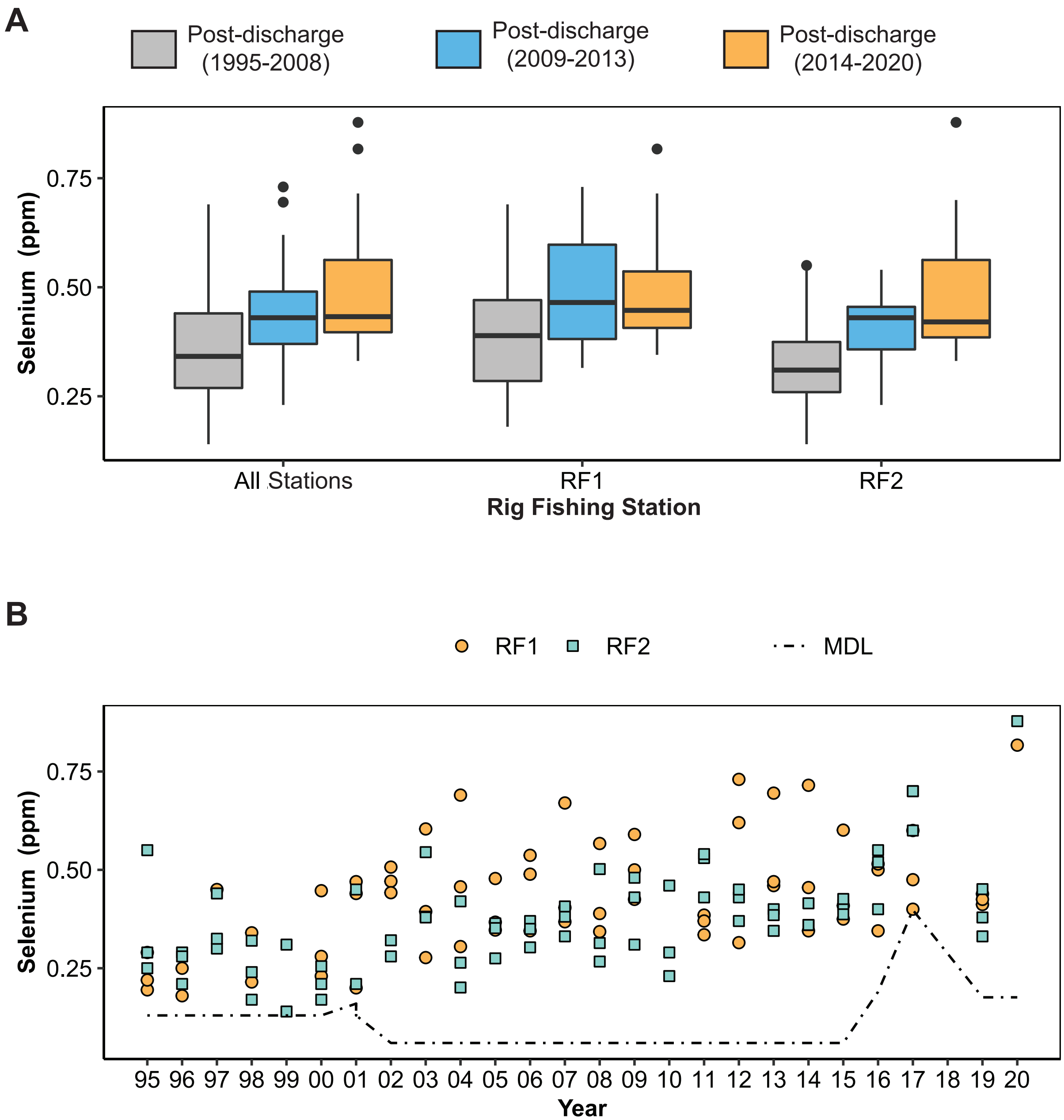



**FIGURE C5-20**
Selenium concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

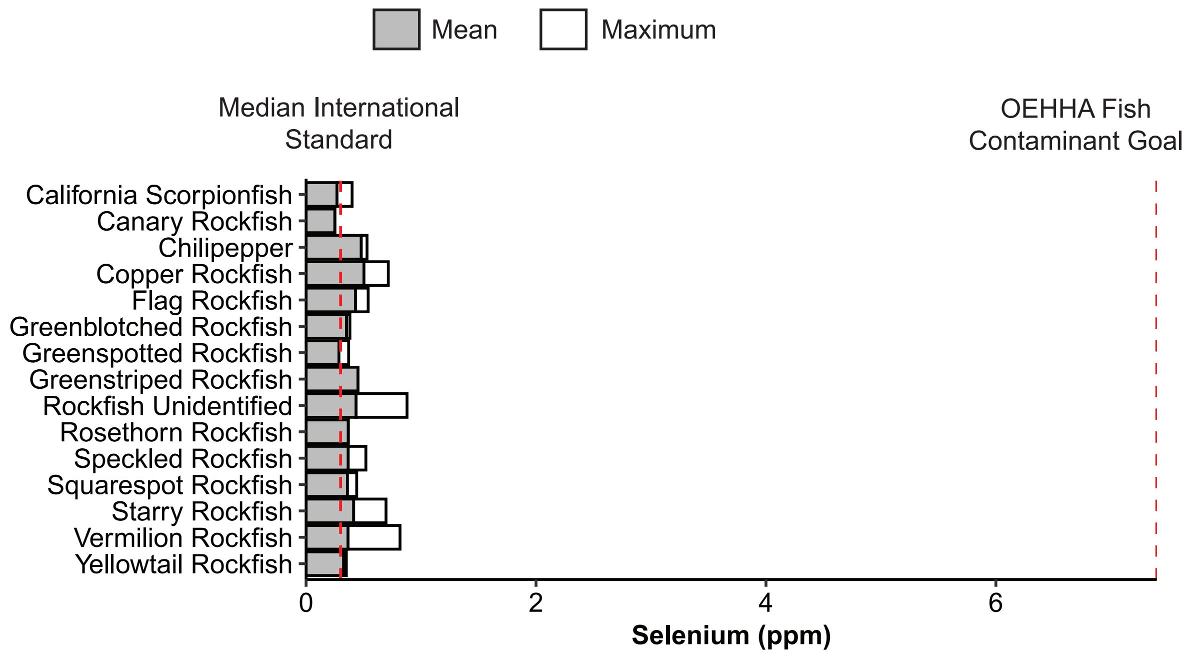



**FIGURE C5-21**
Mean and maximum concentrations of selenium in muscle tissues of all fishes collected off San Diego at rig fishing stations compared to the median international standard (from Mearns et al. 1991). See Table C5-2 for sample sizes.

and by zone/station in Table C5-18, and Figures C5-19 and C5-20. Selenium was detected in 98% of liver tissue samples from trawl-caught fishes, at concentrations of 0.18 to 3.68 ppm, and was detected in 97% of muscle tissue samples from rig fishing stations, at concentrations of 0.14 to 0.88 ppm (Table C5-17). Mean detected concentrations of selenium in sanddab liver tissues ranged from 1.03 to 1.16 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 0.43 ppm at station RF1 and 0.38 at station RF2 (Table C5-18). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of selenium concentrations over surveys combined for the three post-discharge periods (Figures C5-19A, C5-20A) or over time (Figures C5-19B, C5-20B). Regionally, selenium levels have been highly variable over the years, with the highest liver values reported during 1996, 1997, 2001-2003, 2015 and 2020 from trawl zones, and the highest muscle values report during 2020.

Selenium concentrations exceeded the MIS of 0.3 ppm in muscle tissues from California scorpionfish and 14 rockfish species, but none of the samples had concentrations higher than the OEHAA fish contaminant goal of 7.4 ppm (Table C5-4, Figure C5-21). As with mercury and arsenic, elevated levels of selenium are not uncommon in sport fish from other areas of the San Diego region, including the Coronado Islands (City of San Diego 2020a, McLaughlin et al. 2020).

### *Silver*

Silver has historically been present in wastewater as a result of its use in photography and dentistry. However, these inputs have dropped significantly over the years with the implementation of stringent source control measures. For reference purposes, annual average silver concentrations in Point Loma effluent ranged from not detected to 0.13 ppb from 2014 through 2020. Mean concentrations of silver in outfall depth sediments off Point Loma were 0.1 and 0.3 ppm during the pre- and post-discharge periods, respectively, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (0.1 – 0.5 ppm; see Table C1-2, Appendix C1).

Tissue concentrations of silver in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-19 and by zone/station in Table C5-20, and Figures C5-22 and C5-23. Silver was detected in just 22% of liver tissue samples from trawl-caught fishes, at concentrations of 0.03 to 2.20 ppm, and was detected in only 5% of muscle tissue samples from rig fishing stations, at concentrations of 0.05 to 0.50 ppm (Table C5-19). Mean detected concentrations of silver in sanddab liver tissues averaged from 0.13 to 0.30 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 0.07 ppm at station RF1 and 0.14 at station RF2 (Table C5-20). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of silver concentrations over surveys combined for the three post-discharge periods (Figures C5-22A, C5-23A) or over time (Figures C5-22B, C5-23B). As with most other metals, silver was detected sporadically with variable concentrations in fish tissues from trawl zones. It was only detected in seven samples from the rig fishing sites, collected in 2005, 2008, and 2009. There are no U.S. or international standards for concentrations of silver in seafood.

**TABLE C5-19**
Summary of silver concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 1 | 3 | 0.68 | 0.68 | 0.68 | 0.68 |
| Dover Sole | 2 | 0 | 0 | nd | nd | nd | nd |
| English Sole | 20 | 13 | 65 | 0.05 | 0.14 | 0.49 | 0.18 |
| Flag Rockfish | 2 | 1 | 50 | 0.68 | 0.68 | 0.68 | 0.68 |
| Greenblotched Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Halfbanded Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Longfin Sanddab | 65 | 7 | 11 | 0.18 | 0.66 | 1.14 | 0.59 |
| Mixed Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Pacific Sanddab | 208 | 52 | 25 | 0.03 | 0.08 | 2.20 | 0.17 |
| ALL SPECIES | 336 | 74 | 22 | 0.03 | 0.09 | 2.20 | 0.22 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 0 | 0 | nd | nd | nd | nd |
| Canary Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Chilipepper | 2 | 0 | 0 | nd | nd | nd | nd |
| Copper Rockfish | 18 | 0 | 0 | nd | nd | nd | nd |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenstriped Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Mixed Rockfish | 34 | 1 | 3 | 0.07 | 0.07 | 0.07 | 0.07 |
| Rosethorn Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Speckled Rockfish | 15 | 1 | 7 | 0.50 | 0.50 | 0.50 | 0.50 |
| Squarespot Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Starry Rockfish | 9 | 0 | 0 | nd | nd | nd | nd |
| Vermilion Rockfish | 45 | 5 | 11 | 0.05 | 0.05 | 0.07 | 0.06 |
| Yellowtail Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| ALL SPECIES | 148 | 7 | 5 | 0.05 | 0.05 | 0.50 | 0.12 |

**TABLE C5-20**

Summary of silver concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | **Zone 1** | **Zone 2** | **Zone 3** | **Zone 4** | **RF1** | **RF2** |
| Total | 62 | 76 | 65 | 70 | 66 | 72 |
| Detected | 14 | 14 | 13 | 18 | 2 | 5 |
| Frequency | 23 | 18 | 20 | 26 | 3 | 7 |
| Minimum | 0.05 | 0.04 | 0.03 | 0.06 | 0.07 | 0.05 |
| Median | 0.09 | 0.13 | 0.08 | 0.08 | 0.07 | 0.05 |
| Maximum | 2.20 | 0.27 | 1.66 | 1.14 | 0.07 | 0.50 |
| Mean | 0.30 | 0.13 | 0.24 | 0.20 | 0.07 | 0.14 |
| 95% CI | 0.33 | 0.04 | 0.28 | 0.15 | 0.03 | 0.25 |

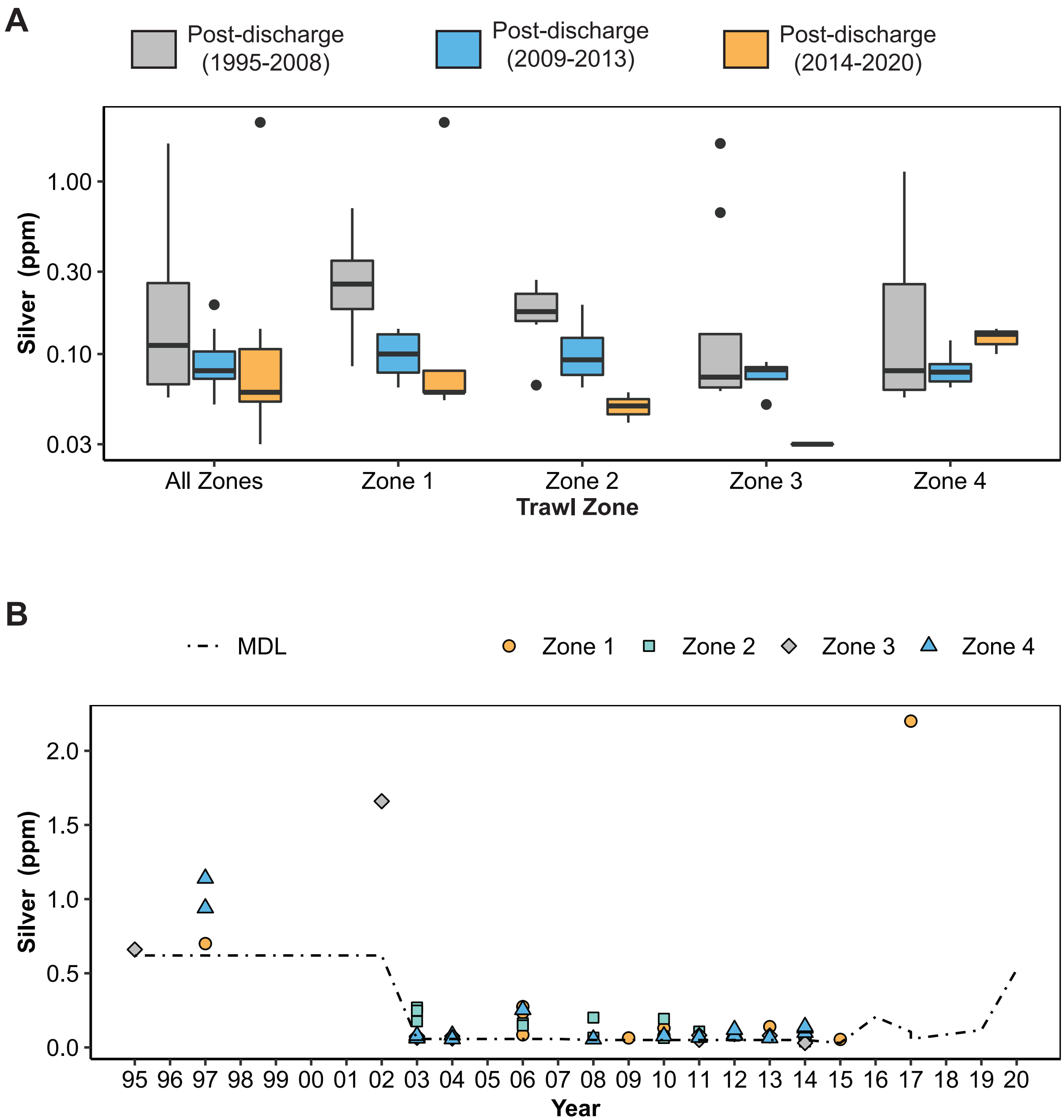



**FIGURE C5-22**

Silver concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

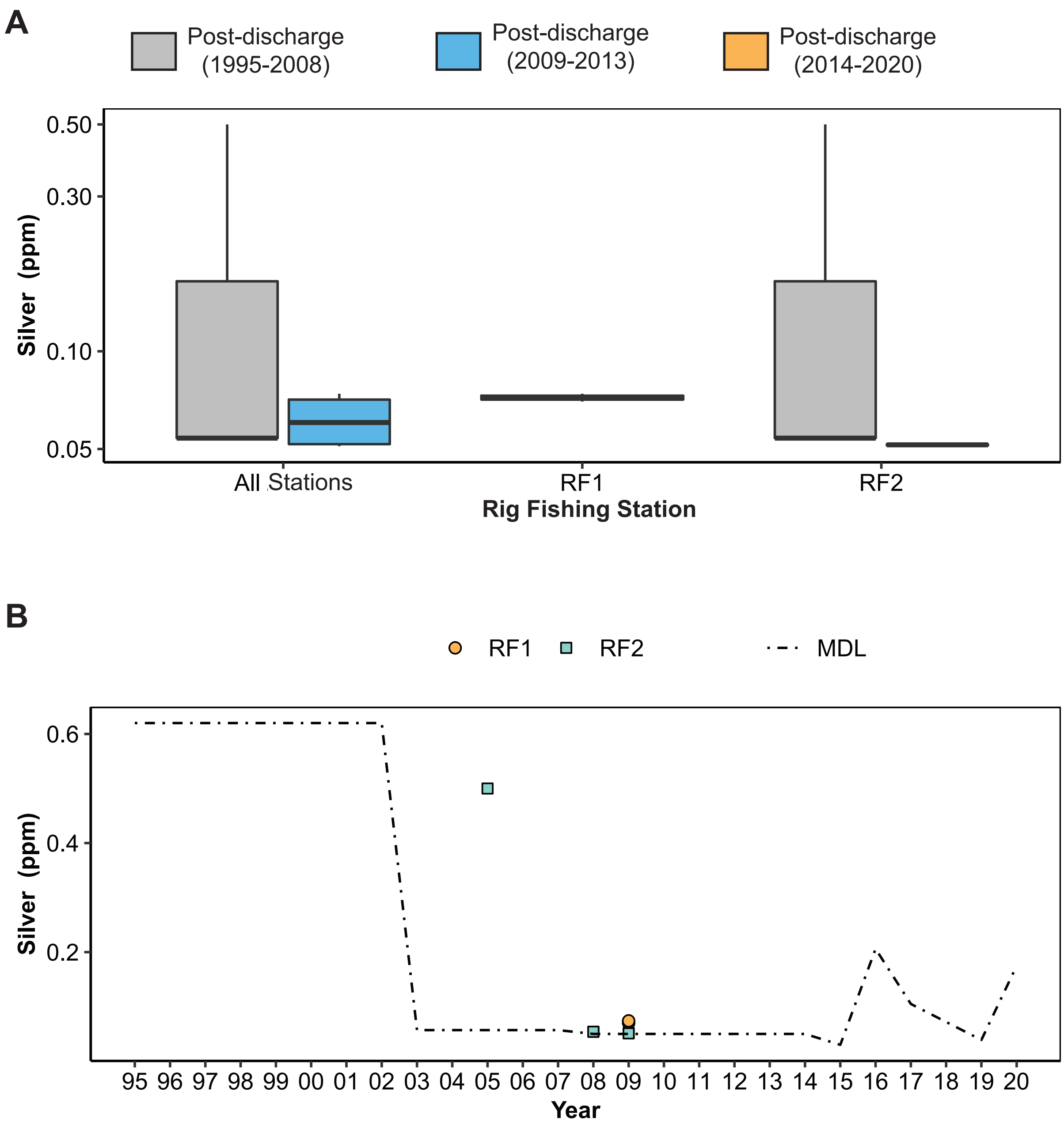



**FIGURE C5-23**
Silver concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

### *Tin*

Historically, sources of tin to the ocean environment have included marine paints, municipal sewage, industrial discharges, and aerial fallout (Mearns et al. 1991). These inputs have dropped significantly over the years with the implementation of source control measures and increased regulation. For reference purposes, levels of tin in outfall depth sediments off Point Loma have ranged from not-detected to 42.0 ppm since monitoring began (City of San Diego 2020a, 2021). These concentrations are comparable to background conditions in the SCB and found regionally off San Diego (City of San Diego 2020a, 2021).

Tissue concentrations of tin in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-21 and by zone/station in Table C5-22, and Figures C5-24 and C5-25. Tin was detected in just 49% of liver tissue samples from trawl-caught fishes, at concentrations of 0.20 to 11.10 ppm, and was detected in 37% of muscle tissue samples from rig fishing stations, at concentrations of 0.21 to 2.12 ppm (Table C5-21). Detected concentrations of tin in sanddab liver tissues averaged from 1.68 to 2.14 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 0.94 ppm at station RF1 and 0.95 at station RF2 (Table C5-20). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of tin concentrations over surveys combined for the three post-discharge periods (Figures C5-24A, C5-25A) or over time (Figures C5-24B, C5-25B). As with most other metals, tin was detected sporadically with variable concentrations in fish tissues from trawl zones and rig fishing stations. All of the muscle tissue concentrations were well below the MIS of 175 ppm for tin (Table C5-4).

### *Zinc*

Zinc is the metal with typically the highest metal loads in Point Loma effluent. This metal is used routinely in batteries, vehicle tires, and a variety of industrial, commercial, and household products, and it has been found distributed throughout the southern California marine environment. However, source control efforts have resulted in decreasing concentrations of zinc in Point Loma wastewater and bringing average effluent concentrations down to 28 µg/L for 2013.

For reference purposes, annual average zinc concentrations in Point Loma effluent ranged from 1.6 to 39.4 ppb from 2014 through 2020. Mean concentrations of zinc in outfall depth sediments off Point Loma were 28 and 28 ppm during the pre- and post-discharge periods, respectively, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (31 – 59 ppm; see Table C1-2, Appendix C1).

Tissue concentrations of zinc in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-23 and by zone/station in Table C5-24, and Figures C5-2 and C5-27. Zinc was detected in 100% of liver tissue samples from trawl-caught fishes, at concentrations of 8.61 to 213.00 ppm, and was detected in 99% of muscle tissue samples from rig fishing stations, at concentrations of 1.02 to 6.91 ppm (Table C5-23). Detected concentrations of zinc in sanddab liver tissues averaged from

**TABLE C5-21**
Summary of tin concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 1 | 3 | 11.10 | 11.10 | 11.10 | 11.10 |
| Dover Sole | 2 | 0 | 0 | nd | nd | nd | nd |
| English Sole | 20 | 13 | 65 | 0.26 | 0.60 | 2.67 | 0.95 |
| Flag Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenblotched Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Greenspotted Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Halfbanded Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Longfin Sanddab | 65 | 3 | 5 | 1.24 | 1.25 | 1.58 | 1.36 |
| Mixed Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Pacific Sanddab | 208 | 149 | 72 | 0.20 | 1.10 | 7.96 | 1.99 |
| ALL SPECIES | 336 | 166 | 49 | 0.20 | 1.10 | 11.10 | 1.95 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 0 | 0 | nd | nd | nd | nd |
| Canary Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Chilipepper | 2 | 1 | 50 | 0.24 | 0.24 | 0.24 | 0.24 |
| Copper Rockfish | 18 | 7 | 39 | 0.58 | 1.63 | 1.77 | 1.37 |
| Flag Rockfish | 2 | 1 | 50 | 0.28 | 0.28 | 0.28 | 0.28 |
| Greenblotched Rockfish | 3 | 3 | 100 | 1.31 | 1.56 | 2.01 | 1.63 |
| Greenspotted Rockfish | 2 | 1 | 50 | 0.24 | 0.24 | 0.24 | 0.24 |
| Greenstriped Rockfish | 1 | 1 | 100 | 0.88 | 0.88 | 0.88 | 0.88 |
| Mixed Rockfish | 34 | 13 | 38 | 0.36 | 0.50 | 2.02 | 0.83 |
| Rosethorn Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Speckled Rockfish | 15 | 7 | 47 | 0.40 | 0.50 | 1.08 | 0.70 |
| Squarespot Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Starry Rockfish | 9 | 3 | 33 | 0.82 | 0.98 | 1.55 | 1.12 |
| Vermilion Rockfish | 45 | 16 | 36 | 0.21 | 0.58 | 2.12 | 0.84 |
| Yellowtail Rockfish | 2 | 2 | 100 | 1.69 | 1.70 | 1.71 | 1.70 |
| ALL SPECIES | 148 | 55 | 37 | 0.21 | 0.74 | 2.12 | 0.94 |

**TABLE C5-22**
Summary of tin concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 | Zone 4 | RF1 | RF2 |
| Total | 62 | 76 | 65 | 70 | 66 | 72 |
| Detected | 36 | 38 | 40 | 38 | 26 | 29 |
| Frequency | 58 | 50 | 62 | 54 | 39 | 40 |
| Minimum | 0.27 | 0.20 | 0.21 | 0.20 | 0.21 | 0.24 |
| Median | 1.05 | 1.42 | 1.40 | 1.00 | 0.67 | 0.82 |
| Maximum | 7.96 | 7.96 | 7.96 | 7.96 | 2.01 | 2.12 |
| Mean | 1.97 | 2.11 | 2.14 | 1.68 | 0.94 | 0.95 |
| 95% CI | 0.72 | 0.69 | 0.67 | 0.51 | 0.23 | 0.23 |

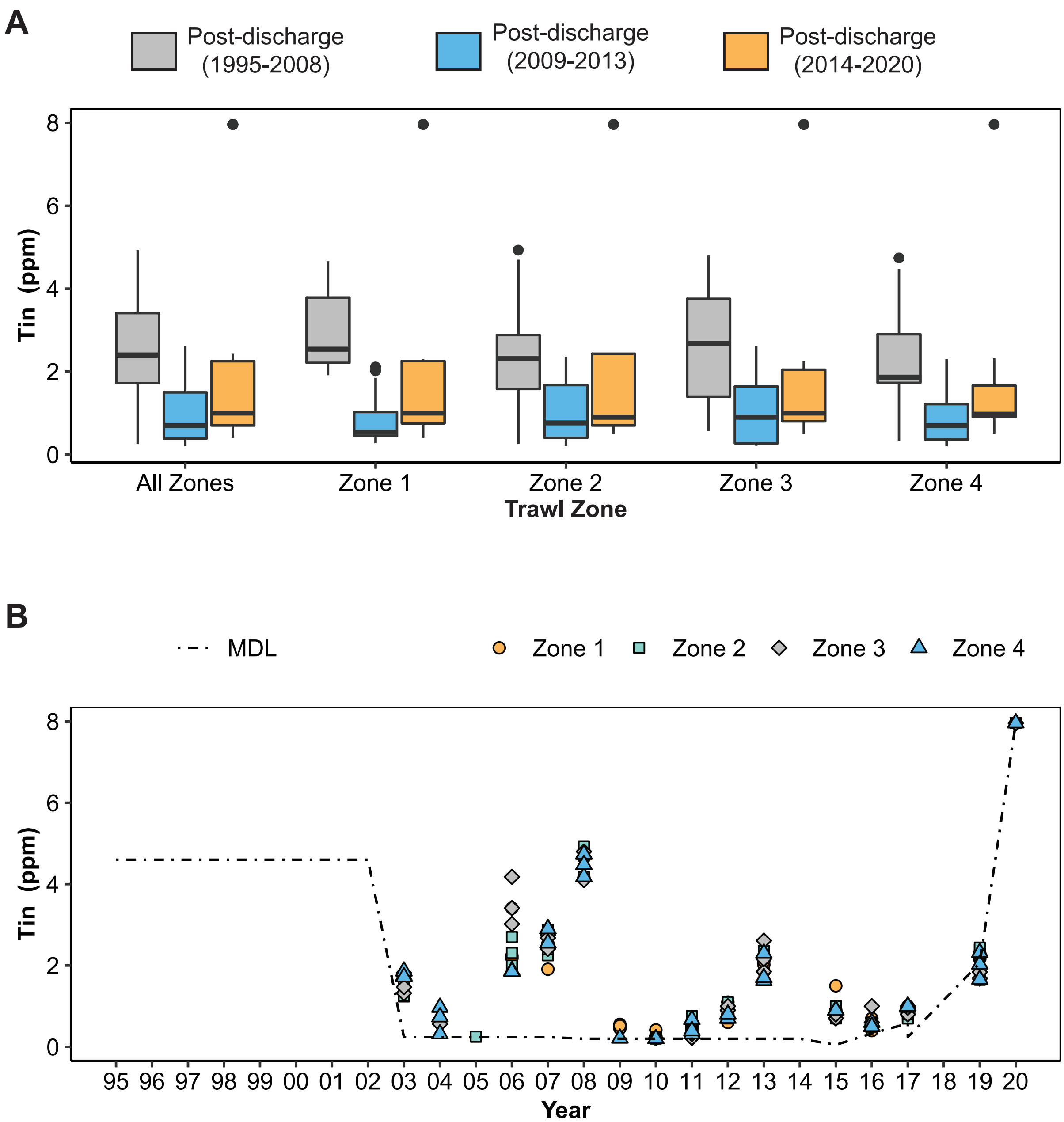
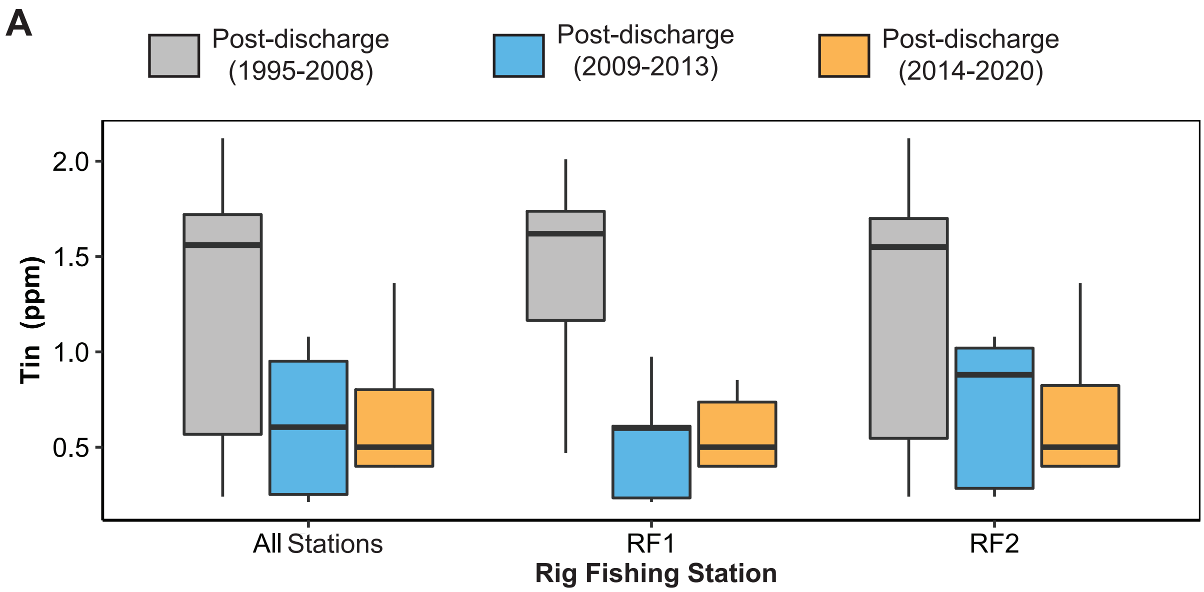



**FIGURE C5-24**
Tin concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.



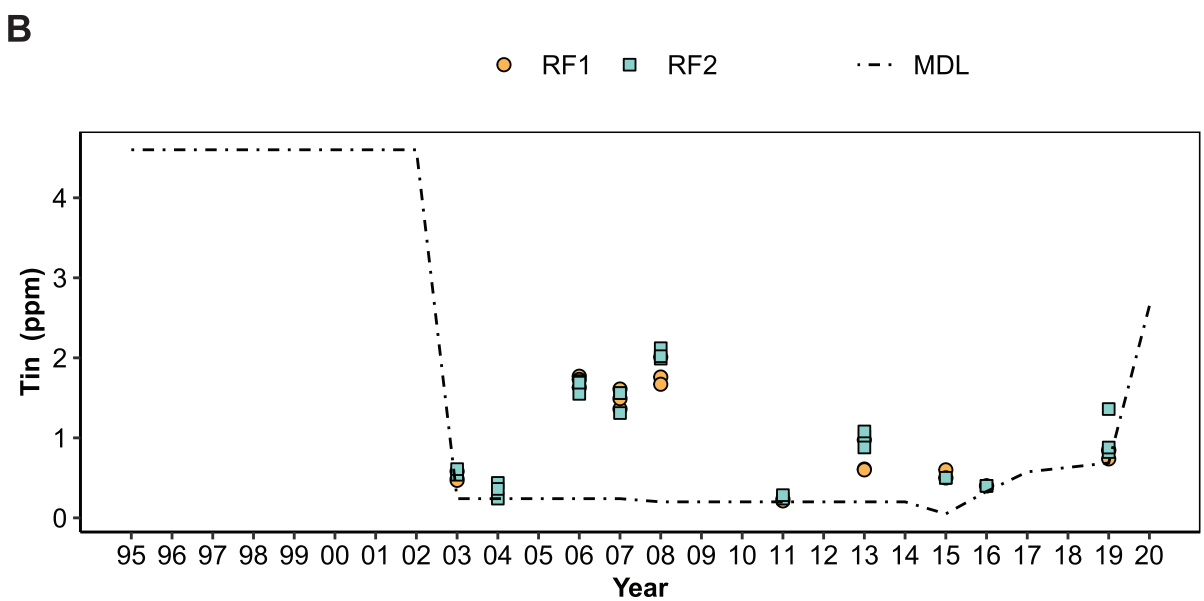




**FIGURE C5-25**
Tin concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

**TABLE C5-23**
Summary of zinc concentrations (ppm) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 31 | 31 | 100 | 31.30 | 109.00 | 213.00 | 116.51 |
| Dover Sole | 2 | 2 | 100 | 19.40 | 29.80 | 40.20 | 29.80 |
| English Sole | 20 | 20 | 100 | 27.60 | 51.10 | 86.90 | 50.91 |
| Flag Rockfish | 2 | 2 | 100 | 53.00 | 59.35 | 65.70 | 59.35 |
| Greenblotched Rockfish | 2 | 2 | 100 | 45.50 | 56.15 | 66.80 | 56.15 |
| Greenspotted Rockfish | 2 | 2 | 100 | 65.40 | 69.10 | 72.80 | 69.10 |
| Halfbanded Rockfish | 2 | 2 | 100 | 12.90 | 43.65 | 74.40 | 43.65 |
| Longfin Sanddab | 65 | 65 | 100 | 10.30 | 20.00 | 74.20 | 21.47 |
| Mixed Rockfish | 2 | 2 | 100 | 47.00 | 82.50 | 118.00 | 82.50 |
| Pacific Sanddab | 208 | 208 | 100 | 8.61 | 24.15 | 69.30 | 25.43 |
| ALL SPECIES | 336 | 336 | 100 | 8.61 | 25.20 | 213.00 | 35.70 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 9 | 9 | 100 | 3.34 | 3.91 | 6.91 | 4.18 |
| Canary Rockfish | 1 | 1 | 100 | 3.82 | 3.82 | 3.82 | 3.82 |
| Chilipepper | 2 | 2 | 100 | 3.67 | 3.70 | 3.72 | 3.70 |
| Copper Rockfish | 18 | 18 | 100 | 2.01 | 4.64 | 5.90 | 4.30 |
| Flag Rockfish | 2 | 2 | 100 | 2.89 | 3.64 | 4.38 | 3.64 |
| Greenblotched Rockfish | 3 | 3 | 100 | 4.46 | 4.55 | 5.09 | 4.70 |
| Greenspotted Rockfish | 2 | 2 | 100 | 3.29 | 3.59 | 3.88 | 3.59 |
| Greenstriped Rockfish | 1 | 1 | 100 | 3.18 | 3.18 | 3.18 | 3.18 |
| Mixed Rockfish | 34 | 34 | 100 | 2.37 | 3.51 | 5.72 | 3.61 |
| Rosethorn Rockfish | 1 | 1 | 100 | 2.91 | 2.91 | 2.91 | 2.91 |
| Speckled Rockfish | 15 | 14 | 93 | 2.40 | 3.09 | 4.50 | 3.33 |
| Squarespot Rockfish | 3 | 3 | 100 | 3.24 | 3.34 | 3.37 | 3.32 |
| Starry Rockfish | 9 | 9 | 100 | 1.85 | 3.20 | 4.35 | 3.34 |
| Vermilion Rockfish | 45 | 45 | 100 | 1.02 | 3.57 | 5.80 | 3.64 |
| Yellowtail Rockfish | 2 | 2 | 100 | 3.77 | 4.03 | 4.28 | 4.03 |
| ALL SPECIES | 147 | 146 | 99 | 1.02 | 3.67 | 6.91 | 3.71 |

**TABLE C5-24**
Summary of zinc concentrations (ppm) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | **Zone 1** | **Zone 2** | **Zone 3** | **Zone 4** | **RF1** | **RF2** |
| Total | 62 | 76 | 65 | 70 | 66 | 72 |
| Detected | 62 | 76 | 65 | 70 | 66 | 71 |
| Frequency | 100 | 100 | 100 | 100 | 100 | 99 |
| Minimum | 8.61 | 14.90 | 13.10 | 15.00 | 1.97 | 1.02 |
| Median | 21.10 | 21.35 | 23.80 | 24.10 | 3.93 | 3.37 |
| Maximum | 69.30 | 41.40 | 74.20 | 41.60 | 5.90 | 5.09 |
| Mean | 23.70 | 23.17 | 25.79 | 25.40 | 3.95 | 3.43 |
| 95% CI | 2.31 | 1.37 | 2.06 | 1.56 | 0.21 | 0.17 |

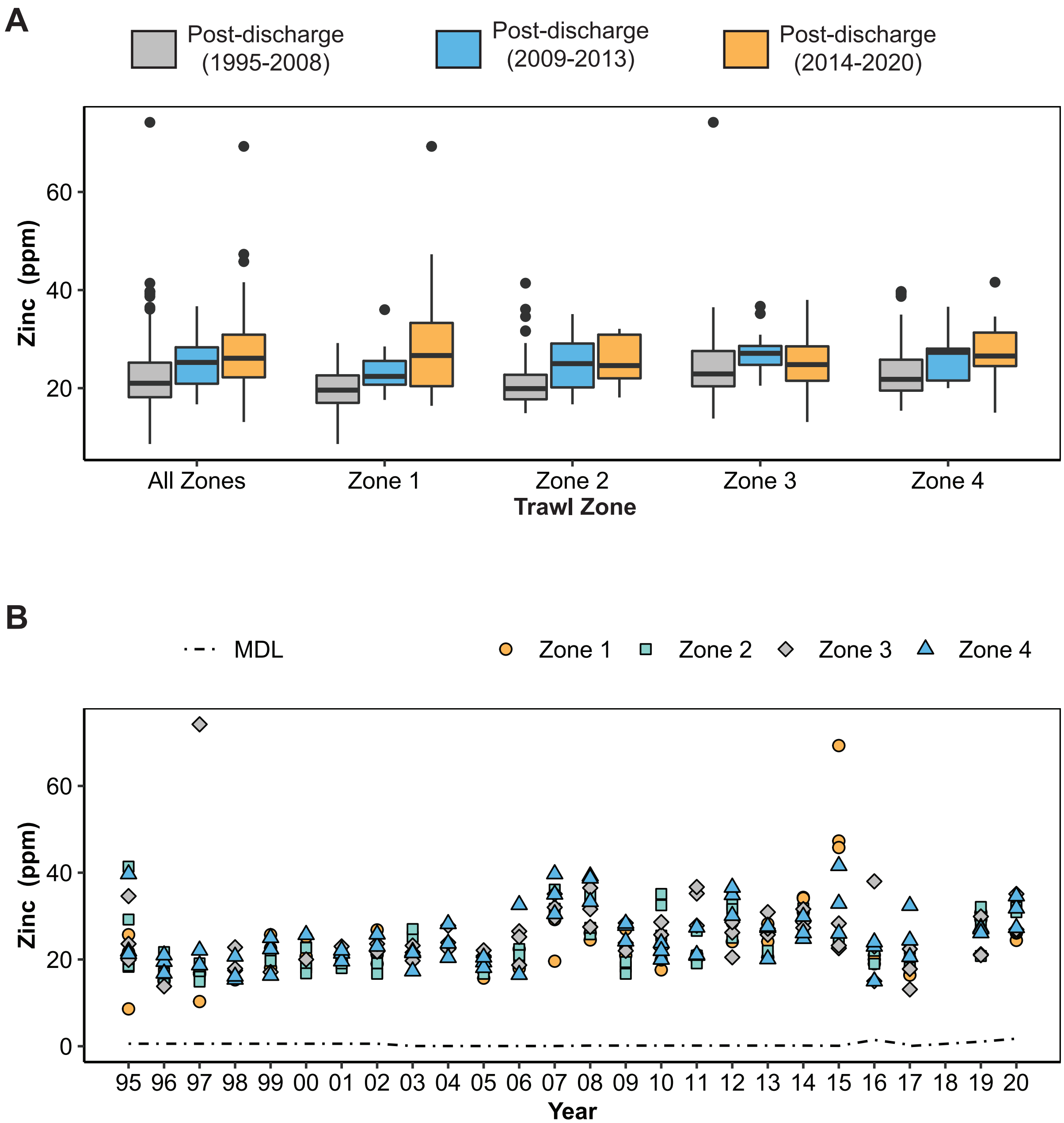



**FIGURE C5-26**
Zinc concentrations (ppm) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

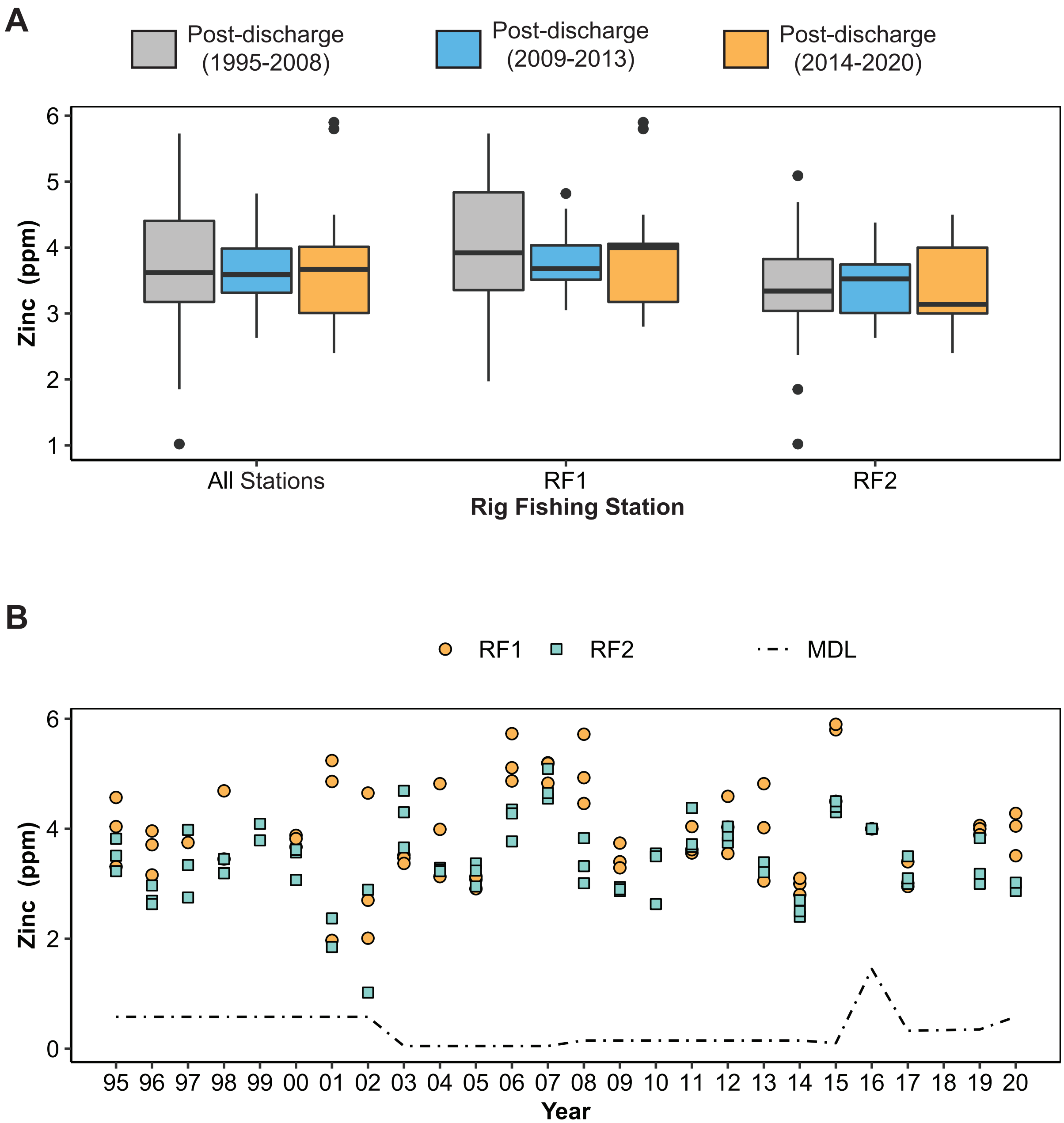



**FIGURE C5-27**

Zinc concentrations (ppm) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles); MDL = method detection limit.

23.17 to 25.79 ppm per trawl zone, while concentrations in rockfish muscle tissues averaged 3.95 ppm at station RF1 and 3.43 at station RF2 (Table C5-24). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of zinc concentrations over surveys combined for the three post-discharge periods (Figures C5-26A, C5-27A) or over time (Figures C5-26B, C5-27B). In contrast to other metals, zinc concentrations have generally been stable in liver tissues of fishes from trawl stations. Exceptions occurred in 1995, 1997, and 2015 (Figure C5-26B). Levels of zinc in muscle tissues of fishes from rig fishing stations have been much more variable (Figure C5-27B), but all of the muscle tissue concentrations were well below the MIS of 70 ppm for zinc (Table C5-4).

## Chlorinated Hydrocarbons

Chlorinated hydrocarbons, like the pesticide DDT, and polychlorinated biphenyl compounds (PCBs) are persistent environmental contaminants with widespread distribution and well-known bioaccumulation in southern California. The impact of these synthetic chemicals was most notable in the late 1960s and 1970s when DDT discharged from Whites Point outfall in Los Angeles County accumulated in fish-eating birds and marine mammals causing reproductive effects and population declines (Mearns et al. 1991). Since the ban of these chemicals in the early 1970s, environmental levels have steadily decreased. Most current residues in marine animals are from the reservoir of these contaminants still present in marine sediments (i.e., legacy contaminants), especially off the Palos Verdes Peninsula and in some local bays and harbors.

### *DDT*

DDT metabolites were not detected in Point Loma effluent prior to 2006, and have been detected very rarely since, despite improvements in technology that have lowered method detection limits. For reference purposes, DDT and its constituents were generally not detected from 2014 through 2020. Mean concentrations of total DDT in outfall depth sediments off Point Loma were 1,247 and 579 parts per trillion (ppt) during the pre- and post-discharge periods, respectively, and were comparable to background conditions in the SCB as reported during past Bight surveys and found regionally off San Diego (1,069 – 53,830 ppt; see Table C1-2, Appendix C1).

Tissue concentrations of total DDT in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are summarized by species in Table C5-25 and by zone/station in Table C5-26, and Figures C5-28 and C5-29. Individual DDT constituents are summarized in Attachment C5-C. DDT was detected in 98% of liver tissue samples from trawl-caught fishes, at concentrations of 35.0 to 4252.0 ppb, and was detected in 92% of muscle tissue samples from rig fishing stations, at concentrations of 0.3 to 217.3 ppb (Table C5-25). Total DDT in fishes from the PLOO monitoring region were largely composed of p,p-DDE. This final degradation product of DDT was also detected in 98% of samples from trawl zones, at concentrations of 35.0 to 4190.0 ppb, and in 92% of samples from rig fishing stations, at concentrations of 0.3 to 200.0 ppb (Attachment C5-C). It should be noted that p,p-DDMU, which was only analyzed from 2004 through 2020, and therefore not included in total DDT

**TABLE C5-25**
Summary of total DDT concentrations (ppb) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 33 | 33 | 100 | 130.0 | 1033.0 | 4252.0 | 1205.7 |
| Dover Sole | 3 | 3 | 100 | 38.0 | 57.0 | 94.0 | 63.0 |
| English Sole | 20 | 17 | 85 | 75.9 | 130.0 | 827.0 | 236.5 |
| Flag Rockfish | 2 | 2 | 100 | 900.0 | 1415.0 | 1930.0 | 1415.0 |
| Greenblotched Rockfish | 2 | 2 | 100 | 140.0 | 435.0 | 730.0 | 435.0 |
| Greenspotted Rockfish | 2 | 2 | 100 | 250.0 | 599.0 | 948.0 | 599.0 |
| Halfbanded Rockfish | 2 | 2 | 100 | 320.0 | 345.0 | 370.0 | 345.0 |
| Hornyhead Turbot | 2 | 2 | 100 | 170.0 | 195.0 | 220.0 | 195.0 |
| Longfin Sanddab | 71 | 69 | 97 | 390.0 | 1297.5 | 3800.0 | 1372.6 |
| Mixed Rockfish | 2 | 2 | 100 | 340.0 | 1078.0 | 1816.0 | 1078.0 |
| Pacific Sanddab | 205 | 204 | 100 | 35.0 | 321.0 | 1826.0 | 362.0 |
| ALL SPECIES | 344 | 338 | 98 | 35.0 | 400.5 | 4252.0 | 653.0 |
| ***Muscle Tissues (RFStations)*** | | | | | | | |
| California Scorpionfish | 10 | 10 | 100 | 1.6 | 20.2 | 30.1 | 17.7 |
| Canary Rockfish | 1 | 1 | 100 | 14.0 | 14.0 | 14.0 | 14.0 |
| Chilipepper | 2 | 2 | 100 | 4.8 | 5.8 | 6.7 | 5.8 |
| Copper Rockfish | 18 | 16 | 89 | 1.3 | 7.6 | 217.3 | 29.6 |
| Flag Rockfish | 2 | 2 | 100 | 5.3 | 37.5 | 69.7 | 37.5 |
| Greenblotched Rockfish | 3 | 3 | 100 | 4.1 | 9.2 | 9.7 | 7.7 |
| Greenspotted Rockfish | 2 | 2 | 100 | 3.0 | 8.0 | 13.0 | 8.0 |
| Mixed Rockfish | 33 | 31 | 94 | 0.7 | 8.3 | 60.0 | 12.4 |
| Rosethorn Rockfish | 1 | 1 | 100 | 2.2 | 2.2 | 2.2 | 2.2 |
| Speckled Rockfish | 15 | 14 | 93 | 0.3 | 2.1 | 16.0 | 4.6 |
| Squarespot Rockfish | 3 | 3 | 100 | 11.0 | 13.0 | 20.0 | 14.7 |
| Starry Rockfish | 8 | 8 | 100 | 1.7 | 21.4 | 117.3 | 38.3 |
| Vermilion Rockfish | 42 | 35 | 83 | 0.3 | 5.1 | 24.0 | 6.3 |
| Yellowtail Rockfish | 2 | 2 | 100 | 3.3 | 4.8 | 6.3 | 4.8 |
| ALL SPECIES | 142 | 130 | 92 | 0.3 | 6.8 | 217.3 | 14.0 |

**TABLE C5-26**
Summary of total DDT concentrations (ppb) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | **Zone 1** | **Zone 2** | **Zone 3** | **Zone 4** | **RF1** | **RF2** |
| Total | 64 | 80 | 65 | 67 | 63 | 69 |
| Detected | 64 | 77 | 65 | 67 | 56 | 64 |
| Frequency | 100 | 96 | 100 | 100 | 89 | 93 |
| Minimum | 81.4 | 98.5 | 83.9 | 35.0 | 0.3 | 0.3 |
| Median | 414.8 | 393.3 | 370.0 | 363.8 | 6.4 | 6.2 |
| Maximum | 2251.0 | 2100.0 | 2400.0 | 3800.0 | 217.3 | 117.3 |
| Mean | 649.0 | 589.5 | 531.7 | 702.7 | 15.7 | 11.9 |
| 95% CI | 141.7 | 104.0 | 117.5 | 177.4 | 8.4 | 4.9 |

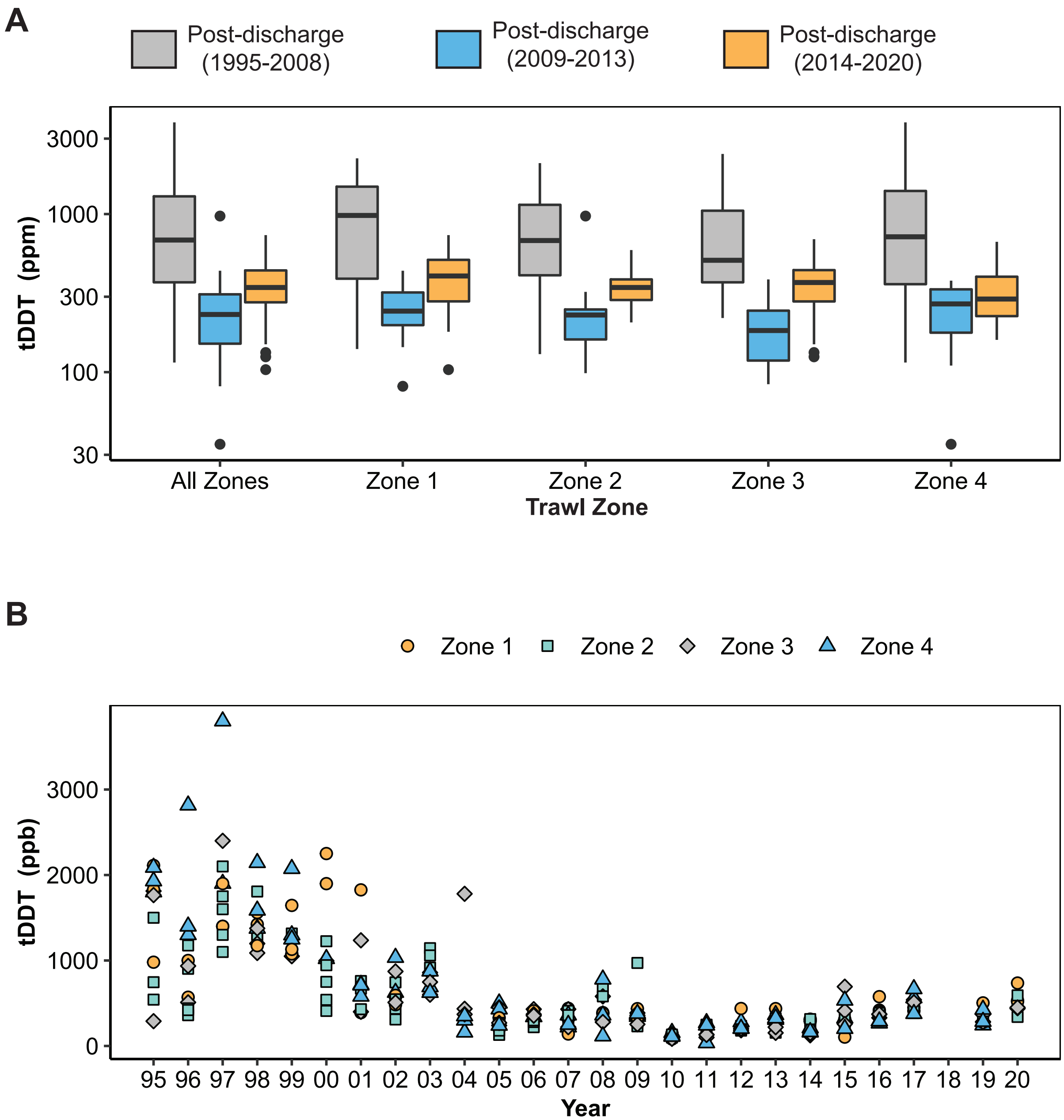



**FIGURE C5-28**
Total DDT concentrations (ppb) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

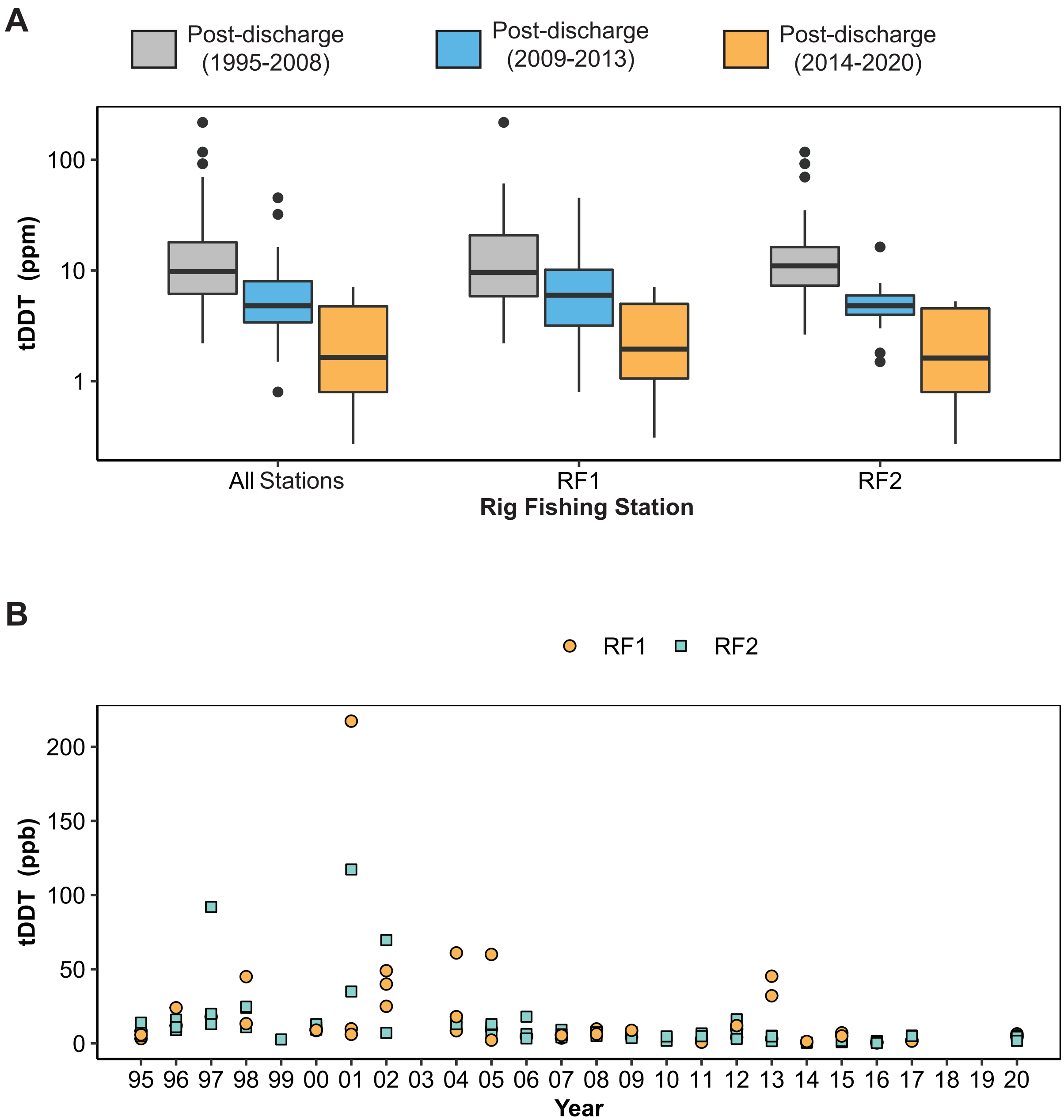



**FIGURE C5-29**
Total DDT concentrations (ppb) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each post-discharge period (A) and by survey (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey. Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

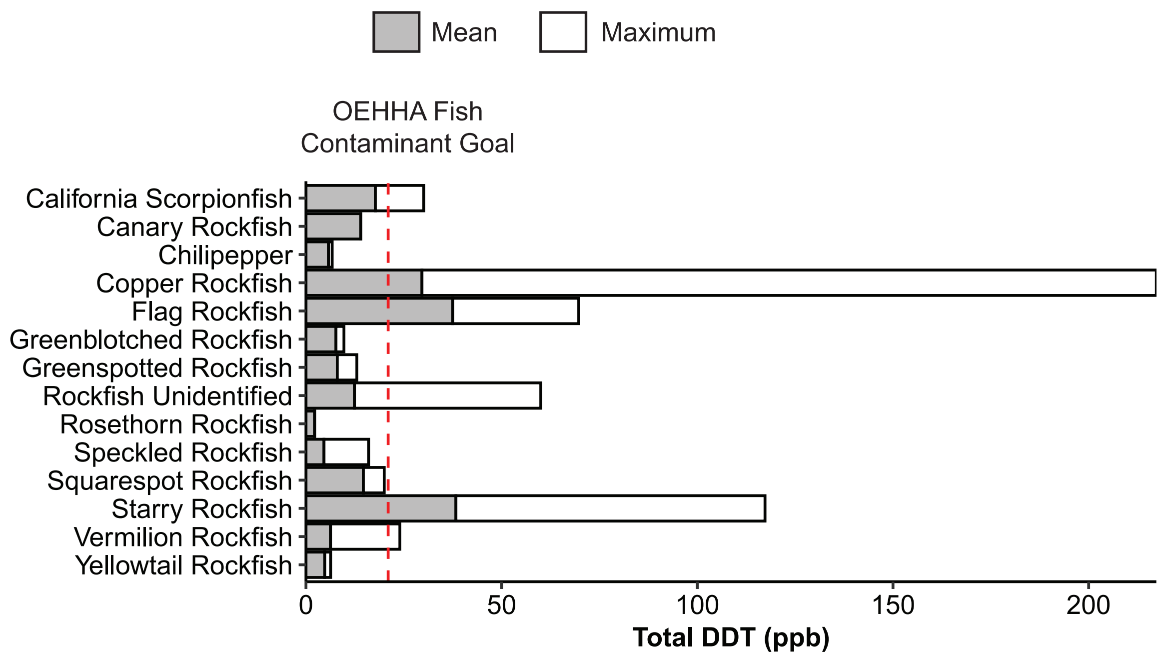



**FIGURE C5-30**
Mean and maximum concentrations of total DDT in muscle tissues of all fishes collected off San Diego at rig fishing stations compared to the OEHHA fish contaminant goal (Klasing and Brodberg 2008). The USFDA action limit of 5000 ppb not shown (see Mearns et al. 1991). See Table C5-2 for sample sizes.

calculations, was detected in 81% of liver tissue samples and 14% of muscle tissue samples, at concentrations up to 70.0 and 1.6 ppb, respectively (Attachment C5-C).

Mean detected concentrations of DDT in sanddab liver tissues ranged from 531.7 to 702.7 ppb per trawl zone, while concentrations in rockfish muscle tissues averaged 15.7 ppb at station RF1 and 11.9 ppb at station RF2 (Table C5-26). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of DDT concentrations over surveys combined for the three post-discharge periods (Figures C5-28A, C5-29A) or over time (Figures C5-28B, C5-29B). From 1995 through 2004, concentrations of DDT in liver tissues of fishes from trawl stations were highly variable, and then remained below 1000 ppt through the present. This change corresponds to an adjustment in the fishes collected for analysis- prior to 2004; the sanddab guild was represented by a mix of Longfin and Pacific Sanddab, with variability in the size (age) of fishes kept for analysis. Subsequently, the sanddab guild has been represented almost entirely by Pacific Sanddab, of similar, smaller sizes. DDT concentrations in muscle tissues of rockfishes from rig fishing stations have also been somewhat variable, across both locations.

Total DDT levels exceeded the OEHHA fish contaminant goal of 21 ppb in tissue samples from at least six species, including California Scorpionfish, Copper Rockfish, Flag Rockfish, Starry Rockfish, Vermilion Rockfish, and Mixed Rockfish (>1 species/sample), but never exceeded the USFDA action limit of 5,000 ppb and the MIS of 5,000 ppb (Table C5-4, Figure C5-30). As with several of the metals, levels of DDT in exceedance of the OEHHA fish contaminant goal are not uncommon in sport fish from other areas of the San Diego region, including the Coronado Islands (City of San Diego 2020a, McLaughlin et al. 2020).

## Other Chlorinated Pesticides

As with DDT, other chlorinated pesticides such as chlordane, hexachlorocyclohexane (HCH), aldrin, dieldrin, endosulfan, endrin, mirex, and toxaphene are rarely, if ever, detected in PLWTP effluent. Detection rates in sediments have also been low historically (City of San Diego 2020a). While some of these chlorinated pesticides have been detected in fish tissues off Point Loma, their detection rates and concentrations have consistently been low in muscle tissues, and highly variable in liver tissues (Table C5-27). For example, overall detection rates in liver tissues were 27% and 26% for trans-nonachlor (the most frequently detected chlordane constituent) and hexachlorobenzene, respectively. In contrast, detection rates in liver tissues for alpha (cis) chlordane, heptachlor, dieldrin, and alpha, beta, and gamma isomers of HCH were below 7%. Aldrin, components of endosulfan, components of endrin, mirex, the delta isomer of HCH, and toxaphene were not detected in liver tissue samples collected during October surveys from 1995 through 2020.

Concentrations of these pesticides were also highly variable, but tended to be highest in California Scorpionfish, and Longfin and Pacific Sanddabs. These pesticides were detected in fish samples from all zones, no matter what distance from the outfall. All rockfish muscle samples from the

**TABLE C5-27**
Summary of pesticide concentrations (ppb) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Detected values are summarized for liver tissues from trawl zones and muscle tissues from rig fishing zones sampled during October surveys; ns = not sampled; nd = not detected.

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticide** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| Aldrin | ALL SPECIES | 335 | 0 | 0 | nd | nd | nd | nd | 142 | 0 | 0 | nd | nd | nd | nd |
| Alpha(cis)Chlordane | ALL SPECIES | 347 | 24 | 7 | 2.1 | 4.4 | 58.0 | 10.2 | 148 | 1 | 1 | 0.6 | 0.6 | 0.6 | 0.6 |
| | Longfin Sanddab | 72 | 7 | 10 | 7.5 | 15.0 | 58.0 | 22.1 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 207 | 17 | 8 | 2.1 | 3.3 | 28.0 | 5.3 | ns | — | — | — | — | — | — |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 1 | 11 | 0.6 | 0.6 | 0.6 | 0.6 |
| AlphaChlordene | ALL SPECIES | 41 | 0 | 0 | nd | nd | nd | nd | 12 | 0 | 0 | nd | nd | nd | nd |
| CisNonachlor | ALL SPECIES | 275 | 0 | 0 | nd | nd | nd | nd | 124 | 0 | 0 | nd | nd | nd | nd |
| Gamma(trans)Chlordane | ALL SPECIES | 275 | 0 | 0 | nd | nd | nd | nd | 124 | 0 | 0 | nd | nd | nd | nd |
| GammaChlordene | ALL SPECIES | 23 | 0 | 0 | nd | nd | nd | nd | 6 | 0 | 0 | nd | nd | nd | nd |
| HeptachlorEpoxide | ALL SPECIES | 347 | 0 | 0 | nd | nd | nd | nd | 148 | 0 | 0 | nd | nd | nd | nd |
| Heptachlor | ALL SPECIES | 347 | 2 | 1 | 12.5 | 18.8 | 25.0 | 18.8 | 148 | 0 | 0 | nd | nd | nd | nd |
| | Longfin Sanddab | 72 | 1 | 1 | 12.5 | 12.5 | 12.5 | 12.5 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 207 | 1 | 0 | 25.0 | 25.0 | 25.0 | 25.0 | ns | — | — | — | — | — | — |
| Methoxychlor | ALL SPECIES | 95 | 0 | 0 | nd | nd | nd | nd | 42 | 0 | 0 | nd | nd | nd | nd |
| Oxychlordane | ALL SPECIES | 275 | 0 | 0 | nd | nd | nd | nd | 124 | 0 | 0 | nd | nd | nd | nd |
| TransNonachlor | ALL SPECIES | 347 | 93 | 27 | 2.6 | 7.1 | 91.0 | 11.9 | 148 | 3 | 2 | 0.4 | 0.7 | 2.4 | 1.2 |
| | California Scorpionfish | 33 | 9 | 27 | 6.1 | 22.0 | 25.3 | 19.5 | 10 | 0 | 0 | nd | nd | nd | nd |
| | Greenspotted Rockfish | 2 | 1 | 50 | 20.0 | 20.0 | 20.0 | 20.0 | 2 | 0 | 0 | nd | nd | nd | nd |
| | Longfin Sanddab | 72 | 16 | 22 | 4.3 | 18.5 | 91.0 | 26.1 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 207 | 66 | 32 | 2.6 | 5.8 | 28.0 | 7.1 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 1 | 50 | 22.0 | 22.0 | 22.0 | 22.0 | 34 | 1 | 3 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 2 | 22 | 0.7 | 1.6 | 2.4 | 1.6 |

**TABLE C5-27** *continued*

| Pesticide | Species | Liver Tissues (Trawl Zones) Total | Detect | Freq | Min | Med | Max | Mean | Muscle Tissues (RF Stations) Total | Detect | Freq | Min | Med | Max | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dieldrin | ALL SPECIES | 323 | 7 | 2 | 2.3 | 3.1 | 15.8 | 6.2 | 136 | 0 | 0 | nd | nd | nd | nd |
| | Longfin Sanddab | 72 | 2 | 3 | 14.0 | 14.9 | 15.8 | 14.9 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 184 | 5 | 3 | 2.3 | 2.8 | 3.2 | 2.8 | ns | — | — | — | — | — | — |
| AlphaEndosulfan | ALL SPECIES | 335 | 0 | 0 | nd | nd | nd | nd | 142 | 0 | 0 | nd | nd | nd | nd |
| BetaEndosulfan | ALL SPECIES | 167 | 0 | 0 | nd | nd | nd | nd | 63 | 0 | 0 | nd | nd | nd | nd |
| EndosulfanSulfate | ALL SPECIES | 191 | 0 | 0 | nd | nd | nd | nd | 78 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Endrin | ALL SPECIES | 323 | 0 | 0 | nd | nd | nd | nd | 136 | 0 | 0 | nd | nd | nd | nd |
| EndrinAldehyde | ALL SPECIES | 95 | 0 | 0 | nd | nd | nd | nd | 42 | 0 | 0 | nd | nd | nd | nd |
| HCH, Alpha isomer | ALL SPECIES | 275 | 1 | 0.4 | 1.8 | 1.8 | 1.8 | 1.8 | 124 | 0 | 0 | nd | nd | nd | nd |
| | Pacific Sanddab | 198 | 1 | 1 | 1.8 | 1.8 | 1.8 | 1.8 | ns | — | — | — | — | — | — |
| HCH, Beta isomer | ALL SPECIES | 270 | 17 | 6 | 2.2 | 2.7 | 22.0 | 4.1 | 118 | 1 | 1 | 5.8 | 5.8 | 5.8 | 5.8 |
| | Pacific Sanddab | 194 | 17 | 9 | 2.2 | 2.7 | 22.0 | 4.1 | ns | — | — | — | — | — | — |
| | Squarespot Rockfish | ns | — | — | — | — | — | — | 2 | 1 | 50 | 5.8 | 5.8 | 5.8 | 5.8 |
| HCH, Delta isomer | ALL SPECIES | 275 | 0 | 0 | nd | nd | nd | nd | 124 | 1 | 1 | 7.6 | 7.6 | 7.6 | 7.6 |
| | Squarespot Rockfish | ns | — | — | — | — | — | — | 2 | 1 | 50 | 7.6 | 7.6 | 7.6 | 7.6 |
| HCH, Gamma isomer | ALL SPECIES | 347 | 1 | <1 | 19.0 | 19.0 | 19.0 | 19.0 | 146 | 0 | 0 | nd | nd | nd | nd |
| | Longfin Sanddab | 71 | 1 | 1 | 19.0 | 19.0 | 19.0 | 19.0 | ns | — | — | — | — | — | — |

**TABLE C5-27** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticide** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| Hexachlorobenzene | ALL SPECIES | 327 | 86 | 26 | 1.7 | 5.3 | 120.0 | 7.8 | 138 | 16 | 12 | 0.2 | 0.5 | 15.0 | 1.4 |
| | California Scorpionfish | 33 | 1 | 3 | 12.0 | 12.0 | 12.0 | 12.0 | 10 | 1 | 10 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Chilipepper | ns | — | — | — | — | — | — | 2 | 2 | 100 | 0.3 | 0.4 | 0.4 | 0.4 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 1 | 6 | 0.5 | 0.5 | 0.5 | 0.5 |
| | English Sole | 20 | 1 | 5 | 3.4 | 3.4 | 3.4 | 3.4 | ns | — | — | — | — | — | — |
| | Greenblotched Rockfish | 1 | 0 | 0 | nd | nd | nd | nd | 3 | 1 | 33 | 15.0 | 15.0 | 15.0 | 15.0 |
| | Pacific Sanddab | 188 | 84 | 45 | 1.7 | 5.3 | 120.0 | 7.8 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 0 | 0 | nd | nd | nd | nd | 30 | 5 | 17 | 0.3 | 0.6 | 1.3 | 0.7 |
| | Speckled Rockfish | ns | — | — | — | — | — | — | 14 | 1 | 7 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 2 | 25 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 41 | 3 | 7 | 0.2 | 0.3 | 0.5 | 0.3 |
| Mirex | ALL SPECIES | 347 | 0 | 0 | nd | nd | nd | nd | 148 | 0 | 0 | nd | nd | nd | nd |
| Toxaphene | ALL SPECIES | 180 | 0 | 0 | nd | nd | nd | nd | 76 | 0 | 0 | nd | nd | nd | nd |

rig fishing stations had total chlordane concentrations below the OEHHA fish contaminant goal of 5.6 ppb, as well as the MIS of 100 ppb and the USFDA Action Limit of 300 ppb (Table C5-4).

### *PCBs*

PCBs have historically been used in a wide variety of industrial applications, including insulation for electrical capacitors and transformers, hydraulic fluids, plasticizers in waxes, additives in paints and other compounds, and components in the manufacture of paper (USEPA 1984, Mearns et al. 1991). PCBs were not historically detected in PLWTP effluent and remained undetected from 2014 through 2020. Levels of total PCB (all detected congers) in outfall depth sediments off Point Loma have ranged from not-detected to 22,690 ppt since monitoring of congeners began in 1998, with a mean of 147 ppt for the post-discharge years of 1998-2020 (PCBs were reported as aroclors prior to 1998; see Appendix C1). These concentrations are comparable to background conditions in the SCB reported during past Bight surveys and found regionally off San Diego (1,195 – 13,0000 ppt; see Table C1-2, Appendix C1).

Tissue concentrations of total PCB in trawl and rig-caught fishes collected off Point Loma during October surveys from 1995 through 2020 are reported herein in two different ways: all detected congeners combined and limited to congeners analyzed consistently overall years (see Section C5.3 - General Methodology). Values are summarized by species in Tables C5-28 and C-528B, and by zone/station in Table C5-29 and Figures C5-31 to C5-34. Individual PCB congeners are summarized in Attachment C5-D, and Figures C5-35 to C5-39. PCB was detected in 96% (96% for limited congeners) of liver tissue samples from trawl-caught fishes, at concentrations of 14.0 (14.0 for limited congeners) to 5320.0 (4374.0 for limited congeners) ppb, and was detected in 39% (38%) of muscle tissue samples from rig fishing stations, at concentrations of 0.2 (0.2) to 69.0 (50.9) ppb (Tables C5-28A, C5-28B).

Mean detected concentrations of PCB in sanddab liver tissues ranged from 298.7 (248.6) to 524.7 (405.5) ppb per trawl zone, while concentrations in rockfish muscle tissues averaged 11.2 (9.0) ppb at station RF1 and 8.2 (6.1) ppb at station RF2 (Tables C5-29A, C5-29B). No discernible relationship to the outfall was evident amongst zones for the sanddab feeding guild, or amongst rig fishing stations for rockfish in terms of PCB concentrations over surveys combined for the three post-discharge periods (Figures C5-31, C5-33) or over time (Figures C5-32, C5-34). Overall, the highest total PCB concentrations were most frequently found in sanddab liver tissues from Zone 3, located near the LA-5 disposal site (Table C5-29, Figure C5-32). These results are consistent with previous assessments of bioaccumulation of PCB in fishes off San Diego (City of San Diego 2020a, Parnell et al. 2008).

Total PCB (all detected congeners) exceeded the OEHHA fish contaminant goal of 3.6 ppb in seven species, including California Scorpionfish, Canary Rockfish, Copper Rockfish, Flag Rockfish, Mixed Rockfish, Starry Rockfish, and Vermilion Rockfish (Table C5-4, Figure C5-35). As with several of the metals and total DDT, elevated levels of PCB over the OEHHA fish contaminant goal are not uncommon in sport fish from other areas of the San Diego region, including the Coronado Islands (City of San Diego 2020a, McLaughlin et al. 2020).

A more detailed analysis of the distribution of individual PCB congeners detected in fish tissues revealed patterns similar to total PCB. More than 40 different congeners were detected in tissue samples collected between 1995 and 2020, with highly variable detection rates per congener (Attachment C5-D, Figures C5-36 and C5-37). As mentioned above, concentrations of most of these PCBs were highest in fish collected near the LA-5 site (i.e., Zone 3). The five congeners with the highest concentrations in liver tissues were PCB 87, PCB 118, PCB 138, PCB 153, and PCB-153/168 (Figure C5-38). The five congeners with the highest concentrations in muscle tissues were PCB 87, PCB 126, PCB 138, PCB 153/168, and PCB 200 (Figure C5-39. Overall, there were no patterns consistent with an outfall effect.

## SECTION C5.4 | SUMMARY & CONCLUSIONS

Several trace metals, PCB congeners, and chlorinated pesticides (e.g., DDT) were detected in liver tissues from trawl-caught fishes collected in the Point Loma outfall region from 1995 through 2020. Many of the same metals, PCBs, DDT and other pesticides were also detected in rockfish muscle tissues from rig fishing stations over the past 26 years, although often less frequently and/or in lower concentrations. Although tissue contaminant concentrations varied among different species of fish and between stations/zones, all values were within ranges reported previously for SCB fishes (see Mearns et al. 1991, Allen et al 1998, 2002, City of San Diego 2000, City of San Diego 2020a, McLaughlin et al. 2020). In addition, concentrations of these contaminants were generally similar to those reported previously by the City of San Diego for this survey area (City of San Diego 2001a, b, 2007, 2015, 2020a).

None of the muscle tissue samples from sport fish collected in the region during October surveys had concentrations of mercury and total DDT above the USFDA action limits. Further, in the history of the monitoring program, only a single Vermilion Rockfish sample exceeded the USFDA action limit for mercury (City of San Diego 2015). Because data have been limited to October surveys, this value is not included in this report. Although several species had arsenic, chromium, and selenium concentrations above median international standards for human consumption, and some had concentrations of mercury, total DDT and total PCB above OEHHA limits, elevated levels of these contaminants are not uncommon in sport fish from the PLOO survey area or from the rest of the San Diego region (e.g., see City of San Diego 2020a, McLaughlin et al. 2020). For example, muscle tissue samples from fishes collected since 1995 in the South Bay outfall survey area, including the Coronado Islands which are used by the City as a reference area for the South Bay Ocean Outfall, have occasionally had concentrations of arsenic, mercury, selenium and total PCB that exceeded different consumption limits.

The frequent occurrence of different trace metals and chlorinated hydrocarbons in the tissues of fish collected from the PLOO and SBOO regions is likely influenced by multiple factors. For example, many metals occur naturally in the environment, although little information is available on background levels in fish tissues. Brown et al. (1986) determined that there may be

**TABLE C5-28A**
Summary of total PCB concentrations (ppb) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 33 | 30 | 91 | 15.0 | 385.0 | 1227.0 | 400.0 |
| Dover Sole | 3 | 2 | 67 | 14.0 | 118.3 | 222.6 | 118.3 |
| English Sole | 20 | 16 | 80 | 14.0 | 28.0 | 224.0 | 54.9 |
| Flag Rockfish | 2 | 2 | 100 | 1199.0 | 1713.0 | 2227.0 | 1713.0 |
| Greenblotched Rockfish | 2 | 1 | 50 | 305.0 | 305.0 | 305.0 | 305.0 |
| Greenspotted Rockfish | 2 | 2 | 100 | 182.0 | 333.5 | 485.0 | 333.5 |
| Halfbanded Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Hornyhead Turbot | 2 | 1 | 50 | 48.0 | 48.0 | 48.0 | 48.0 |
| Longfin Sanddab | 72 | 72 | 100 | 107.0 | 599.5 | 2651.0 | 765.9 |
| Mixed Rockfish | 2 | 2 | 100 | 3415.0 | 4367.5 | 5320.0 | 4367.5 |
| Pacific Sanddab | 201 | 199 | 99 | 14.5 | 205.7 | 3179.5 | 280.9 |
| ALL SPECIES | 341 | 327 | 96 | 14.0 | 272.2 | 5320.0 | 420.0 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 4 | 40 | 1.0 | 5.7 | 9.0 | 5.3 |
| Canary Rockfish | 1 | 1 | 100 | 15.0 | 15.0 | 15.0 | 15.0 |
| Chilipepper | 2 | 2 | 100 | 0.8 | 1.5 | 2.2 | 1.5 |
| Copper Rockfish | 18 | 8 | 44 | 0.9 | 8.9 | 64.5 | 16.1 |
| Flag Rockfish | 2 | 2 | 100 | 1.9 | 13.7 | 25.5 | 13.7 |
| Greenblotched Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Greenspotted Rockfish | 2 | 1 | 50 | 0.6 | 0.6 | 0.6 | 0.6 |
| Mixed Rockfish | 33 | 14 | 42 | 0.3 | 6.7 | 69.0 | 11.8 |
| Rosethorn Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Speckled Rockfish | 15 | 3 | 20 | 0.2 | 0.9 | 3.3 | 1.5 |
| Squarespot Rockfish | 3 | 1 | 33 | 3.4 | 3.4 | 3.4 | 3.4 |
| Starry Rockfish | 8 | 5 | 63 | 1.6 | 17.9 | 44.1 | 18.8 |
| Vermilion Rockfish | 42 | 15 | 36 | 0.5 | 1.5 | 28.0 | 3.7 |
| Yellowtail Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| ALL SPECIES | 142 | 56 | 39 | 0.2 | 3.5 | 69.0 | 9.3 |

**TABLE C5-28B**

Summary of total PCB concentrations (ppb), limited to congeners analyzed consistently over all years, in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Data are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; nd= not detected.

| Species | Total | Detect | Freq | Min | Median | Max | Mean |
|---|---|---|---|---|---|---|---|
| ***Liver Tissues (Trawl Zones)*** | | | | | | | |
| California Scorpionfish | 33 | 30 | 91 | 15.0 | 364.0 | 946.0 | 361.1 |
| Dover Sole | 3 | 2 | 67 | 14.0 | 118.3 | 222.6 | 118.3 |
| English Sole | 20 | 16 | 80 | 14.0 | 28.0 | 192.0 | 50.2 |
| Flag Rockfish | 2 | 2 | 100 | 1010.0 | 1388.5 | 1767.0 | 1388.5 |
| Greenblotched Rockfish | 2 | 1 | 50 | 259.0 | 259.0 | 259.0 | 259.0 |
| Greenspotted Rockfish | 2 | 2 | 100 | 167.0 | 293.0 | 419.0 | 293.0 |
| Halfbanded Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| Hornyhead Turbot | 2 | 1 | 50 | 48.0 | 48.0 | 48.0 | 48.0 |
| Longfin Sanddab | 72 | 72 | 100 | 107.0 | 560.5 | 1961.5 | 652.0 |
| Mixed Rockfish | 2 | 2 | 100 | 2596.0 | 3485.0 | 4374.0 | 3485.0 |
| Pacific Sanddab | 208 | 206 | 99 | 14.5 | 154.0 | 2363.5 | 211.3 |
| ALL SPECIES | 348 | 334 | 96 | 14.0 | 206.2 | 4374.0 | 338.3 |
| ***Muscle Tissues (RF Stations)*** | | | | | | | |
| California Scorpionfish | 10 | 4 | 40 | 1.0 | 4.7 | 6.8 | 4.3 |
| Canary Rockfish | 1 | 1 | 100 | 15.0 | 15.0 | 15.0 | 15.0 |
| Chilipepper | 2 | 2 | 100 | 0.8 | 1.4 | 1.9 | 1.4 |
| Copper Rockfish | 18 | 8 | 44 | 0.9 | 8.9 | 50.9 | 14.2 |
| Flag Rockfish | 2 | 2 | 100 | 1.9 | 12.2 | 22.5 | 12.2 |
| Greenblotched Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Greenspotted Rockfish | 2 | 1 | 50 | 0.6 | 0.6 | 0.6 | 0.6 |
| Greenstriped Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Mixed Rockfish | 34 | 14 | 41 | 0.3 | 6.3 | 19.2 | 7.1 |
| Rosethorn Rockfish | 1 | 0 | 0 | nd | nd | nd | nd |
| Speckled Rockfish | 15 | 2 | 13 | 0.2 | 0.6 | 0.9 | 0.6 |
| Squarespot Rockfish | 3 | 0 | 0 | nd | nd | nd | nd |
| Starry Rockfish | 9 | 5 | 56 | 1.6 | 12.3 | 35.4 | 15.6 |
| Vermilion Rockfish | 45 | 17 | 38 | 0.5 | 1.4 | 28.0 | 3.4 |
| Yellowtail Rockfish | 2 | 0 | 0 | nd | nd | nd | nd |
| ALL SPECIES | 148 | 56 | 38 | 0.2 | 2.7 | 50.9 | 7.3 |

**TABLE C5-29A**

Summary of total PCB concentrations (ppb) in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 | Zone 4 | RF1 | RF2 |
| Total | 62 | 77 | 66 | 68 | 63 | 69 |
| Detected | 62 | 75 | 66 | 68 | 23 | 29 |
| Frequency | 100 | 97 | 100 | 100 | 37 | 42 |
| Minimum | 36.0 | 18.5 | 42.0 | 14.5 | 0.5 | 0.2 |
| Median | 257.3 | 205.5 | 318.0 | 273.7 | 6.3 | 1.9 |
| Maximum | 2030.9 | 985.0 | 2928.0 | 3179.5 | 64.5 | 69.0 |
| Mean | 445.4 | 298.7 | 524.7 | 388.2 | 11.2 | 8.2 |
| 95% CI | 109.3 | 52.7 | 143.3 | 106.7 | 6.1 | 5.8 |

**TABLE C5-29B**

Summary of total PCB concentrations (ppb), limited to congeners analyzed consistently over all years, in sanddab and rockfish tissues by zone/station. Data are summarized over all samples collected during October surveys from 1995 through 2020; CI=confidence interval.

| | Sanddab Liver Tissues | | | | Rockfish Muscle Tissues | |
|---|---|---|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 | Zone 4 | RF1 | RF2 |
| Total | 64 | 80 | 66 | 70 | 66 | 72 |
| Detected | 64 | 78 | 66 | 70 | 25 | 27 |
| Frequency | 100 | 98 | 100 | 100 | 38 | 38 |
| Minimum | 36.0 | 18.5 | 42.0 | 14.5 | 0.5 | 0.2 |
| Median | 207.7 | 151.3 | 258.6 | 196.3 | 5.7 | 1.6 |
| Maximum | 1961.5 | 985.0 | 1952.0 | 2363.5 | 50.9 | 35.4 |
| Mean | 356.3 | 248.6 | 405.5 | 307.3 | 9.0 | 6.1 |
| 95% CI | 90.3 | 45.3 | 109.3 | 80.5 | 4.7 | 3.6 |

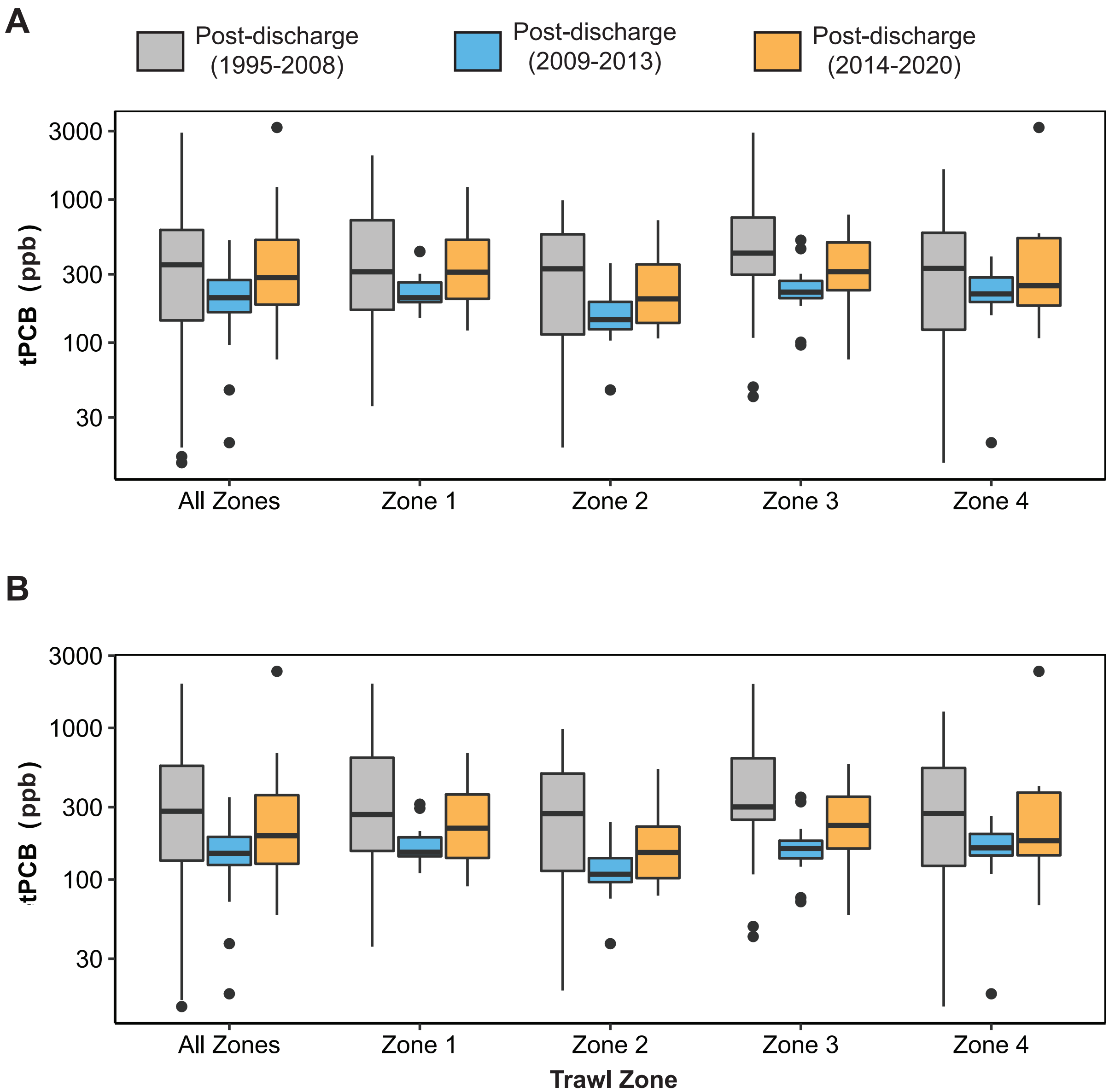



**FIGURE C5-31**

Total PCB concentrations (ppb) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for all detected congeners (A) and limited to congeners analyzed consistently over all years (B). Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

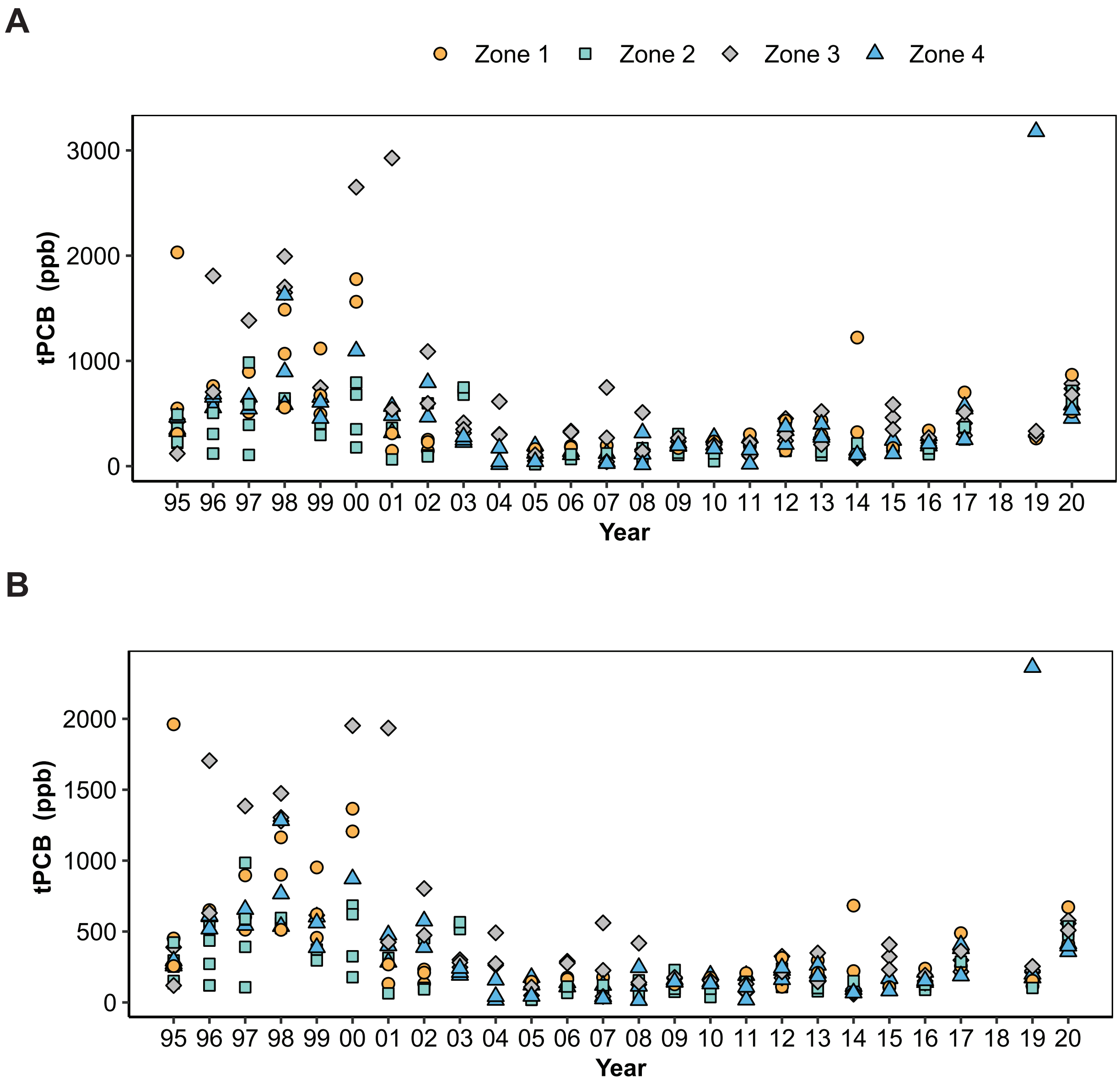



**FIGURE C5-32**
Total PCB concentrations (ppb) detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. Data are summarized by zone for each survey for all detected congeners (A) and limited to congeners analyzed consistently over all years (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey.

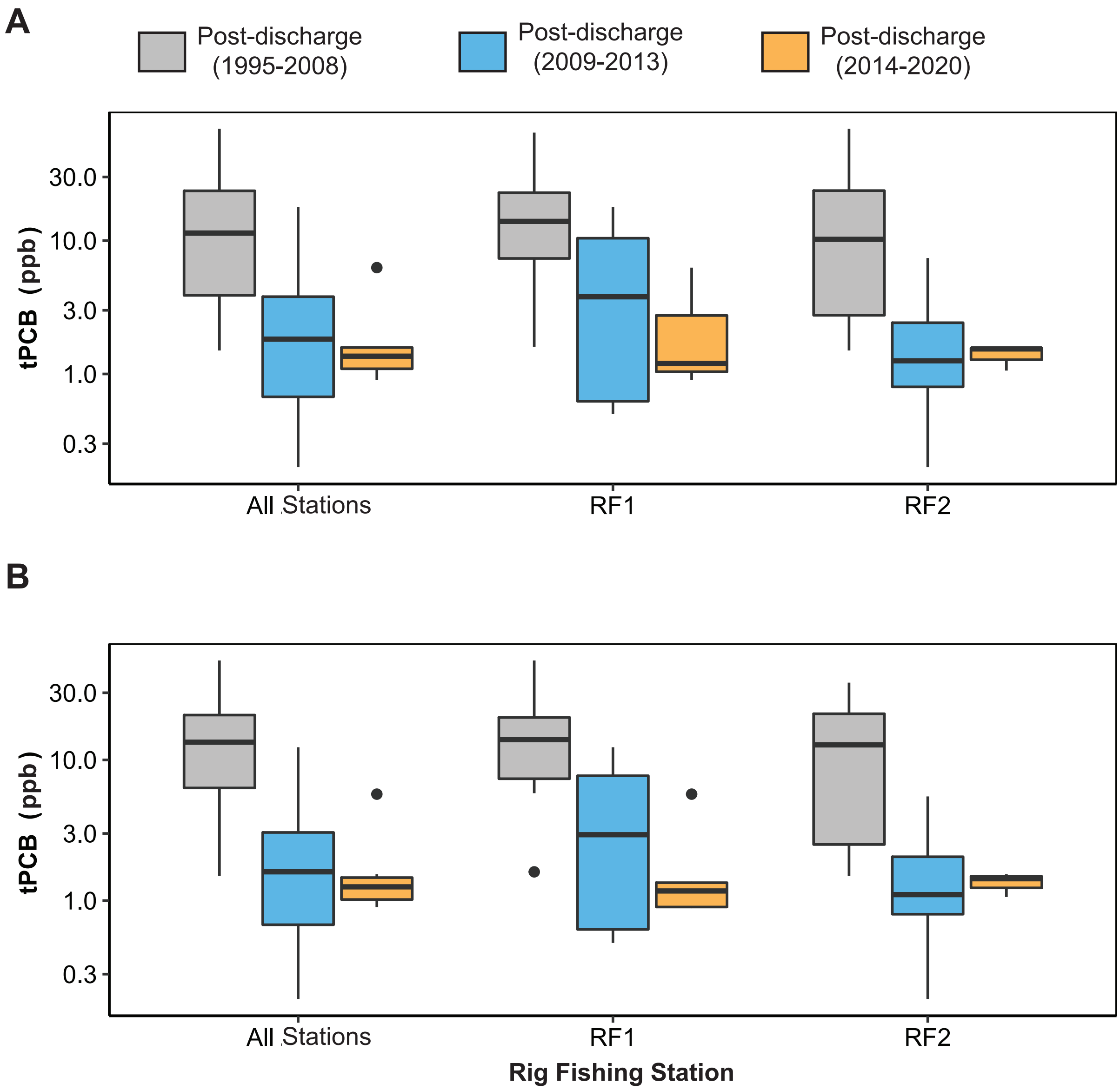



**FIGURE C5-33**
Total PCB concentrations (ppb) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for all detected congeners (A) and limited to congeners analyzed consistently over all years (B). Boxplots are median, upper and lower quartiles, 1.5 times the interquartile range (whiskers), and outliers (solid circles).

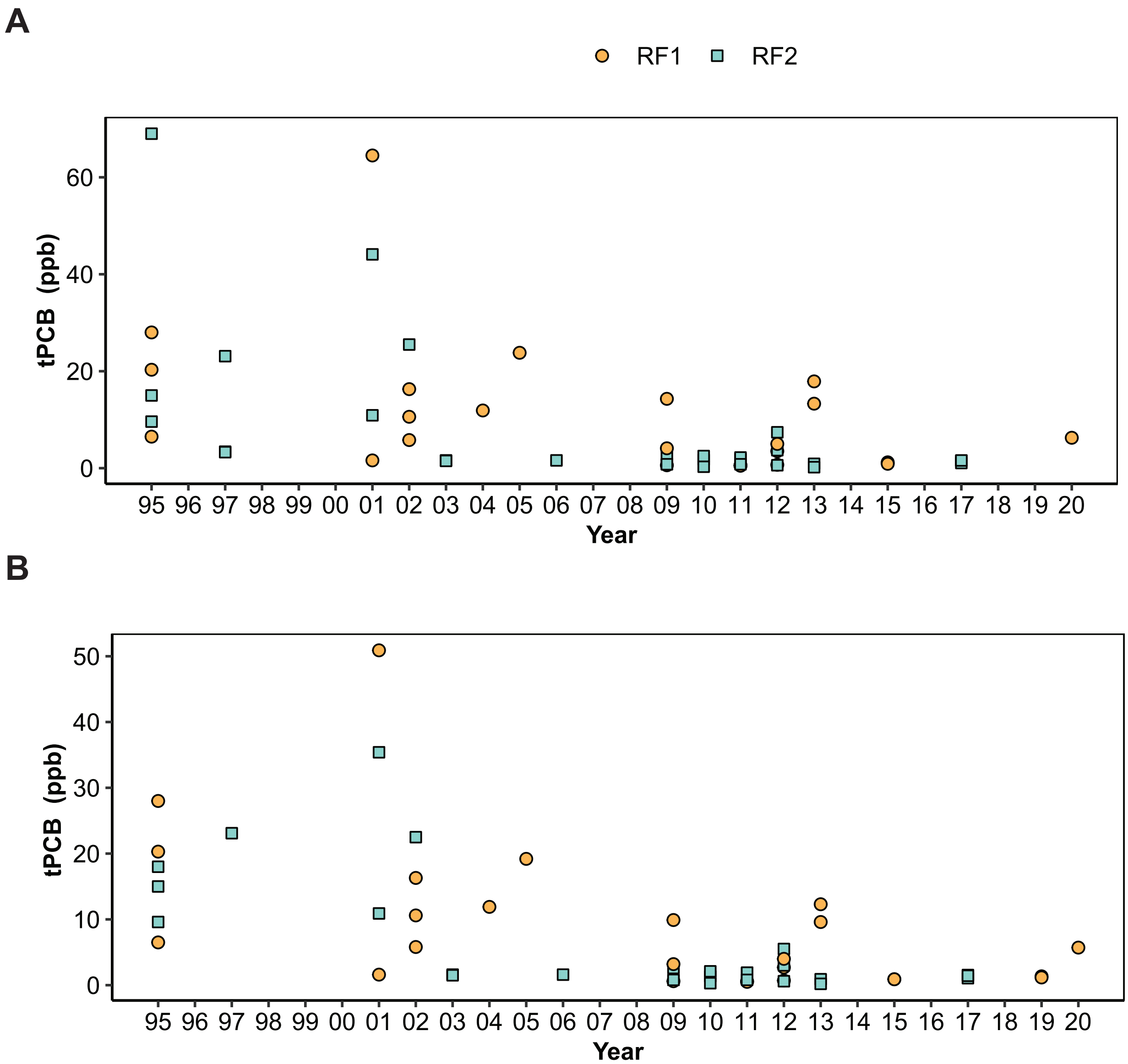



**FIGURE C5-34**
Total PCB concentrations (ppb) detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. Data are summarized by station for each survey for all detected congeners (A) and limited to congeners analyzed consistently over all years (B). No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight’18 survey.

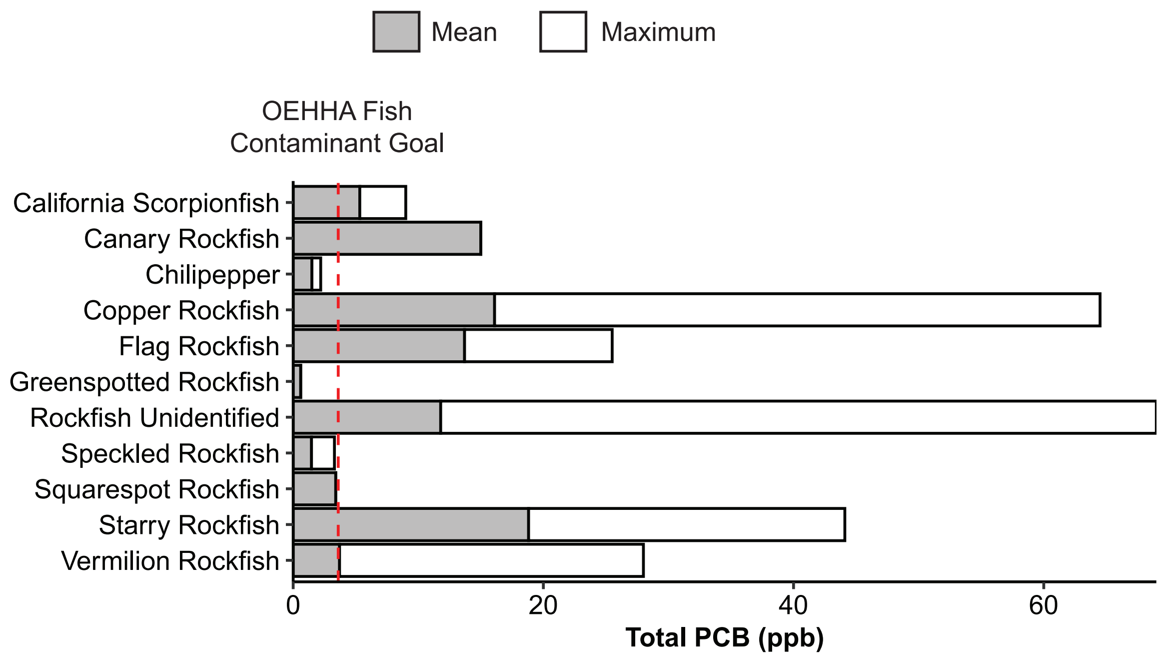



**FIGURE C5-35**
Mean and maximum concentrations of total PCB in muscle tissues of all fishes collected off San Diego at rig fishing stations compared to the OEHHA fish contaminant goal (Klasing and Brodberg 2008). See Table C5-2 for sample sizes.

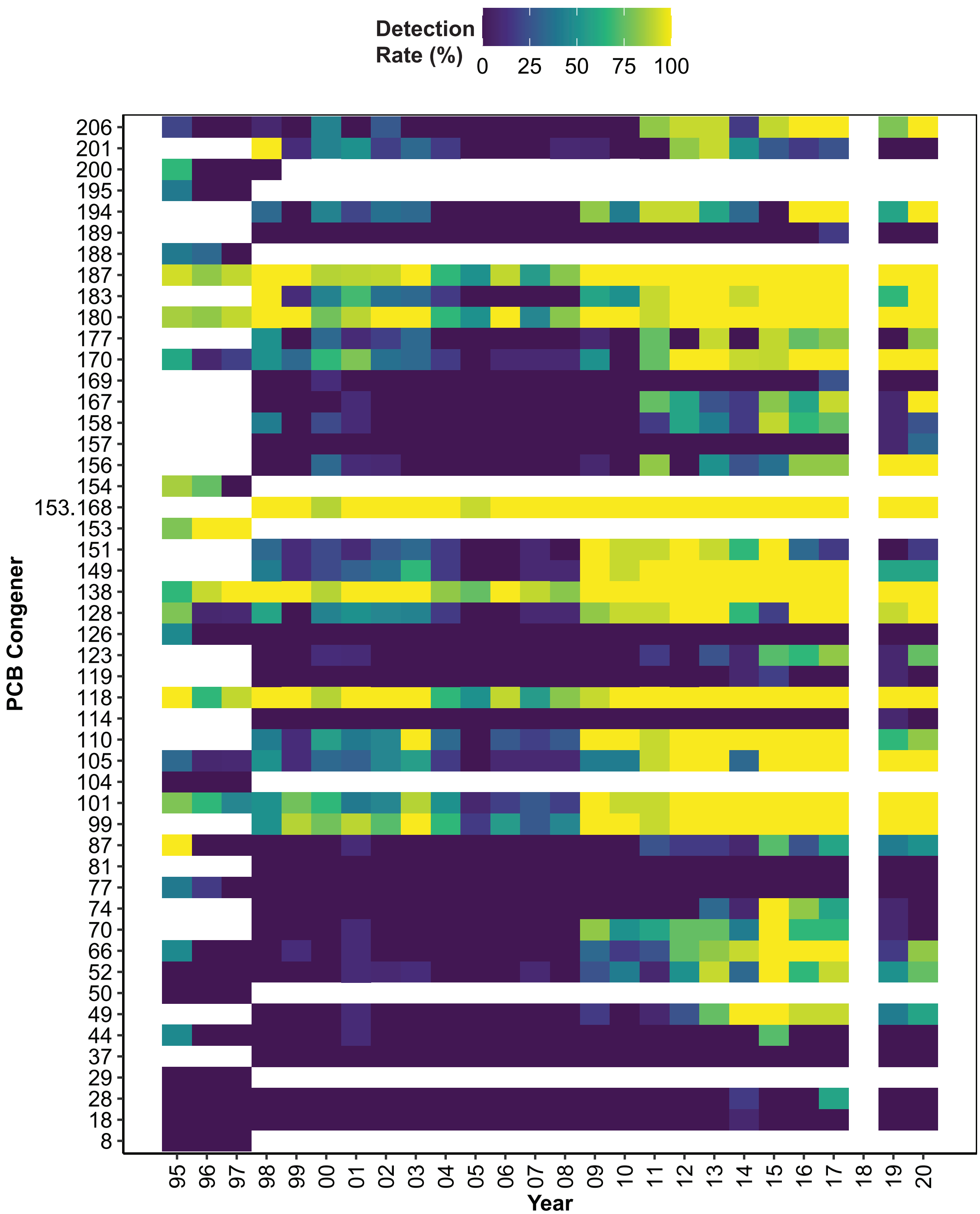



**FIGURE C5-36**
Detection rates (%) of individual PCB congeners in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020. No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey.

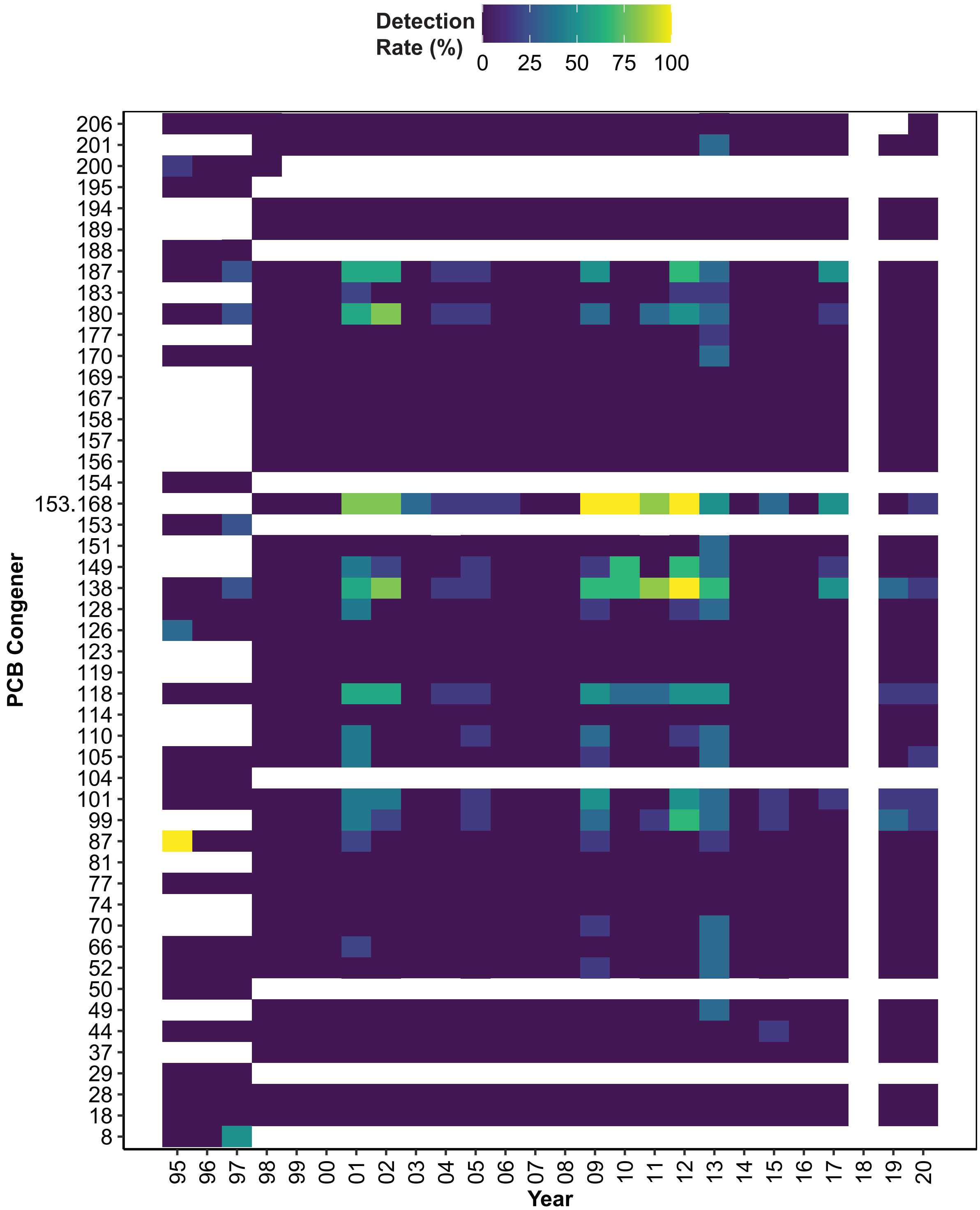



**FIGURE C5-37**
Detection rates (%) of individual PCB congeners in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020. No fish tissue samples were collected during 2018 due to a resource exchange granted by the San Diego Regional Water Quality Control Board for participation in the region-wide Bight'18 survey.

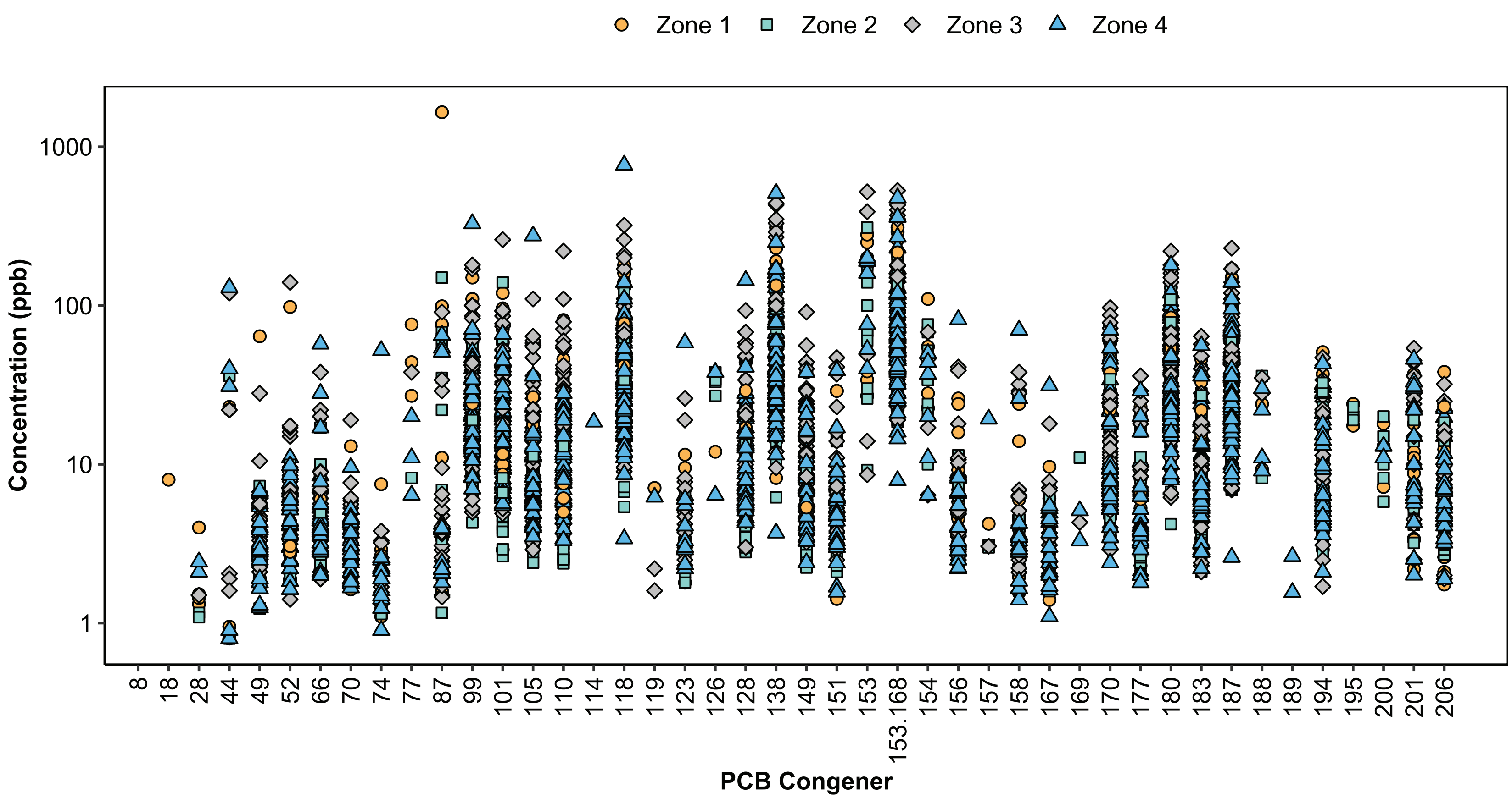



**FIGURE C5-38**
Concentrations (ppb) of individual PCB congeners detected in sanddab guild liver tissues collected from trawl zones during October surveys 1995–2020.

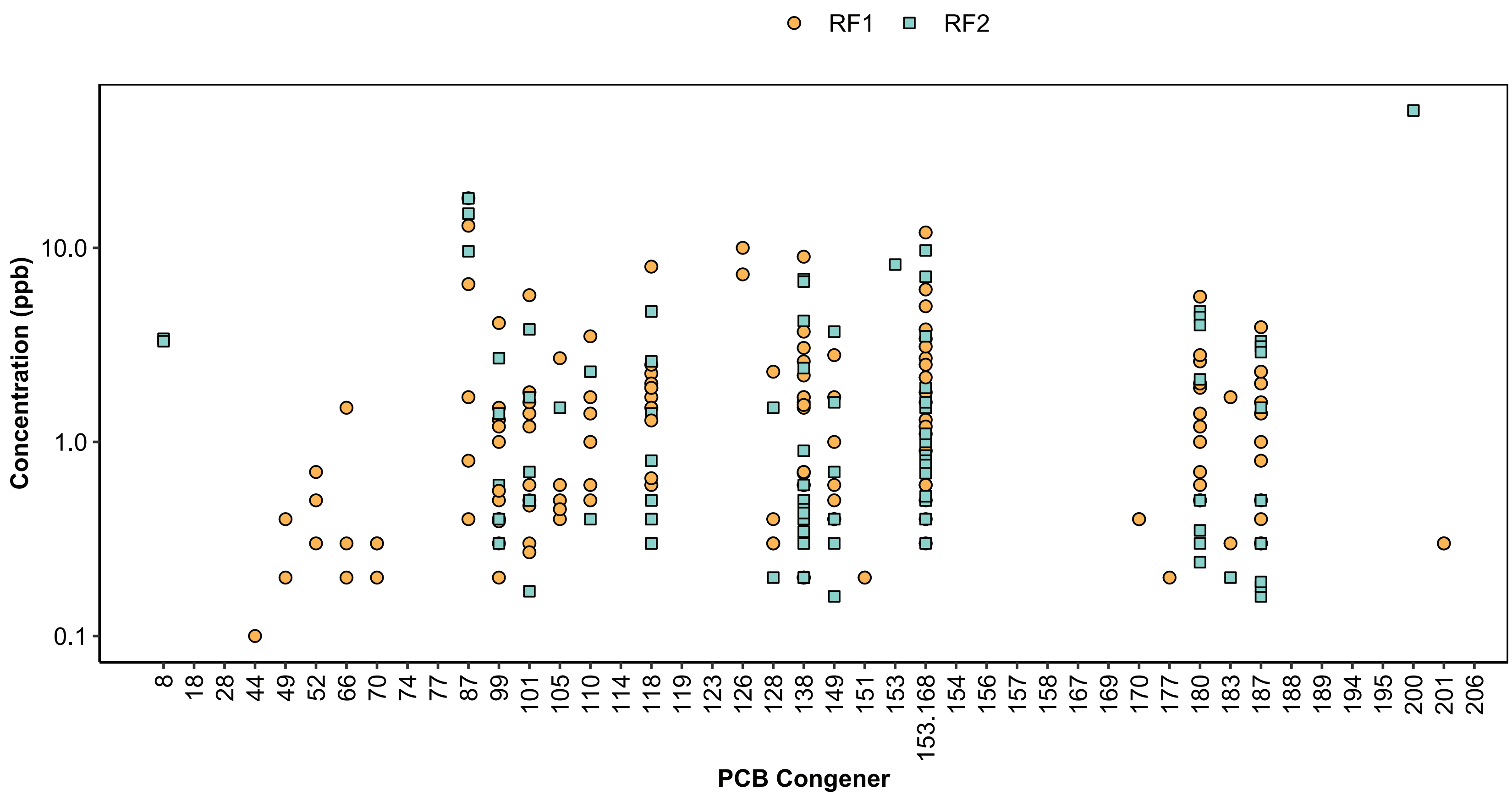



**FIGURE C5-39**
Concentrations (ppb) of individual PCB congeners detected in rockfish muscle tissues collected from rig fishing stations during October surveys 1995–2020.

no area in the SCB sufficiently free of chemical contaminants to be considered a reference site, while Mearns et al. (1991) described the distribution of several contaminants, such as arsenic, mercury, DDT, and PCBs as being ubiquitous. The wide-spread distribution of contaminants in SCB fishes has been supported by work regarding PCBs and DDT (e.g., Allen et al. 1998, 2002).

Other factors that affect contaminant loading in fish tissues include the physiology and life history of different species (Groce 2002). Exposure to contaminants can also vary greatly between different species of fish and among individuals of the same species depending on migration habits (Otway 1991). Fishes may be exposed to contaminants in a highly polluted area and then move into an area that is not. For example, California Scorpionfish tagged in Santa Monica Bay have been recaptured as far south as the Coronado Islands (Hartmann 1987, Love et al. 1987). This is of particular concern for fishes collected in the vicinity of the PLOO, as there are many point and non-point sources that may contribute to local contamination in the region including the San Diego River, San Diego Bay, and offshore dredged material disposal sites (see Appendix C1, this application). However, assessments of contaminant loading in San Diego offshore sediments have revealed no evidence to indicate that the PLOO is a major source of pollutants to the area (Parnell et al. 2008, City of San Diego 2020a).

Overall, there was no evidence that the discharge of wastewater via the Point Loma outfall has caused abnormal body burdens of any toxic pollutants known to have adverse effects on marine fishes or their consumers. Fishes collected in the region do not appear to be significantly affected by the discharge of wastewater from the outfall or from other possible sources of contamination. Concentrations of most contaminants were generally similar across zones or stations, and no relationship relevant to the PLOO was evident. These results are consistent with findings of other assessments of bioaccumulation in fishes off San Diego (City of San Diego 2007, 2015, 2020a, Parnell et al. 2008). Finally, the absence of physical abnormalities or any indication of disease (e.g., fin rot, tumors) on local fishes indicates that populations in the Point Loma region remain healthy after 20 years of wastewater discharge (e.g., see City of San Diego 2020a).

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# APPENDIX C5

# Bioaccumulation Assessment

# ATTACHMENTS

**ATTACHMENT C5-C**

Summary of DDT constituent concentrations (ppb) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Detected values are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; ns = not sampled; nd = not detected.

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticide** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| o,p-DDT | ALL SPECIES | 347 | 0 | 0 | nd | nd | nd | nd | 148 | 0 | 0 | nd | nd | nd | nd |
| p,p-DDT | ALL SPECIES | 347 | 118 | 34 | 2.7 | 8.3 | 96.0 | 14.9 | 143 | 8 | 6 | 0.3 | 0.6 | 4.1 | 1.3 |
| | California Scorpionfish | 33 | 6 | 18 | 11.7 | 14.8 | 36.0 | 17.5 | ns | — | — | — | — | — | — |
| | Chilipepper | ns | — | — | — | — | — | — | 2 | 1 | 50 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 1 | 6 | 1.6 | 1.6 | 1.6 | 1.6 |
| | Flag Rockfish | ns | — | — | — | — | — | — | 2 | 1 | 50 | 2.7 | 2.7 | 2.7 | 2.7 |
| | Greenspotted Rockfish | 2 | 1 | 50 | 18.0 | 18.0 | 18.0 | 18.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 25 | 35 | 15.0 | 26.8 | 96.0 | 38.4 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 207 | 85 | 41 | 2.7 | 5.4 | 22.0 | 7.6 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 1 | 50 | 36.0 | 36.0 | 36.0 | 36.0 | ns | — | — | — | — | — | — |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 3 | 38 | 0.4 | 0.7 | 4.1 | 1.7 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 43 | 2 | 5 | 0.3 | 0.4 | 0.5 | 0.4 |
| o,p-DDD | ALL SPECIES | 347 | 8 | 2 | 6.8 | 19.2 | 88.0 | 29.9 | 145 | 1 | 1 | 0.3 | 0.3 | 0.3 | 0.3 |
| | California Scorpionfish | 33 | 2 | 6 | 7.7 | 7.9 | 8.1 | 7.9 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 6 | 8 | 6.8 | 34.5 | 88.0 | 37.3 | ns | — | — | — | — | — | — |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 44 | 1 | 2 | 0.3 | 0.3 | 0.3 | 0.3 |
| p,p-DDD | ALL SPECIES | 344 | 104 | 30 | 2.2 | 5.7 | 110.0 | 11.1 | 143 | 6 | 4 | 0.5 | 0.8 | 5.7 | 1.9 |
| | California Scorpionfish | 33 | 9 | 27 | 12.4 | 21.0 | 39.8 | 21.1 | ns | — | — | — | — | — | — |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 1 | 6 | 5.7 | 5.7 | 5.7 | 5.7 |
| | English Sole | 20 | 1 | 5 | 110.0 | 110.0 | 110.0 | 110.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 71 | 17 | 24 | 11.9 | 16.4 | 33.0 | 18.5 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 205 | 77 | 38 | 2.2 | 5.1 | 56.0 | 7.0 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | ns | — | — | — | — | — | — | 33 | 2 | 6 | 0.5 | 0.6 | 0.6 | 0.6 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 3 | 38 | 0.6 | 1.0 | 3.2 | 1.6 |

**ATTACHMENT C5-C** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticide** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| o,p-DDE | ALL SPECIES | 347 | 75 | 22 | 1.7 | 6.9 | 120.0 | 20.8 | 142 | 6 | 4 | 0.3 | 0.4 | 10.0 | 2.0 |
| | California Scorpionfish | 33 | 1 | 3 | 11.0 | 11.0 | 11.0 | 11.0 | ns | — | — | — | — | — | — |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 1 | 6 | 10.0 | 10.0 | 10.0 | 10.0 |
| | English Sole | 20 | 3 | 15 | 2.9 | 25.0 | 47.0 | 25.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 33 | 46 | 6.4 | 27.0 | 120.0 | 39.7 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 207 | 38 | 18 | 1.7 | 3.5 | 22.0 | 4.3 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | ns | — | — | — | — | — | — | 33 | 1 | 3 | 0.7 | 0.7 | 0.7 | 0.7 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 2 | 25 | 0.3 | 0.4 | 0.4 | 0.4 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 42 | 2 | 5 | 0.3 | 0.3 | 0.3 | 0.3 |
| p,p-DDE | ALL SPECIES | 347 | 341 | 98 | 35.0 | 390.0 | 4190.0 | 636.4 | 148 | 136 | 92 | 0.3 | 6.4 | 200.0 | 13.4 |
| | California Scorpionfish | 33 | 33 | 100 | 130.0 | 1000.0 | 4190.0 | 1196.0 | 10 | 10 | 100 | 1.6 | 20.2 | 30.1 | 17.7 |
| | Canary Rockfish | ns | — | — | — | — | — | — | 1 | 1 | 100 | 14.0 | 14.0 | 14.0 | 14.0 |
| | Chilipepper | ns | — | — | — | — | — | — | 2 | 2 | 100 | 4.5 | 5.6 | 6.7 | 5.6 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 16 | 89 | 1.3 | 7.6 | 200.0 | 28.6 |
| | Dover Sole | 3 | 3 | 100 | 38.0 | 57.0 | 94.0 | 63.0 | ns | — | — | — | — | — | — |
| | English Sole | 20 | 17 | 85 | 73.0 | 130.0 | 780.0 | 225.6 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 900.0 | 1415.0 | 1930.0 | 1415.0 | 2 | 2 | 100 | 5.3 | 36.2 | 67.0 | 36.2 |
| | Greenblotched Rockfish | 2 | 2 | 100 | 140.0 | 435.0 | 730.0 | 435.0 | 3 | 3 | 100 | 4.1 | 9.2 | 9.7 | 7.7 |
| | Greenspotted Rockfish | 2 | 2 | 100 | 250.0 | 590.0 | 930.0 | 590.0 | 2 | 2 | 100 | 3.0 | 8.0 | 13.0 | 8.0 |
| | Greenstriped Rockfish | ns | — | — | — | — | — | — | 1 | 1 | 100 | 2.9 | 2.9 | 2.9 | 2.9 |
| | Halfbanded Rockfish | 2 | 2 | 100 | 320.0 | 345.0 | 370.0 | 345.0 | ns | — | — | — | — | — | — |
| | Hornyhead Turbot | 2 | 2 | 100 | 170.0 | 195.0 | 220.0 | 195.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 70 | 97 | 352.0 | 1240.0 | 3800.0 | 1318.0 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 207 | 206 | 100 | 35.0 | 317.5 | 1800.0 | 355.3 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 2 | 100 | 340.0 | 1060.0 | 1780.0 | 1060.0 | 34 | 32 | 94 | 0.7 | 8.0 | 60.0 | 12.1 |
| | Rosethorn Rockfish | ns | — | — | — | — | — | — | 1 | 1 | 100 | 2.2 | 2.2 | 2.2 | 2.2 |
| | Speckled Rockfish | ns | — | — | — | — | — | — | 15 | 14 | 93 | 0.3 | 2.1 | 16.0 | 4.6 |

**ATTACHMENT C5-C** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticide** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| p,p-DDE | Squarespot Rockfish | ns | — | — | — | — | — | — | 3 | 3 | 100 | 11.0 | 13.0 | 20.0 | 14.7 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 9 | 100 | 1.7 | 18.0 | 110.0 | 33.5 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 38 | 84 | 0.3 | 5.2 | 24.0 | 6.3 |
| | Yellowtail Rockfish | ns | — | — | — | — | — | — | 2 | 2 | 100 | 3.3 | 4.8 | 6.3 | 4.8 |
| p,-p-DDMU | ALL SPECIES | 188 | 152 | 81 | 3.0 | 14.0 | 70.0 | 15.5 | 96 | 13 | 14 | 0.2 | 0.5 | 1.6 | 0.7 |
| | California Scorpionfish | ns | — | — | — | — | — | — | 3 | 1 | 33 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 11 | 1 | 9 | 0.9 | 0.9 | 0.9 | 0.9 |
| | English Sole | 10 | 3 | 30 | 3.0 | 19.0 | 70.0 | 30.7 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 178 | 149 | 84 | 4.3 | 14.0 | 40.0 | 15.2 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | ns | — | — | — | — | — | — | 23 | 3 | 13 | 0.3 | 0.4 | 1.6 | 0.8 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 6 | 2 | 33 | 0.7 | 0.9 | 1.0 | 0.9 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 28 | 6 | 21 | 0.2 | 0.5 | 1.0 | 0.6 |

**ATTACHMENT C5-D**

Summary of PCB congener concentrations (ppb) in liver and muscle tissue samples for each fish species sampled from 1995 through 2020. Detected values are summarized for liver tissues from trawl zones and muscle tissues from rig fishing stations sampled during October surveys; ns = not sampled; nd = not detected.

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Congener | Species | Total | Detect | Freq | Min | Med | Max | Mean | Total | Detect | Freq | Min | Med | Max | Mean |
| PCB 8 | ALL SPECIES | 54 | 0 | 0 | nd | nd | nd | nd | 18 | 2 | 11 | 3.3 | 3.4 | 3.4 | 3.4 |
| | Speckled Rockfish | ns | — | — | — | — | — | — | 3 | 1 | 33 | 3.3 | 3.3 | 3.3 | 3.3 |
| | Squarespot Rockfish | ns | — | — | — | — | — | — | 1 | 1 | 100 | 3.4 | 3.4 | 3.4 | 3.4 |
| PCB 18 | ALL SPECIES | 346 | 1 | 0 | 8.0 | 8.0 | 8.0 | 8.0 | 148 | 0 | 0 | nd | nd | nd | nd |
| | Pacific Sanddab | 206 | 1 | 0 | 8.0 | 8.0 | 8.0 | 8.0 | ns | — | — | — | — | — | — |
| PCB 28 | ALL SPECIES | 344 | 9 | 3 | 1.1 | 1.5 | 4.0 | 1.8 | 145 | 0 | 0 | nd | nd | nd | nd |
| | Pacific Sanddab | 204 | 9 | 4 | 1.1 | 1.5 | 4.0 | 1.8 | ns | — | — | — | — | — | — |
| PCB 44 | ALL SPECIES | 348 | 17 | 5 | 0.8 | 22.0 | 130.0 | 29.4 | 147 | 1 | 1 | 0.1 | 0.1 | 0.1 | 0.1 |
| | Longfin Sanddab | 72 | 7 | 10 | 22.1 | 36.0 | 130.0 | 57.4 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 9 | 4 | 0.8 | 1.0 | 22.0 | 3.5 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 1 | 50 | 66.0 | 66.0 | 66.0 | 66.0 | 34 | 1 | 3 | 0.1 | 0.1 | 0.1 | 0.1 |
| PCB 49 | ALL SPECIES | 294 | 74 | 25 | 1.2 | 3.0 | 64.0 | 4.6 | 127 | 2 | 2 | 0.2 | 0.3 | 0.4 | 0.3 |
| | English Sole | 16 | 1 | 6 | 1.6 | 1.6 | 1.6 | 1.6 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 1 | 2 | 6.8 | 6.8 | 6.8 | 6.8 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 72 | 36 | 1.2 | 3.0 | 64.0 | 4.7 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | ns | — | — | — | — | — | — | 29 | 1 | 3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 7 | 1 | 14 | 0.4 | 0.4 | 0.4 | 0.4 |
| PCB 50 | ALL SPECIES | 54 | 0 | 25 | 1.2 | 3.0 | 64.0 | 4.6 | 18 | 0 | 0 | nd | nd | nd | nd |
| PCB 52 | ALL SPECIES | 348 | 81 | 23 | 1.0 | 4.4 | 240.0 | 11.1 | 143 | 3 | 2 | 0.3 | 0.5 | 0.7 | 0.5 |
| | English Sole | 20 | 1 | 5 | 1.0 | 1.0 | 1.0 | 1.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 1 | 1 | 9.8 | 9.8 | 9.8 | 9.8 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 78 | 38 | 1.4 | 4.4 | 140.0 | 8.3 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 1 | 50 | 240.0 | 240.0 | 240.0 | 240.0 | 33 | 2 | 6 | 0.3 | 0.5 | 0.7 | 0.5 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 1 | 13 | 0.5 | 0.5 | 0.5 | 0.5 |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Congener | Species | Total | Detect | Freq | Min | Med | Max | Mean | Total | Detect | Freq | Min | Med | Max | Mean |
| PCB 66 | ALL SPECIES | 348 | 99 | 28 | 1.8 | 4.1 | 130.0 | 7.7 | 144 | 3 | 2 | 0.2 | 0.3 | 1.5 | 0.7 |
| | California Scorpionfish | 33 | 2 | 6 | 7.4 | 10.7 | 14.0 | 10.7 | ns | — | — | — | — | — | — |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 1 | 6 | 1.5 | 1.5 | 1.5 | 1.5 |
| | English Sole | 20 | 1 | 5 | 1.8 | 1.8 | 1.8 | 1.8 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 7 | 10 | 7.8 | 17.0 | 38.0 | 18.9 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 88 | 42 | 1.9 | 3.9 | 57.3 | 5.4 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 1 | 50 | 130.0 | 130.0 | 130.0 | 130.0 | 33 | 1 | 3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 1 | 11 | 0.2 | 0.2 | 0.2 | 0.2 |
| PCB 70 | ALL SPECIES | 294 | 76 | 26 | 1.0 | 2.9 | 19.0 | 3.6 | 128 | 3 | 2 | 0.2 | 0.3 | 0.3 | 0.3 |
| | English Sole | 16 | 1 | 6 | 1.0 | 1.0 | 1.0 | 1.0 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 75 | 38 | 1.6 | 2.9 | 19.0 | 3.6 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | ns | — | — | — | — | — | — | 29 | 2 | 7 | 0.2 | 0.3 | 0.3 | 0.3 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 1 | 13 | 0.3 | 0.3 | 0.3 | 0.3 |
| PCB 74 | ALL SPECIES | 294 | 34 | 12 | 0.9 | 1.8 | 52.1 | 3.6 | 128 | 0 | 0 | nd | nd | nd | nd |
| | Pacific Sanddab | 199 | 34 | 17 | 0.9 | 1.8 | 52.1 | 3.6 | ns | — | — | — | — | — | — |
| PCB 77 | ALL SPECIES | 348 | 9 | 3 | 6.4 | 27.0 | 76.0 | 28.8 | 148 | 0 | 0 | nd | nd | nd | nd |
| | California Scorpionfish | 33 | 1 | 3 | 29.0 | 29.0 | 29.0 | 29.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 6 | 8 | 6.4 | 23.5 | 76.0 | 30.7 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 2 | 1 | 8.2 | 23.1 | 38.0 | 23.1 | ns | — | — | — | — | — | — |
| PCB 81 | ALL SPECIES | 54 | 0 | 25 | 1.2 | 3.0 | 64.0 | 4.6 | 18 | 0 | 0 | nd | nd | nd | nd |
| PCB 87 | ALL SPECIES | 348 | 57 | 16 | 1.2 | 4.0 | 1650.0 | 52.1 | 148 | 9 | 6 | 0.4 | 9.6 | 18.0 | 9.2 |
| | California Scorpionfish | 33 | 2 | 6 | 18.0 | 51.5 | 85.0 | 51.5 | ns | — | — | — | — | — | — |
| | Canary Rockfish | ns | — | — | — | — | — | — | 1 | 1 | 100 | 15.0 | 15.0 | 15.0 | 15.0 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 2 | 11 | 1.7 | 7.4 | 13.0 | 7.4 |
| | Dover Sole | 3 | 1 | 33 | 160.0 | 160.0 | 160.0 | 160.0 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 1 | 50 | 34.0 | 34.0 | 34.0 | 34.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 11 | 15 | 4.0 | 62.0 | 1650.0 | 197.5 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 42 | 20 | 1.2 | 3.5 | 150.0 | 12.0 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | ns | — | — | — | — | — | — | 34 | 3 | 9 | 0.8 | 9.6 | 18.0 | 9.5 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 1 | 11 | 0.4 | 0.4 | 0.4 | 0.4 |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Congener** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 2 | 4 | 6.5 | 12.3 | 18.0 | 12.3 |
| PCB 99 | ALL SPECIES | 294 | 215 | 73 | 4.3 | 19.0 | 328.0 | 29.2 | 130 | 18 | 14 | 0.2 | 0.5 | 4.1 | 1.0 |
| | California Scorpionfish | 27 | 10 | 37 | 21.0 | 34.0 | 72.0 | 37.5 | 8 | 1 | 13 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Chilipepper | ns | — | — | — | — | — | — | 2 | 1 | 50 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 16 | 3 | 19 | 0.4 | 0.5 | 4.1 | 1.7 |
| | English Sole | 16 | 2 | 13 | 4.8 | 9.4 | 14.0 | 9.4 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 76.0 | 103.0 | 130.0 | 103.0 | 2 | 1 | 50 | 1.4 | 1.4 | 1.4 | 1.4 |
| | Greenblotched Rockfish | 1 | 1 | 100 | 15.0 | 15.0 | 15.0 | 15.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 2 | 100 | 15.0 | 21.0 | 27.0 | 21.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 36 | 84 | 15.0 | 46.0 | 170.0 | 53.9 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 161 | 81 | 4.3 | 15.5 | 328.0 | 21.6 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 200.0 | 200.0 | 200.0 | 200.0 | 29 | 6 | 21 | 0.2 | 0.7 | 1.5 | 0.8 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 3 | 38 | 0.6 | 1.2 | 2.7 | 1.5 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 42 | 3 | 7 | 0.3 | 0.4 | 0.6 | 0.4 |
| PCB 101 | ALL SPECIES | 348 | 224 | 64 | 2.6 | 15.6 | 1100.0 | 29.9 | 148 | 18 | 12 | 0.2 | 0.7 | 5.7 | 1.3 |
| | California Scorpionfish | 33 | 12 | 36 | 20.0 | 27.5 | 66.0 | 34.3 | 10 | 1 | 10 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 4 | 22 | 0.5 | 1.0 | 5.7 | 2.1 |
| | Dover Sole | 3 | 1 | 33 | 15.0 | 15.0 | 15.0 | 15.0 | ns | — | — | — | — | — | — |
| | English Sole | 20 | 3 | 15 | 4.7 | 17.0 | 26.0 | 15.9 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 88.0 | 129.0 | 170.0 | 129.0 | 2 | 1 | 50 | 1.7 | 1.7 | 1.7 | 1.7 |
| | Greenblotched Rockfish | 2 | 1 | 50 | 20.0 | 20.0 | 20.0 | 20.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 2 | 100 | 15.0 | 24.0 | 33.0 | 24.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 47 | 65 | 5.8 | 43.0 | 120.0 | 44.6 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 154 | 74 | 2.6 | 11.0 | 260.0 | 16.3 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 2 | 100 | 180.0 | 640.0 | 1100.0 | 640.0 | 34 | 6 | 18 | 0.2 | 0.9 | 1.8 | 0.9 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 3 | 33 | 0.7 | 1.8 | 3.8 | 2.1 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 3 | 7 | 0.3 | 0.5 | 0.5 | 0.4 |
| PCB 104 | ALL SPECIES | 54 | 0 | 43 | 2.4 | 8.1 | 540.0 | 19.9 | 14 | 0 | 0 | nd | nd | nd | nd |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Congener** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| PCB 105 | ALL SPECIES | 348 | 151 | 43 | 2.4 | 8.1 | 540.0 | 19.9 | 148 | 6 | 4 | 0.4 | 0.6 | 2.7 | 1.0 |
| | California Scorpionfish | 33 | 4 | 12 | 5.3 | 19.0 | 24.0 | 16.8 | ns | — | — | — | — | — | — |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 1 | 6 | 2.7 | 2.7 | 2.7 | 2.7 |
| | Flag Rockfish | 2 | 2 | 100 | 43.0 | 60.0 | 77.0 | 60.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 1 | 50 | 14.0 | 14.0 | 14.0 | 14.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 24 | 33 | 8.5 | 32.0 | 64.0 | 33.3 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 118 | 57 | 2.4 | 6.5 | 275.0 | 11.8 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 2 | 100 | 75.0 | 307.5 | 540.0 | 307.5 | 34 | 2 | 6 | 0.4 | 0.5 | 0.6 | 0.5 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 2 | 22 | 0.5 | 1.0 | 1.5 | 1.0 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 1 | 2 | 0.5 | 0.5 | 0.5 | 0.5 |
| PCB 110 | ALL SPECIES | 294 | 168 | 57 | 2.4 | 11.0 | 220.0 | 17.1 | 130 | 8 | 6 | 0.4 | 1.2 | 3.5 | 1.4 |
| | California Scorpionfish | 27 | 3 | 11 | 15.0 | 20.0 | 35.0 | 23.3 | ns | — | — | — | — | — | — |
| | Copper Rockfish | ns | — | — | — | — | — | — | 16 | 2 | 13 | 0.5 | 2.0 | 3.5 | 2.0 |
| | English Sole | 16 | 1 | 6 | 3.0 | 3.0 | 3.0 | 3.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 21 | 49 | 15.0 | 35.0 | 110.0 | 41.4 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 142 | 71 | 2.4 | 8.7 | 220.0 | 13.3 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 45.0 | 45.0 | 45.0 | 45.0 | 29 | 3 | 10 | 0.6 | 1.4 | 1.7 | 1.2 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 3 | 38 | 0.4 | 1.0 | 2.3 | 1.2 |
| PCB 114 | ALL SPECIES | 294 | 1 | 0 | 18.5 | 18.5 | 18.5 | 18.5 | 130 | 0 | 0 | nd | nd | nd | nd |
| | Pacific Sanddab | 199 | 1 | 1 | 18.5 | 18.5 | 18.5 | 18.5 | ns | — | — | — | — | — | — |
| PCB 118 | ALL SPECIES | 348 | 291 | 84 | 3.4 | 29.0 | 767.0 | 48.6 | 148 | 24 | 16 | 0.3 | 1.0 | 8.0 | 1.6 |
| | California Scorpionfish | 33 | 24 | 73 | 14.0 | 61.0 | 120.0 | 61.8 | 10 | 2 | 20 | 0.6 | 0.7 | 0.7 | 0.7 |
| | Chilipepper | ns | — | — | — | — | — | — | 2 | 1 | 50 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 4 | 22 | 0.6 | 2.1 | 8.0 | 3.2 |
| | English Sole | 20 | 3 | 15 | 5.4 | 20.0 | 23.0 | 16.1 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 160.0 | 220.0 | 280.0 | 220.0 | 2 | 2 | 100 | 0.3 | 1.5 | 2.6 | 1.5 |
| | Greenblotched Rockfish | 2 | 1 | 50 | 33.0 | 33.0 | 33.0 | 33.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 2 | 100 | 29.0 | 40.5 | 52.0 | 40.5 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 70 | 97 | 11.0 | 69.0 | 260.0 | 79.8 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 187 | 90 | 3.4 | 22.0 | 767.0 | 32.2 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 2 | 100 | 130.0 | 225.0 | 320.0 | 225.0 | 34 | 8 | 24 | 0.3 | 1.5 | 2.5 | 1.3 |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Congener | Species | Total | Detect | Freq | Min | Med | Max | Mean | Total | Detect | Freq | Min | Med | Max | Mean |
| | Speckled Rockfish | ns | — | — | — | — | — | — | 15 | 1 | 7 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 3 | 33 | 0.8 | 1.9 | 4.7 | 2.5 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 3 | 7 | 0.4 | 0.7 | 1.3 | 0.8 |
| PCB 119 | ALL SPECIES | 294 | 4 | 1 | 1.6 | 4.2 | 7.1 | 4.3 | 130 | 0 | 0 | nd | nd | nd | nd |
| | Pacific Sanddab | 199 | 4 | 2 | 1.6 | 4.2 | 7.1 | 4.3 | ns | — | — | — | — | — | — |
| PCB 123 | ALL SPECIES | 294 | 45 | 15 | 1.8 | 4.2 | 58.4 | 7.1 | 130 | 0 | 0 | nd | nd | nd | nd |
| | Longfin Sanddab | 43 | 2 | 5 | 6.0 | 16.0 | 26.0 | 16.0 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 42 | 21 | 1.8 | 4.1 | 58.4 | 6.2 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 27.0 | 27.0 | 27.0 | 27.0 | ns | — | — | — | — | — | — |
| PCB 126 | ALL SPECIES | 348 | 8 | 2 | 5.8 | 30.0 | 38.0 | 24.3 | 148 | 2 | 1 | 7.3 | 8.7 | 10.0 | 8.7 |
| | California Scorpionfish | 33 | 1 | 3 | 5.8 | 5.8 | 5.8 | 5.8 | ns | — | — | — | — | — | — |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 1 | 6 | 7.3 | 7.3 | 7.3 | 7.3 |
| | Longfin Sanddab | 72 | 5 | 7 | 6.4 | 34.0 | 38.0 | 25.7 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 2 | 1 | 27.0 | 30.0 | 33.0 | 30.0 | ns | — | — | — | — | — | — |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 1 | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| PCB 128 | ALL SPECIES | 348 | 164 | 47 | 2.8 | 11.0 | 192.0 | 17.2 | 148 | 7 | 5 | 0.2 | 0.4 | 2.3 | 0.8 |
| | California Scorpionfish | 33 | 5 | 15 | 11.0 | 15.0 | 30.0 | 18.6 | 10 | 1 | 10 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 1 | 6 | 2.3 | 2.3 | 2.3 | 2.3 |
| | Flag Rockfish | 2 | 1 | 50 | 61.0 | 61.0 | 61.0 | 61.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 1 | 50 | 17.0 | 17.0 | 17.0 | 17.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 33 | 46 | 13.0 | 23.0 | 68.0 | 29.8 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 122 | 59 | 2.8 | 8.0 | 144.0 | 11.5 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 2 | 100 | 81.0 | 136.5 | 192.0 | 136.5 | 34 | 2 | 6 | 0.3 | 0.4 | 0.4 | 0.4 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 3 | 33 | 0.2 | 0.3 | 1.5 | 0.7 |
| PCB 138 | ALL SPECIES | 348 | 309 | 89 | 3.7 | 39.0 | 1400.0 | 74.6 | 148 | 41 | 28 | 0.2 | 0.7 | 9.0 | 1.6 |
| | California Scorpionfish | 33 | 27 | 82 | 18.0 | 80.0 | 200.0 | 88.1 | 10 | 4 | 40 | 0.3 | 0.9 | 3.5 | 1.4 |
| | Chilipepper | ns | — | — | — | — | — | — | 2 | 2 | 100 | 0.3 | 0.4 | 0.5 | 0.4 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 6 | 33 | 0.6 | 2.2 | 9.0 | 2.9 |
| | Dover Sole | 3 | 1 | 33 | 17.0 | 17.0 | 17.0 | 17.0 | ns | — | — | — | — | — | — |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Congener** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| | English Sole | 20 | 8 | 40 | 10.0 | 19.5 | 38.0 | 20.3 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 230.0 | 295.0 | 360.0 | 295.0 | 2 | 2 | 100 | 0.5 | 2.3 | 4.2 | 2.3 |
| | Greenblotched Rockfish | 2 | 1 | 50 | 47.0 | 47.0 | 47.0 | 47.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 2 | 100 | 34.0 | 58.5 | 83.0 | 58.5 | 2 | 1 | 50 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Longfin Sanddab | 72 | 69 | 96 | 10.0 | 130.0 | 440.0 | 138.6 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 197 | 95 | 3.7 | 30.0 | 509.0 | 41.4 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 2 | 100 | 610.0 | 1005.0 | 1400.0 | 1005.0 | 34 | 9 | 26 | 0.3 | 1.5 | 3.7 | 1.5 |
| | Speckled Rockfish | ns | — | — | — | — | — | — | 15 | 2 | 13 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 4 | 44 | 0.9 | 4.2 | 6.9 | 4.1 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 11 | 24 | 0.2 | 0.4 | 1.6 | 0.5 |
| PCB 149 | ALL SPECIES | 294 | 154 | 52 | 2.2 | 8.1 | 110.0 | 13.2 | 130 | 15 | 12 | 0.2 | 0.5 | 3.7 | 1.0 |
| | California Scorpionfish | 27 | 2 | 7 | 23.0 | 24.0 | 25.0 | 24.0 | 8 | 1 | 13 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 16 | 2 | 13 | 0.5 | 1.7 | 2.8 | 1.7 |
| | English Sole | 16 | 3 | 19 | 6.2 | 14.0 | 18.0 | 12.7 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 51.0 | 80.5 | 110.0 | 80.5 | 2 | 1 | 50 | 1.6 | 1.6 | 1.6 | 1.6 |
| | Greenblotched Rockfish | 1 | 1 | 100 | 16.0 | 16.0 | 16.0 | 16.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 1 | 50 | 21.0 | 21.0 | 21.0 | 21.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 15 | 35 | 14.0 | 30.0 | 56.0 | 31.8 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 129 | 65 | 2.2 | 7.0 | 91.0 | 9.2 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 90.0 | 90.0 | 90.0 | 90.0 | 29 | 7 | 24 | 0.2 | 0.4 | 1.7 | 0.6 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 3 | 38 | 0.7 | 1.0 | 3.7 | 1.8 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 42 | 1 | 2 | 0.4 | 0.4 | 0.4 | 0.4 |
| PCB 151 | ALL SPECIES | 294 | 103 | 35 | 1.4 | 5.9 | 51.0 | 9.5 | 130 | 2 | 2 | 0.2 | 0.2 | 0.2 | 0.2 |
| | California Scorpionfish | 27 | 1 | 4 | 14.0 | 14.0 | 14.0 | 14.0 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 1 | 50 | 51.0 | 51.0 | 51.0 | 51.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 14 | 33 | 9.0 | 26.0 | 47.0 | 26.6 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 86 | 43 | 1.4 | 5.0 | 37.0 | 5.8 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 45.0 | 45.0 | 45.0 | 45.0 | 29 | 1 | 3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 1 | 13 | 0.2 | 0.2 | 0.2 | 0.2 |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Congener** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| PCB 153 | ALL SPECIES | 54 | 45 | 83 | 8.6 | 140.0 | 790.0 | 145.8 | 18 | 2 | 11 | 3.3 | 5.8 | 8.2 | 5.8 |
| | California Scorpionfish | 6 | 6 | 100 | 40.0 | 107.0 | 170.0 | 104.0 | 2 | 1 | 50 | 3.3 | 3.3 | 3.3 | 3.3 |
| | Dover Sole | 1 | 1 | 100 | 12.0 | 12.0 | 12.0 | 12.0 | ns | — | — | — | — | — | — |
| | English Sole | 4 | 1 | 25 | 51.0 | 51.0 | 51.0 | 51.0 | ns | — | — | — | — | — | — |
| | Hornyhead Turbot | 1 | 1 | 100 | 48.0 | 48.0 | 48.0 | 48.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 29 | 27 | 93 | 14.0 | 180.0 | 520.0 | 167.9 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 9 | 8 | 89 | 8.6 | 48.0 | 190.0 | 62.5 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 790.0 | 790.0 | 790.0 | 790.0 | ns | — | — | — | — | — | — |
| | Starry Rockfish | ns | — | — | — | — | — | — | 1 | 1 | 100 | 8.2 | 8.2 | 8.2 | 8.2 |
| PCB 153/168 | ALL SPECIES | 294 | 284 | 97 | 7.9 | 59.0 | 660.0 | 90.0 | 130 | 45 | 35 | 0.3 | 1.1 | 12.0 | 2.0 |
| | California Scorpionfish | 27 | 23 | 85 | 15.0 | 93.0 | 250.0 | 115.5 | 8 | 3 | 38 | 0.7 | 1.6 | 1.6 | 1.3 |
| | Chilipepper | ns | — | — | — | — | — | — | 2 | 2 | 100 | 0.5 | 0.6 | 0.7 | 0.6 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 16 | 7 | 44 | 0.9 | 2.7 | 12.0 | 3.8 |
| | Dover Sole | 2 | 1 | 50 | 14.0 | 14.0 | 14.0 | 14.0 | ns | — | — | — | — | — | — |
| | English Sole | 16 | 14 | 88 | 14.0 | 18.0 | 53.0 | 22.7 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 270.0 | 355.0 | 440.0 | 355.0 | 2 | 2 | 100 | 0.8 | 4.0 | 7.1 | 4.0 |
| | Greenblotched Rockfish | 1 | 1 | 100 | 79.0 | 79.0 | 79.0 | 79.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 2 | 100 | 48.0 | 84.0 | 120.0 | 84.0 | 2 | 1 | 50 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Longfin Sanddab | 43 | 43 | 100 | 43.0 | 170.0 | 530.0 | 195.4 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 197 | 99 | 7.9 | 50.0 | 477.0 | 63.8 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 660.0 | 660.0 | 660.0 | 660.0 | 29 | 12 | 41 | 0.3 | 1.2 | 6.1 | 1.9 |
| | Speckled Rockfish | ns | — | — | — | — | — | — | 12 | 1 | 8 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 4 | 50 | 1.6 | 2.5 | 9.7 | 4.1 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 42 | 13 | 31 | 0.3 | 0.7 | 2.2 | 0.9 |
| PCB 154 | ALL SPECIES | 54 | 24 | 44 | 6.4 | 34.0 | 380.0 | 52.1 | 18 | 0 | 0 | nd | nd | nd | nd |
| | California Scorpionfish | 6 | 1 | 17 | 29.0 | 29.0 | 29.0 | 29.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 29 | 17 | 59 | 6.4 | 28.0 | 110.0 | 36.3 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 9 | 5 | 56 | 24.0 | 46.0 | 68.0 | 44.8 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 380.0 | 380.0 | 380.0 | 380.0 | ns | — | — | — | — | — | — |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Congener** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| PCB 156 | ALL SPECIES | 294 | 76 | 26 | 2.2 | 5.2 | 81.6 | 9.6 | 130 | 1 | 1 | 0.7 | 0.7 | 0.7 | 0.7 |
| | California Scorpionfish | 27 | 1 | 4 | 24.0 | 24.0 | 24.0 | 24.0 | 8 | 1 | 13 | 0.7 | 0.7 | 0.7 | 0.7 |
| | Flag Rockfish | 2 | 1 | 50 | 40.0 | 40.0 | 40.0 | 40.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 5 | 12 | 8.2 | 24.0 | 41.0 | 23.4 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 68 | 34 | 2.2 | 4.9 | 81.6 | 7.1 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 65.0 | 65.0 | 65.0 | 65.0 | ns | — | — | — | — | — | — |
| PCB 157 | ALL SPECIES | 294 | 5 | 2 | 3.0 | 3.1 | 19.3 | 6.5 | 130 | 1 | 1 | 0.7 | 0.7 | 0.7 | 0.7 |
| | California Scorpionfish | ns | — | — | — | — | — | — | 8 | 1 | 13 | 0.7 | 0.7 | 0.7 | 0.7 |
| | Pacific Sanddab | 199 | 5 | 3 | 3.0 | 3.1 | 19.3 | 6.5 | ns | — | — | — | — | — | — |
| PCB 158 | ALL SPECIES | 294 | 58 | 20 | 1.4 | 3.6 | 70.1 | 10.5 | 130 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0.5 |
| | California Scorpionfish | ns | — | — | — | — | — | — | 8 | 1 | 13 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Flag Rockfish | 2 | 2 | 100 | 25.0 | 33.5 | 42.0 | 33.5 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 7 | 16 | 24.0 | 28.0 | 38.0 | 29.0 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 48 | 24 | 1.4 | 3.1 | 70.1 | 5.7 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 63.0 | 63.0 | 63.0 | 63.0 | ns | — | — | — | — | — | — |
| PCB 167 | ALL SPECIES | 294 | 62 | 21 | 1.1 | 3.0 | 31.3 | 4.2 | 130 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0.5 |
| | California Scorpionfish | ns | — | — | — | — | — | — | 8 | 1 | 13 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Longfin Sanddab | 43 | 1 | 2 | 5.5 | 5.5 | 5.5 | 5.5 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 61 | 31 | 1.1 | 3.0 | 31.3 | 4.2 | ns | — | — | — | — | — | — |
| PCB 169 | ALL SPECIES | 294 | 4 | 1 | 3.3 | 4.7 | 11.0 | 5.9 | 130 | 0 | 0 | nd | nd | nd | nd |
| | Longfin Sanddab | 43 | 1 | 2 | 11.0 | 11.0 | 11.0 | 11.0 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 3 | 2 | 3.3 | 4.3 | 5.1 | 4.2 | ns | — | — | — | — | — | — |
| PCB 170 | ALL SPECIES | 348 | 169 | 49 | 2.4 | 11.5 | 130.0 | 20.7 | 148 | 2 | 1 | 0.4 | 0.4 | 0.4 | 0.4 |
| | California Scorpionfish | 33 | 9 | 27 | 12.0 | 39.0 | 69.0 | 40.3 | ns | — | — | — | — | — | — |
| | Dover Sole | 3 | 1 | 33 | 11.0 | 11.0 | 11.0 | 11.0 | ns | — | — | — | — | — | — |
| | English Sole | 20 | 1 | 5 | 3.6 | 3.6 | 3.6 | 3.6 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 43.0 | 59.0 | 75.0 | 59.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 37 | 51 | 9.5 | 33.0 | 97.0 | 39.2 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 117 | 56 | 2.4 | 7.5 | 78.0 | 11.4 | ns | — | — | — | — | — | — |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Congener** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| | Mixed Rockfish | 2 | 2 | 100 | 96.0 | 113.0 | 130.0 | 113.0 | 34 | 1 | 3 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 1 | 11 | 0.4 | 0.4 | 0.4 | 0.4 |
| PCB 177 | ALL SPECIES | 294 | 80 | 27 | 1.8 | 4.9 | 36.0 | 9.0 | 130 | 1 | 1 | 0.2 | 0.2 | 0.2 | 0.2 |
| | California Scorpionfish | 27 | 3 | 11 | 18.0 | 18.0 | 22.0 | 19.3 | ns | — | — | — | — | — | — |
| | English Sole | 16 | 1 | 6 | 2.9 | 2.9 | 2.9 | 2.9 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 15 | 35 | 7.2 | 20.0 | 36.0 | 21.6 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 60 | 30 | 1.8 | 3.9 | 29.0 | 5.1 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 31.0 | 31.0 | 31.0 | 31.0 | ns | — | — | — | — | — | — |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 1 | 13 | 0.2 | 0.2 | 0.2 | 0.2 |
| PCB 180 | ALL SPECIES | 348 | 289 | 83 | 4.2 | 27.0 | 270.0 | 44.5 | 148 | 21 | 14 | 0.2 | 1.2 | 5.6 | 1.8 |
| | California Scorpionfish | 33 | 23 | 70 | 19.0 | 60.0 | 110.0 | 60.6 | 10 | 1 | 10 | 0.9 | 0.9 | 0.9 | 0.9 |
| | Chilipepper | ns | — | — | — | — | — | — | 2 | 1 | 50 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 6 | 33 | 0.5 | 1.7 | 5.6 | 2.1 |
| | English Sole | 20 | 4 | 20 | 10.0 | 18.0 | 34.0 | 20.0 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 98.0 | 129.0 | 160.0 | 129.0 | 2 | 2 | 100 | 0.4 | 2.2 | 4.0 | 2.2 |
| | Greenblotched Rockfish | 2 | 1 | 50 | 48.0 | 48.0 | 48.0 | 48.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 2 | 100 | 20.0 | 37.0 | 54.0 | 37.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 70 | 97 | 6.7 | 79.0 | 220.0 | 81.7 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 185 | 89 | 4.2 | 20.5 | 150.0 | 26.7 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 2 | 100 | 75.0 | 172.5 | 270.0 | 172.5 | 34 | 6 | 18 | 0.6 | 1.5 | 2.8 | 1.5 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 4 | 44 | 0.5 | 2.8 | 4.7 | 2.7 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 1 | 2 | 0.2 | 0.2 | 0.2 | 0.2 |
| PCB 183 | ALL SPECIES | 294 | 159 | 54 | 2.1 | 7.6 | 88.0 | 14.1 | 130 | 3 | 2 | 0.2 | 0.3 | 1.7 | 0.7 |
| | California Scorpionfish | 27 | 7 | 26 | 22.5 | 27.0 | 35.0 | 28.1 | ns | — | — | — | — | — | — |
| | Copper Rockfish | ns | — | — | — | — | — | — | 16 | 1 | 6 | 1.7 | 1.7 | 1.7 | 1.7 |
| | English Sole | 16 | 1 | 6 | 2.7 | 2.7 | 2.7 | 2.7 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 37.0 | 45.5 | 54.0 | 45.5 | ns | — | — | — | — | — | — |
| | Greenblotched Rockfish | 1 | 1 | 100 | 15.0 | 15.0 | 15.0 | 15.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 1 | 50 | 18.0 | 18.0 | 18.0 | 18.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 30 | 70 | 13.5 | 27.5 | 64.0 | 31.1 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 116 | 58 | 2.1 | 6.0 | 40.0 | 7.7 | ns | — | — | — | — | — | — |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Congener** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| | Mixed Rockfish | 1 | 1 | 100 | 88.0 | 88.0 | 88.0 | 88.0 | ns | — | — | — | — | — | — |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 2 | 25 | 0.2 | 0.3 | 0.3 | 0.3 |
| PCB 187 | ALL SPECIES | 348 | 292 | 84 | 2.6 | 25.0 | 270.0 | 38.9 | 148 | 23 | 16 | 0.2 | 0.7 | 3.9 | 1.2 |
| | California Scorpionfish | 33 | 22 | 67 | 16.0 | 57.5 | 130.0 | 55.8 | 10 | 2 | 20 | 0.5 | 0.6 | 0.7 | 0.6 |
| | Copper Rockfish | ns | — | — | — | — | — | — | 18 | 5 | 28 | 0.3 | 1.6 | 3.9 | 1.7 |
| | Dover Sole | 3 | 1 | 33 | 7.6 | 7.6 | 7.6 | 7.6 | ns | — | — | — | — | — | — |
| | English Sole | 20 | 5 | 25 | 9.9 | 15.0 | 27.0 | 18.4 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 2 | 100 | 78.0 | 94.0 | 110.0 | 94.0 | 2 | 1 | 50 | 2.9 | 2.9 | 2.9 | 2.9 |
| | Greenblotched Rockfish | 2 | 1 | 50 | 32.0 | 32.0 | 32.0 | 32.0 | ns | — | — | — | — | — | — |
| | Greenspotted Rockfish | 2 | 2 | 100 | 21.0 | 33.5 | 46.0 | 33.5 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 71 | 99 | 13.0 | 70.0 | 230.0 | 74.9 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 208 | 186 | 89 | 2.6 | 18.5 | 110.0 | 22.1 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 2 | 100 | 51.0 | 160.5 | 270.0 | 160.5 | 34 | 8 | 24 | 0.2 | 0.6 | 2.3 | 0.9 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 9 | 4 | 44 | 0.5 | 2.1 | 3.3 | 2.0 |
| | Vermilion Rockfish | ns | — | — | — | — | — | — | 45 | 3 | 7 | 0.2 | 0.2 | 0.3 | 0.2 |
| PCB 188 | ALL SPECIES | 54 | 13 | 24 | 8.2 | 24.0 | 130.0 | 31.0 | 18 | 0 | 0 | nd | nd | nd | nd |
| | California Scorpionfish | 6 | 2 | 33 | 16.0 | 30.0 | 44.0 | 30.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 29 | 7 | 24 | 9.1 | 24.0 | 36.0 | 23.9 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 9 | 3 | 33 | 8.2 | 9.3 | 28.0 | 15.2 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 130.0 | 130.0 | 130.0 | 130.0 | ns | — | — | — | — | — | — |
| PCB 189 | ALL SPECIES | 294 | 2 | 1 | 1.6 | 2.1 | 2.6 | 2.1 | 130 | 0 | 0 | nd | nd | nd | nd |
| | Pacific Sanddab | 199 | 2 | 1 | 1.6 | 2.1 | 2.6 | 2.1 | ns | — | — | — | — | — | — |
| PCB 194 | ALL SPECIES | 294 | 112 | 38 | 1.7 | 7.7 | 58.0 | 13.4 | 130 | 1 | 1 | 0.9 | 0.9 | 0.9 | 0.9 |
| | California Scorpionfish | 27 | 3 | 11 | 26.0 | 28.0 | 29.0 | 27.7 | 8 | 1 | 13 | 0.9 | 0.9 | 0.9 | 0.9 |
| | Longfin Sanddab | 43 | 17 | 40 | 14.2 | 29.0 | 47.0 | 29.7 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 91 | 46 | 1.7 | 6.2 | 50.9 | 9.4 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 58.0 | 58.0 | 58.0 | 58.0 | ns | — | — | — | — | — | — |

**ATTACHMENT C5-D** *continued*

| | | Liver Tissues (Trawl Zones) | | | | | | | Muscle Tissues (RF Stations) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Congener** | **Species** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** | **Total** | **Detect** | **Freq** | **Min** | **Med** | **Max** | **Mean** |
| PCB 195 | ALL SPECIES | 54 | 8 | 15 | 9.5 | 20.0 | 24.0 | 19.6 | 18 | 0 | 0 | nd | nd | nd | nd |
| | California Scorpionfish | 6 | 2 | 33 | 9.5 | 16.8 | 24.0 | 16.8 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 29 | 4 | 14 | 17.5 | 19.5 | 23.0 | 19.9 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 9 | 2 | 22 | 20.0 | 22.0 | 24.0 | 22.0 | ns | — | — | — | — | — | — |
| PCB 200 | ALL SPECIES | 63 | 12 | 19 | 5.8 | 13.0 | 22.0 | 13.6 | 24 | 1 | 4 | 51.0 | 51.0 | 51.0 | 51.0 |
| | California Scorpionfish | 11 | 2 | 18 | 20.0 | 21.0 | 22.0 | 21.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 33 | 7 | 21 | 5.8 | 11.0 | 20.0 | 11.2 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 9 | 3 | 33 | 10.0 | 15.0 | 18.0 | 14.3 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | ns | — | — | — | — | — | — | 6 | 1 | 17 | 51.0 | 51.0 | 51.0 | 51.0 |
| PCB 201 | ALL SPECIES | 294 | 71 | 24 | 2.0 | 12.0 | 67.0 | 17.1 | 130 | 2 | 2 | 0.3 | 0.3 | 0.3 | 0.3 |
| | California Scorpionfish | 27 | 4 | 15 | 17.5 | 21.8 | 42.0 | 25.8 | ns | — | — | — | — | — | — |
| | Flag Rockfish | 2 | 1 | 50 | 33.0 | 33.0 | 33.0 | 33.0 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 43 | 26 | 60 | 14.0 | 26.5 | 54.0 | 28.1 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 199 | 39 | 20 | 2.0 | 5.7 | 31.0 | 7.2 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 1 | 1 | 100 | 67.0 | 67.0 | 67.0 | 67.0 | 29 | 1 | 3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Starry Rockfish | ns | — | — | — | — | — | — | 8 | 1 | 13 | 0.3 | 0.3 | 0.3 | 0.3 |
| PCB 206 | ALL SPECIES | 341 | 98 | 29 | 1.8 | 6.8 | 40.0 | 9.1 | 142 | 0 | 0 | nd | nd | nd | nd |
| | California Scorpionfish | 33 | 1 | 3 | 7.9 | 7.9 | 7.9 | 7.9 | ns | — | — | — | — | — | — |
| | English Sole | 20 | 1 | 5 | 5.5 | 5.5 | 5.5 | 5.5 | ns | — | — | — | — | — | — |
| | Longfin Sanddab | 72 | 11 | 15 | 4.2 | 16.0 | 32.0 | 17.4 | ns | — | — | — | — | — | — |
| | Pacific Sanddab | 201 | 84 | 42 | 1.8 | 5.7 | 38.2 | 7.7 | ns | — | — | — | — | — | — |
| | Mixed Rockfish | 2 | 1 | 50 | 40.0 | 40.0 | 40.0 | 40.0 | ns | — | — | — | — | — | — |