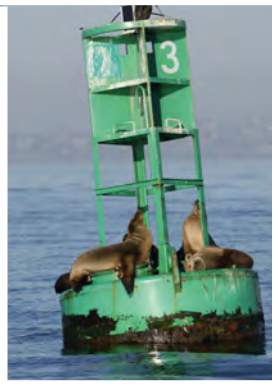
2023 Biological Surveys

Los Angeles and Long Beach Harbors











Submitted to:

THE PORT OF LOS ANGELES

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THE GREEN PORT

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2023 BIOLOGICAL SURVEYS OF THE LONG BEACH AND LOS ANGELES HARBORS

April 2026

Prepared for:
Port of Los Angeles (Agreement #: 22-9879)
Port of Long Beach (Contract #: HD-9463)

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Acknowledgements:

This report is the result of hard work by and dedication from many individuals with a common goal: improve our understanding of the biological communities within the Ports of Los Angeles and Long Beach. Thanks to the lead agency participants for their great ideas and input throughout: Justin Luedy from the Port of Long Beach and Kat Prickett and Victoria Wood from the Port of Los Angeles.

Special thanks to the following for all of the outstanding support provided to implement the program and prepare this report: Captain Chris Clark and his crew from Seaventures for vessel and sampling support; Mary Tamburro and Brandon Stidum from Merkel for field sampling support; Andy Martin from Anchor QEA for providing sediment and infauna data; Dean Pasko and the Dancing Coyote Environmental team for epifaunal taxonomy support; Jimmy Nunez, David Schuessler, and James Sloan of MBC Aquatic Sciences for vessel and ichthyoplankton sampling support; Jeremy Burns, Rolf Schottle, Marisa Swiderski, Kate Buckley, Mackenzie Tassiello, and Tyler Daniel of WSP for a wide variety of support in the field, data analyses, and reporting-related efforts; and Bill Isham of WSP for ichthyoplankton taxonomy.

EXECUTIVE SUMMARY

I. INTRODUCTION

San Pedro Bay is home to rich and diverse biological communities that play an important role in the coastal marine biological resources of Southern California. These communities co-exist among the operations of the nation's largest port complex: the Ports of Los Angeles and Long Beach. This report describes both the current state of those communities and the changes in those communities over the past 40 years in response to federal and state regulatory programs and the robust environmental initiatives of the two ports.

The Long Beach-Los Angeles Port Complex (Port Complex) today (Figure ES-1) consists largely of deep channels and basins for the navigation of cargo vessels and other watercraft, and dry land to support marine cargo terminals and other water-related uses. Most of the shoreline is protected by rock dikes, rock revetments, and sheet-pile or concrete bulkheads, and is lined by pile-supported wharves and piers. Virtually none of the original coastal features on which the ports were built over the past 100+ years – tidal marshes, mudflats, sandy beaches, and tidal channels – are still present. Small stretches of sandy beach and small areas of shallow water are present, largely as byproducts of past development or as mitigation efforts by the ports.

The ports are charged by various laws with both accommodating maritime commerce, navigation, and fisheries and with managing and protecting the marine resources of the harbors for the people of California. As part of that stewardship, the ports have conducted periodic, comprehensive biological surveys (Biosurveys). Early studies focused on one port or the other, but starting in 2000, the Biosurveys covered the entire Port Complex. Other studies sponsored by state and local agencies and public utilities have provided additional information on conditions in the Port Complex and nearby coastal areas over the past 70 years. The earliest studies documented degraded conditions in the harbors, including areas virtually devoid of marine life because of low dissolved oxygen levels partially the result of unregulated pollution from the urbanized greater Los Angeles area. Since the mid-1970s, however, conditions have steadily improved because of pollution control efforts mandated by the Clean Water Act of 1972.

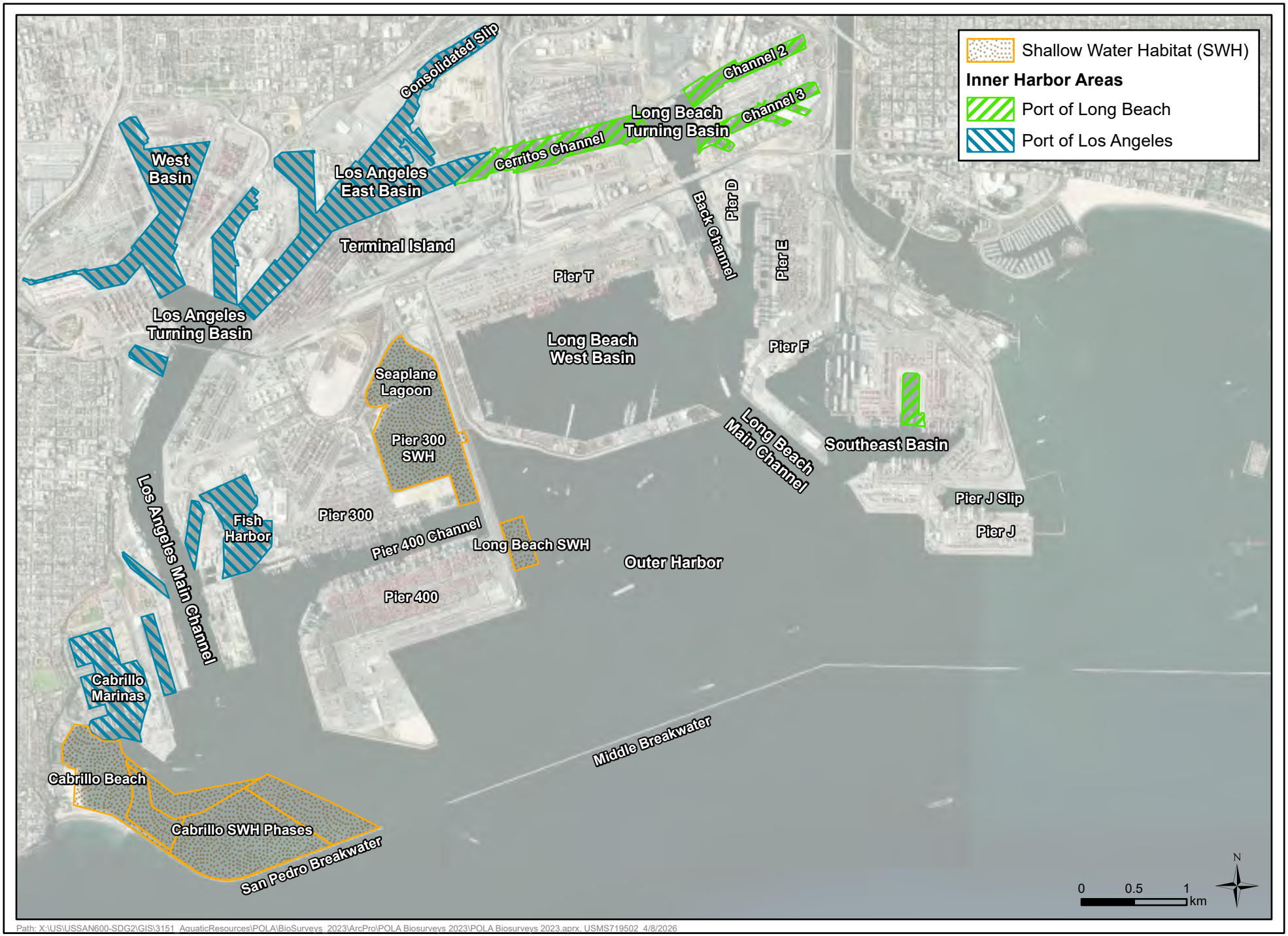
The latest harbor-wide Biosurvey, conducted from April 2023 to March 2024, is the subject of this report. This Biosurvey supplements and updates the information provided by the four previous harbor-wide Biosurveys (2000, 2008, 2013, 2018). Like those surveys, the current Biosurvey focuses on the following physical conditions and the marine biota of the Port Complex:

- Pelagic (open water) zone
- Harbor soft bottom habitats (including eelgrass beds)
- Hard substrate habitats (riprap and boulder shorelines, pilings, breakwaters, kelp beds)
- Birds and marine mammals of the Port Complex

The 2023 Biosurvey, as with the previous Biosurveys, has four key objectives:

1) Describe the biological communities of the various habitats in the Port Complex.
2) Describe how those communities have changed over time.
3) Describe how those communities compare among different habitats and subregions within the Port Complex and in the greater Southern California coastal region.
4) Document the occurrence of non-native species in the Port Complex.

On the basis of the past Biosurveys, the ports and the wildlife resource agencies recognize three ecological zones in the Port Complex (Figure ES-1): Outer Harbor, consisting of deep open-water areas and most of the deep channels and basins; Shallow-Water Habitat (SWH), consisting of areas in the Outer Harbor less than 20 feet deep; and Inner Harbor, consisting largely of dead-end slips and other areas in the interior reaches of the Port Complex (Figure ES-1). Sampling was conducted at the stations and in the zones indicated in Figures ES-2 through ES-5, the number and location of stations varying with the type of sampling. In the case of kelp and eelgrass, sampling covered the entire Port Complex rather than being restricted to stations.



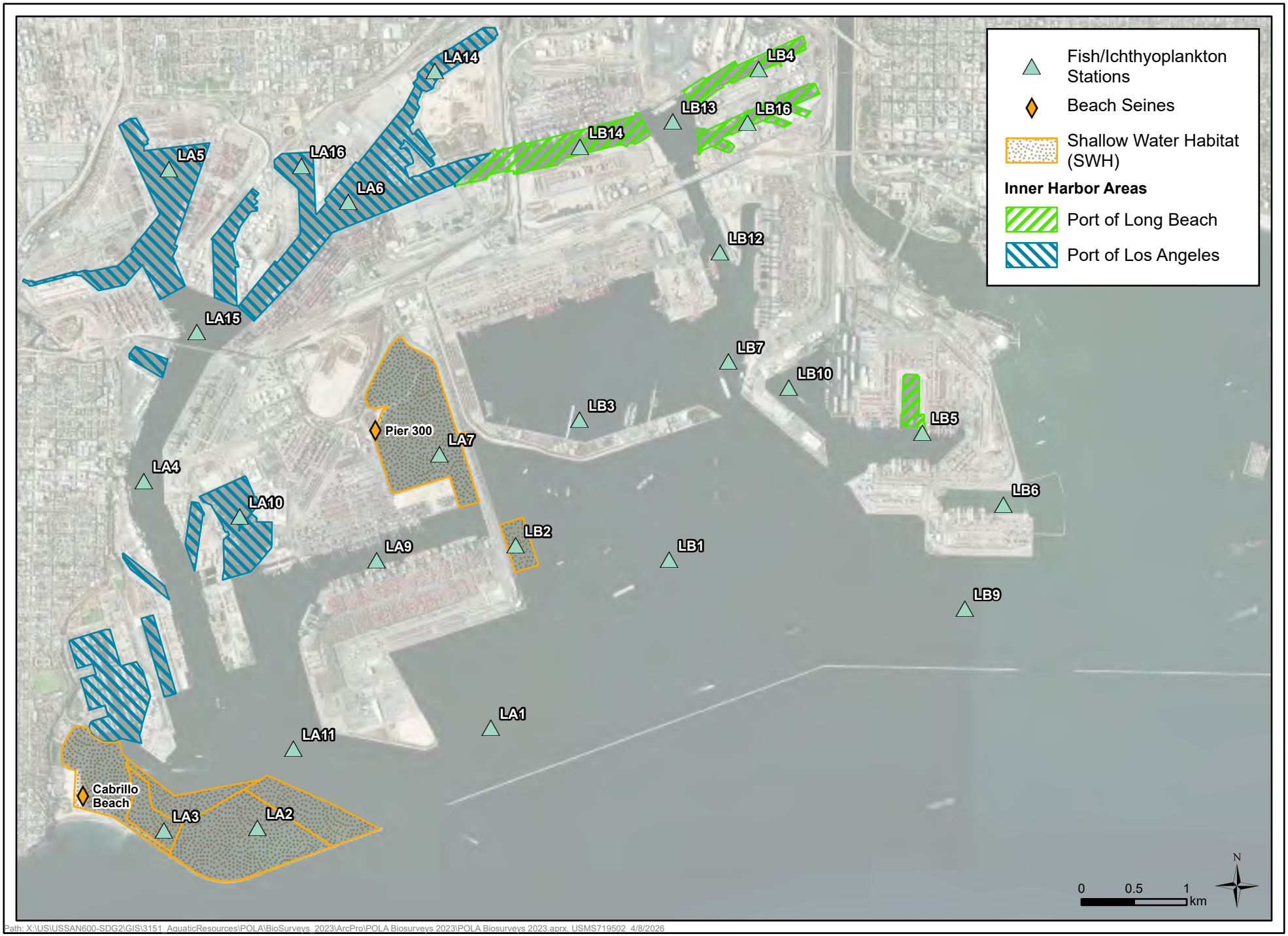
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2023 Biological Survey
Long Beach and Los Angeles Harbors
Port of Long Beach and Port of Los Angeles

Figure ES-1. The Los Angeles and Long Beach Port Complex

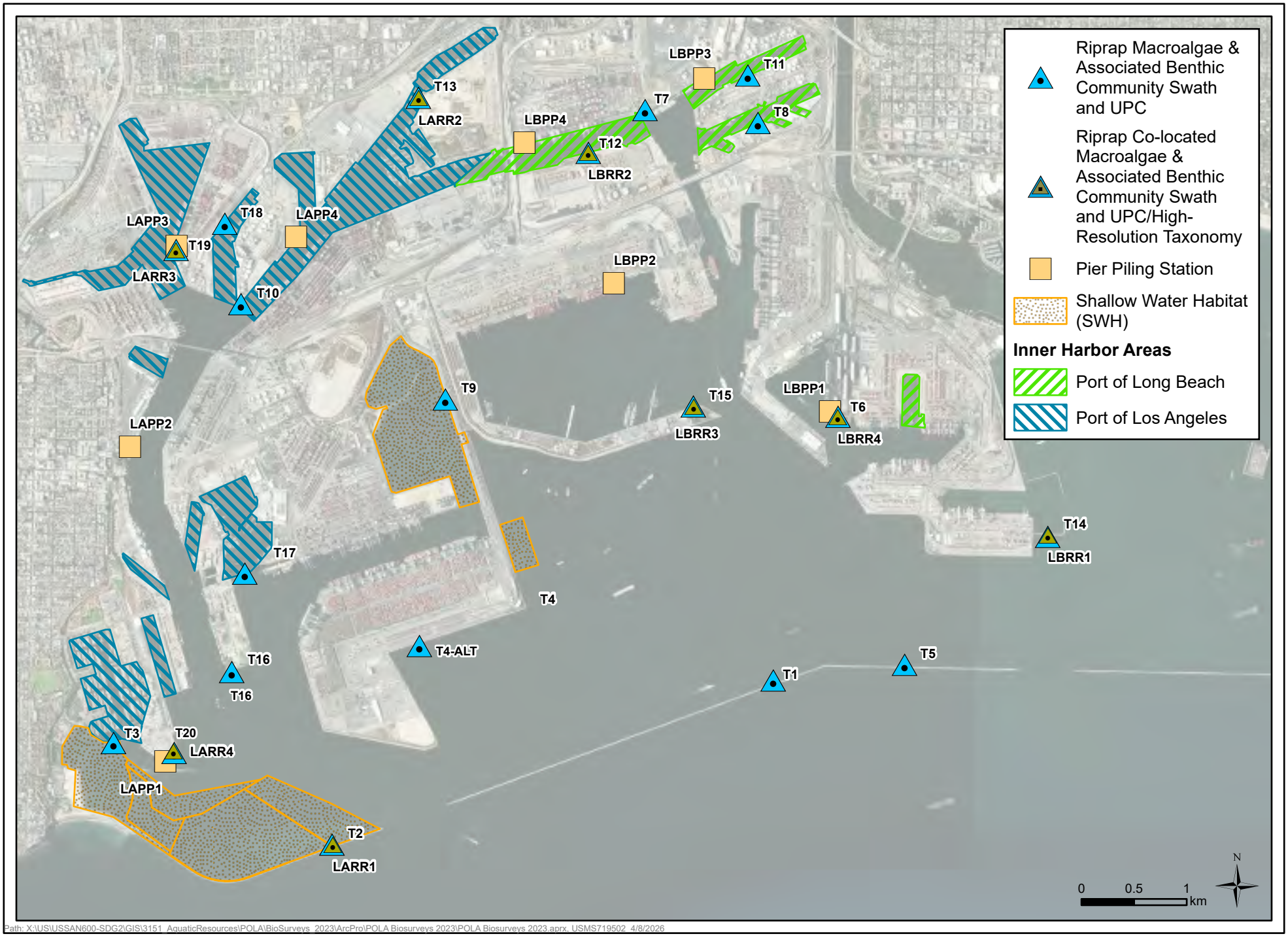


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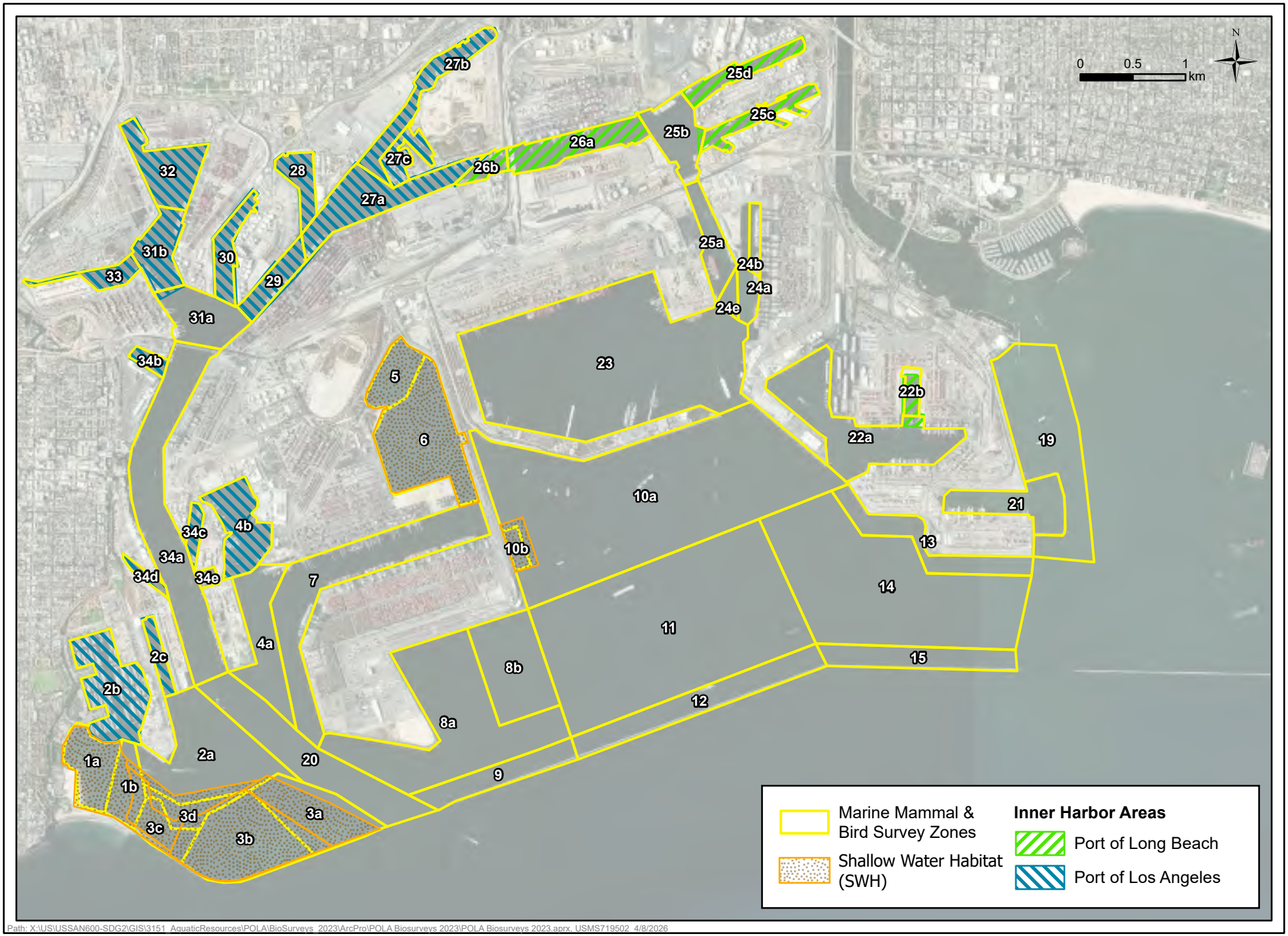


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Figure ES-3. Ichthyoplankton, Trawl, Lampara, and Beach Seine Stations



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In general, the sampling effort was equally divided between the two ports, although in the case of certain Biosurvey elements (i.e., beach seines and eelgrass), the absence of beaches and scarcity of SWH in the Port of Long Beach resulted in sampling being concentrated on the Port of Los Angeles side of the Port Complex.

To achieve these objectives, the 2023 Biosurvey was designed to closely resemble the design of the four previous Biosurveys. The following changes from those previous studies are summarized below and detailed in Appendix A:

- Incorporate satellite imagery to measure kelp canopy acreage, sea surface temperature, turbidity, chlorophyll-a, and water clarity (as satellite-derived secchi disk depth).
- Adjust sediment and water quality sampling stations to align with the Greater Harbor Waters Regional Monitoring Coalition (RMC) locations.
- Alter a few elements of the hard substate sampling methodology to better capture density of large and mobile invertebrates and algae.

II. PHYSICAL CONDITIONS

→ **Physical characteristics of the water column, such as temperature and wave energy, differed between Inner and Outer Harbor habitats. The Outer Harbor is similar to nearshore coastal conditions versus the Inner Harbor which is more variable across seasons and similar to other Southern California embayments.**

→ **The 2023 survey occurred during a year in which the region experienced below-average sea surface temperatures and above average rainfall, as a strong El Niño established by mid-2023.**

→ **Benthic habitats in the Inner Harbor had more fine-grained sediments with higher organic content than the Outer Harbor. Riprap in the Outer Harbor is characterized by large boulders, while sedimentation in the Inner Harbor limits available space for organisms to settle on.**

The physical conditions in the Port Complex profoundly influence the plants and animals that live in harbor waters and the changes in their abundances and distributions over time. The following are general examples:

- Areas with consistently low dissolved oxygen (DO), which can indicate organic enrichment and/or pollution, are often populated by only those few species that can tolerate such conditions.
- Water clarity can limit photosynthesis by marine plants (e.g., eelgrass, attached seaweeds, and pelagic phytoplankton).
- Composition of sediments (sand, silt, clay) and organic carbon content can influence suitability for establishment of eelgrass and the composition of benthic infauna that can burrow and forage in that area.

The physical parameters of water temperature, DO concentration, water clarity and turbidity, pH, chlorophyll-a concentration (as a measure of phytoplanktonic algae), and salinity were measured throughout the water column in May (spring) and September (summer) 2023 and March (winter) 2024. Sediment characteristics (i.e., grain size and total organic carbon [TOC] content) were sampled in spring and summer 2023. Remote sensing imaging of sea surface temperature, turbidity, chlorophyll-a, and satellite-derived secchi disk depth was successful in all months except May and June 2023, when persistent cloud cover prevented remote imaging.

Water temperatures measured by CTD casts varied by season and depth, with summer surface temperatures reaching a high of 21.3 degrees Celsius (ºC) at the surface in the Inner Harbor in summer and a low of 12.7ºC at the bottom in the Outer Harbor in the spring of 2023. Changes in surface temperatures were relatively small between the Inner Harbor and Outer Harbor across all seasons, but bottom temperatures in spring and summer were lower at Outer Harbor Stations than at Inner Harbor and SWH stations.

DO concentrations were above the Water Quality Control Plan for the Los Angeles Basin (Basin Plan) water quality objective of 5.0 milligrams per liter (mg/L) at every station in all three seasons.

Water clarity at Outer Harbor stations varied little with either season or depth. At some Inner Harbor stations, the winter clarity was as low as 12.5 percent (%) light transmittance, compared with the typical values of 60 to 80% elsewhere in the Port Complex, potentially the result of increased suspended particles caused by heavy rainfall and discharge from the Dominguez Channel watershed.

pH values in the Port Complex varied little with season, depth, or location, and were consistent with those of typical coastal ocean waters (i.e., 8.17 to 8.25).

Salinity in the Port Complex varied little in spring and summer with depth or location, and values were typical of the nearshore coastal ocean (33.5 practical salinity units [PSU]). In winter, however, salinity values as low as 30.8 PSU were recorded at the surface at numerous stations because of stormwater runoff from the Los Angeles Basin.

Chlorophyll-a concentrations were similar in summer and winter throughout the Port Complex (0.8 to 1.2 micrograms per liter [µg/L]), but values were higher in spring (average of 3.5 µg/L at the surface), reflecting the typical "spring bloom" of planktonic algae. As would be expected in a coastal embayment such as San Pedro Bay, concentrations were generally somewhat higher than in nearby open coastal waters, where chlorophyll concentrations average 1 to 2 µg/L.

Monthly water quality imagery throughout 2023 provided valuable information on harbor-wide water quality trends (Figure ES-6), especially in light of Hurricane Hilary making landfall in August 2023 and the second highest amount of winter precipitation (17.99 inches) in 25 years, including record rainfall in February 2024.

Soft-bottom sediments in the Outer Harbor were composed largely of silt and sand, whereas sediments in Inner Harbor areas were muddier, containing an average of over 70% silt and clay. This pattern reflects the more energetic environment of the Outer Harbor, which results in less deposition of fine sediments. TOC concentrations were higher on average at Inner Harbor stations (1.47%) than at Outer Harbor stations (0.70%).

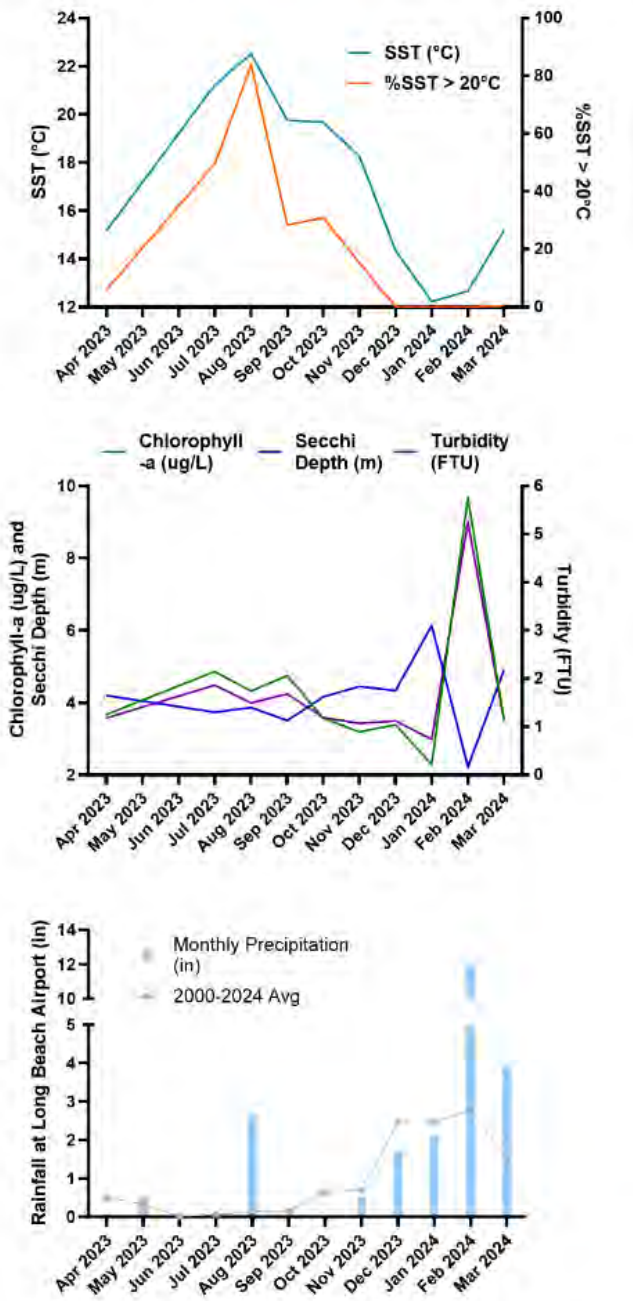


Figure ES-6. Monthly Satellite-Derived Water Quality Parameters and Rainfall at Long Beach Airport

Riprap habitats in the Outer Harbor tended to have higher percentages of boulders compared with those in the Inner Harbor. Sediment deposition was higher in the Inner Harbor, which may have contributed to the expansion of eelgrass beds observed in 2023.

III. PELAGIC HABITAT

→ **Pelagic adult fish communities were more abundant in the Outer Harbor than in the Inner Harbor; however, there were no clear differences in diversity between habitats for larval fishes. Larval fishes showed distinct seasonal differences with the highest abundances in spring and summer, while no seasonal patterns were observed for adult pelagic fishes.**

→ **Northern anchovy, the most abundant pelagic fish in the Port Complex, showed a unique diurnal pattern. During the day, anchovy shoal in dense schools in deep and very deep areas of the Port Complex, possibly to avoid predation, while at night they return to shallow areas in loose schools, which may be in response to higher prey abundance near the surface at night**.

→ **The core community of pelagic fishes in the Port Complex has remained remarkably consistent over the past two decades, with anchovy, topsmelt, and California grunion the most common pelagic species.**

→ **Northern anchovy, Pacific sardine, jack mackerel, and Pacific mackerel use the Port Complex as nursery habitat before moving offshore as adults. These are the only species managed under the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP) found in the Port Complex.**

The pelagic habitat is the portion of the water column that extends from just above the sea bottom to the water surface. It is the most widespread habitat type in the Port Complex, totaling some 3,600 hectares (8,900 acres) of water area. Unlike static habitats such as sediments and riprap, the pelagic habitat is a dynamic, three-dimensional, moving environment.

Pelagic organisms of particular concern for Biosurveys are the fish species managed by National Oceanic and Atmospheric Administration (NOAA) Fisheries under the CPS FMP through the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). The common Coastal Pelagics in the Port Complex are northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax caeruleus*), Pacific (chub) mackerel (*Scomber japonicus*), and jack mackerel (*Trachurus symmetricus*). In addition to juvenile and adult pelagic fish species, the 2023 Biosurvey sampled the eggs and larvae (referred to as ichthyoplankton) of pelagic fish. Fish were sampled in spring, summer, and winter, with samples collected only at night to minimize visually based net avoidance by the larger larvae.

Ichthyoplankton

Many of the pelagic and bottom-dwelling (demersal) adult fishes that live in the Port Complex also spawn there by broadcasting their eggs into the water column, where their larvae begin life as part of the plankton. Some of those species, such as blennies and gobies, are common in the Port Complex but are rarely caught in the nets used to sample adult and juvenile fish because they live concealed in structures, such as breakwaters, or have burrowing or otherwise cryptic habits. Accordingly, sampling the ichthyoplankton provides a more complete picture of the diversity of fishes living in the Port Complex.

Fish eggs were collected in every sample with a mean concentration per sampling station of 211 eggs per 100 cubic meters (m^3) of water. The eggs belonged to four groups: (1) unidentified eggs, which accounted for 96% of the eggs, (2) turbot (*Pleuronectes* spp., 3.24%), (3) northern anchovy (*Engraulis mordax*, 0.73%), and (4) silversides family (*Atherinidae*, 0.01%). Fish eggs were more abundant in winter and spring than in summer, but there were no obvious trends in abundance with location in the Port Complex.

During the ichthyoplankton sampling effort, 11,318 fish larvae were collected, with a mean per station of 435 larvae per 100 m^3 of water. The larvae belonged to 44 taxa, but most taxa were represented by fewer than 10 individuals. The four most abundant taxa accounted for nearly 83% of the total catch: gobies in the *Clevlandia/Ilypnus*/*Quietula* (CIQ) species complex, combtooth blennies (*Hypsoblennius* sp.), shimofuri gobies (*Tridentiger bifasciatus*), and yellowfin gobies (*Acanthogobius flavimanus*); the latter two species are non-native. Larval fishes were more abundant in spring and summer than in winter.

Pelagic Fish

A total of 22 species of pelagic fish were collected in 2023, although only three species (topsmelt [*Atherinops affinis*], northern anchovy [*Engraulis mordax*], and pacific sardine [*Sardinops sagax*]) accounted for 93% of the 22,184 individuals captured (Table ES-1). Very large catches at just 8 of the 26 stations, primarily northern anchovy and topsmelt, accounted for 74% of the total catch.

Table ES-1. Ten Most Abundant Pelagic Fish Species Captured in Lampara Nets During the 2023 Biosurvey

Common Name	Scientific Name	Number Caught	Percentage of Total Catch	Biomass (kg)	Percent Juveniles
Northern Anchovy	*Engraulis mordax*	12,186	54.9	98.0	90
Topsmelt	*Atherinops affinis*	7,594	34.2	119	80
Pacific sardine	*Sardinops sagax*	1,025	4.62	44.2	30
California grunion	*Leuresthes tenuis*	778	3.51	4.70	89
Jacksmelt	*Atherinopsis californiensis*	131	0.59	12.6	99
Jack mackerel	*Trachurus symmetricus*	121	0.55	6.40	99
Shiner Perch	*Cymatogaster aggregata*	113	0.51	0.50	78-81[1]
Salema	*Haemulon californiensis*	81	0.37	0.81	99
Pacific Butterfish	*Peprilus simillimus*	78	0.35	2.67	99
Queenfish	*Seriphus politus*	41	0.19	0.65	86

1. Because of the inability to determine sex in the field and differing male and female ages at maturity, Percent Juveniles was calculated twice, assuming either an all-male or all-female population.

kg = kilogram(s)

During spring sampling, two-thirds of the total number of pelagic fish were caught, although the difference between seasons was not statistically significant because of the high variability in the catch of just a few species. During night surveys, 80% of the fish were caught, with substantially greater species richness than fish caught during daytime sampling; the differences between day and night abundance were statistically significant. The pattern of substantially larger catches at night has been consistent throughout the five Biosurveys and may reflect diurnal patterns of habitat use within the Port Complex by some species, including FMP species.

Of the four Coastal Pelagics FMP species (jack mackerel, northern anchovy, Pacific mackerel, and Pacific sardine), northern anchovy was by far the most abundant pelagic species, with more than 12,000 captured (Table ES-1). The assessment of length at maturity indicated that most of the 10 most abundant pelagic fish species were juveniles, suggesting that the Port Complex contains viable nursery habitat for these species.

Three species made up most of the total biomass of pelagic fish: topsmelt (39% of the biomass), northern anchovy (32%), and Pacific sardine (14%). As with abundance, biomass was concentrated at a few stations where either very large numbers of small fish or a single large individual (such as a bat ray [*Myliobatis californica*]) were caught.

Stations in the SWHs on average supported more abundant, diverse, and balanced communities of pelagic fish species than stations in other areas of the Port Complex. Results of multivariate analyses indicated significantly different communities across depth strata, especially SWH areas, compared with other habitats.

The dominant species of pelagic fish, in terms of abundance, in the Port Complex have remained fairly stable over the five Biosurveys. Northern anchovy, topsmelt, and Pacific sardine, the three most abundant species in the 2023 Biosurvey, were always among the five most abundant species in previous Biosurveys. Other dominant pelagic species have included California grunion (*Leuresthes tenuis*), jacksmelt (*Atherinopsis californiensis*), Pacific mackerel, and shiner perch (*Cymatogaster aggregata)*. Notably, no pelagic fishes had external anomalies such as lesions, tumors, spinal deformities, or other indications of stress associated with degraded habitat quality.

IV. SOFT-BOTTOM HABITATS



Tube anemone on seafloor in Inner Harbor

→ **Eelgrass bed acreage more than doubled in 2023 compared to 2018, with the largest expansion occurring in the Pier 300 Basin and at Cabrillo Beach. The observed trend of eelgrass occurring at deeper depths and in more areas of the Inner Harbor in 2018 continued in 2023, with nearly 7 acres combined at Consolidated Slip and East Basin Yacht Marinas, concurrent with a trend of improving water clarity.**

→ **Soft-bottom habitats showed significant differences between Inner and Outer Harbor Habitats for the benthic infauna, epibenthic invertebrate, and demersal fish communities. Shallow areas, especially those near eelgrass beds, had high diversity and abundance of benthic infauna that support a variety of demersal fish such as perch and bass. Very deep areas, such as the main navigation channels of each Port, had the highest abundance of epibenthic invertebrates (primarily target shrimp) and demersal fish (primarily white croaker and queenfish) but low diversity.**

→ **Infauna species sensitive to pollution continue to be among the most abundant in the Port Complex, indicating the continued improvement of water and sediment quality resulting in a benthic infauna community that has remained in a consistently healthy condition over the past 20 years.**

→ **Changes in the composition of the epibenthic community in soft-bottom habitats may be the result of oceanographic and climatic forces that facilitate the northward extension of home ranges by species with typically subtropical distributions, such as the target shrimp *Sicyonia penicillata*.**

→ **Size classification of fish captured in SWH and areas with eelgrass show that these habitats are essential to juvenile fish species common in the Port Complex such as topsmelt, barred sand bass, and shiner perch, and highlights the nursery function of these areas.**

→ **The core community of pelagic and demersal fishes in the Port Complex has remained remarkably consistent over the past two decades, with queenfish, white croaker, barred sand bass, and California halibut the most common demersal fish species.**

→ **Eleven species managed under the Pacific Coast Groundfish (PCG) Fishery Management Plan were observed in trawl and dive surveys in the 2023 Biosurvey, with most individuals observed in Outer Harbor areas near eelgrass and kelp beds.**

Most of the Port Complex's water area – nearly 8,000 acres – consists of soft-bottom habitats: silty sediments in open-water areas, sandy sediments of beaches and shallow nearshore areas, and sandy-silt eelgrass beds. These habitats are inhabited by eelgrass in shallow areas, invertebrates in the sediments (benthic infauna) and on the sediment surface (epibenthic invertebrates), fish associated with the bottom (demersal fish), and fish in shallow subtidal zones near beaches. The soft-bottom habitats are important resources for adult and juvenile fishes, especially for those managed by NOAA under the Pacific Coast Groundfish (PCG) FMP.

Eelgrass, benthic invertebrates, demersal fish, and subtidal fish were surveyed twice, in spring and summer. Eelgrass surveys covered the entire Port Complex, with benthic infaunal invertebrates sampled at 32 stations, demersal fish and epibenthic invertebrates at 26 stations, and fish in shallow subtidal zones at 2 locations (Cabrillo Beach and Seaplane Lagoon, both in the Port of Los Angeles).

Eelgrass

Eelgrass (*Zostera marina*) is a community-structuring seagrass, typically growing in beds in silty-sand sediments, that in recent years has become abundant in shallow areas of the Port Complex. Eelgrass beds support a rich detrital food web and provide structure, food, and nursery habitat for a diverse range of fish, invertebrates, and birds, including commercially and recreationally important fish species. Given its diverse biological functions, eelgrass has been designated as a Habitat Area of Particular Concern (HAPC) under the Magnuson-Stevens Act, resulting in the development of a formal mitigation policy for minimizing adverse impacts of development projects. Current eelgrass distribution in the Port Complex is likely the result of colonization from outside areas (e.g., Alamitos Bay) and the transplantation efforts that have occurred since the early 1980s.

Eelgrass was identified at 12 locations throughout the Port Complex in 2023 (Table ES-2, Figure ES-7). Two sites – the Cabrillo Beach area and Pier 300 Basin (including Seaplane Lagoon) – contained more than 93% of all the eelgrass within the Port Complex during both seasons (spring and summer). The density of eelgrass plants within the beds varied, with the densest growth off Cabrillo Beach (a shallow area with some tidal exchange) and the sparsest growth in the Consolidated Slip (a deeper area with restricted water movement).

Almost 99% of the eelgrass in the Port Complex occurs between +0.5 foot and -15 feet mean lower low water (MLLW), and more eelgrass was growing at deeper depths within the Inner Harbor in 2023 than has been documented in past Biosurveys. This observation indicates greater average water clarity in the Inner Harbor than in the Outer Harbor, which may be a factor in the recent expansion of eelgrass within the Inner Harbor areas since the 2008 Biosurvey.

Table ES-2. Distribution of Eelgrass Within the Port Complex in 2023

Location of Eelgrass Beds		Spring 2023		Summer 2023	
		Acres	Percentage of Total	Acres	Percentage of Total
Port of Los Angeles	Pier 300 Basin	120.95	73.96	119.17	72.27
	North Cabrillo Beach	33.92	20.74	34.91	21.17
	South Cabrillo Beach	0.42	0.25	0.44	0.27
	East Basin Marinas	3.93	2.40	4.68	2.84
	Cabrillo Marina	0.39	0.24	0.72	0.43
	Fish Harbor	0.37	0.23	0.50	0.30
	Consolidated Slip	1.48	0.90	2.04	1.24
	POLA Turning Basin	0.73	0.45	0.98	0.59
	Slip 1	0.72	0.44	0.67	0.40
	Total	**162.90**	**99.6**	**164.09**	**99.5**
Port of Long Beach	Navy Mole	0.2141	0.1	0.2278	0.1
	Cerritos Channel	0.4163	0.3	0.5778	0.4
	Back Channel	<0.1	<0.1	<0.1	<0.1
Total		**0.6313**	**0.4**	**0.8067**	**0.5**
Total Port Complex		**163.53**	**100**	**164.90**	**100**

POLA = Port of Los Angeles



Figure ES-7. Occurrence of Eelgrass (*Zostera marina*) in the Port Complex – September 2023

Benthic Infauna

Benthic infaunal communities in the Port Complex are composed of a diverse array of invertebrates with differing life histories and feeding strategies that live within the sediments. Benthic organisms are an important link between

primary producers and higher trophic levels of the food web (e.g., fish, marine mammals, and birds), and perform crucial ecological functions such as water filtration, nutrient cycling, and bioturbation of sediments. These organisms vary in their tolerance to physical and chemical stressors from both natural and anthropogenic sources, and as a result can be valuable indicators of habitat quality.

More than 17,500 benthic infaunal organisms comprising 391 unique taxa were collected in sediment grab samples during the Biosurvey. There was very little seasonal variation in any of the summary measures used to characterize biological communities (i.e., abundance, biomass, species numbers, and diversity). The phylum Annelida (principally, polychaete worms) dominated the infauna, comprising over 40% of the total abundance. Arthropoda (crustaceans such as amphipods) was the second most abundant phylum, accounting for approximately 20% of the total abundance. A total of 9 of the 10 most abundant benthic infauna species in each season (Table ES-3) were polychaete worms and amphipods, and those 9 composed nearly half of the total abundance. The pollution-sensitive amphipod *Amphideutopus oculatus* was among the most abundant species in both seasons (2.7% of the total abundance in spring and 11% in summer). Five non-native species (one polychaete worm, one bivalve, and three amphipods) were among the most dominant.

In terms of biomass, however, the phyla Mollusca and Annelida were dominant in both spring and summer, largely because these phyla have species in which a single large individual in a sample can outweigh numerous small individuals of other phyla. The other abundant phyla, Arthropoda and Echinodermata, rarely accounted for more than a small percentage of the total abundance or biomass. Several taxonomic groups were combined in the category "Other Taxa," namely Chordata (mostly tunicates), Porifera (sponges), Cnidaria (anemones), Nemertea (ribbon worms), and several minor phyla.

Table ES-3. Ten Most Abundant Benthic Infauna Collected Across all Stations – Spring and Summer 2023

Spring 2023		Summer 2023	
Taxon	**Percentage of Total**	**Taxon**	**Percentage of Total**
Pseudopolydora paucibranchiata[2]	31.4	*Pseudopolydora paucibranchiata*[2]	21.3
Capitella capitata Complex	11.7	*Amphideutopus oculatus*[1]	11.1
Cossura sp. A	3.5	*Cossura* sp. A	2.8
Theora lubrica[2]	3.0	*Caprella simia*[2]	2.4
Amphideutopus oculatus[1]	2.7	*Photis brevipes*	2.1
Aphelochaeta petersenae	2.5	*Monocorophium acherusicum*[2]	2.1
Oligochaeta	2.1	*Caprella* sp.	2.1
Grandidierella japonica[2]	2.1	*Aphelochaeta petersenae*	2.0
Mediomastus sp.	2.0	*Leitoscoloplos pugettensis*	1.8
Chondrochelia dubia Cmplx	1.7	*Paramicrodeutopus schmitti*	1.6

1. Denotes sensitive, pollution-intolerant species.
2. Denotes non-native species.

Multivariate analysis of infauna abundance showed that depth (Shallow, Deep, and Very Deep) and habitat (Inner Harbor, Outer Harbor, and SWH) were the key factors influencing the benthic community's characteristics. The SWH stations typically exhibited higher abundance but reduced diversity relative to other sites, and results of non-metric multidimensional scaling (nMDS) analysis indicated different community composition among the three habitat types. Among the depth strata, Very Deep stations had significantly greater species richness, biomass, and diversity, and Shallow stations had significantly greater abundance than Deep and Very Deep stations. These results are similar to the 2018 Biosurvey results in that SWH stations had lower diversity with higher abundance, and Inner Harbor and Outer Harbor stations had higher diversity with lower abundance.

The 2023 Biosurvey applied a commonly used pollution tolerance index, the Benthic Response Index (BRI), to the benthic infauna data to evaluate the degree of stress, whether natural or anthropogenic, experienced by the

communities at the sampling stations. The BRI was calculated for the spring and summer, although the index was developed with the recommendation that Southern California sampling should occur in summer (July 1 through September 30; Smith et al., 2003). The results identified 9 of the 33 stations, in at least one season, as stressed to some degree (i.e., Low, Moderate, or High Disturbance), although during the designated index period (summer 2023), only 5 of 33 stations were designated as Low Disturbance with no stations in the Moderate or High Disturbance categories. Stations with impacted benthic communities were most commonly in basins with commercial and recreational vessels (e.g., stations LA12 [Cabrillo Marina] and LA10 [Fish Harbor]) or in areas near discharges from urban watersheds (e.g., station LA14 [Consolidated Slip]).

The 2023 Biosurvey documented a benthic community that shows continued improvement in environmental conditions over the past 7 decades. For example, sampling in the 1950s identified only 70 species of benthic infauna, most of them pollution-tolerant Annelida, and found areas with no infauna at all. Sampling in the Port of Los Angeles in the mid-1970s found benthic infauna at all stations but identified large areas of the Inner Harbor and the Consolidated Slip as severely stressed by pollution. A study in the late 1980s identified several hundred taxa and concluded that sediments, even in the Consolidated Slip, were less contaminated than observed in earlier studies. The five Biosurveys conducted from 2000 to 2023 have documented localized areas that are exploited by pollution-tolerant species such as the polychaetes *Pseudopolydora paucibranchiata* and *Capitella capitata,* but otherwise show unimpacted benthic infauna communities, such as SWH areas with high abundances of the pollution-sensitive amphipod *Amphideutopus oculatus*. The spring and summer surveys followed the exceptionally wet winter of 2022-2023. The results of those surveys indicate that the effects of such events, such as temporary alteration of the composition of the benthic community that may have been evident only in the spring, need to be factored into any consideration of longer-term trends.

Epibenthic Invertebrates

Epibenthic invertebrates include highly mobile animals living on the sediment surface, such as shrimp, crabs, lobsters, and snails, and sessile animals such as tunicates (sea squirts), bryozoans, sea pens, and scallops. These organisms are an important food source for a variety of fish, particularly demersal fish such as bass, juvenile halibut, and other flatfish, and also serve as an important trophic link to top predator species such as birds and marine mammals.



Two-spot octopus caught with trawl net

A total of 14,075 epibenthic invertebrates belonging to 93 species were collected in the otter trawls (91% of the individuals) and beach seine sampling (9.3%). There were no significant differences in trawl-caught species richness by either day/night or by season, but there were statistically significant differences in total abundance: roughly 50% more animals were captured in trawls at night as during the day, and nearly twice as many animals were caught in spring than in summer. Multivariate analysis of trawl abundance indicated statistically significant differences among all habitat groups (Inner Harbor, Outer Harbor, and SWH) and among Shallow and Deep/Very Deep stations. Outer Harbor stations, especially those in deep or very deep navigation channels, had very high abundances of shrimps and crabs. Inner Harbor and SWH stations had more diversity compared with Outer Harbor stations, with Inner Harbor stations dominated mostly by chordates and arthropods and SWH stations composed primarily of arthropods and mollusks.

The most abundant epibenthic species captured in trawls were target shrimp (*Sicyonia penicillata*), Pacific rock shrimp (*Sicyonia ingentis*), European ascidian (*Ascidiella aspersa*), and Xantu's swimming crab (*Achelous xantusii*). The most abundant epibenthic species captured in beach seines were California green shrimp (*Hippolyte californiensis*), Sitka shrimp *(Heptacarpus sitchensis*), California coastal shrimp (*Heptacarpus paludicola*), and mud nassa snail (*Nassarius fossatus*).

The epibenthic species assemblage in the 2023 Biosurvey was generally consistent with those described for past Biosurveys and regional sampling programs. However, in the 2000 and 2008 Biosurveys, the community was dominated by the blackspot shrimp (*Crangon nigromaculatus*) and the tuberculate pear crab (*Pyromaia tuberculata*), but in 2013, 2018, and 2023 Biosurveys, a dramatic shift in dominance to target shrimp was observed. This shift appears to be largely a result of the target shrimp population shifting its distribution northward in response to recent warm-water events and changes in coastal current dynamics. These climatic forces may explain the increase in species richness of the benthic infauna and epifauna, which over time may gain more subtropical species. Although changes in the demersal fish community are less apparent in the 2023 Biosurvey, invertebrate communities, with shorter life cycles and more passive distribution of adults and larvae, have the potential to be more sensitive to and indicative of these larger oceanographic changes. Future Biosurveys and regional monitoring programs may be able to assess the persistence, magnitude, and impacts of such changes.

Demersal Fish

During trawl sampling for demersal fish, 56 species composed of 21,523 individuals were collected. The 10 most abundant species (Table ES-4) accounted for nearly 97% of the total catch, and the 3 most abundant species accounted for 82% of the biomass. All 10 of the most abundant species were widely distributed throughout the Port Complex, being caught in at least two-thirds of the trawls. White croaker (*Genyonemus lineatus*) was by far the most abundant demersal fish species captured in the 2023 Biosurvey and also dominated the biomass, accounting for nearly two-thirds of the total weight of fish captured.

Other abundant demersal species included vermilion rockfish (*Sebastes miniatus*), northern anchovy, longspine combfish (*Zaniolepis latipinnis*), fantail sole (*Xystreurys liolepis*), spotted turbot (*Pleuronichthys ritteri*), and California lizardfish (*Synodus lucioceps).*

Results of the size analysis of the most abundant demersal fish indicate resident populations of mature adult queenfish (*Seriphus politus*) and white croaker within the Port Complex, likely spawning and recruiting locally, although results of past fish tracking studies indicate connectivity with nearshore populations outside the Port Complex, and these fish may seasonally migrate offshore. Most of the sand bass and halibut captured were juveniles, indicating the value of the Port Complex as a nursery area for recreationally and commercially valuable fish species.

Table ES-4. Ten Most Abundant Fish Species Collected in Otter Trawls, 2023

Common Name	Scientific Name	Number Caught	Percentage of Total Catch[1]	Biomass (kg)	Percent Juveniles
White Croaker	*Genyonemus lineatus*	11,475	53.3	367	90
Queenfish	*Seriphus politus*	5,322	24.7	37.6	86
Shiner Perch	*Cymatogaster aggregata*	1,497	7.0	12.9	78–81[2]
Speckled Sanddab	*Citharichthys stigmaeus*	985	4.6	7.40	50
Specklefin Midshipman	*Porichthys myriaster*	538	2.5	5.40	89
Salema	*Haemulon californiensis*	281	1.3	1.40	99
Barred Sand Bass	*Paralabrax nebulifer*	261	1.2	10.7	98
Pacific Butterfish	*Peprilus simillimus*	188	0.87	4.87	99
California Tonguefish	*Symphurus atricaudus*	144	0.67	1.13	95
California Halibut	*Paralichthys californicus*	97	0.5	49.4	42–44[2]

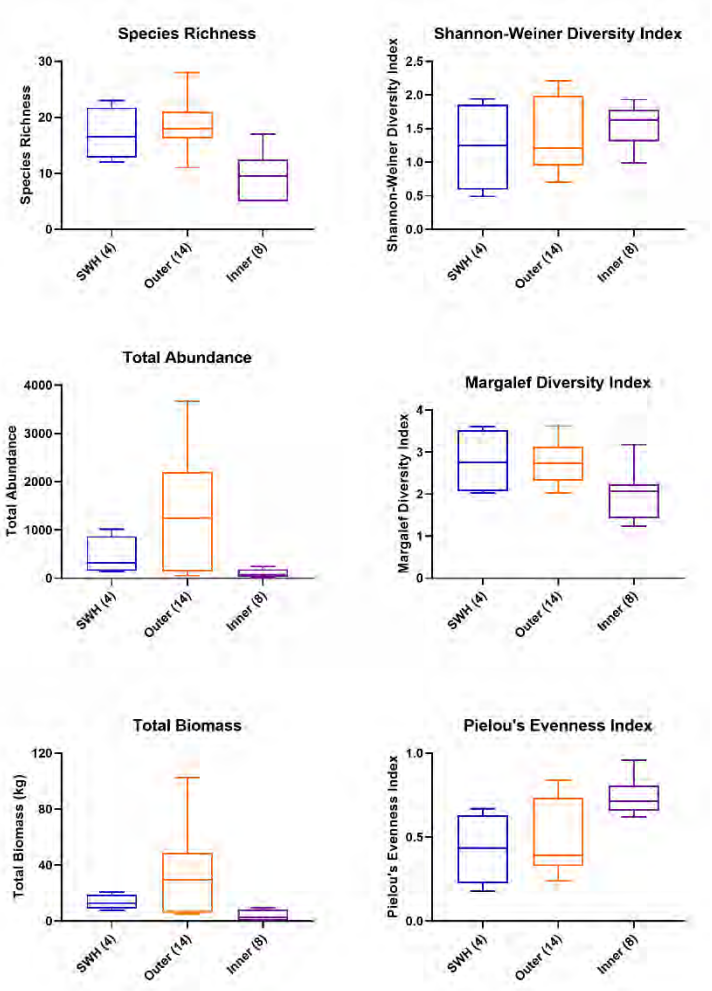
1. Percentage of Total Catch combines catch from lampara and otter trawls.
2. Because of the inability to determine sex in the field and differing male and female ages at maturity, Percent Juveniles was calculated twice, assuming either an all-male or all-female population.

kg = kilogram(s)

Results of the analysis of station groups indicated that the Outer Harbor stations had, on average, higher abundances of demersal fish, higher total biomass, and higher diversity than Inner Harbor and SWH Harbor station groups, and that Inner Harbor stations had the lowest total abundance and biomass of the three habitat groups (Figure ES-8).

During trawl sampling across the five Biosurveys (2000, 2008, 2013, 2018, and 2023), 104 different fish species were captured, although species richness remained similar during each sampling year (from 56 to 63 species). Approximately one-third of those species were captured in every Biosurvey, and although some species are never abundant, nine species are consistently common and can be considered the core species assemblage characteristic of the Port Complex. These nine species – barred sand bass (*Paralabrax nebulifer*), California halibut (*Paralichthys californicus*), California lizardfish, California tonguefish (*Symphurus atricaudus*), fantail sole, northern anchovy, queenfish, specklefin midshipman (*Porichthys myriaster*), and white croaker – accounted for at least 75% of the total abundance of trawl-caught fish in every Biosurvey.

Seven of the species managed under the PCG FMP were captured in otter trawls during the 2023 Biosurvey: California scorpionfish (*Scorpaena guttata*), vermillion rockfish (*Sebastes miniatus*), bocaccio (*Sebastes paucispinis*), chilipepper rockfish (*Sebastes goodei*), English sole (*Parophrys vetulus*), Pacific sanddab (*Citharichthys sordidus*), and California skate (*Raja inornata*). Historically, Biosurvey trawls have documented 16 total PCG FMP managed species to date, although their abundances are typically low and vary from survey to survey.



Box plots show the median, range, and quartiles for each data set.

Figure ES-8. All Seasons Station Habitat Group Summaries

Shallow Subtidal Fish

Sampling at Cabrillo Beach and Seaplane Lagoon using a beach seine identified 23 species of fish totaling 1,875 individuals. Statistical analysis identified distinct assemblages at each location, with dwarf perch (*Micrometrus minimus*), giant kelpfish (*Heterostichus rostratus*), and jacksmelt (*Atherinopsis californiensis*) characteristic of Cabrillo Beach and shiner perch (*Cymatogaster aggregate*), yellowchin sculpin (*Icelinus quadriseriatus*), and bay pipefish (*Syngnathus leptorhynchus*) characteristic of Seaplane Lagoon. Topsmelt (*Atherinops affinis*), shiner perch, unidentified atherinids (topsmelt, jacksmelt, and grunions), and yellowchin sculpin were the most abundant species. Several species rarely captured using other sampling methodologies were caught in appreciable numbers, including leopard sharks (*Triakis semifasciata),* bay pipefish, blennies, and gobies. Some of the species represented by large individuals in trawls were abundant in the beach sampling as early juveniles (e.g., white croaker, barred sand bass, and surfperches), highlighting the value of the shallow subtidal zone as nursery habitat. The proximity of large eelgrass beds to the beaches where sampling took place likely contributed to the abundance and species richness in those areas.

V. HARD SUBSTRATE ASSOCIATED COMMUNITIES



Spiny lobster and rock scallop on piling in the Outer Harbor

- → **For the first time in 2023, a quantitative survey of fish density and size classes on riprap and piling surveys provides new insights into fish communities that use these habitats and how they compare to nearby pelagic and soft-bottom habitats.**
- → **The 2023 Biosurvey was the first to incorporate satellite imagery to map kelp canopy, with archive imagery from 2018 providing historical comparisons. This new methodology provides a foundation for future kelp mapping efforts within the Port Complex and provides comparability with statewide efforts to use remote sensing in kelp management decisions.**
- → **Diver survey methods were expanded in 2023 to include additional surveys in the lower intertidal that better characterized the presence of canopy forming kelp, especially feather boa kelp *Egregia menziesii*. Swath surveys on pilings captured the presence of kelp and other large invertebrates for the first time in 2023.**
- → **Hard substrates (riprap and pilings) had consistently higher diversity, abundance, and biomass of fish, invertebrates, and algae at Outer Harbor stations than at Inner Harbor stations. Kelp was only present on pilings and riprap in the Outer Harbor, which likely contributed to increased diversity in those areas.**
- → **Hard-substrate communities were less diverse and less abundant in the upper intertidal than in the lower intertidal and subtidal, consistent with the harsher conditions in the upper intertidal.**

The Port Complex contains over 80 miles of altered, hard shoreline, including rocky shoreline, bulkheads, and tens of thousands of concrete, wood, and steel pilings. These features support canopy-forming algae (chiefly giant kelp, *Macrocystis pyrifera*, and feather boa kelp, *Egregia menziesii*), various understory and encrusting algae, diverse assemblages of attached and motile invertebrates, and numerous reef-associated and pelagic fish species. The growth of attached algae and inverterbrates is often quite dense, especially on pilings.

The 2023 Biosurvey characterized intertidal and subtidal riprap and piling communities using methods similar to those used in past 2018 Biosurveys and consistent with those used in regional surveys of coastal rocky reefs. Modifications in 2023 to the 2018 methodology included additional surveys in the lower intertidal zone on riprap embankments to better characterize algae and invertebrates, surveys to quantify macroalgae and large invertebrates on pilings, and a quantitative fish survey at riprap and piling stations.

Kelp canopy at and near the surface was monitored only via high-resolution satellite imagery for the first time in the Port Complex as part of the 2023 Biosurveys in place of the aerial imagery used in previous Biosurveys. Reference areas outside the Port boundaries in Eastern San Pedro Bay (the eastern breakwater and energy islands) and natural rocky reef off of Palos Verdes (Point Fermin and White's Point) were mapped to provide context for considering seasonal and annual variability in the kelp canopy within the Port Complex.



Kelp canopy on breakwater

Kelp Canopy and Understory Algae

Kelp canopy covered 39.1 acres in the spring and 43.6 acres in the summer of 2023. The areas of the Port Complex that contained the most kelp canopy were the Cabrillo Breakwater and SWH (over 7 acres across both seasons), the Middle Breakwater (over 9.5 acres), Port of Long Beach outer anchorages (over 5 acres), and outer Pier J (over 3 acres). Historical archived imagery from 2018 through 2024 indicated that the highest summer kelp canopy acreage occurred during the 2018 Biosurvey (71.4 acres). Diver surveys at riprap stations found higher kelp densities and more stipes per individual in the summer rather than spring, providing additional insight into kelp recruitment and the location of suitable habitat conditions in the Port Complex. Giant kelp and feather boa kelp were not observed in the Inner Harbor, which is consistent with their requirement for an energetic current regime to ensure adequate nutrient supply and with the seasonally higher temperatures in Inner Harbor areas, which can prevent recruitment and growth of kelp. However, drifting giant kelp and submerged kelp detritus were observed at Inner Harbor stations throughout the Port Complex, indicating connectivity between Outer Harbor kelp forests and Inner Harbor benthic communities that can augment secondary production in these areas.

All four piling stations in the Outer Harbor had giant kelp growing on them during the summer for the 2023 Biosurvey. For the first time, using the additional diver survey techniques deployed at riprap stations, giant kelp was documented on pilings because the canopy does not extend far enough from the edge of the wharves to be detected by remote sensing.

Four understory algal species are found on riprap and pilings in the Port Complex: *Sargassum horneri, Sargassum muticum, Undaria pinnatifida*, and *Stephanocystis osmundacea*. The two *Sargassum* species and *Undaria* are non-native species that are considered invasive. At least one of the four species was documented at all but one of the riprap stations sampled by divers. The exception was the station at Outer East Pier 400, which was devoid of any but encrusting algae, likely due to very high densities of sea urchins. *Sargassum* and *Undaria* were substantially more abundant at the Inner Harbor riprap stations than at Outer Harbor stations, whereas *Stephanocystis* was observed only at Outer Harbor stations. No *Sargassum muticum* was observed on pilings, and *S. horneri* was observed only on Outer Harbor pilings, although at low densities. *Undaria* was observed on pilings in both the Inner Harbor and Outer Harbor, at similar densities in both areas.

Both riprap and piling substrates supported a variety of encrusting and low-growing algae, primarily coralline red algae (e.g., *Corallina* spp.) but also a number of species of red (*Ceramiaceae and Pterocladia*), brown (*Colpomenia*), and green algae (*Ulva)*.

Invertebrates

Surveys observed marked differences between Outer Harbor and Inner Harbor stations in the composition of the invertebrate species assemblages. Specifically, Outer Harbor stations were commonly characterized by predators such as spiny lobster (*Panulirus interruptus*), filter feeding gorgonians (*Muricea* spp.), and large anemones; these results

are consistent with the increased wave energy and currents in the Outer Harbor. Inner Harbor stations were characterized by bat stars (*Patiria miniata*) and sea cucumbers (*Apostichopus parvimensis*). The primary herbivores in the Port Complex were urchins, primarily purple urchins (*Strongylocentrotus purpuratus*), although abalone were also present in the Outer Harbor. Uniform point contact (UPC) surveys of percent cover indicated that Inner Harbor stations on average had higher percentages of bare substrate, reflecting higher sedimentation at subtidal depths, and lower percentages of gastropod mollusks (i.e., snails), gorgonians, and coralline algae, than results at Outer Harbor stations.

Finally, the scraped quadrat methodology, in which divers removed all the organisms from a small area at eight riprap stations, provided high-resolution taxonomy of the animals living at three tidal zones (upper intertidal, lower intertidal, and subtidal). A total of 578 species (545 invertebrate species and 33 algae species) were identified across all riprap and piling stations; the average number of species at individual riprap stations was 175, and the average number of individuals was 2,739. Outer Harbor stations had higher species richness, total abundance, biomass, and diversity than Inner Harbor stations (Figure ES-9).



Divers collecting intertidal quadrat scrapings in POLB Cerritos Channel

As is typical of rocky shorelines, the upper intertidal zone was characterized by a few species that are tolerant of the harsh physical conditions present, such as Mediterranean mussels *(Mytilus galloprovincialis)*, barnacles (*Balanus crenatus* and *Chthamalus fissus*), and bivalves (*Lasaea adansoni*) that thrive in crevices in rocks and between mussels. The lower intertidal and subtidal communities are less distinct from one another than they are from the upper intertidal communities. The lower intertidal samples had a diverse assemblage of species, including barnacles and mussels, but also many crustaceans (e.g., *Caprella* sp.*,* non-native *Caprella simia, Zeuxo normani,* and *Laticorophium baconi*) and annelids (e.g., *Exogone lourei* and *Spirorbinae*) that cannot tolerate the long exposure to air and the resultant high temperatures and desiccation that occur in the upper intertidal zone. The subtidal zone contained far fewer of the species that are found in the upper intertidal zone such as barnacles, although Mediterranean mussels were still present at many stations. Subtidal samples included many of the crustaceans that were found in the lower intertidal zone, but also had numerous invertebrate species that were almost exclusively seen in the subtidal zone such as the brachiopod ("lamp shells") *Annuloplatidia horni* and the small burrowing bivalve *Neolepton subtrigonum*.

The piling community differed from the riprap community in that it generally had a higher proportion of mollusks (e.g., mussels and lower proportion of arthropods [e.g., barnacles]). Piling stations also had more green and fleshy red algae than the riprap stations, which tended to be dominated by coralline red algae.

Fish of the Riprap and Piling Habitats

The divers observed 37 species of fish at riprap stations and 14 species at piling stations. Many of those species were not captured during trawl or lampara net sampling because they are typically associated with rocky reef or high-relief habitats; examples include garibaldi (*Hypsypops rubicundus*), opaleye (*Girella nigricans*), sheephead (*Pimelometopon pulchrum*; both males and females), horn shark (*Heterodontus francisci*), and moray eel (*Gymnothorax mordax*).

Across all stations, barred sand bass, black perch (*Embiotoca jacksoni*), and kelp bass (*Paralabrax clathratus*) were the most common species observed, occurring at more than 50% of the stations. Riprap stations had a more diverse fish community, with 15 species observed at more than 25% of stations; pilings had only 8 species observed at more than 25% of stations. Piling stations included higher occurrences of pelagic species such as blacksmith (*Chromis punctipinnis*), jacksmelt, and juvenile smelt. Several species common at riprap stations, such as opaleye and garibaldi, were absent from piling stations, and only white surfperch was observed only at piling stations.

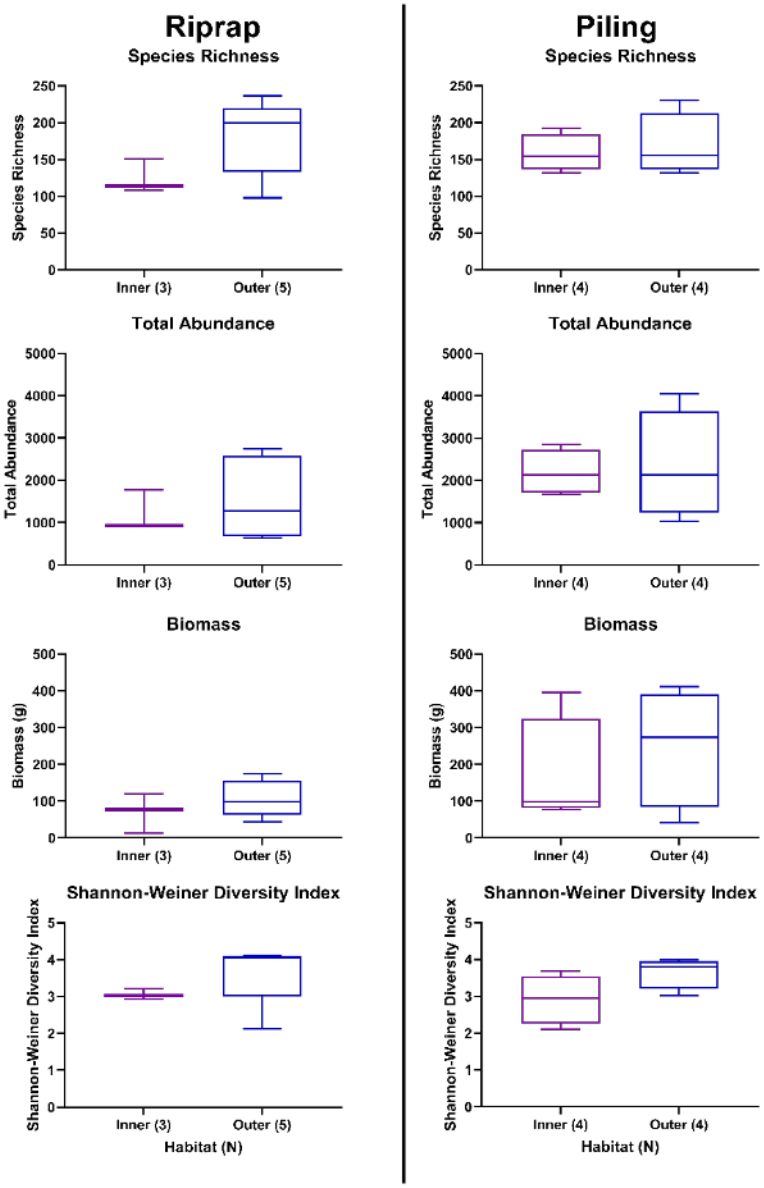


Figure ES-9. Species Richness, Abundance, Biomass and Diversity Index Values for Riprap and Piling Quadrat Scrapings At Inner and Outer Harbor Habits

Species richness in the spring across all riprap stations ranged from 1 to 9 total fish species, and densities ranged from 2.50 to 150 fish per 100 square meter (m^2). In summer, the number of species per station ranged from 1 to 14, and densities from 5 to 190 fish per 100 m^2. Species richness at piling stations ranged from 1 to 9 species, and densities ranged from 2.50 to 535 fish per 100 m^2. Pilings had lower mean species richness but higher mean fish density than riprap across both seasons, although these differences were not statistically significant.

The riprap stations with the highest species richness and density of fishes tended to be on the breakwaters and in the Outer Harbor. Those stations had high densities of barred sand bass, black perch, blacksmith, garibaldi, kelp bass, opaleye, rock wrasse (*Halichoeres semicinctus*), and zebra perch (*Kyphosus vaigiensis*). Only one Inner Harbor



Garibaldi guarding nest with eggs in Outer Harbor

station, T13 (South of Consolidated Slip), had densities of fish similar to the densities in the Outer Harbor, but the community was composed primarily of shiner perch, topsmelt, black perch, and round rays. Black perch were generally the most abundant species in both seasons across all Inner Harbor stations.

Piling stations with the highest diversity and density of fishes were in the Outer Harbor; all those stations had kelp growing on the pilings that likely affords additional refuge and foraging habitat compared with Inner Harbor piling stations, which were devoid of kelp. These Outer Harbor piling stations were the only piling locations where species such as kelp bass, sargo (*Anisotremus davidsonii*), sheephead, kelp perch (*Brachyistius frenatus*), and halfmoons (*Medialuna californiensis*) were observed. Inner Harbor piling stations only had one to three species per station, most commonly barred sand bass.

VI. BIRDS

→ **Four of the ten most abundant bird species observed in the 2013-2023 Biosurveys are special-status, indicating the importance of the Port Complex to these protected species.**

→ **The total bird species and mean abundance of birds per monthly survey in 2023 were in line with historical observations from the 2000-2013 surveys, indicating that the low diversity and abundance observed in 2018 was likely the outlier as a result of regional oceanographic phenomena such as the 2014-2016 heatwave event**

The Port Complex features an assortment of habitats that provide shelter, foraging, and nesting opportunities for a wide variety of avian species. In the Biosurveys, birds are evaluated through a concept called "guilds," which groups bird species according to habitat usage and foraging patterns rather than taxonomy. The eight guilds encountered in the Port Complex are (1) Aerial Fish Foragers, (2) Large Shorebirds, (3) Small Shorebirds, (4) Wading/Marsh Birds, (5) Gulls, (6) Upland Birds, (7) Waterfowl, and (8) Raptors. The Biosurveys recorded birds from a vessel each month in 55 survey zones (Figure ES-5), noting their presence on a variety of physical features throughout the Port Complex, such as open water, breakwaters, docks/pilings, barges, sandy beach, etc., to assess the value of such features for the various bird guilds.

A total of 63,551 individual birds belonging to 110 species in 33 taxonomic families were observed in the Port Complex during the 2023 Biosurvey. Monthly species numbers ranged from 30 in July 2023 to 66 in February 2024. Abundance was highly seasonal, with bird numbers peaking during the fall migration and winter and at their lowest during the summer. This pattern was driven primarily by the abundance of overwintering Waterfowl (e.g., ducks, grebes, and cormorants) and Aerial Fish Foragers (e.g., terns and pelicans). However, 21 of the species observed are likely year-round residents because they were present during at least 10 of the 12 survey events.

As in previous Biosurveys, the 10 most abundant bird species (Table ES-5) accounted for 88% of all observations, and the top three species – western gull, Brandt's cormorant, and surf scoter – accounted for over half of the total bird abundance. All of these species have been numerically dominant in all five Biosurveys, indicating a consistent and stable species assemblage. Only 1 of the 10 most abundant species was an Upland Bird species: rock pigeon (*Columba*

livia) are closely associated with structures such as docks, warehouses, and marina structures, and therefore are easily observed from the water. A total of 8 of the 10 most abundant species, except elegant tern and surf scoter, are year-round residents of the Port Complex, and 4 of those (i.e., western gulls, rock pigeons, Brandt's cormorant, and double-crested cormorant) are known to breed and nest in the Port Complex.

Abundant Bird Guilds: Over 80% of the birds observed in the Port Complex in the 2023 Biosurvey belonged in three guilds: Waterfowl, Gulls, and Aerial Fish Foragers. The most abundant guild was the Waterfowl guild, which accounted for 39% of total bird sightings; 4 of the 10 most abundant species were in this guild. The large expanses of open water in the Port Complex are attractive to grebes, scoters, and migratory ducks, which often form large rafts in the Outer Harbor.

Gulls represented 29.3% of all birds observed during the survey period, and by far the most abundant gull (and the most abundant species observed in the Port Complex) was the western gull, *Larus occidentalis* (Table ES-5).

Table ES-5. Ten Most Abundant Bird Species In the Port Complex, 2023–2024

Species		Percentage of Total	Guild
Western Gull	*Larus occidentalis*	24.3	Gulls
Brandt's Cormorant	*Phalacrocorax penicillatus*	19.3	Waterfowl
Surf Scoter	*Melanitta perspicillata*	11.3	Waterfowl
Brown Pelican	*Pelecanus occidentalis*	9.6	Aerial Fish Foragers
Rock Pigeon	*Columba livia*	9	Upland Birds
Western Grebe	*Aechmophorus occidentalis*	3.6	Waterfowl
Elegant Tern	*Thalasseus elegans*	3.3	Aerial Fish Foragers
California Gull	*Larus californicus*	2.7	Gulls
Double-crested Cormorant	*Nannopterum auritum*	2.6	Waterfowl
Heermann's Gull	*Larus heermanni*	2.3	Gulls
Total		**88.0**	

Aerial Fish Foragers accounted for 14.2% of observations and were most abundant in late spring and summer. Large numbers of elegant terns, as well as lower numbers of other terns, arrive in the Port Complex in late spring, nest on Pier 400 in the Port of Los Angeles, and then depart in August for their overwintering grounds. Brown pelicans, the fourth-most abundant bird, return to the Port Complex in summer from their offshore island breeding grounds.

Rare and Special-Status Birds: Two of the species observed during the 2023 Biosurvey are rare in southern California: one American oystercatcher (*Haematopus palliates*) was observed foraging and resting on riprap in 5 of the 12 survey months in Zone 15 and Zone 12 and once in Zone 19, and four yellow-crowned night herons (*Nyctanassa violacea*) were documented resting on riprap in Zones 12, 15, 4b, and 4c in September and October 2023. In addition, 25 special-status bird species (i.e., species protected by state or federal regulations or otherwise listed as having a special status) were observed during the 2023 Biosurvey. A total of 13 of those species were observed nesting in the Port Complex (Table ES-6), and for them the harbor area is an important habitat resource. For a number of other special-status species that do not nest within the Port Complex, the harbor area may be valuable for foraging and resting. These species include the brown pelican (*Pelecanus occidentalis*), California gull (*Larus californicus*), common loon (*Gavia immer*), and redhead (*Aythya americana*).

Habitat Utilization: Seven survey zones in the Outer Harbor, two in the Shallow Water Habitats in the Port of Los Angeles and one in the Inner Harbor, consistently supported large numbers of birds, and these zones accounted for more than half of all observations. The Outer Harbor zones, in particular, had large numbers of Aerial Fish Foragers and Waterfowl in spring and summer and large rafts of grebes and surf scoters in winter. The Outer Harbor zones that included the Middle Breakwater had large numbers of birds, primarily because of cormorants, pelicans, and gulls roosting on the boulders. The SWH zones had the highest species numbers, largely because of the variety of physical features – sandy beach, riprap, open water, dredge pipe – available. Fish Harbor attracted large numbers of gulls, likely because of the presence of the commercial fishing fleet and of rock pigeons, possibly because of the numerous shoreline structures there.

These geographic patterns are consistent with the results of previous Biosurveys, as are the patterns in types of physical features used by birds. Open water, riprap, and dock/pilings have continually been the most heavily used physical

features in the Port Complex. During all five Biosurveys, no less than 70% of observations have occurred in these three types of features, which is not surprising given that these are the dominant physical features of the water areas of the Port Complex.

Table ES-6. Special-Status Bird Species Observed Nesting in Port Complex in 2023

Species		Status	Abundance
Black-crowned Night Heron	*Nycticorax nycticorax*	SA	Common
Black Skimmer	*Rhyncops niger*	BCC, SCC	Common
California Gull	*Larus californicus*	WL, BCC	Abundant
Caspian Tern	*Hydroprogne caspia*	SA, BCC	Common
Common Loon	*Gavia immer*	SSC	Occasional
Coopers Hawk	*Accipiter cooperii*	WL	Occasional
Double-crested Cormorant	*Nannopterum auritum*	WL	Abundant
Elegant Tern	*Thalasseus elegans*	WL	Abundant
Great Blue Heron	*Ardea herodias*	SA	Abundant
Great Egret	*Ardea herodias*	SA	Occasional
Osprey	*Pandion halieatus*	WL	Common
Redhead	*Aythya americana*	SSC	Occasional
Snowy Egret	*Egretta thula*	SA	Common

BCC = Bird of Conservation Concern; FE = Federally Endangered; FP = Fully Protected; SA= Special Animal; SE = State Endangered; SSC = Species of Special Concern; WL = Watch List



Sea lions and a cormorant in the Outer Harbor

VII. MARINE MAMMALS

→ Marine mammals have only been quantified as part of the Biosurveys since 2013, added during a period of unually high sea lion strandings in California.

→ The 2023 survey found similar results to previous surveys, with California sea lions, harbor seals, and common bottlenose dolphins comprising at least 92% of all sightings, and the remaining observations consisting of sporadic encounters with species such as the gray whale that are not typically found in harbor environments.

Pinnipeds that are commonly observed within the Port Complex include harbor seal (*Phoca vitulina*) and California sea lion (*Zalophus californianus*). These species forage in harbor waters and rest on the shoreline and structures in the harbors. Cetaceans known to occur within the Port Complex include common bottlenose dolphin (*Tursiops truncatus)* and common dolphins (*Delphinus* spp.), which forage in harbor waters. The gray whale (*Eschrichtius robustus*) is a rare visitor to the Port Complex but is commonly observed nearshore along coastal California during migration periods.

As in previous Biosurveys, marine mammals were recorded as they were observed during the bird surveys. A total of 1,141 marine mammals belonging to four species were recorded during the 2023 Biosurvey. California sea lions accounted for 71.5% of total marine mammal observations and were present year-round. They were typically observed resting on buoys, docks, riprap shoreline, and the bulbous bows of large container ships in

the Outer Harbor, and were especially abundant in the Long Beach West Basin. During previous Biosurveys, California sea lions were also identified as the most abundant marine mammal in the Port Complex. Harbor seals, the second most abundant marine mammal, were most commonly observed resting or foraging along riprap shorelines, especially on the breakwaters and outer Pier 400.

Common dolphins were the most abundant cetacean and were observed several times in small groups throughout the Port Complex. Three gray whales were observed during the Biosurvey, two in the Outer Harbor (Port of Long Beach Outer Harbor Main Channel) and one in the Port of Los Angeles Cabrillo SHW, where it was feeding.

VIII. NON-NATIVE SPECIES

- → **Of the 979 invertebrate, algae, and fish taxa observed in 2023, 49 (5%) were non-native species. The increase from the 46 species observed in 2018 and 27 observed in 2013 may be in part due to the inclusion of new habitats in 2018 and modifications of survey methods in 2023.**
- → **The reference non-native species database Cal-NEMO was updated after the 2018 survey report was published, which complicates historical comparisons.**
- → **Riprap and piling communities had a higher proportion of non-native species (8-10% of all species) compared to soft-bottom infaunal communities (5%).**
- → **The relative abundance of non-native organisms was higher in soft-bottom habitats (33%) than in riprap and piling habitats (10-13%).**
- → **It does not appear that non-native species are displacing native species within the Port Complex, given the high diversity and abundance of fish, invertebrates and algae across the habitats examined and the similar proportion of non-native species across survey years.**

Species identified in the 2023 Biosurvey and in previous Biosurveys (2000 through 2018) were cross referenced to determine their status with the California Non-native Estuarine and Marine Organisms (Cal-NEMO) database, which includes comprehensive and user-friendly information on established non-native invertebrates and algae in the marine and estuarine waters of California. A collaboration between the Office of Spill Prevention and Response (OSPR) and the Smithsonian Environmental Research Center, the Cal-NEMO database is a portal of the National Exotic Marine and Estuarine Species Information System (NEMESIS) database, which was compiled with information previously held in the California Aquatic Non-Native Organism Database (CANOD) and used in previous Biosurveys.

In total, 49 non-native species were identified in the current study (Table ES-7), which is an increase over the 46 species observed in 2018, 27 species observed in 2013, 19 species observed in 2008, and 25 species observed in 2000. Non-natives made up 4.5% of the 1,093 fish, invertebrate, and algal taxa observed during the 2023 survey, a proportion similar to those in past Biosurveys.

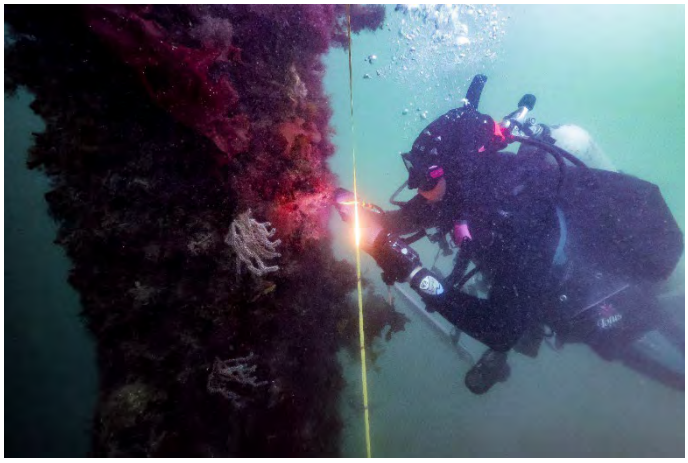
Table ES-7. Number of Non-Native Species by Community Type in 2023

Phyla		# Non-Native Species	Ichthyo-plankton	Demersal Fishes	Epibenthic Invertebrates	Benthic Infauna	Riprap Epifauna	Piling Epifauna
Chordates	Fishes	3	2	2				
	Sea Squirts	14			7	5	7	12
Invertebrates	Annelids	6				3	4	5
	Arthropods	13				7	12	12
	Bryozoa	3					3	3
	Cnidaria	1					1	
	Mollusca	5			3	4	3	3
Macroalgae	Ochrophyta	3					2	
	Rhodophyta	1					1	1
Total Non-Native Species		**49**	**2**	**2**	**10**	**19**	**33**	**36**

The expanded methods used and habitat types surveyed in 2018 and 2023 may have contributed to the increase in non-native species detected, in addition to the possibility that climate-mediated changes have resulted in new species, particularly invertebrates, appearing in new locations as their ranges expand.

Most non-native species, and all of the species not observed in previous Biosurveys, were invertebrates. Most species observed for the first time were new to the Cal-NEMO database, which was updated in 2021 between the publication of the 2018 Biosurvey report and this report; however, species persistence within the Port Complex environment will require further monitoring to determine whether they become established. The number of non-native fish species has remained consistent across the past four Biosurveys. Only two species (yellowfin goby [*Acanthogobius flavimanus*] and chameleon goby [*Tridentiger trigonocephalus*]) were observed in all five Biosurveys in the ichthyoplankton and demersal fish trawls; chameleon gobies were also observed in the diver fish surveys at Inner Harbor riprap stations in 2023. The shimofuri goby (*Tridentiger bifasciatus*) was observed in ichthyoplankton trawls for the first time in 2023, indicating that this freshwater species is becoming more established in aqueduct and riverine habitats in the watersheds that terminate at the Port Complex. The non-native macroalgae, namely *Sargassum horneri*, *S. muticum*, and *Undaria pinnatifida*, have been present on riprap and pilings throughout the Port Complex in all five Biosurveys, with the highest densities in the Inner Harbor areas**.**

Epifaunal communities on riprap and pilings had similar relative percentages of non-native invertebrate species (8.4% and 10.1%, respectively), and benthic infauna communities in sediments had the lowest percentage of non-native species (5.1%). In terms of abundance, however, results for riprap and pilings were similar (10.7% and 13.1%, respectively), and these habitats had less than half of the relative abundance of non-natives in soft-bottom habitats (33.4%). As stated in the soft-bottom habitat discussion, many of these non-natives were present in the spring following above-average rainfall during the prior winter, and the abundances in the summer sampling period were much lower.



Diver surveying piling in the Inner Harbor

Although non-native species are present in most anthropogenically influenced coastal habitats in southern California, it does not appear that they are disproportionately displacing native species within the Port Complex because the diversity and abundance of fish, invertebrates, and algae have remained high across the habitats examined in the 2023 Biosurvey.

IX. CONCLUSIONS

Results of the 2023 Biosurvey indicate that the Port Complex continues to support healthy and robust biological communities. Although demersal fish assemblages have remained relatively consistent across all Biosurveys, there has been a notable shift in the epibenthic invertebrate community, with the establishment of target shrimp as the dominant species. For the third Biosurvey in a row, a pollution-sensitive infaunal species was one of the two most abundant species collected in sediments within the Port Complex, an indication of good sediment quality. Pelagic and demersal fishes continue to use the Port Complex to forage for prey, and many of the most abundant species used the Port Complex as a nursery habitat. Critical habitats such as kelp and eelgrass are key resources for numerous species, and in the case of eelgrass there appears to be an expansion into Inner Harbor areas that may be a result of continued improvements in water clarity in these areas. New survey methods on riprap and pilings have cataloged numerous algae, invertebrate, and fish species, and results have shown that these habitats can support a diverse and productive community of attached and associated organisms. The Port Complex continues to support numerous bird species that forage in the open water and use various port structures for nesting, including several special-status species. Marine mammals are common, especially sea lions and harbor seals, and dolphins and seasonal visitors such as gray whales can occasionally be spotted in Outer Harbor areas.

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APPENDICES

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Abbreviations and Acronyms

Abbreviation/Acronyms	Description
°C	degree(s) Celsius
µg/L	microgram(s) per liter
ac	acre(s)
ANOSIM	analysis of similarities
ANOVA	analysis of variance
AOI	area of interest
avg	average
Basin Plan	Water Quality Control Plan for the Los Angeles Basin
BCC	Bird of Conservation Concern
Biosurvey	biological survey
BLM:S	Bureau of Land Management – Sensitive
BRI	Benthic Response Index
Cal-NEMO	California Non-native Estuarine and Marine Organisms
CANOD	California Aquatic Non-Native Organism Database
CDFG	California Department of Fish and Game
CDF:S	California Department of Forestry and Fire Protection – Sensitive
CDFW	California Department of Fish and Wildlife
CDFW:SA	California Department of Fish and Wildlife – Special Animal
CDFW:FP	California Department of Fish and Wildlife – Fully Protected Species
CDFW:WL	California Department of Fish and Wildlife – Watch List
CDFW:SSC	California Department of Fish and Wildlife – Species of Special Concern
CDFW:SA	California Department of Fish and Wildlife – Special Animal, tracked by CDFW but not protected status
CEMP	California Eelgrass Mitigation Policy
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
CIQ	*Clevlandia/Ilypnus*/*Quietula*
cm	centimeter(s)
CO_2	carbon dioxide
CPS	coastal pelagic species
CTD	conductivity, temperature, and depth
DCE	Dancing Coyote Environmental
DNA	deoxyribonucleic acid
DO	dissolved oxygen
DQO	data quality objecting
EFH	essential fish habitat
EI	Ecological Index
ENSO	El Niño Southern Oscillation
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
ESHA	Environmentally Sensitive Habitat Area

Abbreviation/Acronyms	Description
FE	Federally Endangered
FMP	Coastal Pelagics Fisheries Management Plan
FP	Fully Protected
FTU	formazin turbidity unit(s)
GIS	geographic information system
HAPC	Habitat Area of Particular Concern
Harbor Toxics TMDL	Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Load
ID	identifier
ITIS	Integrated Taxonomic Information System
IUCN	International Union for Conservation of Nature and Natural Resources
kg	kilogram(s)
$kg/m^2/yr$	kilogram(s) per square meter per year
km^2	square kilometer(s)
KRMP	Kelp Restoration and Management Plan
LA	Los Angeles
LBC	Langdon Biological Consulting, LLC
LED	light-emitting diode
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
m^2	square meter(s)
m^3	cubic meter(s)
max	maximum
MEC	MEC Analytical Systems
med	median
mg/L	milligram(s) per liter
min	minimum
MLLW	mean lower low water
mm	millimeter(s)
MODIS	Moderate Resolution Imaging Spectroradiometer
MQO	measurement quality objective
NA	not applicable
NASA	National Aeronautical and Space Administration
NEMESIS	National Exotic Marine and Estuarine Species Information System
nMDS	non-metric multidimensional scaling
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit(s)
ONI	Oceanic Niño Index
OPC	California Ocean Protection Council
OSPR	Office of Spill Prevention and Response
PCG	Pacific Coast Groundfish
PDO	Pacific Decadal Oscillation
PEI	Pielou's Evenness Index

Abbreviation/Acronyms	Description
PFMC	Pacific Fisheries Management Council
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
POLA	Port of Los Angeles
POLB	Port of Long Beach
Port Complex	Long Beach-Los Angeles Port Complex
Primer	Plymouth Routines in Multivariate Ecological Research
PSU	practical salinity unit(s)
QA	quality assurance
QC	quality control
Rincon	Rincon Consultants, Inc.
RMC	Greater Harbor Waters Regional Monitoring Coalition
ROV	remotely operated vehicle
SA	Special Animal
SAIC	Science Applications International Corporation
SCCWRP	Southern California Coastal Water Research Project
SCEMP	Southern California Eelgrass Mitigation Policy
SD	standard deviation
SE	State Endangered
SIMPER	similarity percentage
SIMPROF	similarity profile
SL	standard length
SSC	Species of Special Concern
SST	sea surface temperature
SWH	shallow water habitat
TL	total length
TMDL	total maximum daily load
TOC	total organic carbon
UME	Unusual Mortality Event
UPC	uniform point contact
USACE	United States Army Corps of Engineers
USC	University of Southern California
USFWS	United States Fish and Wildlife Service
USFWS:BCC	United States Department of Fish and Wildlife – Bird of Conservation Concern
USFS:S	United States Forest Service – Sensitive
WL	Watch List
Wood	Wood Environment & Infrastructure Solutions, Inc.
WoRMS	World Register of Marine Species
WQO	water quality objective
WSP	WSP USA Inc.

1 INTRODUCTION

The biological communities of San Pedro Bay represent an important element of the coastal marine biological resources of southern California. These communities co-exist with, and are affected by, the operations of the nation's largest port complex: the Ports of Los Angeles and Long Beach. As discussed in more detail in this section, this report describes both the current state of those communities and the changes in those communities over the past 45 years in response to federal and state regulatory programs and the environmental initiatives of the two ports.

The Ports of Long Beach and Los Angeles are in the western portion of San Pedro Bay, which is bounded by the City of Los Angeles communities of San Pedro and Wilmington on the north and west and by the City of Long Beach on the north and east (Figure 1-1). Both ports are departments of their respective city governments, having jurisdiction over harbor land and water areas, consistent with the provisions of the State of California Tidelands Trust Act and the California Coastal Act. Both laws charge the ports primarily with accommodating and promoting maritime commerce, navigation, and fisheries, but also with managing and protecting the marine resources of the harbors for the benefit of the people of California. As part of that stewardship, over the past 4 decades the ports have conducted periodic, comprehensive biological surveys (Biosurveys) of the Long Beach-Los Angeles Port Complex (Port Complex).

The first large-scale Biosurveys were performed in the late 1970s under the University of Southern California (USC) Harbors Environmental Project (HEP), and a series of reports from those surveys (e.g., HEP-USC, 1979) provided an overview of oceanographic and marine biological conditions at that time. In the early 1980s, the ports commissioned biological baseline studies of their respective harbors (MBC Applied Environmental Sciences [MBC], 1984; MEC Analytical Systems [MEC], 1988). Recognizing that both they and the governmental agencies that oversee marine wildlife resources would benefit from a comprehensive, simultaneous survey of the entire Port Complex, the ports collaborated to commission the year 2000 baseline Biosurvey (MEC, 2002) and agreed to repeat the Biosurvey on a regular basis. The next Biosurvey was conducted in 2008 (Science Applications International Corporation [SAIC], 2010); the third Biosurvey was conducted in 2013 (MBC, 2016), and the fourth Biosurvey was conducted in 2018 (Wood Environment & Infrastructure Solutions, Inc. [Wood], 2021.

This report documents the results of the fifth collaborative harbor-wide Biosurvey, conducted over three seasons in 2023 and 2024. Because this Biosurvey used techniques similar to those used the prior four Biosurveys, it updates and supplements the information provided by those previous Biosurveys. Similar to the previous harbor-wide Biosurveys, this Biosurvey Report, by means of systematic field sampling and observation spaced throughout an entire year, describes basic physical factors (e.g., water quality and sediment types) and the marine biota in a variety of habitats.

The marine biota studied during the Biosurveys over the past 4 decades constitute the major biological elements of the Port Complex. These include the invertebrates living in, on, and immediately above the bottom sediments (the benthic infauna and epifauna); bottom-dwelling and open-water fish, including their eggs and larvae (the ichthyoplankton); animals, plants, and algae living on the rock dikes and pilings (hard substrate associated epifauna and macroalgae); eelgrass and kelp; marine mammals; and seabirds and shorebirds.

1.1 OVERVIEW OF THE STUDY AREA

Physical Configuration

The Port Complex (Figure 1-1) occupies the western half of San Pedro Bay, a semi-enclosed embayment at the southeastern corner of Los Angeles County. The harbors are protected by a 14-kilometer (9-mile)-long series of three breakwaters constructed in the first half of the 20th century. Prior to the 20th century, the Port Complex was an estuarine system at the mouth of the San Gabriel and Los Angeles Rivers, with extensive mudflats and marsh areas protected by barrier beaches. The estuary's shallow waters, mudflats, and beaches provided habitat for a wide variety of fish, invertebrates, and seabirds.

Rapid urbanization of the region starting in the 1890s led to a need for commercial harbor facilities, and the resultant dredging of channels and basins, filling of marshes, open water areas, and mudflats to create land and construct port facilities, which has entirely altered the area. In addition, the Los Angeles River no longer flows directly into the Port Complex but empties into the San Pedro Bay adjacent to POLB. As a result of this change and the changes caused by development of the ports, the harbor area is no longer a true estuary. Today, the Port Complex consists largely of deep



Port Complex with San Gabriel Mountains in the Distance

channels and basins for navigation of cargo vessels and dry land to support marine cargo terminals and other industrial uses. Most of the shoreline is lined with rock dikes and revetments, and sheet-pile bulkheads. As a result of these developments, very little sandy beach or tidal marsh habitat remains. In contrast, placement of shoreline structures, such as bulkheads, riprap, and pier pilings, has greatly increased the hard substrate available for species characteristic of rocky shores, such as mussels, barnacles, and macroalgae. The open-water areas are largely characterized by muddy bottoms, as were the former tidal marshes, but now most of the soft-bottom habitat is in deeper water.

Today, the Port Complex is one of the major commercial port facilities in the world and a major gateway for Pacific Rim economies. In 2023, the more than 3,700 vessels that called at the marine terminals of the two ports (compared with 3,916 vessels in 2018) conveyed approximately one-third of the cargo entering and leaving the United States (valued at nearly $500 billion). The two ports are similar in physical size, sharing approximately 7,860 acres of water area, including anchorage and maneuvering areas in open waters behind the breakwaters, navigational channels, slips, turning basins, and berthing areas farther inside the Port Complex. On the basis of the past Biosurveys, the ports and the wildlife resource agencies recognize three ecological zones in the Port Complex (Figure 1-1): Outer Harbor, consisting of deep open-water areas and most of the deep channels and basins; Shallow-Water Habitat (SWH), consisting of areas in the Outer Harbor less than 20 feet deep; and Inner Harbor, consisting largely of dead-end slips and other areas in the interior reaches of the Port Complex.

Climate and Oceanography

Southern California lies in a climatic regime defined as Mediterranean, characterized by mild winters and warm, dry summers. Annual average rainfall is approximately 31 centimeters (cm; 12 inches), most of which falls from November through April.

The Port Complex is in approximately the center of the geographical feature known as the Southern California Bight, which extends from Point Conception in the north to the international border with Mexico in the south. Winds in the area produce a weak, generally onshore southerly flow of air (Dailey et al., 1993). Near the shoreline, a diurnal onshore land breeze is typical, particularly during summer, driven by a thermal low over the deserts east of the Los Angeles area. On occasion, a high-pressure area develops over the Great Basin that causes strong, dry, offshore winds in the coastal areas. These Santa Ana winds are most common in late summer and fall but can occur any time of year.

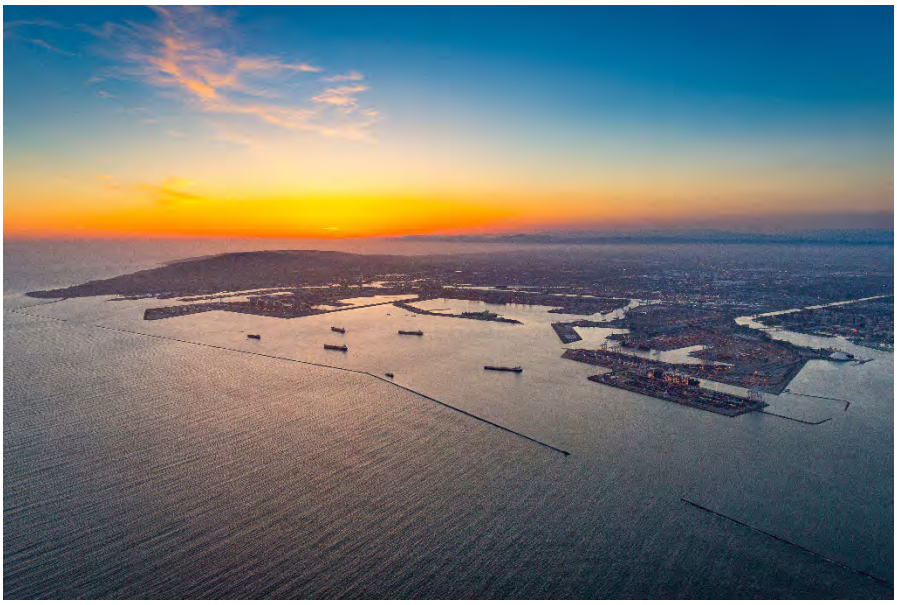
Tides along the coast of Southern California are classified as mixed semi-diurnal, with two unequal high tides (high water and higher high water) and two unequal low tides (low water and lower low water) each lunar day (approximately 24.5 hours). Since 2000, water level extremes in the Outer Los Angeles Harbor (National Oceanic and Atmospheric Administration [NOAA] Buoy 9410660) ranged from -0.71 meter to +2.41 meters (-2.34 feet to + 7.92 feet) above mean lower low water (MLLW; NOAA, 2024). These tides are the primary drivers of water circulation in the Port Complex, although strong wind events can affect circulation in the Outer Harbor.

Hydrodynamic modeling by the United States Army Corps of Engineers has described circulation in the Port Complex (Figure 1-2). Strong flood tide currents enter the Port Complex through the Angel's Gate and Queen's Gate, and weaker currents enter through the opening between the tip of the breakwater and the shoreline of eastern Long Beach.

Flood currents passing through Angel's Gate flow to either side of Pier 400, and those passing through Queen's Gate flow to either side of Pier J.

During ebb tide, the flow in the harbors is drawn from all directions toward the exits through the breakwaters. Ebb currents leaving the Port of Los Angeles flow mainly through the Angel's Gate. In the Port of Long Beach, ebb currents exit either through the Queen's Gate or the eastern opening at the tip of the breakwater. As Figure 1-2 shows, tidal currents within the Ports of Los Angeles and Long Beach are generally weak (less than 0.15 meter per second [0.5 foot per second]) except in the main navigational channels (Port of Los Angeles Main Channel and Port of Long Beach Back Channel). Water in the Outer Harbor has a residence time of roughly 10 days, and residence time in the Inner Harbor is as much as 32 days (Anchor QEA, 2015). As a result, many areas of the Port Complex, particularly Inner Harbor slips and basins, are characterized by limited tidal circulation.

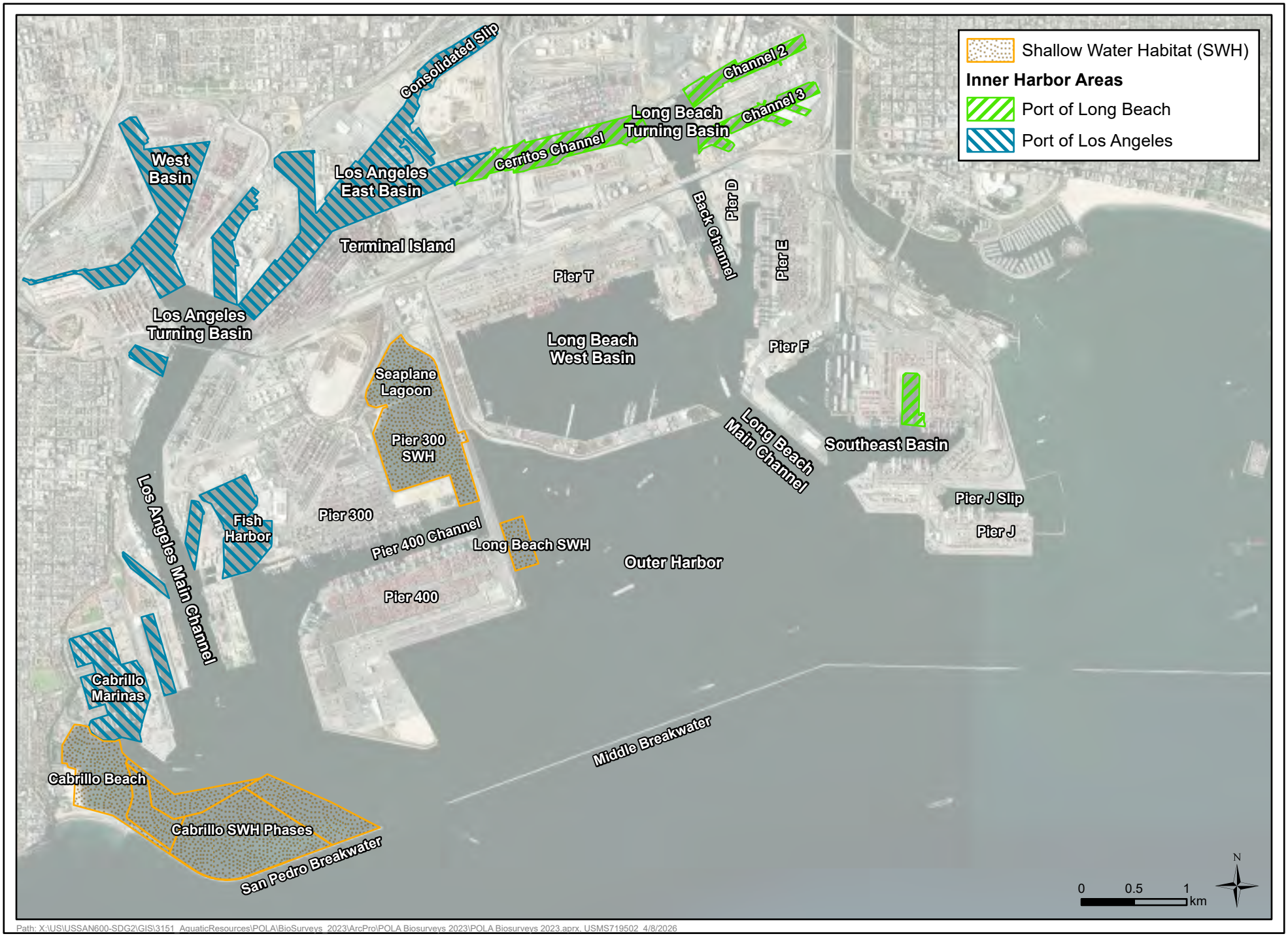
1.2 PORT DEVELOPMENT SINCE 2013



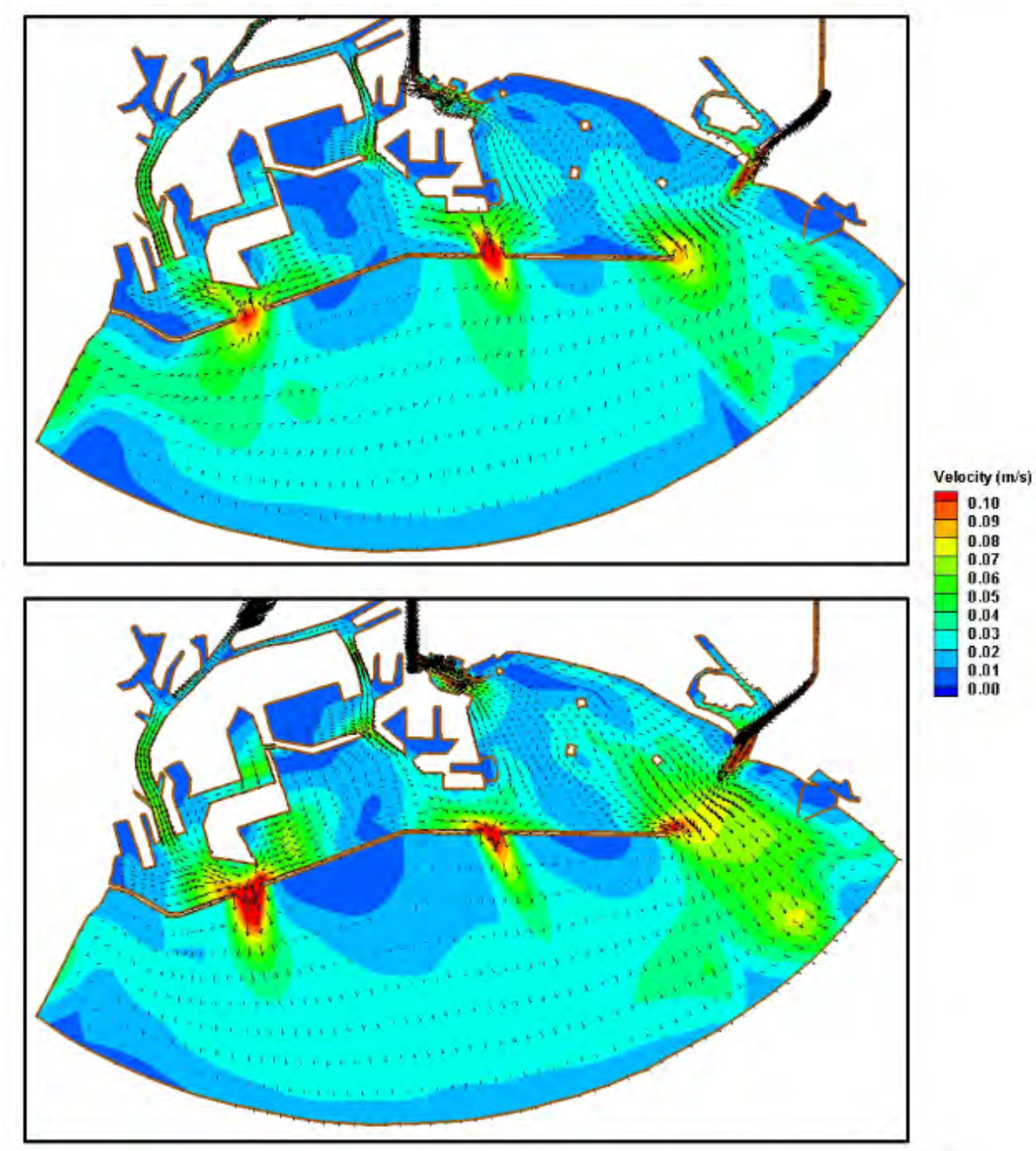
Port Complex with Palos Verdes and Santa Monica Bay in the Distance

Over the past 4 decades the ports have changed their configuration, sometimes dramatically, as port facilities were expanded or redeveloped. These changes have affected the marine ecology of the ports by altering water circulation, water depth, and substrate types. The most substantial changes in recent times occurred from approximately 1990 through 2010, when both ports undertook major fill projects to create new land for terminals and deepened their main channels to accommodate rapidly increasing ship sizes. The 2013 Biosurvey Report (MBC, 2016) listed several such projects that had occurred from 2008 through 2013.

From 2013 to the present, however, Port Complex development has focused largely on landside projects. Except for filling of nearly 55 acres of water and substantial shoreline improvements to complete the Port of Long Beach Middle Harbor terminal (completed in 2021), the configuration of the water area of the ports experienced little change since 2013. Some shoreline work has occurred (e.g., maintenance, berth deepening, small fill projects, and wharf and dike improvements), but neither the configuration nor the character of the shoreline has substantially changed for most of the Port Complex other than development of the Port of Long Beach Pier E. Accordingly, the current physical environment of the Port Complex is very similar to the 2013 environment.



Path: X:\US\USSAN600-SDG2\GIS\3151_AquaticResources\POLA\BioSurveys_2023\ArcPro\POLA Biosurveys 2023\POLA Biosurveys 2023.aprx, USMS719502_4/8/2026



Top: Typical flood tide currents. Bottom: Typical ebb tide currents.

Figure 1-2. Current Patterns in the Ports of Los Angeles and Long Beach Predicted by the WRAP Model (Ports of Los Angeles and Long Beach, 2009)

1.3 PREVIOUS BIOLOGICAL STUDIES IN THE PORT COMPLEX

Marine habitat and associated biological communities within the ports have been studied periodically since the 1950s. In addition to the systematic, harbor-wide Biosurveys summarized in the previous section, a number of other physical and biological studies unrelated to the harbor-wide Biosurveys have been conducted.

Physical and biological sampling by the State of California Department of Public Health and the California Department of Fish and Game performed within the Ports (State of California Department of Public Works, 1952) and Reish (1959) identified areas within the harbors with low dissolved oxygen (DO) concentrations and high bacterial counts that supported virtually no animals, although other areas, such as the Outer Harbor, had enough DO to support fairly diverse invertebrate populations. At that time, harbor waters were subject to untreated discharges from storm drains, industrial sources such as refineries, and domestic/sanitary discharges. The discharge of oil refinery waste was prohibited in 1968, and by 1970, improvements to water quality and species diversity were documented (Reish, 1972). In the years following passage of the Clean Water Act (Public Law 92-500) in 1972, untreated discharges to the harbors were further reduced.

Physical, chemical, and marine biological monitoring studies were also carried out in association with the Long Beach Generating Station (Environmental Quality Analysts, Inc. and Marine Biological Consultants, Inc. [EQA and MBC], 1978), the Los Angeles Harbor Generating Station, and the Terminal Island Treatment Plant in Los Angeles Harbor. The Port of Los Angeles conducted a Biological Baseline study in 1986—1987 (MEC, 1988) following Port Complex development since the prior surveys in 1978. The City of Los Angeles Department of Public Works (Los Angeles Sanitation & Environment) conducts comprehensive environmental monitoring of the effluent from the Terminal Island Water Reclamation Plant as part of their National Pollutant Discharge Elimination System (NPDES) permit compliance, with efforts focused on the outfall on the outside of Pier 400. The Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Load (Harbor Toxics TMDL) covers all of San Pedro Bay, Dominguez Channel Estuary, and Los Angeles River Estuary. It was promulgated by the United States Environmental Protection Agency (EPA) and the State of California and took effect in March 2012. Sediment quality monitoring occurs twice every 5 years in coordination with regional monitoring efforts, and includes characterization of sediment infauna (which is used in the 2023 Biosurvey). Finally, sampling has been conducted in the Port Complex as part of the Southern California Coastal Water Research Project (SCCWRP) periodic Southern California Bight regional monitoring program in 1998, 2003, 2008, 2013, 2018, and 2023.

1.4 STUDY OBJECTIVES

The key objectives of the 2023 Biosurvey, as with the previous Biosurveys, is to describe (1) how key biological community metrics vary among different subregions and habitat types within the Port Complex, (2) how those metrics may have changed over time and how the biological communities of the Port Complex compare with those throughout the Southern California region, and (3) how prevalent non-native species are throughout the Port Complex.

To achieve those objectives, the following elements were evaluated in the 2023 Biosurvey:

- Physical characteristics (water quality and sediment grain size)
- Benthic infauna and epibenthic macroinvertebrates
- Ichthyoplankton
- Demersal, pelagic, and shallow-water fishes
- Hard substrate-associated communities (i.e., giant kelp, other macroalgae, fish and invertebrates associated with the riprap, concrete pier pilings, and other hard structures in the Port Complex)
- Eelgrass
- Birds and marine mammals

1.5 STUDY DESIGN

The study design for the 2023 Biosurvey was similar to that used during the 2000, 2008, 2013, and 2018 Biosurveys. The California Department of Fish and Wildlife (CDFW), National Marine Fisheries Service (NMFS), and United States Fish and Wildlife Service (USFWS) reviewed and provided comments on the initial Biosurvey plan. Proposed survey method updates were primarily recommended to fill data gaps noted in the 2018 Biosurvey Report (Wood, 2021a) or to incorporate new technology such as satellite imagery. The most notable changes in the 2023 Biosurvey from the previous Biosurvey included the following:

- To better assess harbor-wide patterns in water quality, the 2023 Biosurvey incorporated monthly satellite imagery that measures sea surface temperature, turbidity, chlorophyll-a, and secchi disk depth. The ports have completed a series of pilot and validation studies that have shown that water quality parameters obtained from high-resolution satellite imagery appear to have strong correlations with field conductivity, temperature, and depth (CTD) measurements of temperature, turbidity, and secchi disk depth measured on the same day as the image (WSP USA Inc. [WSP], 2023). Satellite imagery allows for calculation of harbor-wide averages for water quality metrics to examine trends over time. These trends can be used to analyze habitat distribution and the response of species of interest to seasonal variability within the Port Complex.
- The 2018 Biosurvey used aerial imagery obtained from the Central Region Kelp Consortium monitoring to estimate the extent of kelp canopy; however, inconsistencies with field observations were noted in 2018. The ports have completed a series of pilot and validation studies that have shown that kelp canopy estimates obtained from high-resolution satellite imagery appear to be highly accurate compared with those from aerial imagery (Wood, 2021) and have a high degree of agreement with field surveys of surface and submerged kelp canopy (WSP USA Inc., 2023). Using satellite imagery gives the ports more control over timing of images to better coordinate with field surveys of kelp canopy and replaced aerial imagery in 2023.
- Dive teams used data collection methods on the presence of surface and submerged kelp that were similar to the methods outlined in the kelp canopy validation study (WSP, 2023) at all 20 riprap stations where visual diver surveys were conducted.
- An adopted swath survey was added for the face of pilings to capture the density of large and mobile invertebrates that are often missed by point-counts.
- An additional lower intertidal swath transect at 0 MLLW was added for riprap to characterize feather boa kelp and intertidal invertebrates.
- A subtidal benthic fish survey was added for riprap and piling stations to match invertebrate/kelp/uniform point contact (UPC) target depths, and pilings had bottom and near-surface (~1-meter depth) surveys.
- Riprap UPC surveys included a measurement of sediment deposition (cm) at each meter for subtidal transects.
- Swath surveys included the following additional target species based on their observed presence in 2018 and the desire to better characterize scavenger and detritivore species:
    - Kellet's whelk
    - Turban snails (red/wavy)
    - Warty sea cucumber
    - California sea cucumber

For most project elements, an equal number of stations were sampled in each port (e.g., water quality, infauna, fish, ichthyoplankton, and riprap; Table 1-1), but some project elements involved one port more often than another (e.g., shallow-water fish, eelgrass). Station maps for each project element (e.g., physical characteristics, riprap, kelp and macroalgae, shallow-water fish, eelgrass, and birds) are provided in the respective report sections. Several stations were changed since the 2018 Biosurvey to better represent the various habitat types and allow for better comparisons of biological metrics among stations:

- Similar to methods used for previous Biosurveys, sampling stations for sediment and water quality were closely coordinated with sediment sampling locations used for the Greater Harbor Waters Regional

Monitoring Coalition (RMC) and the Bight Regional Monitoring Program. The Biosurvey stations have historically been moved less than 300 meters to align with the randomly drawn RMC station locations, although a few station locations have had larger adjustments in past years. In 2023, the following stations were adjusted to align with RMC sampling stations: LA4, LA14, and LB16.

- A new sediment/water quality station in the Cabrillo Shallow Water Habitat (SHW) Phase 4 was added, called LA3-ALT, to meet mitigation bank requirements and assess spatial variability between Cabrillo SWH Phase 3 and Phase 4.
- Several sediment/water quality stations were relocated to their baseline location set in 2000 (with year noted if different) for better historical comparisons: stations LA1, LA3, LA6, LA8, LA9, LA10, LA12, LB1 (2008), LB10, LB12 (2013), and LB13.
- The station naming convention was updated to better track the movement of sediment and water quality stations over time. For stations that have maintained the same location since the original 2000 Biosurvey or are now in the baseline location moving forward, the name will not change from the original designation (e.g., LB8). For stations that have moved from the baseline locations because of RMC coordination, the name will have a suffix that indicates the year that the station first occupied that location. For example, LB11-18 indicates that station has been in that location since 2018.
- The dive survey station T9 was moved from the innermost part of Seaplane Lagoon prior to the field surveys because of persistently low water clarity (secchi disk depth <0.5 meter) and high turbidity, which caused low visibility that restricts the ability to properly conduct visual surveys for fish and invertebrates. In 2018, the station was moved from its location from 2000 through 2013 because station depth (~2.5 meters) was insufficient to allow for the modified survey protocols. At the new location in 2018, dive teams were able to successfully survey only the upper subtidal transect; the survey for the lower subtidal transect was abandoned in both seasons because of low visibility. The new location preserves an Inner Harbor station designation close to the 2018 location, and based on satellite measurements of turbidity and secchi disk depth, improves visibility by approximately 1 meter or more depending on the season.
- The dive station T4 at the southeastern corner of Pier 400 was moved following the spring portion of the Biosurvey because low water clarity that resulted in visibility less than 30 cm. This location experiences strong currents and wave action from Outer Harbor boat traffic, and high turbidity and low water clarity were noted in satellite imagery obtained as part of the pilot and validation study for water quality images (Wood, 2021b; WSP, 2023). Similar poor visibility was documented in 2018; however, with the addition of fish surveys to the protocol in 2023, the conditions prohibited obtaining reliable visual survey data. The dive survey station was moved approximately 1 kilometer to the west to an area with suitable visibility, named T4-ALT, to complete the spring portion of the Biosurvey, and the same location was surveyed in summer 2023 for consistency. The original T4 location was maintained as a surface kelp canopy survey station.

Table 1-1. Sampling Dates for Spring 2023, Summer 2023, and Winter 2024

Survey Type	Spring 2023 Sampling Dates	Summer 2023 Sampling Dates	Winter 2024 Sampling Dates
Physical Characteristics (Water)	May 18–19	September 21–22	March 7–8
Physical Characteristics (Sediment) and Benthic Infauna[1]	April 11–12	August 10–14	Not Sampled
Ichthyoplankton	May 2–5	September 5–8	January 23–24
Demersal Fishes and Epibenthic Invertebrates (Otter Trawl)	Day: April 17–20 Night: April 23–26	Day: August 17–19 Night: July 10–13	Not Sampled
Pelagic Fishes (Lampara Net)	Day: May 1–3 Night: May 7–10	Day: July 24–25 Night: July 31–August 2	Not Sampled
Shallow-water Fishes (Beach Seines)	April 13	July 7–9	Not Sampled
Swath and UPC Diver Surveys on Riprap and Pier Pilings	June 12–16	August 7–11	Not Sampled
Riprap and Pier Piling Quadrat Sampling	April 10–13	August 7–11	Not Sampled
Eelgrass	May 1–3	September 7–8	Not Sampled
Birds and Marine Mammals	Monthly for 12 months; April 2023–March 2024[2]		
Satellite images	Monthly for 12 months[3]; April 2023–March 2024		

1. Sampling conducted by Anchor QEA as part of the Harbor Toxics TMDL Program.
2. March 2024 surveys were completed in April 2024 because of weather conditions.
3. Because of extended cloudy conditions, no images were available from May through June 2023.

TMDL = total maximum daily load; UPC = uniform point contact

1.6 SURVEY METHODS

Field sampling and laboratory processing methods used in the Biosurvey are summarized in this section, and detailed descriptions are presented in Appendix A. In general, the field methodology was consistent with those of the previous Biosurveys, but departures from previous techniques are noted in this section and in Appendix A.

1.6.1 PHYSICAL CHARACTERISTICS

1.6.1.1 WATER QUALITY

As in the previous Biosurveys, continuous vertical profiles of temperature, conductivity (as a measure of salinity), pH, light transmittance (as a measure of water clarity), and DO in the water column were collected at 32 stations. Data were stored in real time on a field laptop computer. For consistency with previous Biosurveys, transparency of the surface waters was also measured at each station using a secchi disk. Water quality was surveyed in May 2023 (spring), September 2023 (summer), and March 2024 (winter).

New methods to characterize harbor-wide water quality patterns include monthly satellite images from Sentinel-2 (10-meter resolution) processed for turbidity, chlorophyll-a, and secchi disk depth data; Landsat-8/9 (30-meter resolution) images are processed for sea surface temperature.

1.6.1.2 SEDIMENTS

Sediment data were generated by Anchor QEA as part of a separate program (the Harbor Toxics TMDL program, described in Section 1.6.2). Samples were collected at 32 stations using a Van Veen grab, and sediment from the top 5 cm of each grab sample was used for grain size and total organic carbon (TOC) analysis.

1.6.2 BENTHIC INFAUNA AND EPIBENTHIC INVERTEBRATES

Sampling to characterize the benthic infaunal community was conducted by Anchor QEA in coordination with the RMC program. Sampling was conducted in spring (April 2023) and summer (August 2023) at 32 stations. Sediment samples were collected using a 0.1-square-meter (m^2) Van Veen grab sampler and sieved through a 1.0-millimeter (mm) screen to collect infauna.

Epibenthic macroinvertebrates (the larger invertebrates that dwell on and just above the sediment surface) were collected in the benthic trawls used to collect demersal fish (see Section 1.6.4).

1.6.3 ICHTHYOPLANKTON

Ichthyoplankton collections were made at 26 stations (13 in each harbor). Surveys were performed in the spring (May 2023), summer (September 2023), and winter (January 2024), and were performed only at night to minimize visual net avoidance by the larger larvae.

Ichthyoplankton were collected from both the epibenthic (near-bottom) habitat and the water column using a bongo net array (two 1-meter-diameter nets mounted side by side); the nets had a 0.333-mm mesh and a removable cod end. For the epibenthic sampling, a weighted, wheeled bongo net apparatus was used to suspend the nets just above the bottom and allow them to be towed along the bottom. Water column sampling used the bongo net towed in an oblique pattern from near bottom to the surface, retrieved at a constant rate over the length of the tow.

Each station yielded two samples: one sample per side from the paired nets of each tow (epibenthic and oblique). Accordingly, each seasonal survey yielded 52 samples, for a total of 156 samples over the course of the Biosurvey. Samples were fixed in 10% buffered formalin and then transferred to 70% ethanol for subsequent laboratory analysis.

1.6.4 DEMERSAL, PELAGIC, AND SHALLOW-WATER FISH

Juvenile and adult fish were collected with three types of gear:

- Otter trawls were used to sample demersal (bottom-associated) fish.
- Lampara nets were used to collect pelagic (open-water) fish.
- Beach seines were used to collect shallow subtidal fish.

Trawling and lampara sampling was conducted during both the day and night in spring (May 2023) and summer (July through August 2023) at the same 26 stations sampled for ichthyoplankton. Beach seine sampling was conducted at or near low tide during the day in spring (April 2023) and summer (July 2023) at two stations at the Port of Los Angeles (Cabrillo Beach and at the Pier 300 SWH).



Processing trawl catch at night in POLB

Collection and processing methodologies for the demersal fish sampling were consistent with those used for the prior harbor-wide Biosurveys but with minor additional procedures consistent with those of the Bight 2023 Regional Monitoring program to make data as regionally comparable as possible. Table 1-2 lists the procedures for processing large samples (note that epibenthic invertebrates were counted and weighed but were not measured for length or size similar to fish).

The following Ecological Index (EI) is a metric based on the percentage of individual fish collected, the percentage of biomass, and the percentage of frequency of occurrence (VRG, 2009). Results using this index indicate the relative importance of each species to the energy flow within each habitat (Allen et al., 2002; Williams et al., 2015):

- **Index of Ecological Importance for Individual Fish:** Calculated by (number of fish as a % of catch + weight of the fish as a % of catch) × (% frequency of catch).

Table 1-2. Procedures for Measuring and Weighing

Abundance of Single Taxon	Measured to Nearest Centimeter by Individual?	Weighed to the Nearest 0.1 Kilogram	Comments
0–30	Yes	Individually	--
31–250	Yes	Batch Weight	--
251+	No	Batch Weight	Batch weights can be based on size classes

1.6.5 HARD SUBSTRATE ASSOCIATED COMMUNITIES

As indicated in Sections 1.4 and 1.5, the 2023 Biosurvey included a revised approach for capturing the biota associated with the various hard substrate habitats in the Port Complex. The riprap and pier piling surveys had three sub-elements: (1) kelp canopy, (2) riprap, and (3) pier pilings. The method for each sub element was similar to the methods used in past Biosurveys, except as noted in Section 1.5. The methods are summarized in this section; species lists and an example site schematic are provided in Appendix A.

Kelp Canopy: Kelp canopy at the surface and canopy near the surface (<1 meter deep) were monitored via high-resolution satellite imagery rather than aerial imagery in the Port Complex for the first time as part of the 2023 Biosurvey (Figure 4-6) in Section 4. Based on comparisons with existing visual survey methods, satellite imagery appears to be highly accurate for detecting viable kelp canopy (Wood, 2021b; WSP, 2023; WSP, 2024; WSP, 2025).

Satellite imagery was obtained through WSP's vendor EOMAP, the same vendor used for the pilot and validation studies. The area of interest (AOI) mapped for both kelp and water quality parameters is 102 square kilometers (km^2) to meet minimum AOI requirements from the satellite vendors. Based on results of the pilot study and the desire to quantify the kelp canopy within each individual port, a new approach to compare kelp canopy in different areas was used; the approach was used for the Port Complex (Zones 1–9) and nearby reference areas (Refs A–C; Figure 4-6). Zones in the Port Complex all included at least one field station for kelp canopy and CTD surveys. Reference areas were selected to provide comparison data from nearby kelp habitat outside of the ports' jurisdiction, including the Palos Verdes coastline from White's Point to Cabrillo Beach (Ref A), the east breakwater (Ref B), and the Long Beach waterfront and nearby artificial THUMS islands (Ref C).

The preferred sensor used was Pleiades NEO, which has 6-band multispectral capabilities and a resolution of 1.2 meters. In the event that Pleiades NEO was not available, imagery was obtained from a WorldView-2 8-band sensor with a resolution of 2 meters or a SkySat/Pleiades-1, which are 4-band multispectral sensors with 2-meter resolution; all of these sensors were shown to provide estimates very comparable to kelp estimates from Pleiades NEO (WSP, 2023).

Satellite tasking was requested with the expectation that successful imagery would be taken within a +/- 10-day window of the field survey dates. This window is necessary to obtain good-quality, full-coverage image data. Some environmental factors impact the viability of using satellite data on a particular date. For instance, cloud cover can block satellite transmission and thus effectively eliminate numerous dates because of lack of usable data. Other variables that could affect the quality of the image include floating objects (e.g., ships) and substances (e.g., oil films), water clarity, recording geometries to minimize sun glint, and waves breaking at the water surface. For maximum comparability, satellite imagery collection dates prioritized dates close to the spring and summer field survey dates.

Riprap: Hard-substratum biota on riprap were sampled by certified divers in three depth zones (i.e., upper intertidal, lower intertidal, and subtidal) using scraped quadrats, band transect surveys, and photography at 20 riprap station (8 of which had quadrat scrapings).

At each of the eight riprap stations designated for quadrat sampling (four in each port), divers deployed a transect along the depth contour of three depth zones: upper intertidal, lower intertidal, and subtidal. The three depth zones sampled were delineated based on a combination of biological and tidal factors: upper intertidal zone (the high-tide zone characterized by barnacles), lower intertidal zone (the mid- to low-tide zone characterized by mussels), and subtidal zone (the deepest extent of the riprap). The depths at the upper intertidal and lower intertidal zones remained consistent across all stations. The subtidal zone was at the deepest extent of the riprap, approximately 1 meter above the soft-bottom interface, to minimize the influence of sedimentation on organism recruitment.

At each station, duplicate quadrat scrapings (a quadrat was 7.5 cm by 15 cm, i.e., 0.01 m^2) were collected at two random locations along each of the three depth zones (i.e., six samples per station). Photos were taken of each quadrat prior to scraping. Samples were fixed in 10% buffered formalin then transferred to 70% ethanol for subsequent laboratory analysis.

In addition to scraped quadrats, a rapid assessment method for comparison was used along each riprap transect depth zone, using 10-meter-long band transects and a UPC method to determine percent cover of algae and invertebrates (Appendix A provides details for the UPC method). The divers used a modified species list prepared and used by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) to classify cover type (Appendix A).

The epifuanal community on riprap was also assessed by diver surveys using UPC and swath surveys to determine the percent cover and density of invertebrates and algae (Appendix A provides details on the field methods and the differences from those used in the 2018 Biosurvey). At the 8 riprap stations and 12 additional stations established specifically for this element, divers surveyed 3 to 4 depth zones (depending on station depth) along band transects using the UPC method to estimate percent cover of algae and invertebrates every 0.2 meter, for a total of 50 points per depth zone.



Collecting subtidal data on the breakwater

In addition to the UPC survey, a swath survey along each transect was conducted to quantify macroalgae and invertebrates based on functional community groups (i.e., canopy-forming kelp, understory kelp, non-native algae, herbivores, filter feeders, and carnivores) and to catalog larger, mobile invertebrates that may not be captured using the UPC method. This community-based assessment provided density estimates of key biological communities on riprap habitat, as well as site-specific verification of canopy-forming kelp species density identified via satellite imagery. In particular, canopy-forming kelp is more widely distributed in the Port Complex than indicated by the satellite survey method, and the swath technique indicated the extent of that wider distribution.

Similar to the 2018 survey, fish species observed onsite were noted at each station to document the species that are associated with rocky reefs and would not be captured during otter trawl, lampara, and beach seine surveys (e.g., garibaldi, moray eel, rockfish, etc.). An additional survey element for the 2023 Biosurvey was to conduct a quantitative fish survey during the deployment of subtidal transects using a modified PISCO methodology that requires all fish that swim through the survey "window" (2 meters wide, 2 meters high) to be identified to species (or lowest taxonomic unit possible, often genus) and sized for total length to the nearest cm. This method results in density estimates for those species observed "on transect" and frequency of occurrence for all species noted anywhere on station.

Pier Pilings: Hard-substratum biota on concrete pilings that support wharves throughout the Port Complex were sampled at eight piling stations (four in each port) by certified divers in three depth zones (upper intertidal, lower intertidal, and subtidal) using scraped quadrats, band transect surveys, and photography. The methodology was identical to the method used on the riprap, except that the transect extended vertically down each piling from 0 feet MLLW to the bottom of the piling near the mudline. Also, divers conducted the UPC survey vertically, classifying the cover type at every 0.2 meter along the transect.

1.6.6 EELGRASS

Consistent with the methodology used for the 2018 Biosurvey (Wood, 2021a), eelgrass surveys were conducted using a combination of acoustic techniques (interferometric sidescan sonar), diver-ground truth surveys (if necessary), and remotely operated vehicle (ROV) surveys. Acoustic surveys of all shorelines and waters shallower

than 30 feet MLLW within the Port Complex were conducted during spring (May 2023) and at the height of the summer growing season (September 2023) to detect seasonal variability in eelgrass areal extent and density.

1.6.7 BIRDS AND MARINE MAMMALS

Surveys to enumerate birds and marine mammals were conducted monthly from April 2023 through March 2024 (the March 2024 survey was postponed to April 2024 because of a weather conflict). Surveys recorded species composition, abundance, behavior, and locations of birds and marine mammals across 54 predesignated zones throughout the Port Complex. The methods used were consistent with those from the 2013 and 2018 Biosurveys and involved saturation surveys by boat in all zones. The survey team consisted of a boat captain, an avian observer, and a data recorder; the observer and recorder were both trained ornithologists. The observer was responsible for species identification and counts, and the recorder assisted with counting birds and completing and managing data sheets. Marine mammals were documented as they were encountered and were recorded according to the zone where they were observed.

Beginning with the 2013 Biosurvey, the total number of surveys was reduced from 20 (conducted twice monthly from December through March, and monthly from April through July in each year) to just once per month. Additionally, some habitat types of hard "Structure" (i.e., building, lamp posts, uplands, etc.) were added as strata type separate from "Dock/Pilings." This modification helped to better quantify the effect that physical structures and human activity had on the presence and behavior patterns of birds. All other survey elements have remained consistent since that time.

1.7 DATA ANALYSIS

Laboratory and data analysis methods appropriate to each Biosurvey element were applied to the field-collected data and samples (Appendix A describes laboratory sample processing, data analysis, and quality assurance [QA]/quality control [QC] methodologies). In the case of some elements (e.g., water quality, birds, and marine mammals), no laboratory processing was necessary. In the case of benthic infauna, ichthyoplankton, and the scraped quadrats of the riprap/piling element, however, extensive laboratory processing was necessary to separate, sort, identify, and weigh the organisms collected in the samples.

Task-generated data included enumeration data (e.g., from trawls, marine mammal surveys, seabird surveys, benthos, etc.), continuous data (e.g., physical water quality, analytical data, etc.), metadata, and others. To ensure data quality and usability, these data and data from previous Biosurveys were synthesized into a single project-specific database after undergoing a thorough QA/QC review according to established internal procedures.

Data were analyzed with the key objective of identifying and describing spatial and temporal trends in the various natural resource elements studied in the harbor-wide Biosurveys. Relevant indicators of spatial and temporal trends included selected measures of abundance, biomass, and other metrics such as dominance, diversity, and the Benthic Response Index (BRI) used in previous Biosurveys.

Diversity indices provide information about biological communities by combining species richness, abundance, and relative abundances (or evenness) into one measure. Although there are numerous indices to choose from, two common indices have been used in previous Biosurveys: the Shannon-Weiner index and the Margalef Diversity Index. For both of these indices, higher values represent higher quality communities. The Margalef Diversity Index is the more basic of the two, considering only species richness and abundance, but the Shannon-Weiner Index also factors in the relative abundance of each species. Another community measure, "evenness," has also been evaluated in these Biosurveys using the Pielou's Evenness Index. Similar to the Shannon-Weiner Diversity Index, Pielou's Evenness Index awards higher values to communities that are more evenly balanced (highest score of 1) and not highly dominated by only one or a few species (lowest score of 0), much as the Shannon-Wiener Diversity Index operates. Caution should be used when using only one index to "rank" stations in terms of diversity or evenness; rather, all indices should be considered when evaluating a given station.

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2 PHYSICAL CHARACTERISTICS

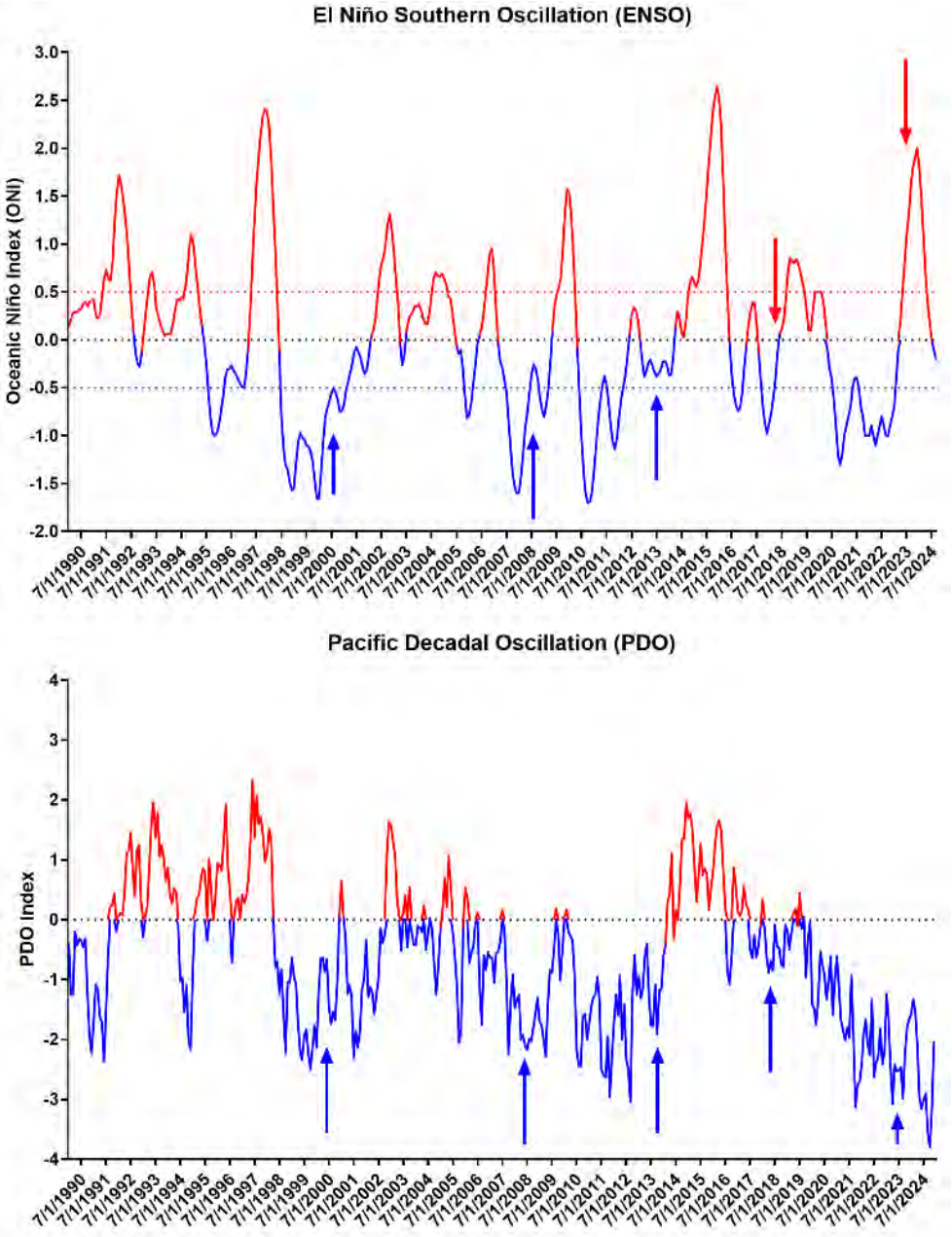
2.1 REGIONAL CLIMATE TRENDS

The coastal ocean of the Southern California Bight, including the Port Complex, is heavily influenced by two cyclical trends in the oceanography of the Pacific Ocean. The El Niño Southern Oscillation (ENSO) is a cyclical environmental condition that occurs across the Pacific Ocean (Lindsey, 2013). ENSO is composed of two different conditions, known as "El Niño" and "La Niña," and is measured by the Oceanic Niño Index (ONI). El Niño occurs when the Pacific Ocean develops warmer waters than average, but easterly winds are weaker than normal and can reverse direction to become westerly. When this occurs, warmer-than-normal water often moves as far north as the coast of California, bringing unusual conditions to local habitats. La Niña, the opposite phase of El Niño in the ENSO climate pattern, produces strong winds and cooler ocean waters. ENSO takes place approximately every 3 to 5 years. In Southern California, El Niños often cause above-average rainfall, reduced upwelling, and increased water temperatures. Alternately, La Niñas can result in an increased upwelling of nutrient-rich water, enhancing fisheries activities along the coast of Southern California (Zhang, 1997).

The Pacific Decadal Oscillation (PDO) is also a cyclical trend that influences sea surface temperatures, sea-level anomalies, and winds across the Pacific Ocean. However, the PDO can be distinguished from ENSO because, although ENSO is felt primarily near the equator, the PDO originates in the northern waters of the Pacific Ocean and affects the path of the jet stream. Additionally, the climate regimes brought on by the PDO are more persistent than those of ENSO, sometimes lasting 20 to 30 years before alternating (Hare and Mantua, 2001).

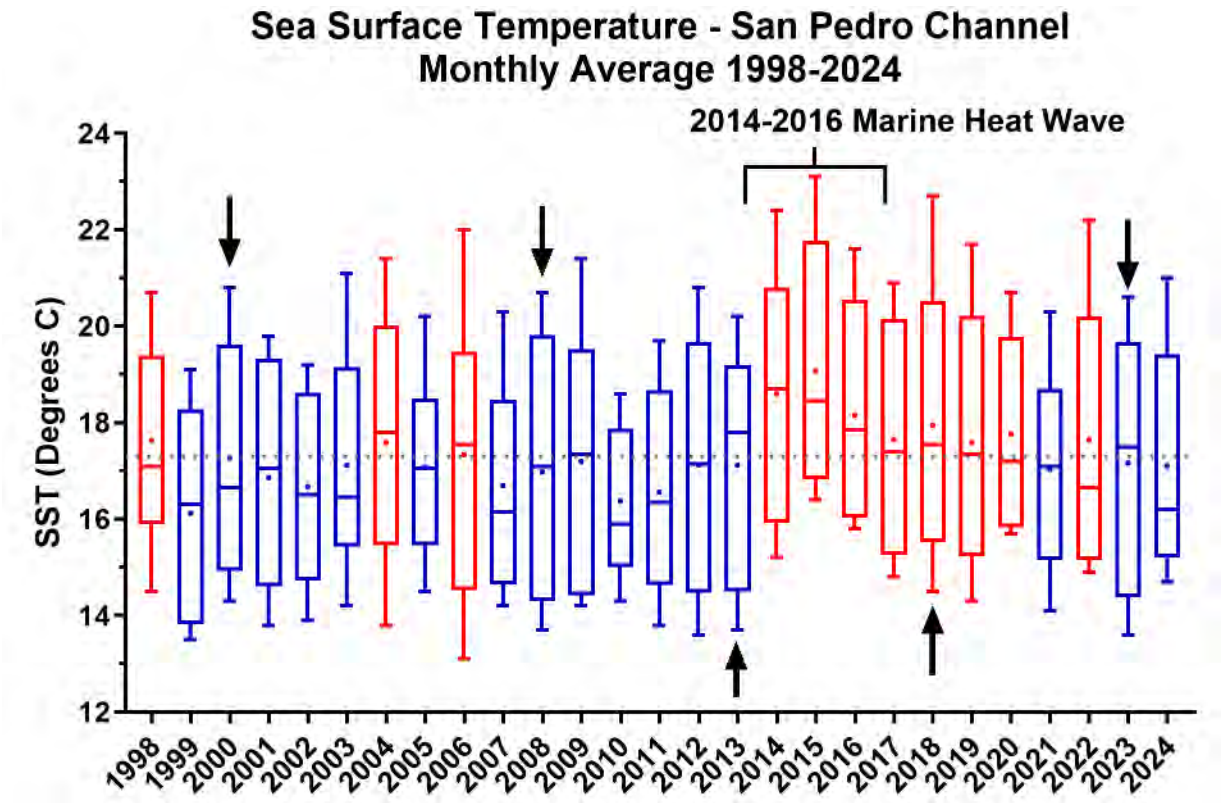
The ENSO and PDO cycles in Southern California over the past 20 years are depicted in Figure 2-1 using the ONI and PDO Index, respectively. Historical Biosurvey sampling events are indicated with arrows: red arrows represent warming trends, and blue arrows represent cooling trends. In ENSO, margins are displayed at ±0.5 to reflect the neutral temperatures. When values rise above this zone, it is considered to be an "El Niño" condition, and when values fall below this zone, it is considered to be a "La Niña" condition. An assessment of regional climate patterns combined with knowledge of temperature tolerances for certain species or species associations (e.g., the presence of tropical species expanding their range as water temperature increases) can assist with the interpretation of biological community data. Over the course of the historical Biosurveys in 2000, 2008, and 2013, ENSO reflects colder waters in 2000 and warming waters from 2008 and 2013. During the previous Biosurvey year (2018), ENSO reflected warm waters within the neutrality zone (+/- 0.5), with no strong conditions present either way. In 2023, however, ONI values were well above the ENSO neutrality zone, with indications of strong El Niño conditions (values of roughly 1.75), which may help explain the unusual rainfall event in the summer and high summer sea surface temperature (SST) despite the PDO cooling trend.

Local SST data were furnished by the Coastal Data Information Program, Integrative Oceanography Division, operated by the Scripps Institution of Oceanography, from an oceanographic buoy in approximately 483 meters of water in the San Pedro Channel, approximately 7 miles southwest of the Angel's Gate. Monthly SST data from 1998 through 2024 show trends in local SST similar to those observed with the Moderate Resolution Imaging Spectroradiometer (MODIS), a key instrument aboard the National Aeronautical and Space Administration (NASA) Terra and Aqua satellites – see MODIS Technical Specifications) data over the same time period (Figure 2-2). The buoy data show a signal from the 2014–2016 heatwave that produced peak summer SSTs in 2014 and 2015 of 22 to 23 degrees Celsius (°C) (Cavole et al., 2016, Jacox et al., 2019), followed by a gradual cooling trend through 2024.



Warm periods are depicted by red lines, and cold periods are depicted by blue lines. Historical Biosurvey sampling years are represented by arrows.

Figure 2-1. Regional Climate Trends Between the Years 1990 and 2024 and Depicted by Both the Oceanic Niño Index (ODI) and the Pacific Decadal Oscillation (PDO)



Data from Coastal Data Information Program, Integrative Oceanography Division, operated by the Scripps Institution of Oceanography Buoy 092 – San Pedro (Lat: 33.6179, Long: -118.317). Dotted line is average temperature from 1998 to 2023 (17.3°C). Annual average temperatures below the 21-year average are denoted as blue, and annual average temperatures above the 21-year average are red. Black arrows represent the five historical Biosurvey years. Whiskers represent the min-max, the line represents the median, and the dot represents the average.

Figure 2-2. Sea Surface Temperature Monthly Average – 1998–2024

2.2 RAINFALL

Rainfall data were obtained from the Long Beach Airport (LA Almanac) from 2000 through 2024 to compare water quality measurements with rainfall amounts. The 2023 Biosurvey year (April 2023 through March 2024; Figure 2-3) had a historically high amount of rainfall, with a total of 23.51 inches the second highest total for the 2000 through 2024 period(28.14 inches of rainfall in 2004).

Usually, rainfall in Southern California occurs from October through March with, on average, 95% of the annual rainfall at Long Beach Airport occurring during that time (Table 2-1). The 2023 Biosurvey occurred during the first hurricane in Southern California in 85 years; Hurricane Hilary passed through Southern California from August 16 through 21, 2023, and depositing 2.66 inches of rainfall at Long Beach Airport and up to 7 inches in the Los Angeles mountains, resulting in localized flooding.

From 2000 through 2024, the average rainfall amount for the winter (January through March) at Long Beach Airport was 6.59 inches. In January through March 2024, 17.99 inches of rain fell, which was the second wettest winter over the past 25 years (18.6 inches in 2005). Winter water quality parameters were measured on March 7 and 8, 2024, which followed 11.95 inches of rainfall in February 2024, the most rainfall in any 1-month period over the past 25 years at Long Beach Airport (Table 2-2).

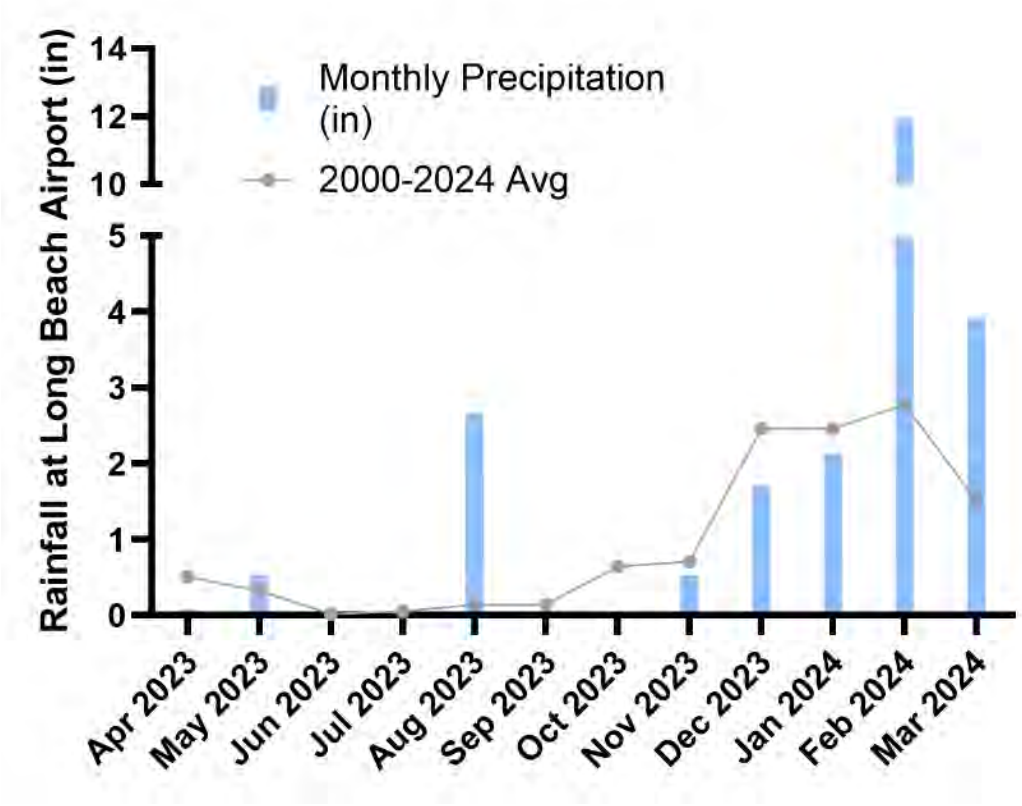


Figure 2-3. Monthly Precipitation for the 2023 Biosurvey Year Compared With 2000–2024 Monthly Averages at Long Beach Airport

Table 2-1. Monthly Rainfall (inches) at Long Beach Airport 2000–2024

Season/Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season Total (Apr-Mar)	Winter Total (Jan-Mar)
2024–2025	0	0	T	T	0.04	0.04	0.6	2.77	---	---	---	---	---	---
2023–2024	0	2.66	0.02	0	0.53	1.71	2.12	11.95	3.92	0.75	0.1	T	23.51	17.99
2022–2023	0	0	0.20	0.18	0.96	3.19	6.32	2.90	6.91	0.07	0.53	0	20.93	16.13
2021–2022	0.03	0.04	T	0.39	0	5.74	0.01	0.08	0.90	0.15	T	0.12	7.21	0.99
2020–2021	0	0	0	0.03	0.04	1.49	1.37	0.05	1.47	0.02	T	T	7.52	2.89
2019–2020	0.01	0	T	0	2.86	4.63	0.31	0.33	3.01	3.03	0.04	T	11.7	3.65
2018–2019	0	0	0	0.55	1.31	1.75	6.42	5.06	1.98	0.02	0.5	0.03	17.12	13.46
2017–2018	0	T	0.12	T	0.07	T	1.48	0.29	1.64	0.04	0.01	0	4.18	3.41
2016–2017	0	0	T	0.41	1.20	3.59	9.33	4.72	0.15	0.18	0.4	0	19.57	14.2
2015–2016	0.54	T	0.95	0.04	0.06	0.90	2.29	0.61	0.92	0.11	0.05	0.01	7.31	3.82
2014–2015	0.01	0.07	0.11	0.18	0.67	4.41	0.87	0.24	0.49	0.22	0.77	0.01	7.42	1.6
2013–2014	0.07	0	0	0.12	0.78	0.34	0.01	2.34	0.47	0.37	0	0	4.81	2.82
2012–2013	0.03	T	0.01	0.32	1.04	2.4	1.04	0.30	0.85	0.02	0.66	T	7.54	2.19
2011–2012	T	T	0.02	0.61	1.25	1.28	1.14	0.32	1.4	1.53	0.02	0	6.74	2.86
2010–2011	T	0	T	1.62	0.6	10.4	1.15	1.60	2.67	0.05	0.66	0.01	18.88	5.42
2009–2010	0	0	0	0.59	0	2.46	6.89	4.64	0.25	0.77	0.05	0.01	14.88	11.78
2008–2009	0	0	0.01	0.08	2.07	2.61	0.17	4.04	0.42	0.01	T	0.04	9.63	4.63
2007–2008	T	0.06	0.46	0.56	0.91	1.11	5.89	2.19	T	0.05	0.18	0	11.66	8.08
2006–2007	0.03	0.01	T	0.07	0.11	0.68	0.2	0.49	0.03	0.48	0	T	3.49	0.72
2005–2006	0	0	0.34	0.66	0.13	0.55	0.86	1.71	2.50	1.32	0.55	T	8.03	5.07
2004–2005	0	0	T	5.34	0.35	3.79	7.66	9.40	1.54	1.23	0.04	0.01	28.14	18.60
2003–2004	0.34	0	0	0.12	0.29	1.32	0.62	3.74	1.02	0.06	T	0	9.65	5.38
2002–2003	T	T	T	T	0.54	1.49	T	3.75	1.67	0.40	1.74	0.06	7.68	5.42
2001–2002	T	0	0	T	1.02	0.59	0.25	0.07	0.05	0.14	0.09	T	2.42	0.37
2000–2001	0	T	T	2.30	T	T	2.11	5.79	0.26	0.44	T	T	11.64	8.16
1999–2000	0.07	0	T	0	0.17	0.11	0.51	2.86	1.70	1.15	0.03	T	---	5.07
Average	0.05	0.14	0.14	0.64	0.68	2.36	2.38	2.78	1.51	0.50	0.32	0.02	11.32	6.59
Maximum	0.54	2.66	0.95	5.34	2.86	10.41	9.33	11.95	6.91	3.03	1.74	0.12	28.14	18.6

Season totals are calculated for the Biosurvey period (April through March). Biosurvey years are highlighted in green. T=trace (<0.01 inch).

2.3 CTD WATER COLUMN PROFILES

A suite of physical water quality parameters (i.e., temperature, DO, clarity, pH, and chlorophyll concentration) were measured *in situ* at 33 stations in the Port Complex (Figure 2-4) during three monitoring periods: May 18 and 19, 2023 (spring), September 21 and 22, 2023 (summer), and March 7 and 8, 2024 (winter). Note that for the 2023 Biosurvey, station LA3-ALT in the Cabrillo SWH was added for both CTD and sediment sampling. These data provide valuable information about the variability in conditions through the water column and complements the harbor-wide monthly data collected using remote sensing (see Section 2.4).

A summary of water quality parameters across all stations at the surface and 1 meter above the bottom, organized by season, is presented in Table 2-2. Regarding these water quality measurements, it is important to note that the values recorded represent a single point in time during each sampling event. Given the inherent temporal and spatial variability, particularly for water quality parameters such as temperature and clarity, the values recorded cannot be regarded as representing overall average conditions or upper or lower bounds throughout seasons at each station. Interpretation of the results of this sampling effort must take this point into consideration.

Table 2-2. Physical Water Quality Parameters by Season

Parameter		Spring			Summer			Winter		
		Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Temperature (°C)	Surface	19.2	15.3	16.8	21.3	17.2	18.6	17.1	14.9	15.6
	Bottom	17.8	12.7	14.7	18.5	15.7	16.9	15.9	14.2	15.1
Dissolved Oxygen (mg/L)	Surface	10.2	7.8	9.1	7.5	6.9	7.3	8.3	7.1	7.7
	Bottom	10.0	6.9	7.8	7.3	5.4	6.6	8.2	7.0	7.6
Light Transmission (%)	Surface	83.8	34.0	62.8	92.2	47.5	67.7	83.6	15.8	63.6
	Bottom	85.8	12.5	62.6	85.6	55.1	75.3	92.2	32.3	70.0
Turbidity (NTU)	Surface	2.7	0.4	1.2	2.4	0.3	0.7	6.2	0.4	1.42
	Bottom	10.1	0.7	2.7	5.8	0.9	2.1	16.2	0.4	3.0
pH	Surface	8.3	7.8	8.2	8.4	8.0	8.2	8.60	7.70	8.35
	Bottom	8.2	7.8	8.1	8.3	7.9	8.1	8.44	7.54	8.30
Chlorophyll A (ug/L)	Surface	7.2	0.8	3.5	2.3	0.3	1.2	4.2	0.5	1.1
	Bottom	5.1	0.5	1.2	7.0	0.2	1.0	3.2	0.2	0.8
Salinity (PSU)	Surface	33.5	32.7	33.3	33.2	24.0	32.6	32.8	22.8	30.8
	Bottom	34.3	33.2	33.5	33.9	33.0	33.2	33.1	31.1	32.8

°C = degree(s) Celsius; µg/L = microgram(s) per liter; avg = average; max = maximum; mg/L = milligram(s) per liter; min = minimum; NTU = nephelometric turbidity unit(s); PSU = practical salinity unit(s)



Path: X:\US\USSAN600-SDG2\GIS\3151_AquaticResources\POLA\BioSurveys_2023\ArcPro\POLA Biosurveys 2023\POLA Biosurveys 2023.aprx, USMS719502_4/8/2026

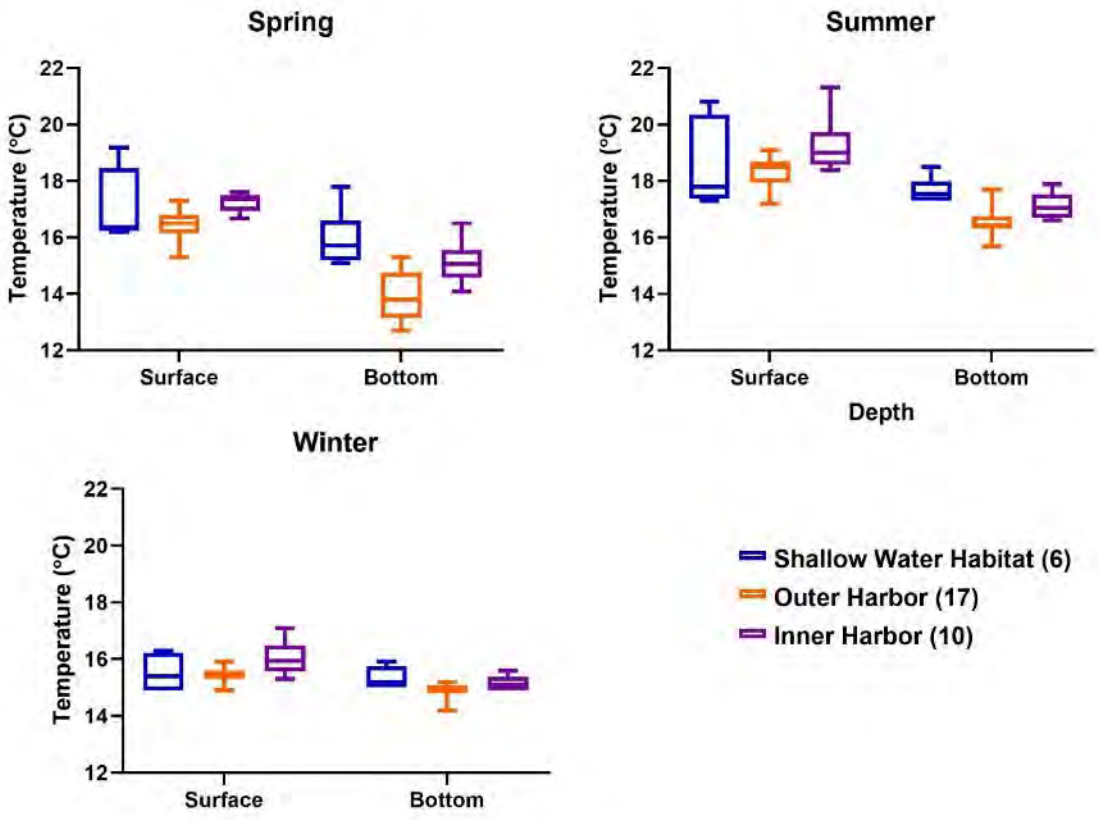
Figure 2-4. Locations of Water Quality and Benthic Sampling Stations

2.3.1 TEMPERATURE

Temperature varied by season and by depth. Water temperatures were highest in summer (surface average of 18.6°C), followed by spring (surface average of 16.8°C), and then winter (surface average of 15.6°C). Surface temperatures were higher than bottom temperatures across all sampling periods, with larger differences in spring (2.1°C difference between average surface and average bottom temperature) and summer (1.7°C) than in winter (0.5°C).

The range of temperatures across the entire sampling period was relatively large, with the coldest temperatures near the bottom at the Outer Harbor stations during spring (average of 13.9°C) and the warmest temperatures at the surface at Inner Harbor stations during the summer (average of 19.3°C). Winter temperature measurements reflected only small differences between the surface and bottom, especially at the SWH stations where there is less distance between the surface and bottom (Figure 2-5).

In waters deeper than a few meters, a thermocline can develop in which the warm upper layer of water abruptly transitions to substantially cooler water below. This phenomenon occurs when the surface water warms more quickly than the bottom layer can mix with it. The occurrence of thermoclines can vary by both season and station depth, becoming most common in the spring and summer when the warm air increases the sea surface temperature but cannot reach deeper waters. In the case of the Port Complex, a number of the stations in the Inner Harbor and SWH areas were too shallow for a steady thermocline to develop. However, thermoclines were observed at several locations, especially at the Outer Harbor stations (Appendix B). The small range in temperatures compared with those in spring and summer (Figure 2-5) indicates the absence of thermoclines in winter.



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 2-5. Temperature Boxplots Across All Sampling Stations, with Respect to Habitat Type and Depth Strata

2.3.2 SALINITY

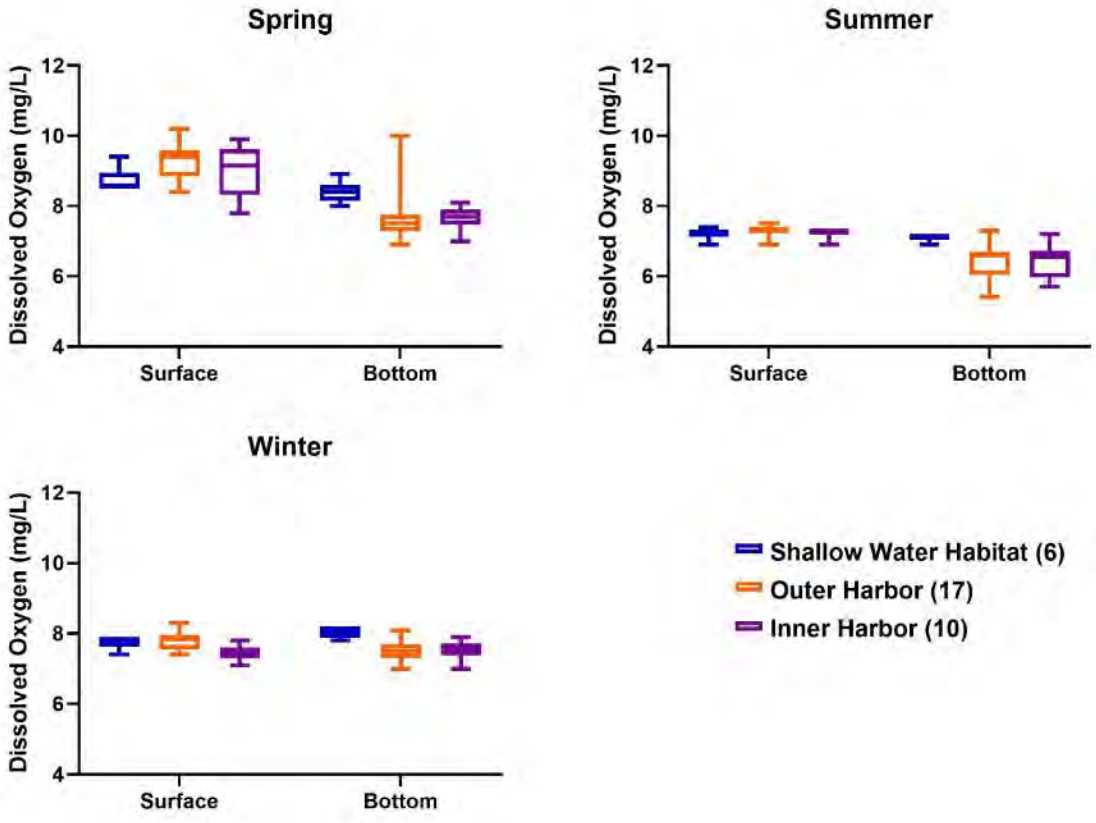
Salinity levels varied from season to season throughout the Port Complex, and the influence of rainfall was evident in the surface readings. Surface spring salinities varied minimally (32.7 to 33.5 PSU), but summer salinities ranged from 24.0 to 33.2 PSU and winter salinities ranged from 22.8 to 32.8 PSU. Across all seasons, there was relatively little variability in average salinity between the surface and bottom, with values typical of the nearshore coastal ocean. The largest difference in average salinity occurred in winter, with a 2.0 PSU difference between the surface and the bottom.

The decreases in surface salinity in the summer were localized at Inner Harbor stations; station LA5 in the West Basin of the Port of Los Angeles had the lowest reading of 24.0 PSU. The only other stations that had surface salinities less than 32.5 PSU were LA13 (Berth 119), LA14 (Consolidated Slip), and LB4 (Channel 2). All of these stations receive stormwater runoff from the local watersheds, which was likely still a factor in the low surface readings after Hurricane Hilary passed through southern California from August 16 through 21, 2023; that storm deposited 2.66 inches of rainfall at Long Beach Airport (see Section 2.2) and up to 7 inches in the Los Angeles mountain areas. Summer water quality parameters were measured on September 21 and 22, 2023. The low salinity readings in the summer were isolated to the top 1 to 2 meters at the stations mentioned above, providing confidence that the observation was the result of discharges of recent rainfall still flowing out of local watersheds into the surface waters of the Inner Harbor.

The low winter surface salinity was also likely tied directly to an above-average rainfall year. From 2000 to 2024, the average rainfall for the winter (January through March) at Long Beach Airport was 6.59 inches. In January through March 2024, 17.99 in of rainfall occurred, making this period the second wettest winter in the past 25 years. Winter water quality parameters were measured on March 7 and 8, 2024, which followed 11.95 inches of rainfall in February 2024, the most rainfall in any 1-month period over the past 25 years. With this record-breaking rainfall in mind, the lower average surface salinity across all stations in the winter 2024 (30.8 PSU) likely reflects the heavy freshwater influence from local watersheds on the Port Complex. Station LA14 (Consolidated Slip) had the lowest surface salinity at 22.8 PSU, and LA5 (Port of Los Angeles West Basin), LA 6 (Port of Los Angeles East Basin), and LA16 (Slip 5) all had surface salinity readings below 30 PSU.

2.3.3 DISSOLVED OXYGEN

To survive in marine habitats, aquatic animals require sufficient concentrations of DO in the seawater. Therefore, the DO concentration at a location can be an important factor in defining the biological community living there, and sustained decreases in DO can lead to complex alterations in marine habitats (National Ocean Center, 2020). Generally, DO concentrations are inversely influenced by salinity and temperature (because cold water can hold more oxygen than warm water). Further, factors such as photosynthetic activity, organic matter decomposition, animal respiration, and ocean mixing can affect local DO concentrations. In Southern California, DO concentrations nearshore waters generally do not fall below the Water Quality Control Plan for the Los Angeles Basin (Basin Plan; California Water Boards 2025) water quality objective (WQO) of 5.0 milligrams per liter (mg/L) because of mixing between ocean and harbor waters and wave action. Concentrations above the Basin Plan WQO are expected to support all aquatic species in this region. During the 2023 Biosurvey, seasonal and depth fluctuations were observed across all stations, as shown in Figure 2-6.



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 2-6. Dissolved Oxygen Boxplots Across All Sampling Stations, with Respect to Habitat Type and Depth Strata

No measurements in spring, summer or winter were below the Basin Plan WQO of 5 mg/L. In the spring, the DO concentration was relatively high at the surface (>8 mg/L), generally decreasing toward the seafloor. Surface DO concentrations ranged from 7.8 mg/L at station LA14 in the Consolidated Slip to 10.2 mg/L at station LB15 in the outer anchorages. Bottom concentrations ranged from 6.9 mg/L at station LA1 to 10.0 mg/L at station LB9.

DO concentrations were slightly lower in the summer than in spring, likely attributable to the lower solubility of oxygen at higher temperatures. There was also less difference between surface and bottom concentrations, likely due to the lack of a strong thermocline in the summer months. Surface concentrations ranged from 6.9 mg/L at stations LA8, LA11, and LA14 to 7.5 mg/L at stations LA1 and LA 4. Bottom concentrations ranged from 5.4 mg/L at station LB5 to 7.3 mg/L at station LA1.

DO concentrations in winter were similar to the summer values. Surface DO concentration ranged from 7.1 mg/L at station LA14 to 8.3 mg/L at LB1. Bottom DO concentrations ranged from 7.0 mg/L at stations LA14, LB6, and LB8 to 8.2 mg/L at stations LA2 and LA3-ALT.

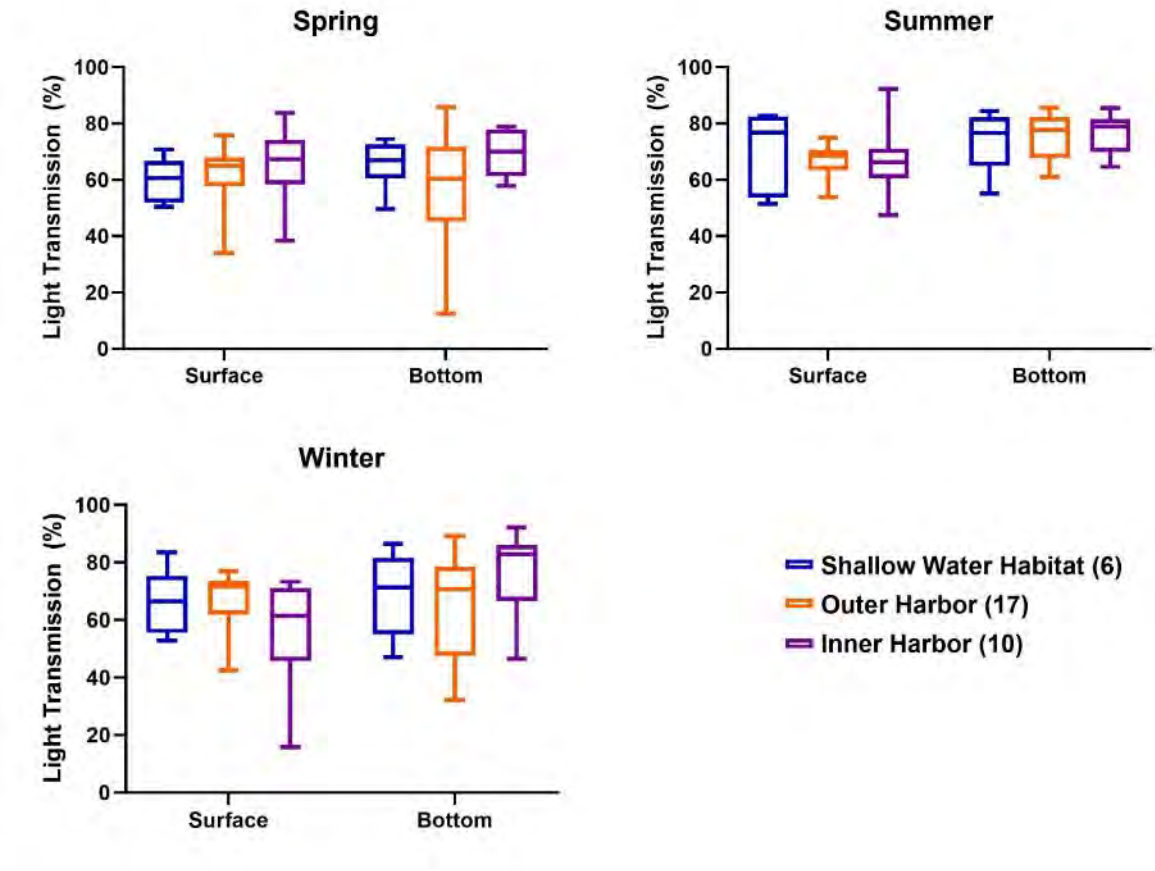
2.3.4 WATER CLARITY

Water clarity has important implications for the diversity and productivity of aquatic ecosystems because it is a key abiotic factor affecting plants and algae, both attached vegetation such as eelgrass and kelp and pelagic primary producers such as phytoplankton. Low clarity can limit photosynthesis, thereby affecting a habitat's biological diversity and productivity. Fluctuations in water clarity can be attributed to factors such as input of suspended particles from urban watersheds and storm drains, resuspension of sediments, tidal currents, and wave action.

In the 2023 Biosurvey, water clarity was evaluated using both light transmission (percentage) and turbidity (nephelometric turbidity units [NTU]) measurements. However, this discussion focuses on transmittance, a more direct measure of light available for biological activity and the method approved for measuring water clarity per Clean Water

Act Section 401 Water Quality Certification (Los Angeles Regional Water Quality Control Board, 2021). NTU values are presented in the detailed water quality data included in Appendix B.

On average, water clarity at the bottom of the water column tended to be higher than at the top at most stations in the summer and winter (Figure 2-7). The highest transmission measured at the bottom (92%) was at Inner Harbor station LA16 (Slip 5) in the winter, with transmission measured at only 46% at the surface at that station. The lowest surface transmission in winter was only 16% at station LA14 (Consolidated Slip). As discussed previously and detailed in Section 2.2, the winter survey was conducted after considerable rainfall, which likely contributed to lower readings at the surface because of increased freshwater inputs with suspended particulates from the watersheds. During the spring, the average water clarity was nearly the same at the surface the bottom. The lowest measured transmission in spring was 12.5% near the bottom at station LB6 (Pier J).



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 2-7. Light Transmission Boxplots Across All Sampling Stations, with Respect to Habitat Type and Depth Strata

2.3.5 PH

Overall, seawater tends to be slightly alkaline (pH > 7) with a global mean of 8.1 (Chan, 2014) and a narrow range of values around that mean. Measuring pH provides useful information regarding the acidity of seawater, which can have significant effects on some organisms living in the water column. As an example, ocean waters act as a sink for increased atmospheric concentrations of carbon dioxide (CO_2), lowering the pH of oceans around the globe. This trend is particularly notable along the West Coast of the United States (NOAA, 2014; Busch et al., 2014). Lower pH has been implicated as the cause of challenges for cultured shellfish and planktonic snails (pteropods) along the West Coast. Both of these classes of organisms, along with other gastropods, bivalves, and coral reefs around the world, rely on the formation of calcium carbonate shells or skeletons, which are unable to form properly when pH drops too low (Hales, 2012; Chan, 2017). Aquatic organisms are influenced by pH at differing thresholds, and impact should be assessed on a species-by-species basis. For example, California mussels (*Mytilus californianus*) have been shown to grow

smaller, thinner, and weaker shells in more acidic conditions, and larvae may be susceptible to reduced growth and increased energetic costs that lowers their overall survival rate (Gaylord et al., 2018).

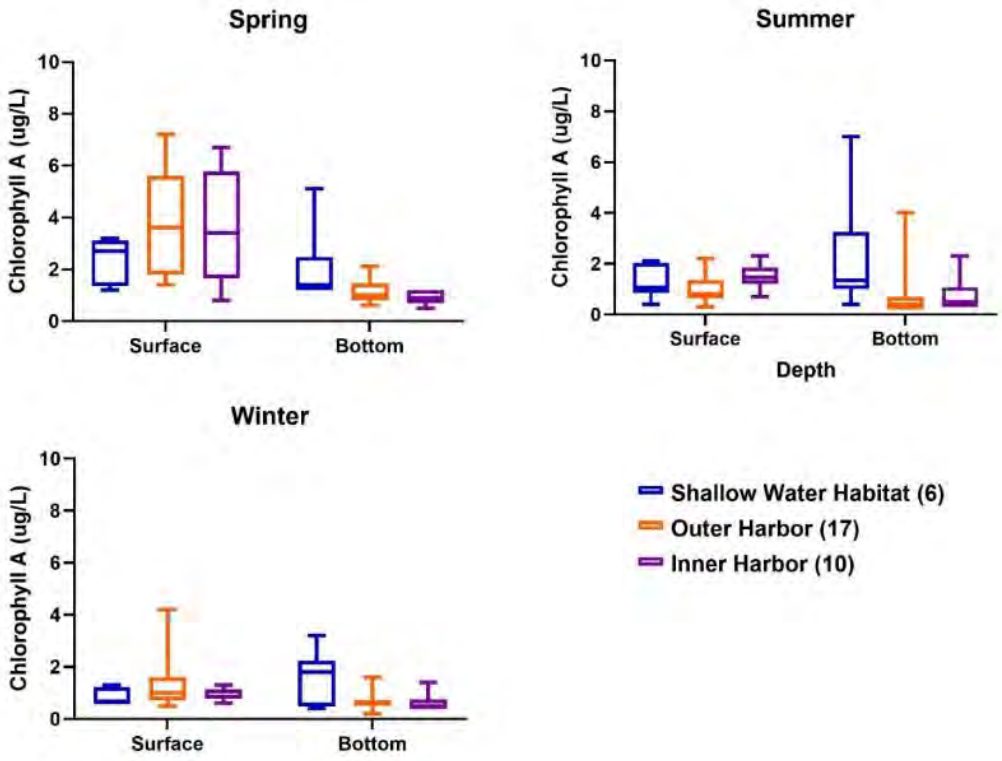
During the 2023 Biosurvey, pH in the Port Complex varied little with season, depth, or location. Across the three seasons, the surface pH ranged from 7.7 to 8.6, and the bottom pH ranged from 7.5 to 8.4, with the lowest pH generally isolated at the bottom and in the winter. The values measured in the Port Complex were typical of coastal ocean waters in the region and do not appear to be low enough to cause concern for local species. The differences among seasons, depths, and locations are likely due to variations in temperature, biological activity, and availability of nutrients in the surrounding waters.

2.3.6 CHLOROPHYLL

Phytoplankton (single-celled planktonic algae) is the base of the marine food web, and chlorophyll is present in most marine algal cells, enabling them to conduct photosynthesis. Accordingly, the concentration of chlorophyll in ocean water provides a good measure of the amount of phytoplankton present. Measurements of chlorophyll can also identify harmful algal blooms that may result from enhanced nutrient loading and bioavailability. A healthy ecosystem sustains a certain level of algal productivity, but too much nutrient loading and availability may also result in algal blooms that can have a wide range of detrimental impacts on marine ecosystems (Heisler et al., 2008).

Concentrations of chlorophyll throughout the Port Complex were similar in the summer and winter sampling periods, but higher concentrations were measured in the spring. Surface concentrations averaged 1.2 micrograms per liter (µg/L) in the summer (maximum of 2.3 µg/L) and 1.12 µg/L in the winter (maximum of 4.2 µg/L; Figure 2-8), compared with the spring average of 3.5 µg/L and maximum of 7.2 µg/L. Only in spring was there a substantial difference between surface and bottom concentrations. The higher chlorophyll concentrations in spring are attributable to the "spring bloom," a typical feature of temperate oceans in which increasing light levels and day length allow phytoplankton to use the nutrients that accumulate during the winter to support rapid growth.

In comparison, chlorophyll-a concentrations measured in the nearshore environment off Scripps pier in San Diego, California, from 1983 through 2010 are typically approximately 1 to 2 µg/L, although occasionally, during a massive algal bloom, concentrations can exceed 100 µg/L (McGowan et al., 2017). Concentrations within the Port Complex were, on average, consistent with the nearshore average of 1 to 2 µg/L at Scripps Pier, and no chlorophyll-a concentrations in the Port Complex approached the concentrations detected during extreme plankton blooms. Elevated chlorophyll-a concentrations are to be expected within a coastal embayment with reduced circulation and increased nutrient concentrations compared with concentrations in a nearshore environment.



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 2-8. Chlorophyll-a Boxplots Across All Sampling Stations, with Respect to Habitat Type and Depth Strata

2.4 SATELLITE IMAGERY

New methods to characterize harbor-wide water quality patterns remotely include monthly satellite images from Sentinel-2 (10-meter resolution), which are processed for turbidity, chlorophyll-a, and secchi disk depth data; Landsat-8/9 (30-meter resolution) images are processed for sea surface temperature. Surface water quality metrics have historically shown significant correlation between both *in situ* CTD and remote sensing satellite methods for sea surface temperature, turbidity, and water clarity in the Port Complex (Wood, 2021; WSP, 2023; WSP, 2024; WSP; 2025).

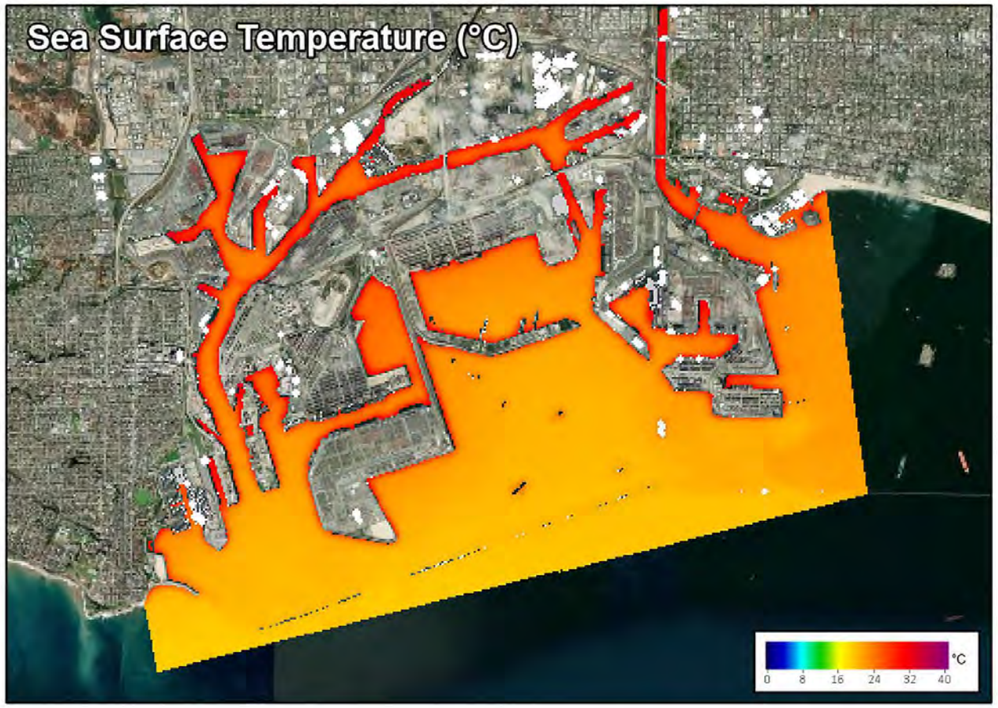
Satellite image acquisition was successful for monthly water quality parameters (temperature, chlorophyll-a, turbidity, and secchi disk depth) during the 2023 Biosurvey (examples of summer conditions are shown in Figure 2-9 and winter conditions in Figure 2-10; imagery for the months of usable data is provided in Appendix B). The exceptions were May and June 2023, when a persistent marine layer precluded use of any usable images for data analysis.

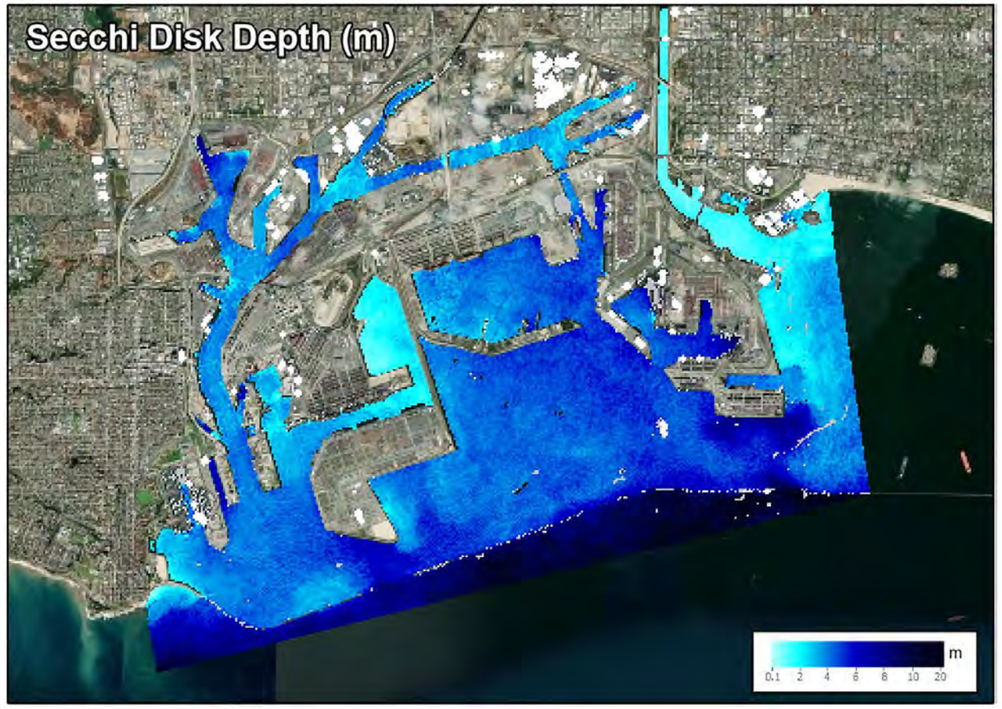
Each water quality image was analyzed for a harbor-wide average that could then be compared across each month to examine temporal and spatial trends and their potential effects on the biological communities observed during other survey elements.

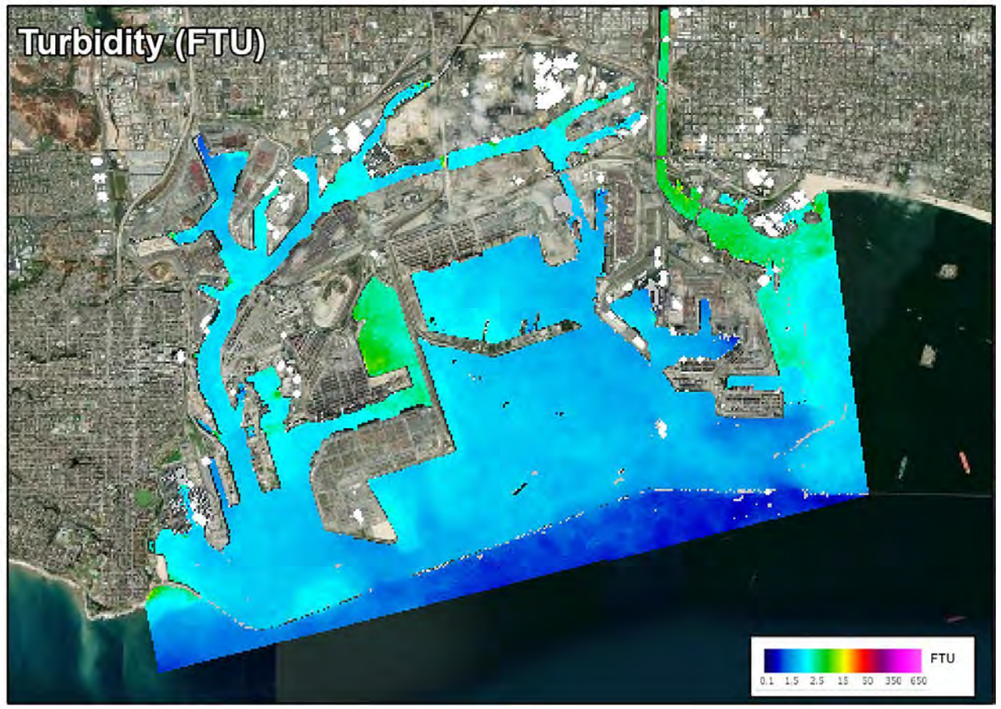
2.4.1 TEMPERATURE

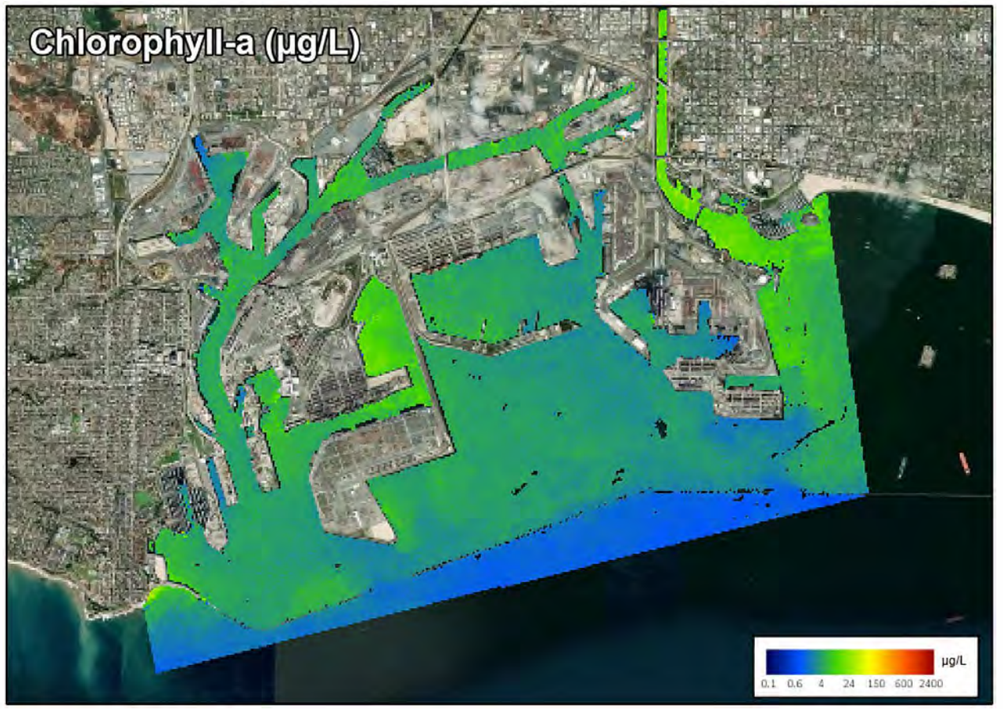
Sea surface temperature is known to influence kelp growth because warmer water negatively affects kelp growth directly. Warmer temperatures are also associated with lower nutrient concentrations in the water column, which can slow kelp growth rates (Schiel and Foster, 2015). Kelp recruitment and growth are higher at cooler temperatures (Graham et al., 2007), and at temperatures above approximately 20°C, kelp growth rate is reduced, and individuals may start to senesce and die off (Simonson et al., 2015).

Sea surface temperatures in much of the Port Complex were above 20°C during July (50%, harbor-wide average of 21.2°C) and August 2023 (84%, 22.5°C; Figure 2-11), but during the remaining months, sea surface temperatures were below 20°C in most of the harbor. SST was coolest in January 2024 (12.2°C). Several year-round patterns were evident; for example, the shallow, Inner Harbor areas tended to have higher temperatures, and the deeper, Outer Harbor areas with more ocean connectivity remained cooler even in the summer months. The influence of the Los Angeles River was also noticeable in the eastern portion of the Port Complex, with the warmer waters from the watershed mixing with cooler water within San Pedro Bay. Consistent with previous findings, harbor-wide satellite imagery average temperatures were generally similar to those obtained via *in situ* methods (19.8°C versus 18.6°C in summer, and 15.2°C versus 15.6°C in winter, respectively). Note that satellite imagery was not available in May 2023 and could not be compared directly with May 2023 *in situ* readings. During the 2018 Biosurvey (Wood, 2021), monthly water quality images were obtained as part of a pilot study to incorporate satellite imagery. These data allow for direct comparison of the 2023 monthly data with the 2018 data (Figure 2-12). At first glance, the two survey periods were similar, with an average temperature across all months of 17.3°C in 2018 and 17.1°C in 2023. The range of temperatures observed in 2023 (12.7 to 21.3°C) was larger than in 2018 (13.2 to 21.9°C), with similar trends in warming during the spring/summer and rapid cooling in the fall and during the start of the rainy season. The most notable difference was that in 2018, the warm conditions persisted longer into the summer, with 57 to 100% of the Port Complex over 20°C from July through September 2018. In 2023, the waters in the Port Complex warmed up from July through August 2023 and then cooled more quickly. In part, this pattern could be because August imagery was taken August 5, 2023, approximately 2 weeks before Hurricane Hilary made landfall in California. In the September 2023 imagery, temperatures in Outer Harbor areas were approximately 1°C lower than in August 2023; Inner Harbor areas such as the inner turning basins in the ports were 4 to 5°C cooler, indicating stormwater runoff from the storm as a key factor in cooling Inner Harbor areas.





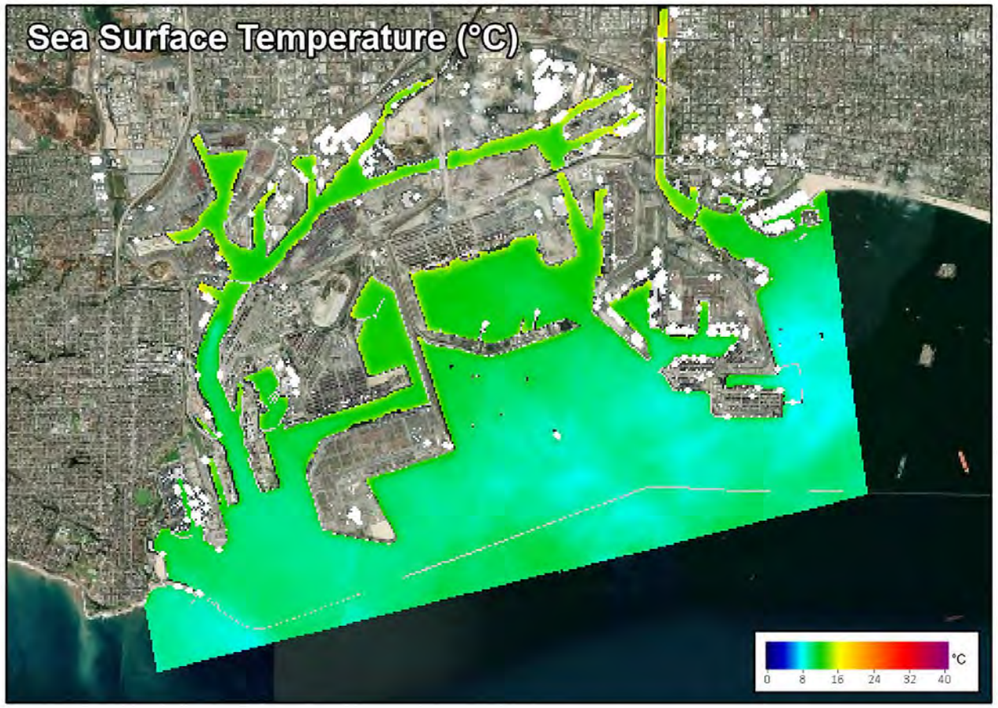


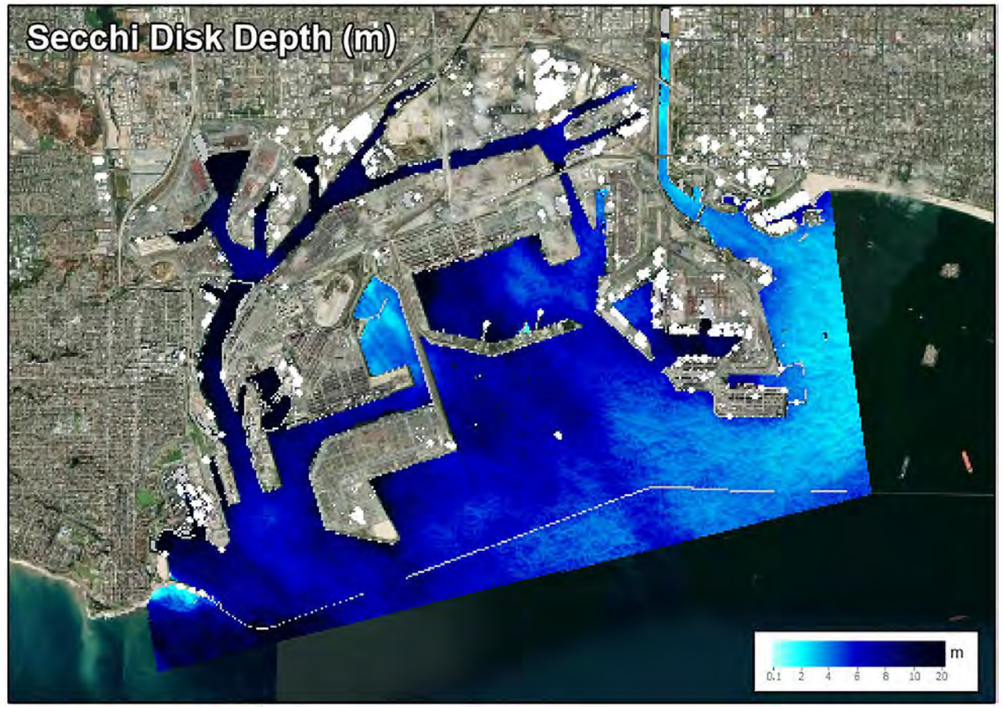


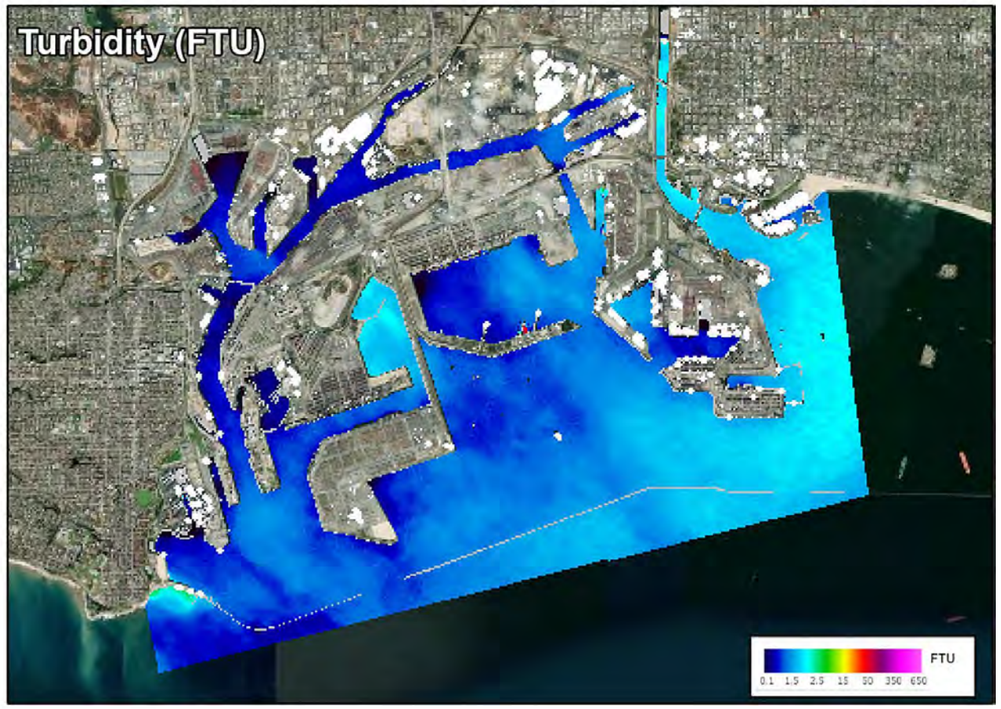
1 inch =7,304 feet
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Service Layer Credits: World Imagery: Earthstar Geographics

Figure 2-9. Satellite Imagery for August 5, 2023: Sea Surface Temperature, Secchi Disk Depth, Turbidity, and Chlorophyll--a







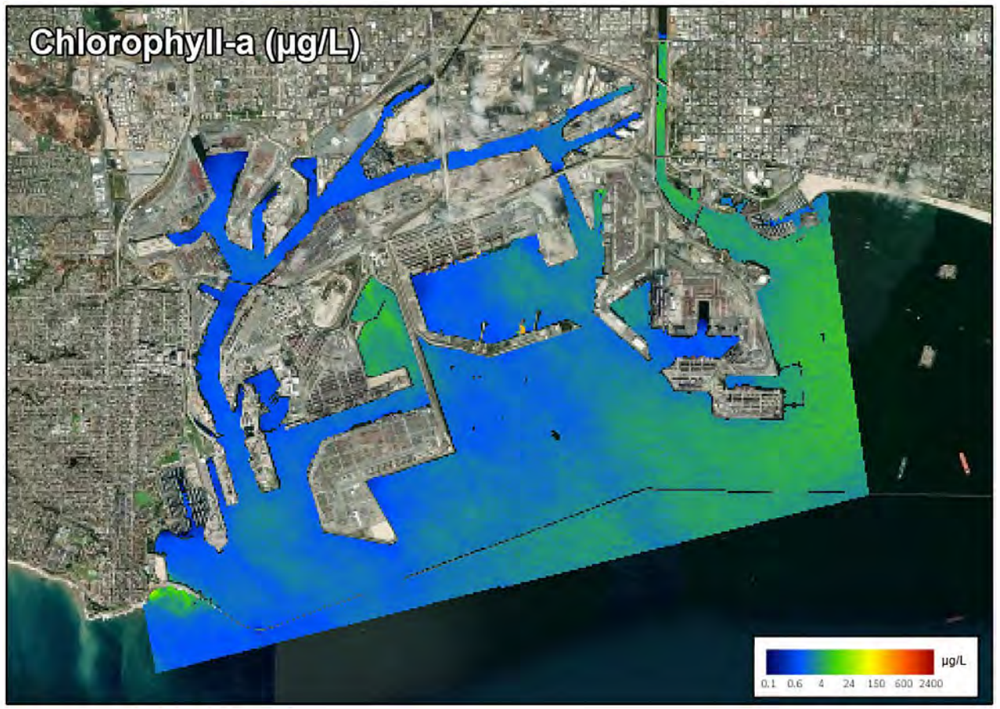


Figure 2-10. Satellite Imagery for January 28, 2023: Sea Surface Temperature, Secchi Disk Depth, Turbidity, and Chlorophyll-a

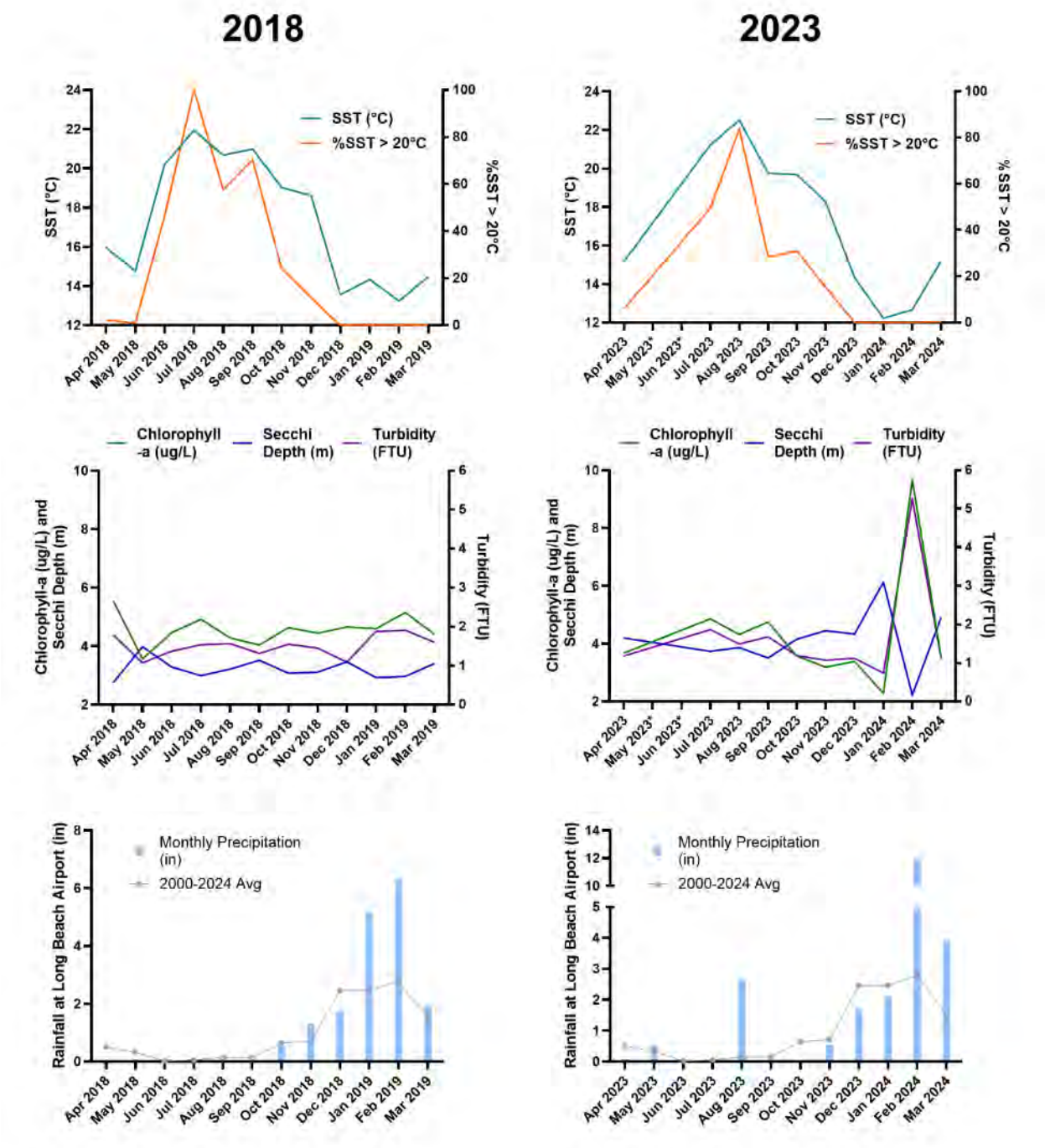
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Service Layer Credits: World Imagery: Earthstar Geographics



		Sea Surface Temperatures Over 20°C Landsat 9 on 8/05/2023 Port of Long Beach and Port of Los Angeles, CA	N	**Water Quality Assessment**	FIGURE **2-11**

SST <= 20°C
SST > 20°C



* Missing May and June 2023 data points because of excessive cloudiness. Data extrapolated between existing datapoints.

Figure 2-12. 2018 and 2023 Satellite-derived Water Quality Parameters. Port Complex Average Sea Surface Temperatures Above 20°C and Percentage of Port Complex for 2023 (Top) and 2018 (Bottom)

An additional SST data set from MODIS (see MODIS Technical Specifications) was accessed. More than 4,100 images were accessed and analyzed as a rolling 9-day average to provide near daily SST coverage from 2013 through 2024 (Figure 2-13). With the images' resolution of 1 kilometer, there is too much shoreline interference within the Port Complex, so the Biosurvey used imagery from just offshore of Cabrillo Beach and Point Fermin, southwest of the Port Complex. This analysis provides additional insight into local conditions in the nearshore environment that drive conditions inside the Port Complex using data collected at a higher temporal scale (near daily images) compared with the monthly images within the Port Complex.

Figure 2-13 shows that the nearshore SST peaked and remained high during the 2014–2016 heatwave event (Cavole et al., 2016; Jacox et al., 2019), with a trend toward lower peak summer temperatures from 2015 through 2023. Similarly, the annual minimum temperatures have been dropping since the heatwave event, with the lowest winter SST observed in 2023, just before the 2023 Biosurvey. In part, this low temperature event in winter 2023 may correlate with a year with above-average rainfall in 2022 and 2023, with 20.93 inches of rainfall (third highest amount since 2000) and 16.13 inches of rainfall from January through March 2023 (third highest since 2000). The average temperature over this time period, using the MODIS data, was 17.1°C, which correlates with NOAA buoy data from San Pedro Channel over a similar time period (average of 17.3°C).

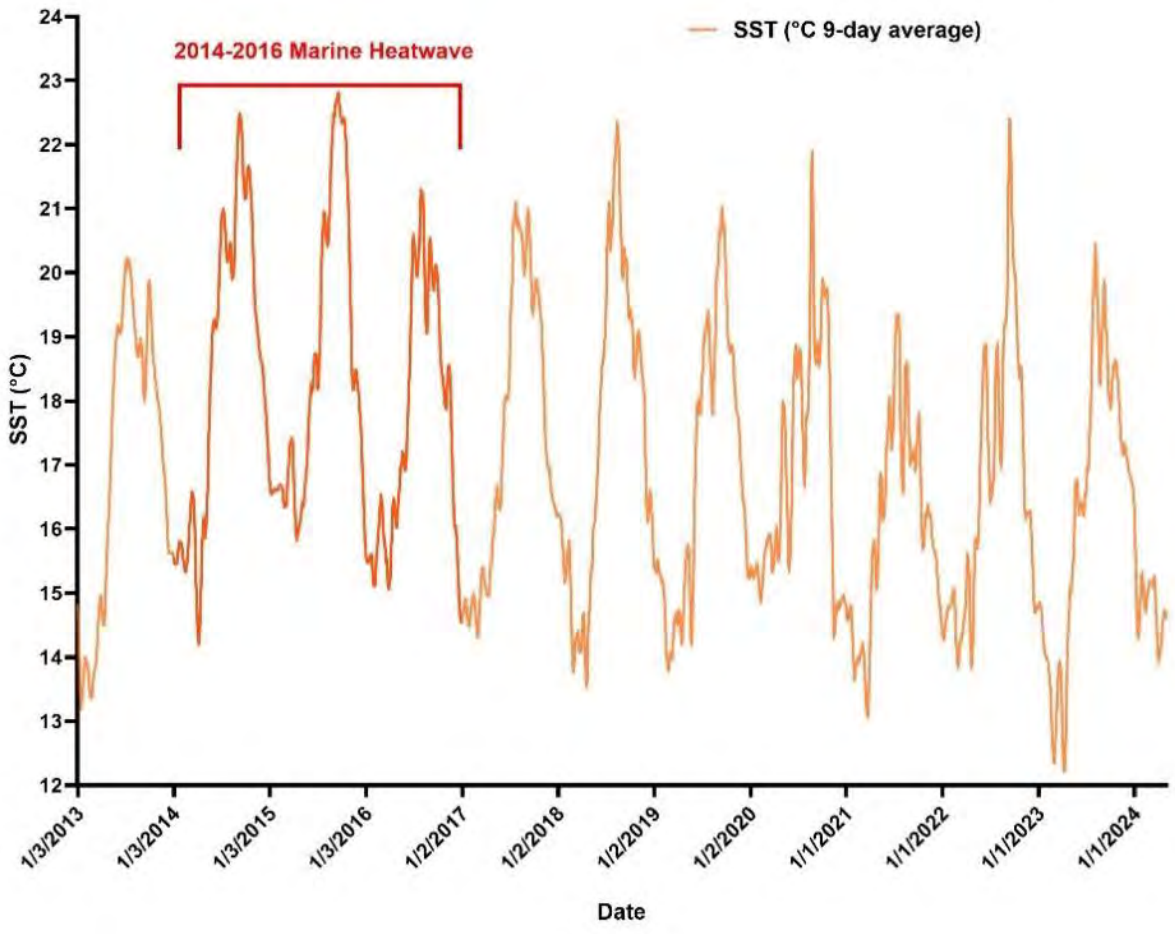


Figure 2-13. MODIS Sea Surface Temperature – 2013–2024

2.4.2 CHLOROPHYLL-A

Satellite imagery showed that chlorophyll-a concentrations were highest at Inner Harbor areas (Figures 2-9 and 2-10, Appendix B). Chlorophyll-a concentrations were high in the spring and early summer before declining through the fall until the rainy season began. The highest mean concentration of chlorophyl in the Port Complex (9.68 µg/L) was detected in February 2024, likely in part because of nutrient inputs from stormwater and local watersheds and wind-driven upwelling in the nearshore environment. Compared with results in 2018, when chlorophyll-a concentrations were relatively consistent throughout the year (average 4.55 µg/L), chlorophyll-a concentrations in 2023 were much more variable prior to, and as a result of, the large storm events during the winter despite a similar annual average of 4.32 µg/L. Satellite imagery provides coarser resolution than *in situ* methods and does not always capture the fine-scale variability in chlorophyll-a concentrations that *in situ* methods do (Wood, 2021; WSP, 2023). Port Complex-wide satellite imagery average chlorophyll values were not always similar to *in situ* surface values (4.7 versus 1.2 µg/L in the summer, and 3.5 versus 1.1 µg/L in the winter, respectively). Note that satellite imagery was not available in May 2023 and could not be compared directly with May 2023 *in situ* readings.

2.4.3 TURBIDITY AND WATER CLARITY

Resuspension of sediments in the Port Complex area from disturbances such as wind-driven mixing, storm events, and wash from boat propellors causes turbidity that decreases water clarity and can release nutrients sequestered in the sediments. Satellite imagery showed that turbidity (formazin turbidity units [FTU], which is a value equivalent to NTU), appeared to be higher at Inner Harbor areas, with the highest average turbidity in February 2024 (5.25 NTU) likely attributable to the intense rainfall and resulting runoff from local watersheds. Satellite imagery provides coarser resolution than *in situ* methods and does not always capture the finer-scale variability in turbidity that *in situ* methods do (Wood, 2021; WSP, 2023). Port Complex-wide satellite imagery average turbidity values were different from *in situ* surface values in the summer (1.7 versus 0.7 FTU, respectively) but were more similar in the winter (1.1 versus 1.4 FTU, respectively). Note that satellite imagery was not available in May 2023 and could not be compared directly with May 2023 *in situ* readings.

The satellite-derived secchi disk measures water clarity using a measurement of light attenuation to simulate the same principle in which the deeper the secchi disk can be perceived from the surface, the clearer the water. During the 2023 Biosurvey, satellite-derived secchi disk depth was highest in the Outer Harbor and lowest in the Inner Harbor, where turbidity and chlorophyll-a concentrations were high (Figures 2-9 and 2-10, Appendix B). Secchi disk depth was highest during January 2024 (average of 6.13 meters). Satellite-derived secchi disk depth was more variable in 2023 than in 2018; however, Port Complex-wide water clarity improved from an annual average of 3.22 meters in 2018 to 4.15 meters in 2023. These patterns have implications for the distribution and growth of key habitats, such as eelgrass and kelp beds. During the peak season of eelgrass growth (April through September), the Port Complex-wide average satellite-derived secchi disk depth was over 0.5 meter higher in 2023 (3.82 meters) than in 2018 (3.29), which could demonstrate that increased water clarity is a factor in the increased size of the eelgrass beds in 2023 compared with 2018 (see Section 4.2).

2.5 PHYSICAL CHARACTERISTICS OF SEDIMENT (TOC AND GRAIN SIZE)

The physical characteristics of the sediments in the Port Complex (sediment TOC and grain size) are summarized in Tables 2-3 and 2-4, and the complete data set is provided in Appendix B. Grain size and TOC data are used to help interpret benthic community composition for all 33 stations at which benthic infauna were collected as part of the RMC TMDL monitoring.

2.5.1 GRAIN SIZE

The Inner Harbor and Outer Harbor were generally similar in terms of grain size percentages, but the SWH stations had more sand and less silt and clay than the deeper habitats did. This pattern reflects the origins of the SWH areas, most of which were constructed and created with dredged fine sands. The highest percent composition of gravel was observed at station LA15 (Outer Harbor) as a notable finding. The grab sample from station LA15 (Turning Basin;

Figure 2-14) had sediments composed of 39.0% gravel, which is consistent with historical observations of the seafloor in that area (i.e., there are patches of uneven hard bottom, with rocks and boulders occasionally picked up in trawls from that area). Results for the summer sample from station LA15 (0.1% gravel) were more consistent with results for other areas of the harbors as the sampling team slightly repositioned the grab for better sediment recovery success.

Percent fines (clay plus silt) at Inner Harbor and Outer Harbor stations were similar across the spring and summer seasons (61 to 73%); however, SWH areas had a substantially smaller percentage of fines (40 to 46%; Table 2-3; Figure 2-15). Within each season, the stations with a higher percentage of fines also had higher TOC content. There was no clear Port Complex-wide difference in grain size composition between seasons, and much of the variability observed in the grain size is likely due to the small-scale heterogeneity of the seafloor.

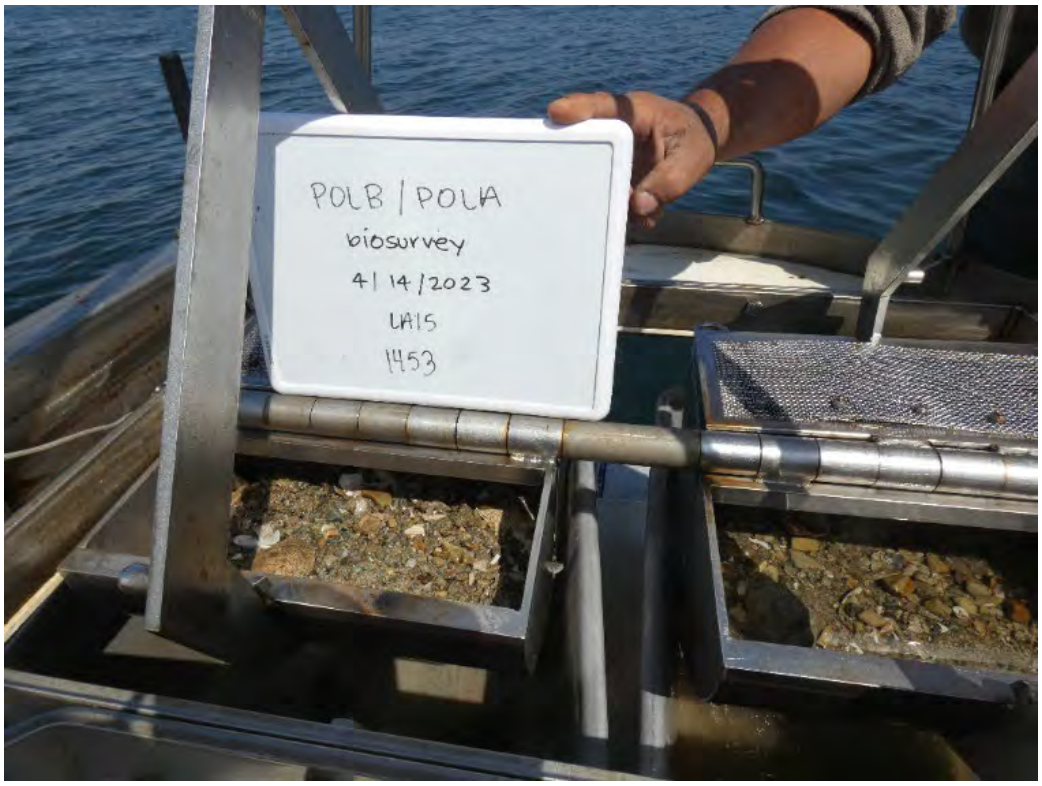


Figure 2-14. Grab Sample from Station LA15 in Spring 2023 Showing High Gravel Content

2.5.2 TOTAL ORGANIC CARBON

TOC was detected in sediments from all 33 locations: 10 at Inner Harbor stations, 17 at Outer Harbor stations, and 6 in SWH stations during spring and summer 2023. Stations in the Inner Harbor had the highest average percent TOC (5.06% in spring and 1.47% in summer), more than double the TOC concentrations at Outer Harbor and Shallow Water Habitat stations (Table 2-3, Figure 2-15). The high TOC concentrations in the Inner Harbor were due in part to the 17.7% TOC result for the spring sample at station LA14 (Consolidated Slip); in the summer, the TOC concentration at station LA14 was 5.45%. The TOC results for the rest of the Inner Harbor stations in spring were more in line with the TOC results from the summer, ranging from 0.24 to 5.45%

Across nearly all station groups, there was an observable decrease of at least 50% in the average TOC concentrations from spring to summer. Given that a similar change in percent fines, which is often positively correlated with TOC, was not observed, the reason for this seasonal difference is not readily apparent, but could be in part due to seafloor heterogeneity, increased organic material on the seafloor following a heavy rainy season, degradation of organic material over time, seafloor disturbance, and consumption of organic material by benthic infauna and epifauna.

Table 2-3. Average Grain Size Across Spring and Summer 2023

Station	Habitat	Clay	Silt	Percent Fines (Clay+Silt)	Sand	Gravel	Total Organic Carbon
LA-1	Outer	7.40	**53.8**	61.2	39.0	< 0.05	1.02
LA-2	SWH	2.50	18.8	21.3	**78.3**	< 0.05	0.20
LA-3	SWH	5.52	**56.0**	61.5	38.7	< 0.05	1.46
LA-3ALT	SWH	3.55	32.0	35.5	**63.4**	< 0.05	0.41
LA-4	Outer	6.25	35.8	42.0	**56.8**	< 0.05	0.66
LA-5	Inner	10.7	**57.6**	68.3	32.4	< 0.05	3.15
LA-6	Inner	8.21	**52.2**	60.4	40.5	< 0.05	3.87
LA-7	SWH	6.35	**53.4**	59.7	40.6	< 0.05	0.78
LA-8	SWH	7.61	**63.1**	70.7	29.9	< 0.05	0.77
LA-9	Outer	6.09	37.7	43.7	**56.5**	< 0.05	0.39
LA-10	Inner	13.4	**63.2**	76.5	24.1	< 0.05	2.26
LA-11	Outer	11.9	**70.7**	82.6	18.7	< 0.05	4.00
LA-12	Inner	12.8	**79.4**	92.2	9.60	< 0.05	4.44
LA-13	Inner	11.1	**66.1**	77.1	23.4	< 0.05	1.36
LA-14	Inner	9.64	**66.3**	75.9	25.0	< 0.05	11.6
LA-15	Outer	7.25	29.2	36.5	**42.7**	19.5	<0.01
LA-16	Inner	8.92	**46.4**	55.3	44.4	< 0.05	3.39
LB-1	Outer	6.64	**53.5**	60.1	40.7	< 0.05	1.53
LB-2	SWH	1.20	9.9	11.1	**89.2**	< 0.05	1.16
LB-3	Outer	11.2	**67.9**	79.1	21.8	< 0.05	1.42
LB-4	Inner	8.70	**57.6**	66.3	34.1	< 0.05	0.78
LB-5	Outer	7.90	**57.5**	65.3	34.5	< 0.05	0.48
LB-6	Outer	9.90	**69.4**	79.3	20.9	< 0.05	0.50
LB-7	Outer	8.33	**52.3**	60.6	38.8	< 0.05	0.48
LB-8	Outer	12.4	**69.2**	81.5	19.3	< 0.05	1.06
LB-9	Outer	6.71	**51.1**	57.8	42.4	< 0.05	0.88
LB-10	Outer	9.86	**60.3**	70.2	30.6	< 0.05	0.84
LB-11	Outer	6.91	**43.8**	50.7	48.9	< 0.05	0.51
LB-12	Outer	10.1	**65.4**	75.5	25.1	< 0.05	0.62
LB-13	Outer	10.1	**55.6**	65.6	34.2	< 0.05	0.60
LB-14	Inner	11.5	**69.7**	81.2	19.8	< 0.05	0.94
LB-15	Outer	7.79	**59.7**	67.4	33.1	< 0.05	2.84
LB-16	Inner	8.75	**57.1**	65.8	34.9	< 0.05	0.92

Bold indicates the highest fraction of grain size measured at each station, gray indicates the combination of two fractions.

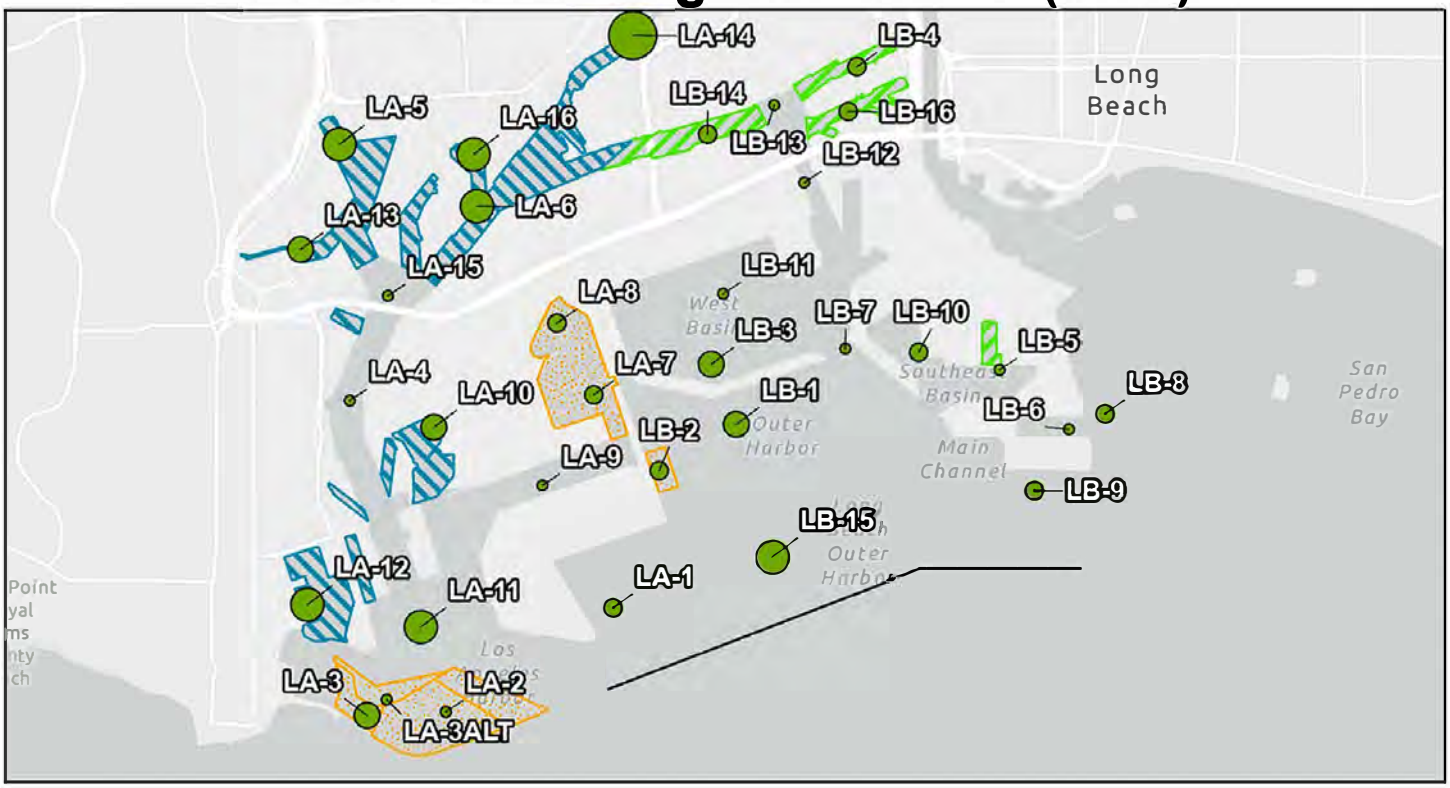
Table 2-4. 2023 Summary of Grain Size and TOC Results Across All Habitat Types (SWH, Inner Harbor, and Outer Harbor)

Parameter		Spring 2023						Parameter		Summer 2023					
		Grain Size (%)					Total Organic Carbon (%)			Grain Size (%)					Total Organic Carbon (%)
		Clay	Silt	Percent Fines (Clay + Silt)	Sand	Gravel				Clay	Silt	Percent Fines (Clay + Silt)	Sand	Gravel	
SWH (6)	Max	7.80	60.0	67.8	88.0	< 0.05	2.31	SWH (6)	Max	7.41	66.1	73.5	90.3	< 0.05	1.34
	Min	1.60	10.8	12.4	33.3	< 0.05	0.39		Min	0.80	8.91	9.71	26.5	< 0.05	< 0.01
	Avg	**4.53**	**35.7**	**40.2**	**59.7**	**< 0.05**	**1.20**		**Avg**	**4.37**	**42.0**	**46.3**	**53.7**	**< 0.05**	**0.58**
	Med	4.05	35.8	39.8	59.3	<0.05	1.17		Med	5.01	47.6	52.6	47.4	< 0.05	0.39
Inner Harbor (10)	Max	14.6	83.6	98.2	48.1	< 0.05	17.7	Inner Harbor (10)	Max	15.7	75.1	86.1	51.8	< 0.05	5.45
	Min	8.40	42.9	51.3	5.30	< 0.05	1.15		Min	6.52	41.7	48.2	13.9	< 0.05	0.24
	Avg	**10.8**	**62.7**	**73.5**	**27.9**	**< 0.05**	**5.06**		**Avg**	**9.95**	**60.3**	**70.3**	**29.7**	**< 0.05**	**1.47**
	Med	10.7	62.8	73.2	28.4	<0.05	3.54		Med	9.72	62.4	72.4	27.7	<0.05	0.50
Outer Harbor (17)	Max	14.4	77.7	92.1	59.1	39.0	5.41	Outer Harbor (17)	Max	11.8	73.6	84.5	61.2	< 0.05	3.29
	Min	2.70	9.70	12.4	10.3	< 0.05	< 0.01		Min	5.38	33.5	38.9	15.6	< 0.05	< 0.01
	Avg	**8.26**	**53.1**	**61.4**	**36.5**	**2.34**	**1.78**		**Avg**	**8.99**	**56.6**	**65.5**	**34.5**	**< 0.05**	**0.70**
	Med	8.00	56.9	63.7	37.8	<0.05	1.01		Med	9.52	59.7	67.3	32.7	<0.05	0.26

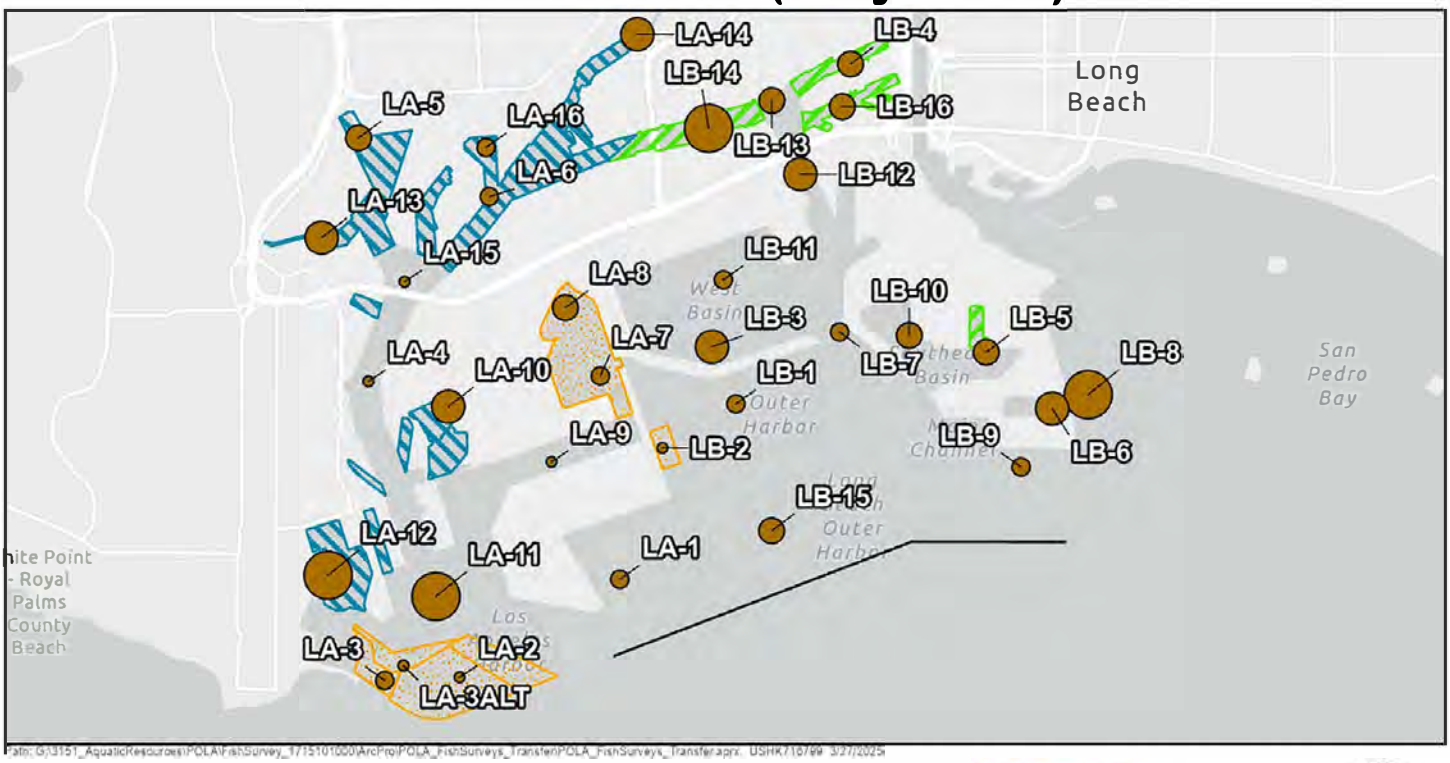
avg = average; max = maximum; med = median; min = minimum; SWH = shallow water habitat; gray indicates the combination of two fractions.

Service Layer Credits: Light Gray Base: Port of Long Beach, Port of Los Angeles, City of Long Beach, County of Los Angeles, California State Parks, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, USFWS

Percent Total Organic Carbon (TOC)



Percent Fines (Clay + Silt)



Path: G:\3151_AquaticResources\POLA\FishSurvey_1715101000\ArcPro\POLA_FishSurveys_Transfer\POLA_FishSurveys_Transfer.aprx USHK715789 3/27/2025

Percent TOC
- 0 - 1
- 2 - 1
- 2 - 2
- 3 - 4
- 5 - 12

Percent Fines (Clay+Silt)
- 11 - 44
- 45 - 62
- 63 - 71
- 72 - 79
- 80 - 92

Port Habitat
- Shallow Water Habitat (SWH)

Inner Harbor Areas
- Port of Long Beach
- Port of Los Angeles
- Breakwater

0 1 2 Miles

FIGURE 2-15

Percent TOC and Percent Fines at Soft Bottom Stations Averaged Across Spring and Summer 2023

2.6 RIPRAP SUBSTRATE

In the course of the riprap sampling (Section 1.6.6), divers collected data on the physical structure that composed the riprap habitat, based on the size of the substrate encountered. Although the designations of sand (<0.5 cm), cobble (0.5–15 cm), boulder (15 cm –1 meter), and reef (>1 meter) are generally descriptive, they are more accurately thought of as a measure of the potential for the substrate to be disturbed. Large substrates such as reefs and boulders would be disturbed only by an extreme event, whereas sand and cobble may be disturbed by winter storms, anchor scour, or propwash scour. The high-relief boulder habitat in the Port Complex is more similar to the reefs around the Channel Islands than to the shelf-like, low-relief rocky reefs found along the mainland coast (Pondella et al., 2015). The category "Other" represents substrates such as rope, cable, concrete, or trash. Figure 2-16 shows examples of substrate habitats in the Port Complex.



Figure 2-16. Examples of Reef Habitat Along the Breakwater (left), Boulder Habitat in the Inner Harbor (center), and Cobble and Sand Habitat in the Inner Harbor (right)

Data were collected at 20 stations, two in the SWH areas and the remainder on the Inner Harbor and Outer Harbor habitats during the spring and summer portions of the Biosurvey, and then were averaged for a combined spring and summer substrate analysis (Figure 2-17).

Reef was the most commonly encountered substrate across Inner Harbor (37% average) and Outer Harbor (63%) stations (Figures 2-17 and 2-19; Table 2-5) within the Port Complex. Outer Harbor stations were characterized primarily by reef, followed by boulder (16%) and sand (12%) in nearly even percentages. Inner Harbor stations differed in that they, on average, had more boulder (24%) and sand (24%) present. In part, the reduced amount of reef and boulder habitat in the Inner Harbor areas may be attributed to the sediment deposition on riprap that buries them, which also explains the increased "sand" measured in these areas. There was no apparent seasonal pattern to the substrate data.

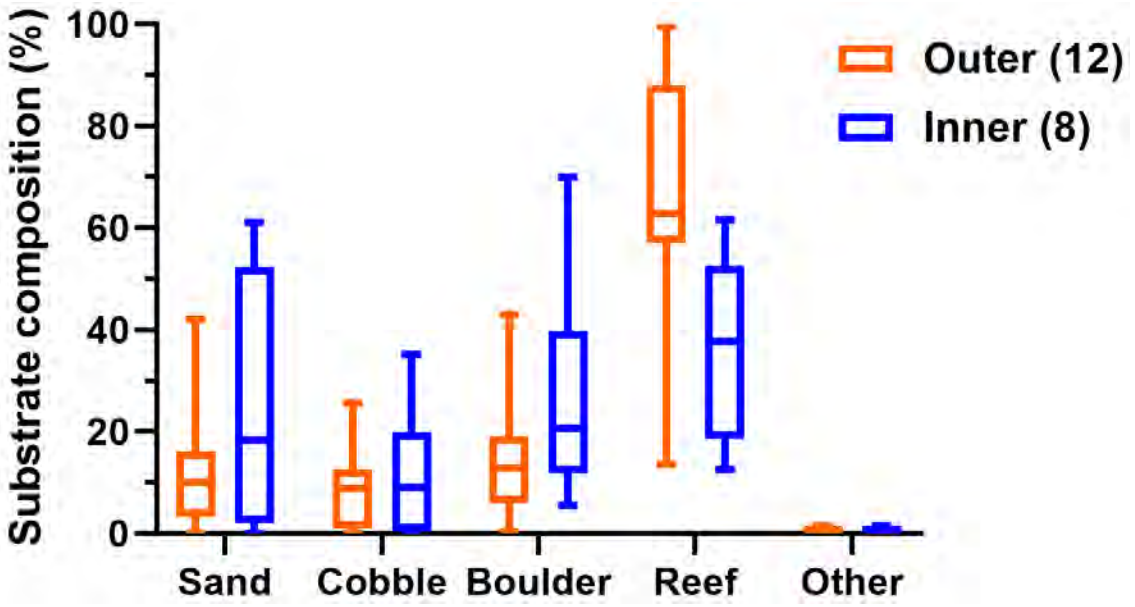
The 2023 Biosurvey was the first to measure the depth of sediment deposition on the riprap habitat (Table 2-5, Figures 2-18 and 2-19) as the average of the results of the spring and summer portions of the Biosurvey. There was no significant difference in results, as measured by a two-tailed unpaired t-test, between spring (1.7-cm average across all stations) and summer (2.0 cm). Although the difference in sediment deposition between Inner Harbor and Outer Harbor stations was not statistically significant, the average of Inner Harbor stations (2.56 cm) was nearly twice that of Outer Harbor stations (1.39 cm). Stations with the highest sediment deposition included station T17 (Fish Harbor, 6.0 cm of sediment), station T9 (Seaplane Lagoon; 5.8 cm), station T13 (Consolidated Slip; 5.4 cm), station T10 (Berth 170; 3.3 cm), and station T19 (Berth 148; 3.0 cm; -219). Increased sediment deposition in the Inner Harbor is likely due to several factors. For example, inputs of suspended particles mobilized from the watershed are deposited in the Inner Harbor during the rainy season. In addition, in the summer, the calmer waters of the Inner Harbor result in an environment in which suspended particles are more

likely to settle to the bottom than in the Outer Harbor, where wind and wave energy result in more constant resuspension and mobilization of sediments from the seafloor and riprap embankments.

Table 2-5. Spring and Summer 2023 Average Substrate Percentage and Site Deposition by Station

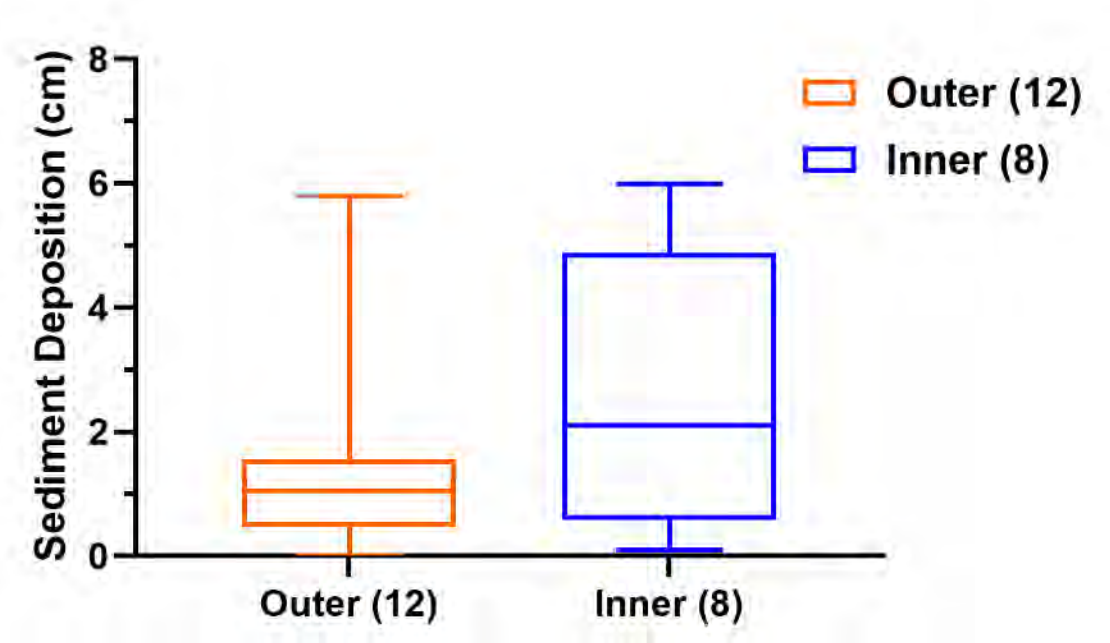
Inner/ Outer Harbor	Site	%Sand (<0.5 cm)	%Cobble (0.5 cm–15 cm)	%Boulder (> 15 cm–1 meter)	%Reef (>1 meter)	%Other (Anthropogenic)	Average Site Deposition (cm)
Outer	T1	8.7	0.0	0.7	90.7	0.0	1.4
Outer	T2	1.0	8.5	9.5	80.0	1.0	0.0
Outer	T3	10.5	11.0	16.0	62.5	0.0	1.6
Outer	T4	13.5	2.0	19.5	64.5	0.5	1.0
Outer	T5	19.3	9.0	8.7	63.0	0.0	1.3
Outer	T6	9.5	25.5	8.5	56.0	0.5	1.1
Outer	T7	17.0	25.0	43.0	13.5	1.5	2.6
Inner	T8	5.0	20.7	20.3	54.0	0.0	1.1
Outer	T9	42.0	2.5	42.0	13.5	0.0	5.8
Inner	T10	31.5	35.0	18.5	15.0	0.0	3.3
Inner	T11	0.0	17.5	70.0	12.5	0.0	0.1
Inner	T12	4.0	13.0	21.0	61.5	0.5	1.2
Inner	T13	58.5	1.5	9.5	29.0	1.5	5.4
Outer	T14	0.0	0.0	0.3	99.7	0.0	0.0
Outer	T15	1.5	0.5	5.0	92.5	0.5	0.4
Outer	T16	9.0	10.5	18.0	62.5	0.0	0.8
Inner	T17	61.0	0.0	5.5	33.0	0.5	6.0
Inner	T18	1.5	5.0	45.5	48.0	0.0	0.4
Inner	T19	34.0	0.0	23.0	42.5	0.5	3.0
Outer	T20	10.5	13.0	16.0	60.0	0.5	0.7

cm = centimeter(s)



Substrate composition groups are defined as follows: sand (<0.5 cm), cobble (0.5–15 cm), boulder (15 cm–1 meter), and reef (>1 meter). Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 2-17. Riprap Substrate by Locations Sampled During Spring and Summer

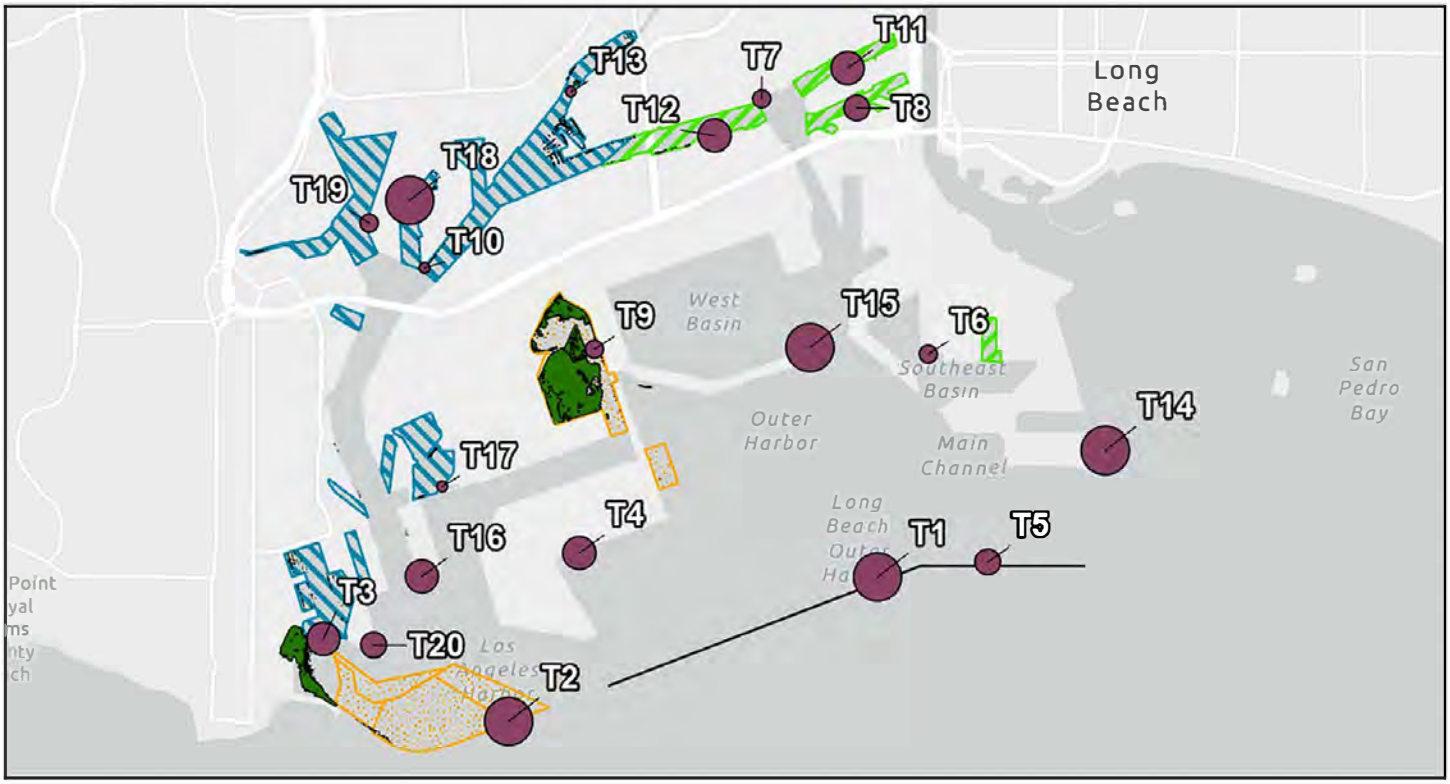


Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

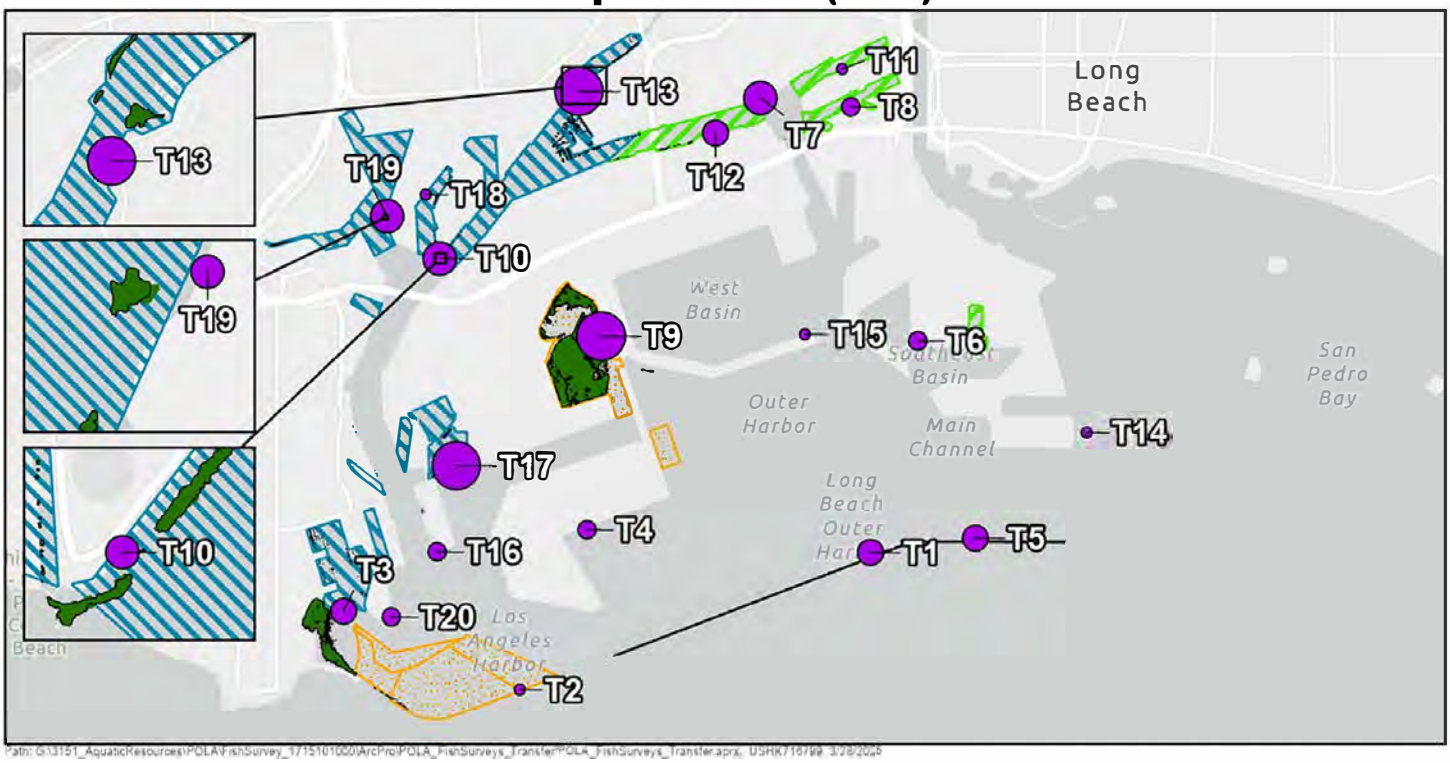
Figure 2-18. Average Site-Wide Sediment Deposition on Riprap Habitats – Spring and Summer 2023

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Percent Boulder and Reef



Deposition (cm)



Deposition (cm)
- 0.0 - 0.4
- 0.5 - 1.1
- 1.2 - 1.6
- 1.7 - 3.3
- 3.4 - 6.0

Boulder and Reef (%)
- 34 - 39
- 40 - 66
- 67 - 76
- 77 - 84
- 85 - 100

Port Habitat
- Shallow Water Habitat (SWH)
- Maximum Eelgrass Extent 2023

Inner Harbor Areas
- Port of Long Beach
- Port of Los Angeles
- Breakwater

0 1 2 Miles

FIGURE 2-19

Average Site Wide Sediment Deposition and Percent Boulder Plus Reef Substrate on Riprap Habitats – Spring and Summer 2023

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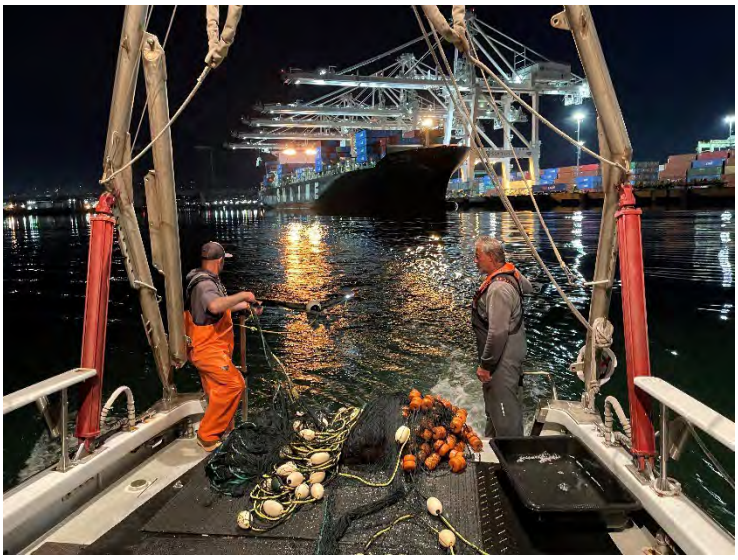
3 PELAGIC HABITAT

Pelagic habitat consists of the portion of the water column that extends from just above the sea bottom to the water surface and is the most widespread habitat type throughout the Port Complex, totaling some 3,600 hectares (8,900 acres) of water.

3.1 HABITAT CHARACTERISTICS

The pelagic habitat in the Port Complex is typically more dynamic than the more stable benthic habitats (Dickey-Collas et al., 2017). Defining and delineating this habitat are important for assessment, targeted management, and communication of key natural resource issues. Hyrenbach et al. (2000) categorize pelagic habitat as having a combination of static, persistent, and ephemeral aspects. Static aspects include fixed bathymetric and coastal features; persistent aspects include hydrographic and climatic features that can vary seasonally; and ephemeral aspects are short-lived and less predictable gradients and other variations in water quality.

Many fish and invertebrate species inhabit the pelagic zone either throughout their life cycle or during some stage of it. One important component of the pelagic community is the plankton, a diverse group of small plants and animals that is generally divided into several subcategories. Planktonic plants – the phytoplankton – are unicellular algae such as diatoms, flagellates, and dinoflagellates that form the base of the pelagic food web. Small animals, typically invertebrates that are moved by currents rather than their own efforts, are the zooplankton. Planktonic animals that spend their entire life cycles in the pelagic habitat, such as copepods, are the holoplankton, whereas those present only during certain life stages (i.e., larval forms of benthic organisms such as worms, echinoderms, and many fish species) are the meroplankton.

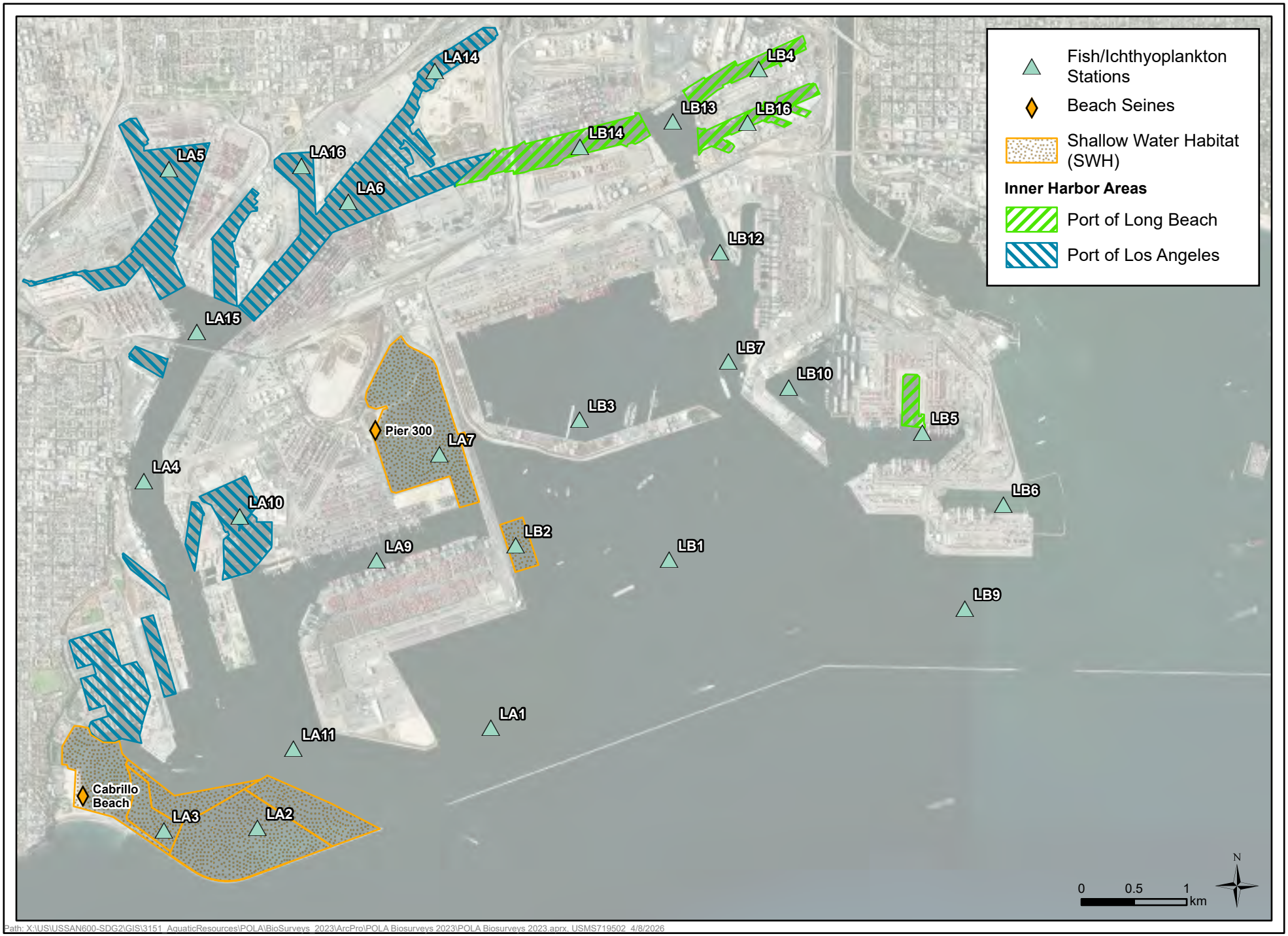


Deploying the lampara net at night

Pelagic sampling in the Biosurvey focuses on pelagic fishes and their meroplanktonic larvae (the ichthyoplankton). It therefore provides information on coastal pelagic species (CPS) and essential fish habitat (EFH) managed under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), 50 Code of Federal Regulations (CFR) 600 (added by the interim final rule published at 62 Federal Regulations 66531; December 19, 1997). EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Several species that are managed under the CPS Fishery Management Plan (FMP) are common within the Port Complex, namely northern anchovy, Pacific sardine, Pacific (chub) mackerel, and jack mackerel. These species, along with the other fish species sampled during the 2023 Biosurvey, are discussed in this section.

In the Biosurvey, pelagic fish were sampled at 26 stations throughout the Port Complex in spring and summer. Ichthyoplankton was sampled at 27 stations in spring, summer, and winter (Figure 3-1). Station identifiers (IDs) and associated characteristic identifiers (e.g., habitat, location, and depths) used for analysis of pelagic fishes and ichthyoplankton groupings highlighted in the following sections are summarized in Table 3-1.

Data analysis included grouping stations according to habitat (Inner Harbor, Outer Harbor, and SWH), location (Outer Harbor, SWH, channel, basin, and slip), and depth stratum (Shallow [0–7 meters], Deep [7.1–18 meters], and Very Deep [18+ meters]). Station designations and the grouping of stations for analysis are listed in Table 3-1.



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Table 3-1. Station Analysis Groups for Pelagic Fishes and Ichthyoplankton

Station	Port	Habitat	Location	Station Description	Station Depth (meters)	Depth Stratum
LB1	POLB	Outer	Outer	Outer Harbor Anchorages	13	Deep
LB2	POLB	SWH	SWH	POLB SWH	7	Shallow
LB3	POLB	Outer	Basin	West Basin	15.5	Deep
LB4	POLB	Inner	Slip	Channel 2	14	Deep
LB5	POLB	Outer	Basin	Southeast Basin East	17.5	Deep
LB6	POLB	Outer	Slip	Pier J South Slip	16.5	Deep
LB7	POLB	Outer	Channel	POLB Main Channel – Pilot Station	24.5	Very Deep
LB9	POLB	Outer	Outer	POLB Outer Main Channel	24.5	Very Deep
LB10	POLB	Outer	Basin	Southeast Basin West	18	Deep
LB12	POLB	Outer	Channel	POLB Main Channel – Police Station	23	Very Deep
LB13	POLB	Outer	Basin	POLB Inner Harbor Turning Basin	20	Very Deep
LB14	POLB	Inner	Channel	Cerritos Channel	18	Deep
LB16	POLB	Inner	Slip	Channel 3	16.5	Deep
LA1	POLA	Outer	Outer	Outer Pier 400	24	Very Deep
LA2	POLA	SWH	SWH	POLA SWH East	6	Shallow
LA3	POLA	SWH	SWH	POLA SWH West	6	Shallow
LA4	POLA	Outer	Channel	POLA Main Channel	18	Deep
LA5	POLA	Inner	Basin	West Basin	16.5	Deep
LA6	POLA	Inner	Basin	POLA East Basin	17.5	Deep
LA7	POLA	SWH	SWH	Seaplane Lagoon	3.5	Shallow
LA9	POLA	Outer	Channel	Pier 300 Channel	18	Deep
LA10	POLA	Inner	Basin	Fish Harbor	7.5	Deep
LA11	POLA	Outer	Outer	POLA Outer Channel	25	Very Deep
LA14	POLA	Inner	Slip	Consolidated Slip	7.5	Deep
LA15	POLA	Outer	Basin	POLA Turning Basin	17.5	Deep
LA16	POLA	Inner	Slip	Banning's Landing	14	Deep

POLA = Port of Los Angeles; POLB = Port of Long Beach; SWH = shallow water habitat

3.2 ICHTHYOPLANKTON

Many species of adult fishes both live and spawn in the Port Complex. Some species lay eggs that attach to hard surfaces; others rear and protect their young within nests. Many, however, are considered broadcast spawners, meaning that they release their eggs into the water column, and the eggs hatch directly into the plankton as larvae, i.e., ichthyoplankton. These broadcast spawners, in addition to pelagic species, include a number of cryptic, reef-associated, or burrowing species that, as adults, are ineffectively surveyed by standard sampling methods such as otter trawl or lampara net. Therefore, a survey of the ichthyoplankton provides a more complete picture of the diversity of fishes living in the waters of the Port Complex, including those that use it only for a portion of their life cycle. Several features of the Port Complex may be important for planktonic larvae, including warmer waters and decreased turbulence compared with the open coast, which is more readily used by adults (MBC, 2011). Seasonally timed surveys focused on the ichthyoplankton may also provide an indication of overall spawning activity and recruitment of adult fish stocks.

For the Biosurvey, ichthyoplankton was surveyed at the same 26 stations used for the benthic and pelagic fish surveys to provide comprehensive spatial coverage of the Port Complex. Samples were collected using a bongo net apparatus, which has paired cylinder-cone nets with 70-cm-diameter openings, 0.333-mm mesh Nitex netting, and a removable

cod-end. Samples collected from the tows were placed in sample jars and preserved with a mixture of 10% buffered formalin in filtered seawater. Fish eggs and larvae were sorted from the samples, identified to the lowest practicable taxon, and counted. Surveys were conducted during the same months as in the 2013 and 2018 Biosurveys (i.e., May, September, and January). To maximize comparability of data with data from previous Biosurveys, the sampling vessel and crew, bongo nets, and sampling techniques used were identical to those used during the 2013 (MBC, 2016) and 2018 Biosurveys (Wood, 2021) and are summarized in Appendix A.

3.2.1 RESULTS

A complete summary of all fish eggs and larvae collected is presented in Table 3-2. A variety of parameters were evaluated to assess their impact on observed capture, including tow type (oblique versus epibenthic), season (i.e., spring, summer, and winter), habitat type, and depth stratum. Additional raw data and graphics, separated by survey, depth stratum, and station location/habitat, are provided in Appendix C.

Table 3-2. Total Abundance of Ichthyoplankton Larvae and Eggs Collected in Long Beach and Los Angeles Harbors, May, September, and January, 2023–2024

Stage	Common Name	Species	Oblique (#/100 m^3)	Epibenthic (#/100 m^3)	All Tow Types Combined (#/100 m^3)	% of Total
Eggs	Unidentified Fish Egg	Unidentified Fish Egg	30273	21702	51975	96.03
	Turbot	Pleuronichthys sp	866	885	1751	3.24
	Anchovy sp	Engraulidae	212	183	394	0.73
	Silverside sp	Atherinidae	0	6	6	0.01
		Total Eggs	**31351**	**22775**	**54126**	**100.00**
Larvae	Clevlandia/Ilypnus/Quietula Goby Complex sp	CIQ goby	2437	1827	4264	37.67
	Combtooth Blennies	Hypsoblennius sp	1427	745	2172	19.19
	Shimofuri Goby	Tridentiger bifasciatus	1291	436	1727	15.26
	Yellowfin Goby	Acanthogobius flavimanus	630	553	1183	10.45
	Bay Goby	Lepidogobius lepidus	192	159	350	3.10
	California Clingfish	Gobiesox rhessodon	173	155	328	2.90
	Northern Anchovy	Engraulis mordax	132	157	289	2.55
	NA	Unidentified Fish	100	68	168	1.48
	Goby sp	Gobiidae	68	91	160	1.41
	Blennies	Chaenopsidae	65	30	94	0.83
	Kelpfishes and Blennies	Labrisomidae	60	19	79	0.70
	White Croaker	Genyonemus lineatus	36	32	68	0.60
	Kelpfish sp	Gibbonsia sp	51	14	65	0.57
	Jacksmelt	Atherinopsis californiensis	36	25	61	0.54
	Roughcheek Sculpin	Ruscarius creaseri	19	24	44	0.39
	Longjaw Mudsucker	Gillichthys mirabilis	27	16	42	0.37
	Sculpin sp	Cottidae	23	14	37	0.33
	Yellowchin Sculpin	Icelinus quadriseriatus	15	12	28	0.24
	Giant Kelpfish	Heterostichus rostratus	9	9	18	0.16
	Blackeye Goby	Rhinogobiops nicholsii	13	4	17	0.15
	Garibaldi	Hypsypops rubicundus	12	2	14	0.13
	Spotted Turbot	Pleuronichthys ritteri	5	7	11	0.10
	California Halibut	Paralichthys californicus	7	4	10	0.09
	Pipefish sp	Syngnathus sp	5	2	7	0.06
	Topsmelt	Atherinops affinis	5	2	7	0.06
	Shortspine Combfish	Zaniolepis frenata	5	2	7	0.06
	Pacific Staghorn Sculpin	Leptocottus armatus	3	3	6	0.05
	Snubnose Pipefish	Cosmocampus artcus	2	3	6	0.05
	Kelpfish sp	Clinidae	5	0	5	0.05
	California Grunion	Leuresthes tenuis	3	2	5	0.04
	Tripletooth Goby	Tridentiger sp	5	0	5	0.04

Table 3-2. Total Abundance of Ichthyoplankton Larvae and Eggs Collected in Long Beach and Los Angeles Harbors, May, September, and January, 2023–2024 (Continued)

Stage	Common Name	Species	Oblique (#/100 m^3)	Epibenthic (#/100 m^3)	All Tow Types Combined (#/100 m^3)	% of Total
	Blind Goby	Typhlogobius californiensis	2	2	5	0.04
	Black Croaker	Cheilotrema saturnum	0	4	4	0.03
	English sole	Pleuronectes vetulus	0	4	4	0.03
	Speckled Sanddab	Citharichthys stigmaeus	4	0	4	0.03
	Silverside sp	Atherinidae	3	0	3	0.03
	Blennies sp	Paraclinus sp	3	0	3	0.03
	Silverside sp	Atherinopsidae	3	0	3	0.02
	Basketweave Cusk-eel	Ophidion scrippsae	2	0	2	0.02
	Scalyhead Sculpin	Artedius harringtoni	2	0	2	0.02
	Diamond Turbot	Pleuronichthys guttulata	0	2	2	0.02
	Painted Greenling	Oxylebius pictus	0	2	2	0.02
	Sculpin sp	Artedius	2	0	2	0.02
	Yellowfin Croaker	Umbrina roncador	2	0	2	0.02
	Zebra Goby	Lythrypnus zebra	0	2	2	0.01
	Hornyhead Turbot	Pleuronichthys verticalis	0	2	2	0.01
		Total Larvae	**6884**	**4434**	**11318**	**100**

M^3 = cubic meter(s)

3.2.1.1 FISH EGGS SUMMARY

Fish eggs were collected in every haul, with abundances that ranged from 1 to 126 eggs per haul, equivalent to 1 to 1,961 per 100 cubic meters (m^3) of water; the mean concentration per haul was 211 eggs/100 m^3 (Appendix C). Capture of eggs at a given station (i.e., with all hauls and seasons at that station combined) was also quite variable, with a total abundance per station ranging from 379 to 4,565 eggs/100 m^3. The greatest abundance of fish eggs was observed at SWH station LA2 (Port of Los Angeles SWH East) and Outer Harbor stations LA9 (Pier 300 Channel) and LB9 (Port of Long Beach Outer Main Channel) (Appendix C).

Only four fish egg taxa were identified across all sampling events. Unidentified fish eggs accounted for 96% of the total catch, consistent with past surveys because taxonomy is generally difficult to identify down to the genus or species level. Species such as northern anchovy and Pacific sardine are well suited for these surveys because they can be easily identified morphologically, but most other species eggs are not as distinct (Choi et al., 2021) Turbot (*Pleuronichthys* sp.) eggs accounted for 3.24%, northern anchovy (*Engraulis mordax*) accounted for 0.73%, and silversides (*Atherinidae*) accounted for only 0.01% of the total catch. Turbot eggs were collected at all but three stations (LB2, LB4, and LB6) and were present in all three seasons. Silverside eggs were collected only at station LA7 in the spring, and anchovy eggs were collected at only six stations, primarily in the Outer Harbor only in spring. The spatial pattern of occurrence in 2023 was similar to that in 2018.

Fish eggs showed a seasonal pattern of abundance consistent with past surveys, with abundances higher in the spring and winter (mean per station of 193.62 eggs/100 m^3 and 286.70 eggs/100 m^3, respectively) than in summer (157.3 eggs/100 m^3). Although notable, this pattern was not statistically different using a nonparametric Friedman one-way analysis of variance (ANOVA).

3.2.1.2 LARVAL FISH SUMMARY

The ichthyoplankton sampling effort identified 44 larval fish taxa in the Port Complex (Table 3-2). The actual number of species was likely higher because numerous determinations were left at family or genus level, some of which likely composed more than one species (e.g., the tube blenny family-level taxon "Chaenopsidae" that includes four species in Southern California: orangethroat pikeblenny [*Chaenopsis alepidote*], yellowfin fringehead [*Neoclinus stephensae*], one spot fringehead [*Neoclinus uninotatus*], and sarcastic fringehead [*Neoclinus blanchardi*]). Larvae were collected in every haul at abundances that ranged from 1 to 124 larvae per haul, equivalent to 1 to 764 larvae/100 m^3, with an average per haul of 16 larvae/100 m^3 (Appendix C), indicating widespread year-round abundance. The

overall mean concentration (all samples at a station combined) was 435 larvae/100 m^3, with the greatest abundances observed at stations LA7, LA10, and LA14 (1,131 to 1,976 larvae/100 m^3).

3.2.1.3 DOMINANT LARVAL FISH TAXA

The *Clevelandia*, *Ilypnus*, *Quietula* (CIQ) goby complex was the most frequently encountered and most abundant taxon over the three seasons combined (Table 3-3). CIQ gobies were collected at every station and accounted for 37.7% of the total abundance, nearly twice as abundant as the second and third most abundant taxa, *Hypsoblennius* sp. (combtooth blennies) and the non-native *Tridentiger bifasciatus* (Shimofuri goby), respectively. CIQ gobies were most abundant at stations LA7 (977 larvae/100 m^3), LA3, (849 larvae/100 m^3), and LA2 (476 larvae/100 m^3) (Appendix C). Combtooth blenny larvae (including the bay blenny *H. gentilis* that was observed in trawl samples, rockpool blenny *Hemilepidotus gilberti*, and mussel blenny *Hypsoblennius jenkinsi*, which were not captured as adults) were also distributed relatively evenly throughout the Port Complex, and Shimofuri goby were generally more abundant at Inner Harbor stations, with the highest densities at stations LA14 (Consolidated Slip; 977 larvae/100 m^3), LA6 (Slip 5;232 larvae/100 m^3), LA16 (LA East Basin;168 larvae/100 m^3), and LB4 (Channel 2;136 larvae/100 m^3). The fourth most abundant taxon, the non-native *Acanthogobius flavimanus* (yellowfin goby), was found in primarily in Inner Harbor stations, with the highest abundances at stations LA14 (Consolidated Slip; 479 larvae/100 m^3), LA10 (Fish Harbor; 428 larvae/100 m^3) and LA6 (Slip 5;130 larvae/100 m^3).

Table 3-3. Ten Most Abundant Larval Fish Collected from All Tows and All Seasons Combined

Species		Total Density (#/100 m^3) per Taxa	Percentage of Total Density
Common Name	Scientific Name		
CIQ goby	*Clevlandia/Ilypnus/Quietula* Goby Complex sp.	4,264	37.7
Combtooth Blenny	*Hypsoblennius* sp.	2,172	19.2
Shimofuri Goby	*Tridentiger bifasciatus*	1,727	15.3
Yellowfin Goby	*Acanthogobius flavimanus*	1,183	10.5
Bay Goby	*Lepidogobius lepidus*	350	3.10
California Clingfish	*Gobiesox rhessodon*	328	2.90
Northern Anchovy	*Engraulis mordax*	289	2.55
N/A	Unidentified Fish	168	1.48
Goby sp.	*Gobiidae*	160	1.41
Tube Blenny	*Chaenopsidae*	94	0.83

M^3 = cubic meter(s)

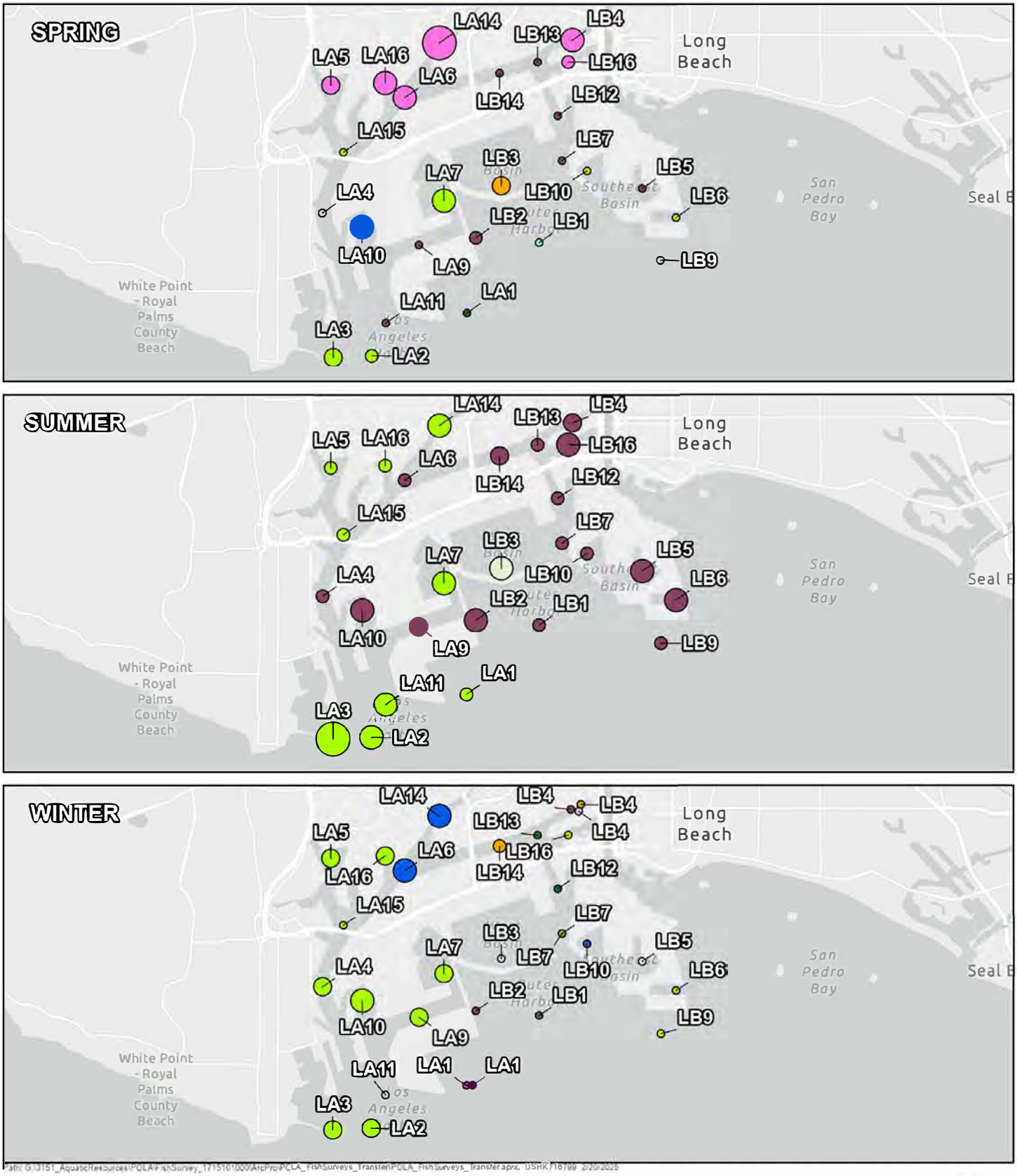
3.2.1.4 SEASONALITY

As shown in Figures 3-2 and 3-3, there were seasonal differences in the abundance of fish larvae and fish eggs, but no clear seasonal patterns for taxa richness. Larvae were most abundant in the spring and summer, and fish eggs were most abundant in the winter.

The most abundant individual larval fish taxa at each station by season (Figure 3-2) showed an interesting seasonal pattern that may be in part related to the heavy rainfall that occurred in the winter of 2023 (16.13 inches of rainfall from January through March 2023; see Section 2.2) before the spring 2023 ichthyoplankton surveys were completed. In spring 2023, the Outer Harbor stations had relatively low densities of larvae (with a few exceptions such as stations LA7 and LA10) and were dominated primarily by CIQ gobies and combtooth blennies. The Inner Harbor areas were dominated by a new species observed in the 2023 Biosurvey for the first time, the Shimofuri goby, a non-native species from Asia that prefers fresh and brackish water and is discussed further in Section 3.4.1.2.

In the summer, combtooth blennies were the most abundant taxon at most stations, and CIQ goby was present at many stations throughout the Port Complex. In the winter, CIQ gobies were caught in higher densities than any other species, although most of the stations had low densities, and therefore several species were the most dominant at their respective stations.

Service Layer Credits: Light Gray Base: Port of Long Beach, Port of Los Angeles, City of Long Beach, County of Los Angeles, California State Parks, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, USFWS



Larval Density (#/100m^3)
- 0 - 25
- 26 - 50
- 51 - 100
- 101 - 500
- 501 - 1,000

Dominant Species
- Bay Goby
- Blackeye Goby
- California Clingfish
- CIQ Goby Complex sp
- Combtooth Blennies
- Jacksmelt
- Northern Anchovy
- Roughcheek Sculpin
- Sculpin sp
- Shimofuri Goby
- Silverside sp
- White Croaker
- Yellowchin Sculpin
- Yellowfin Goby

1:122,771

0 1 2 Miles

FIGURE 3-2

Seasonal Variation of Larval Density by Station and the Most Abundant Larval Fish Species Collected in 2023

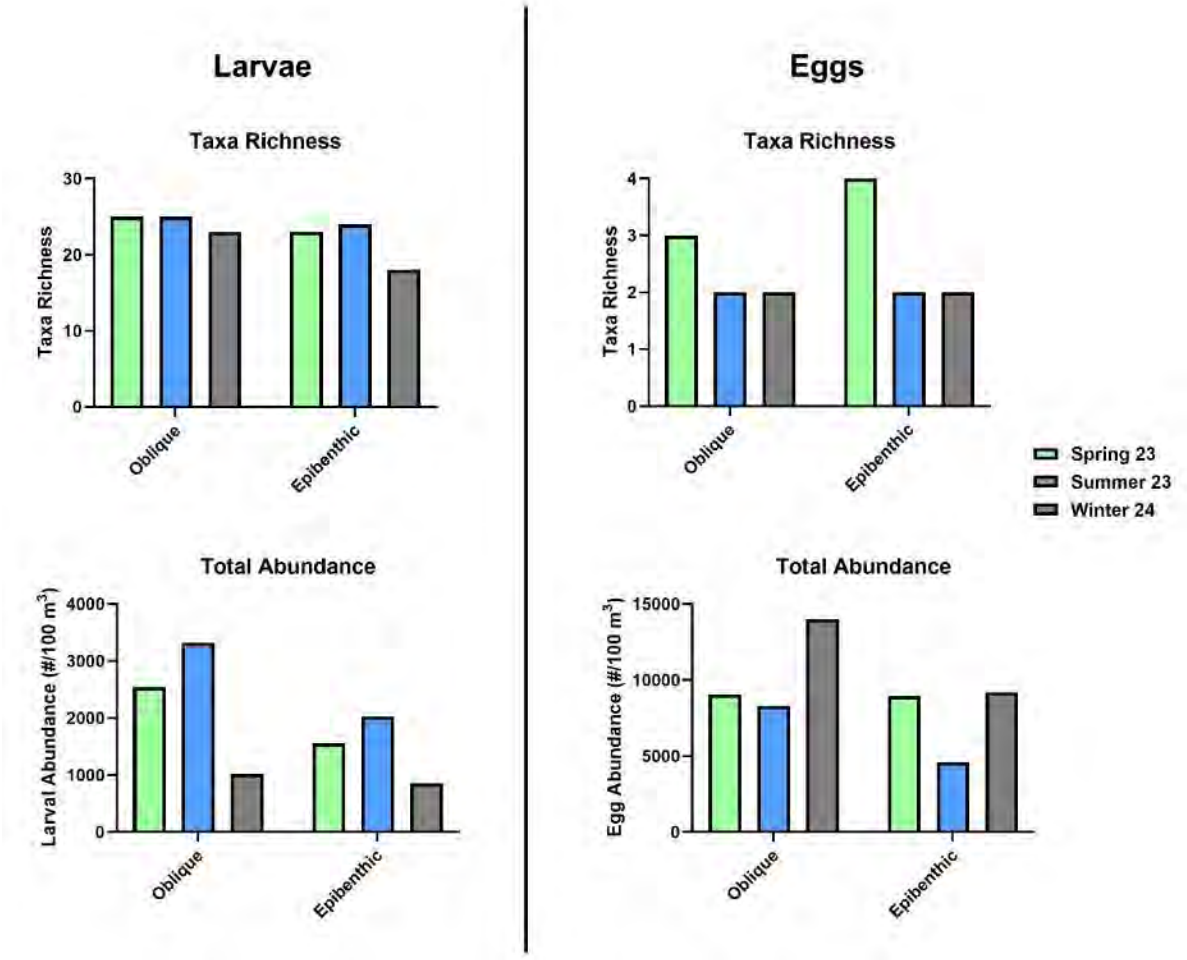
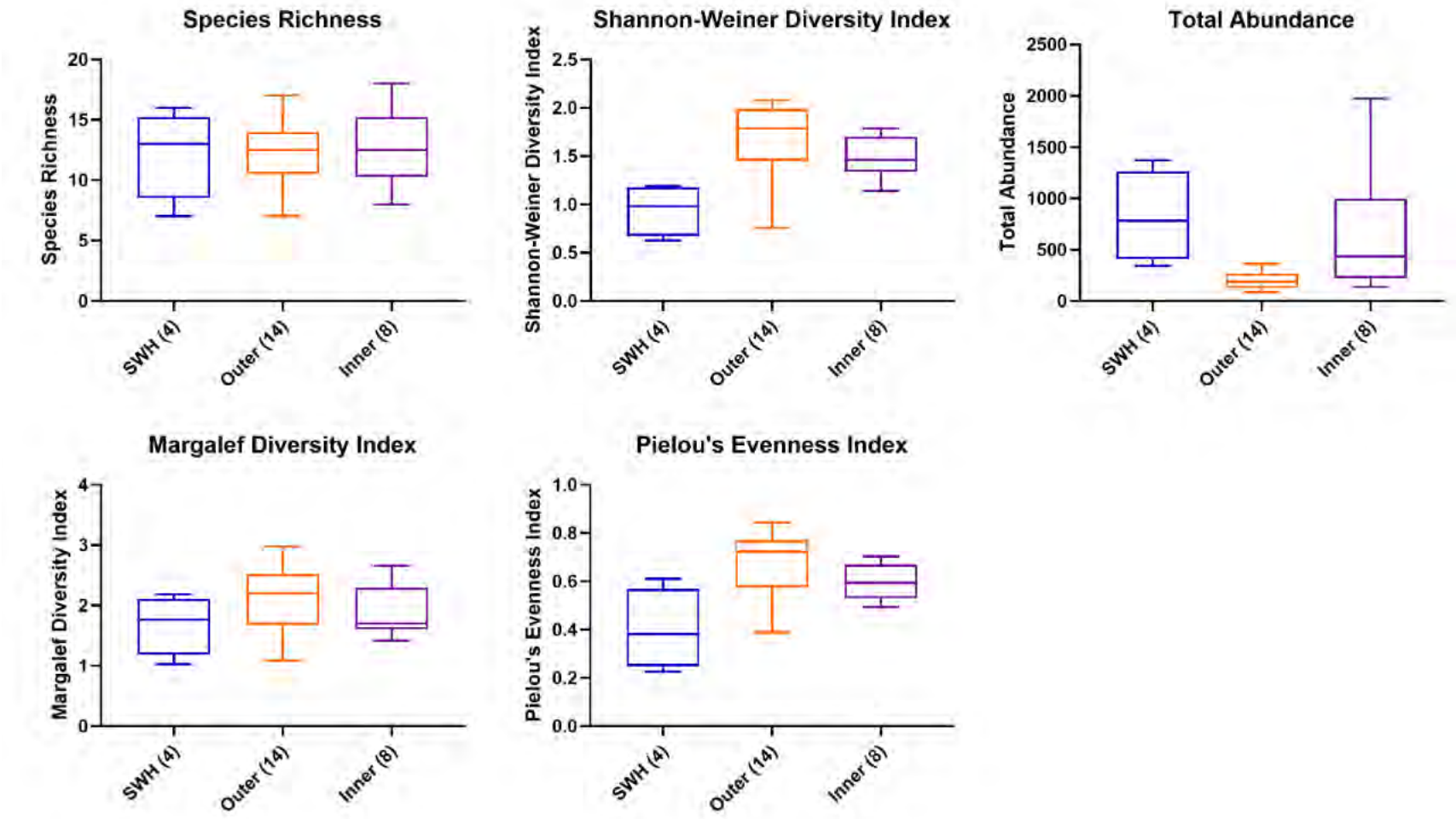


Figure 3-3. Ichthyoplankton and Egg Abundance Based on Tow Type and Season for All Stations Combined – 2023

3.2.1.5 DISTRIBUTION BY DEPTH AND HABITAT TYPES

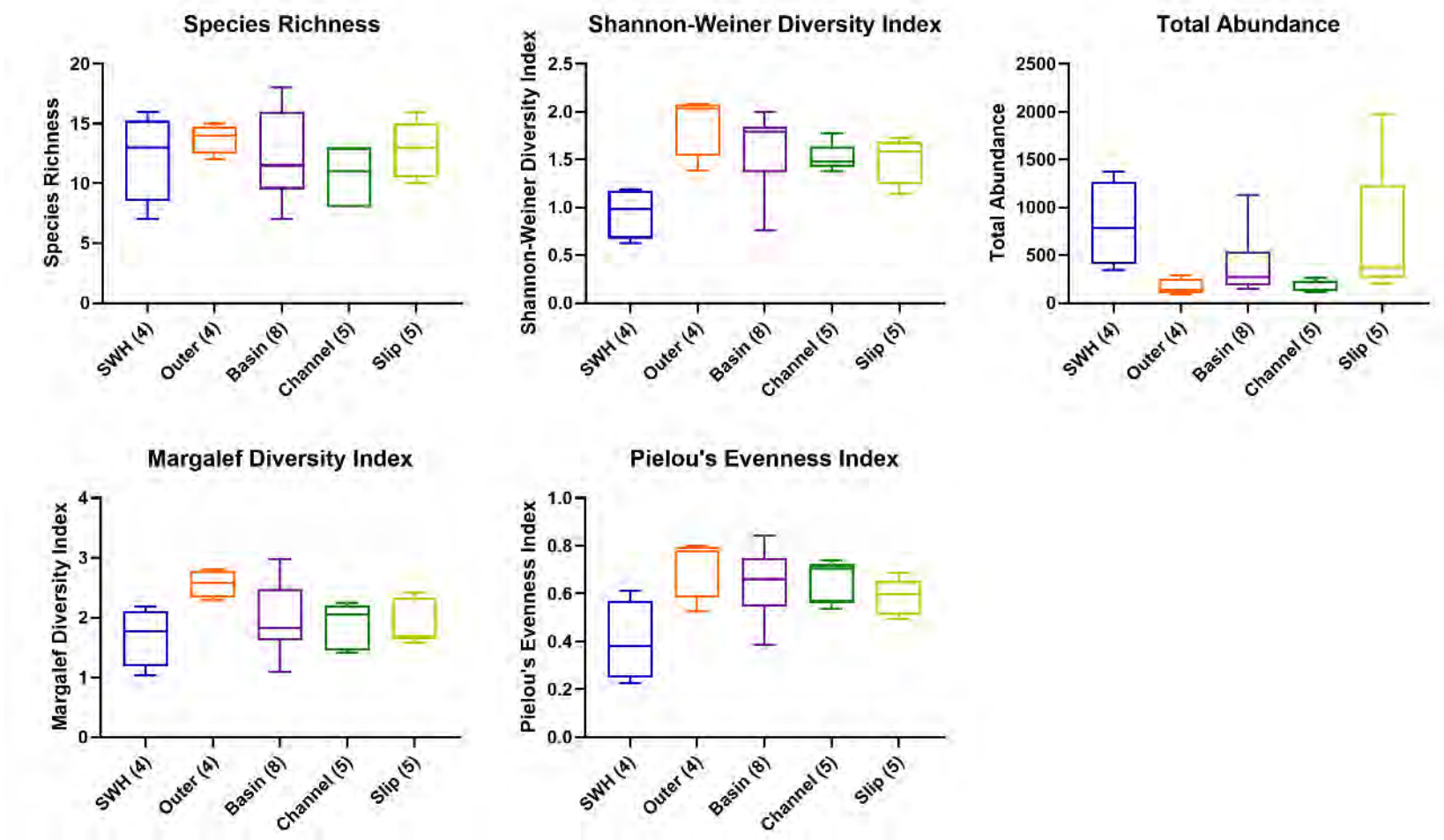
To assess patterns of larval fish distribution within the Port Complex, stations were grouped according to habitat type (SWH, Outer Harbor, and Inner Harbor), location (SWH, Outer Harbor, basin, channel, and slip), and depth (Shallow 0–7 meters, Deep 7.1–18 meters, and Very Deep 18+ meters). Differences in larval species richness, abundance, and diversity indices were then assessed across these station groups and are shown graphically on Figures 3-4 through 3-6.

Groupings of stations by habitat type showed similar species richness across all habitats, but Outer Harbor stations had significantly lower abundance (Kruskal-Wallis ANOVA p=0.003) and significantly higher Shannon-Weiner Diversity Index (p=0.006; Figure 3-4). The only statistically significant differences between location groups were that SWH stations had significantly lower diversity (p=0.024) than Outer Harbor stations and higher abundance (p=0.007) than both Outer Harbor and channel stations (Figure 3-5). Statistically significant differences were identified between Shallow and Very Deep stations for total abundance (p=0.006), Shannon-Weiner Diversity Index (p=0.009), and Pielou's Evenness Index (p=0.018; Figure 3-6).



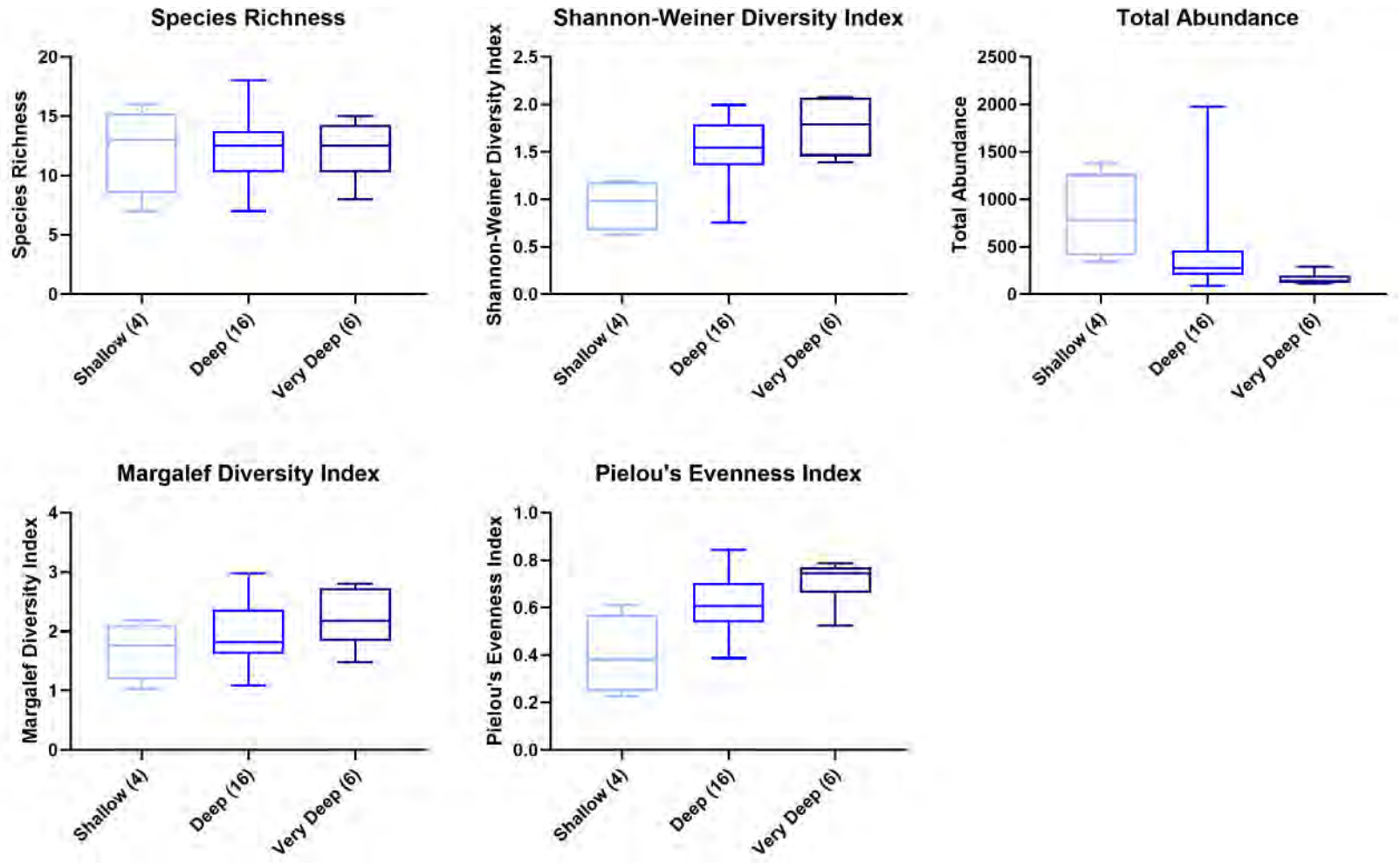
Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 3-4. Larval Fish Species Abundance, Richness, and Diversity Among Habitat Types –All Tows and Seasons Combined – 2023



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 3-5. Larval Fish Species Abundance, Richness, and Diversity Among Location Types – All Tows and Seasons Combined – 2023



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 3-6. Larval Fish Species Abundance, Richness, and Diversity Based on Depth – All Tows and Seasons Combined – 2023

3.2.1.6 DISTRIBUTIONAL PATTERNS OF LARVAL FISH USING MULTIVARIATE ANALYSES

Multivariate analysis of larval fish abundance (per 100 m^3) data combined across all sampling events provided an integrated analysis of larval community patterns throughout the Port Complex (Appendix A describes the analytical methodology). The results of these analyses, as with those presented above, indicated significant differences among habitat types, location groups, and depth strata (Figures 3-7 and 3-8, location group in Appendix C). All habitat types were significantly different from one another (analysis of similarities [ANOSIM] routine in the Plymouth Routines in Multivariate Ecological Research [Primer] statistical software); Shallow stations were significantly different from both Deep and Very Deep stations, but Deep and Very Deep stations were not significantly different. These results support the findings of the comparisons of abundance, species richness, and diversity presented above that indicate that the larval fish assemblages vary by both location and depth throughout the Port Complex. Non-metric multidimensional scaling (nMDS) plots for location groups and a dendrogram showing results of cluster analysis are provided in Appendix C.

Cluster analysis of the larval fish taxonomic data identified four clusters of stations (Figure 3-9). The two largest groups included Inner Harbor stations that were in Deep basins and slips (Group B) and stations in the Outer Harbor in Deep or Very Deep channels and basins (Group C). The Shallow stations were grouped together (Group D) except for station LA7 (Seaplane Lagoon), which was included in Group B. The only station to separate out alone was station LA1 (Outer Pier 400; Group A). Figure 3-10 provides further insight into how stations separate based on the larval fish community composition. Several species appear to make up the core community found throughout the Port Complex, including combtooth blennies, CIQ gobies, clingfish, and smelts. Group B had the highest densities of the non-native Shimofuri and yellowfin gobies, and Groups A and D included several species only identified near the SWH areas and kelp beds, such as garibaldi and California grunion in Group D and painted greenlings and basketweave cusk-eel in Group A.

Seasonality of the fish community was analyzed using larval fish abundance for each station in each season (Figure 3-11). Using ANOSIM, results for all seasons were significantly different, supporting the analytical results in Section 3.2.1.4. The cluster analysis and shade plot (Figure 3-12) give deeper insights into the species that may reproduce year-round throughout the Port Complex, such as the CIQ goby, combtooth blenny, and northern anchovy, although even these species are identified in higher densities in the summer. Other species appear to have distinct seasonality: spotted turbot, California halibut, and pipefish were observed only in the summer, and Shimofuri goby larvae were abundant in the spring and summer but largely absent in the winter.

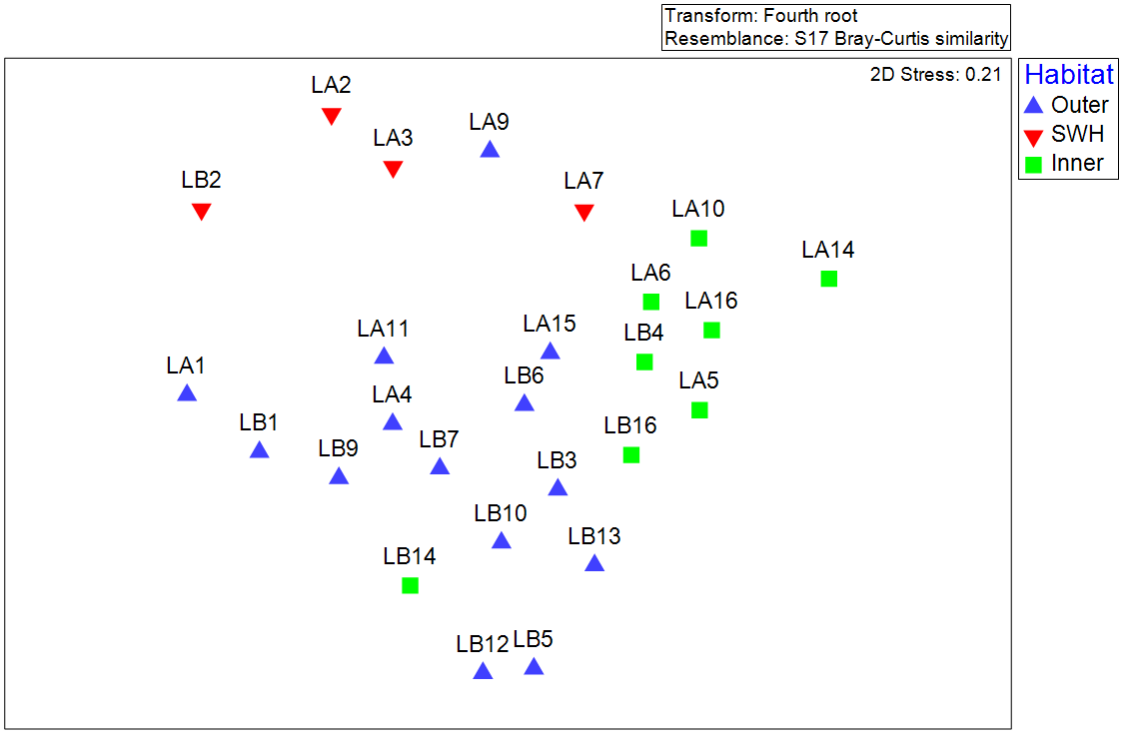


Figure 3-7. Multivariate nMDS Plot Showing the Relationship Among Larval Fish Populations Based on Habitat Grouping – All Seasons Combined

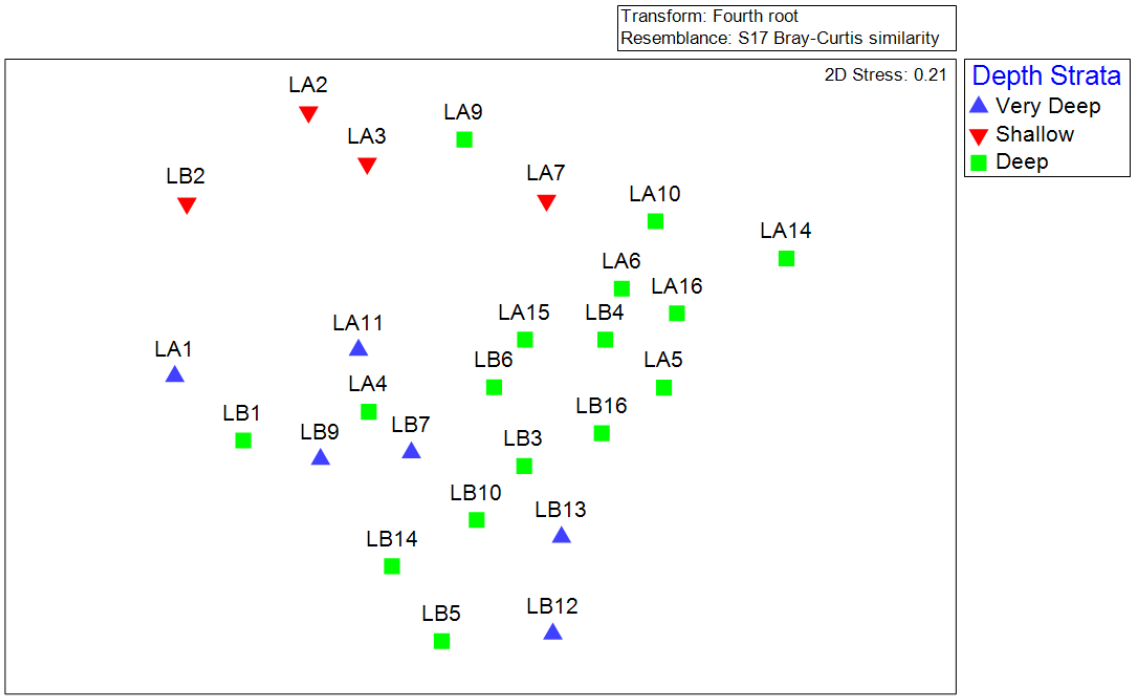
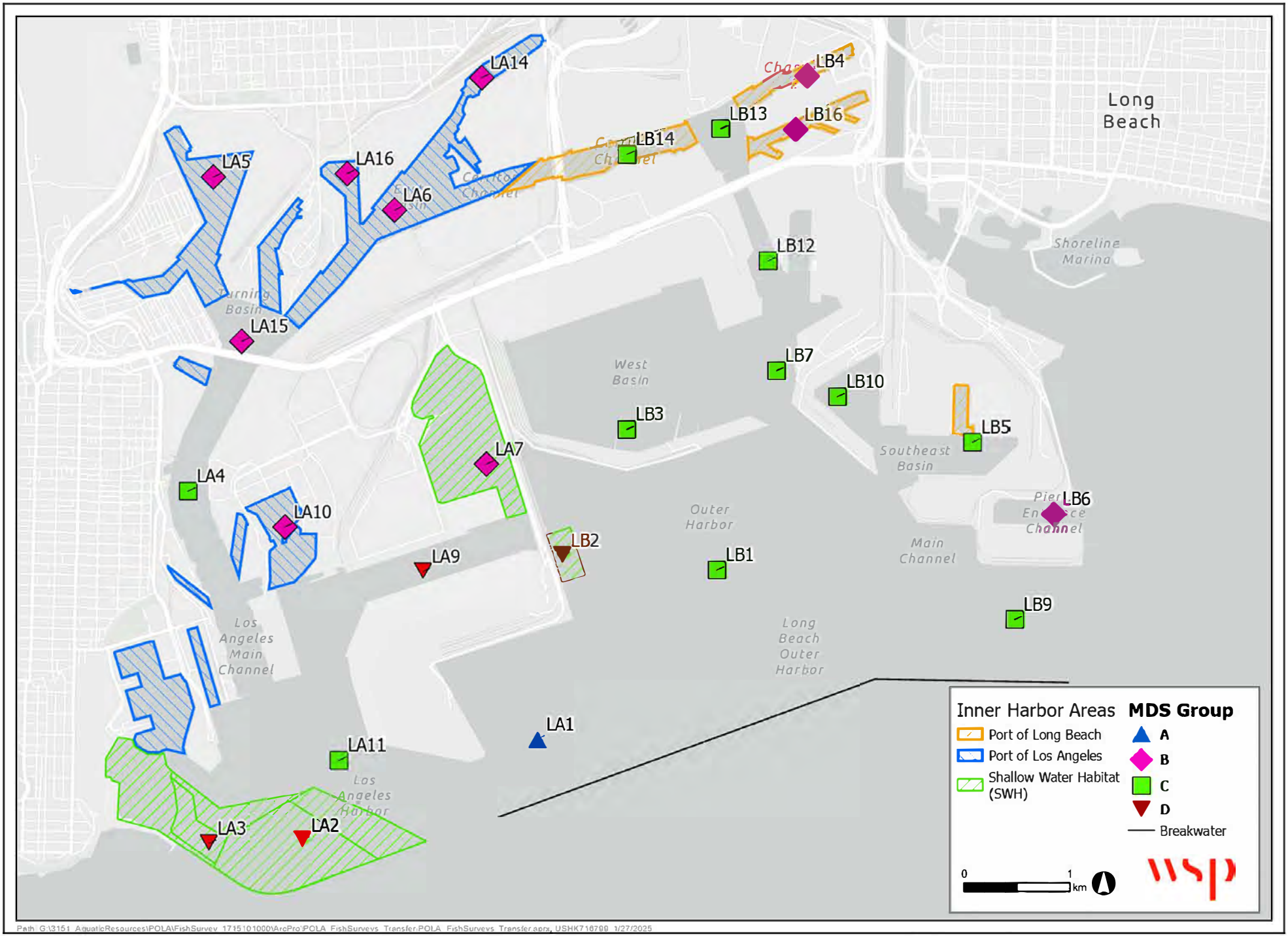
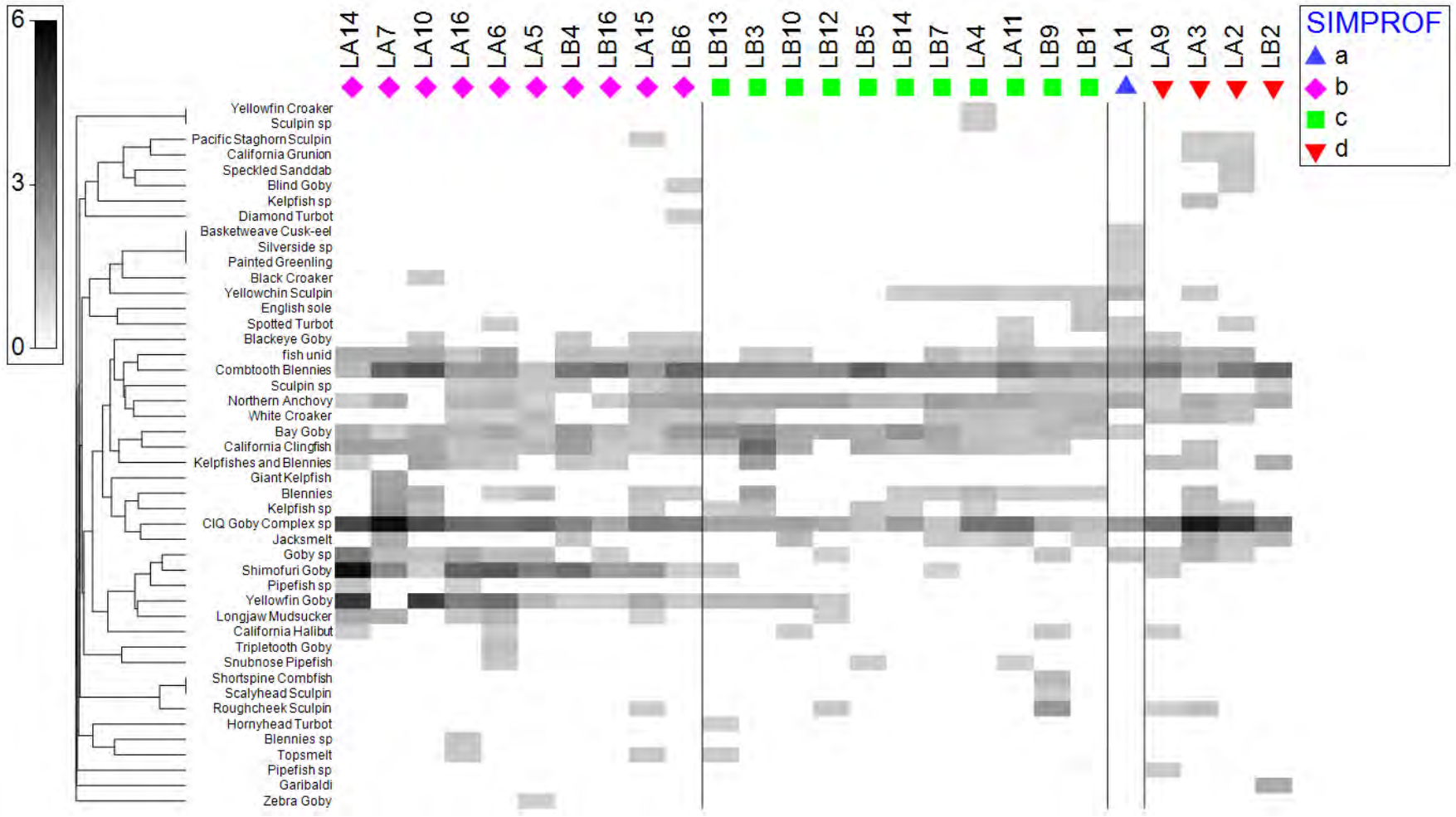


Figure 3-8. Multivariate nMDS Plot Showing the Relationship Among Larval Fish Populations Based on Depth – All Seasons Combined



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Figure 3-9. Similarity Profile Analysis Showing the Distribution of Cluster Groupings for Larval Fish Populations Across All Seasons



The scale reflects abundance data that have been transformed and normalized

Figure 3-10. Shade Plot of Similarity Profile Analysis Showing the Distribution of Cluster Groupings for Larval Fish Populations Across All Seasons

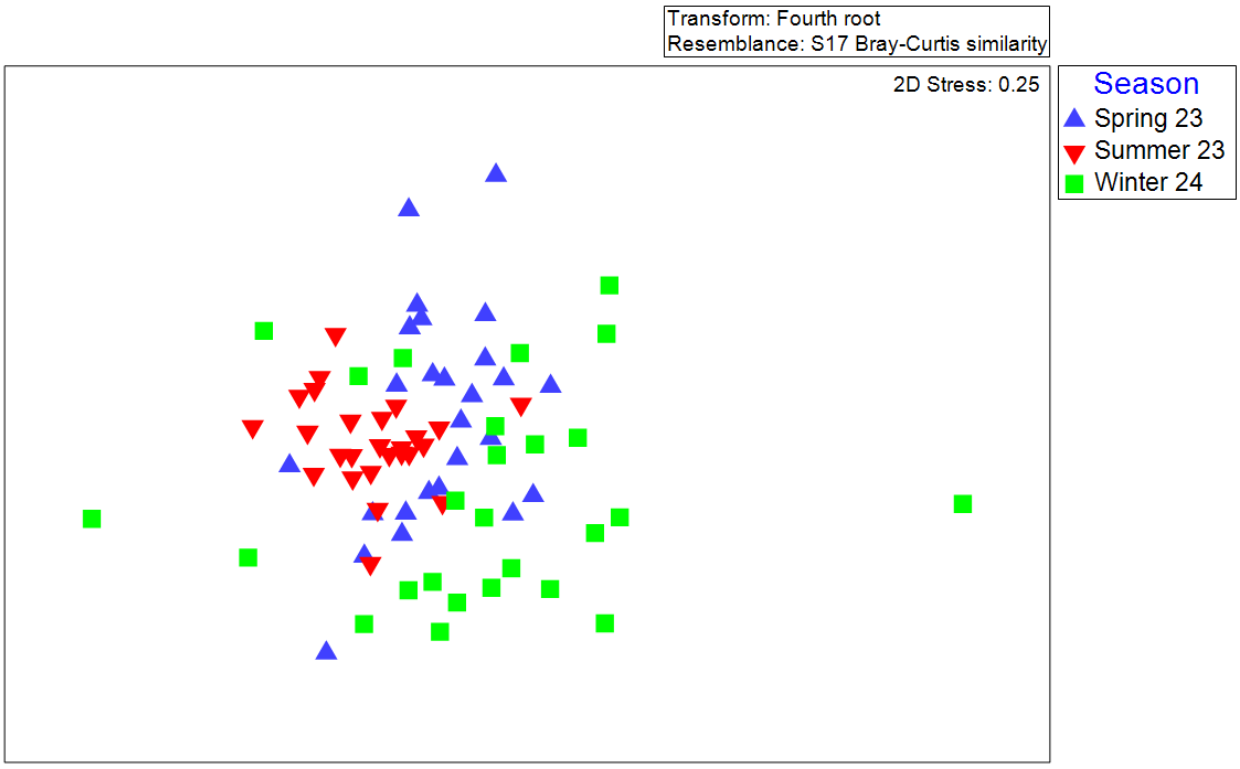
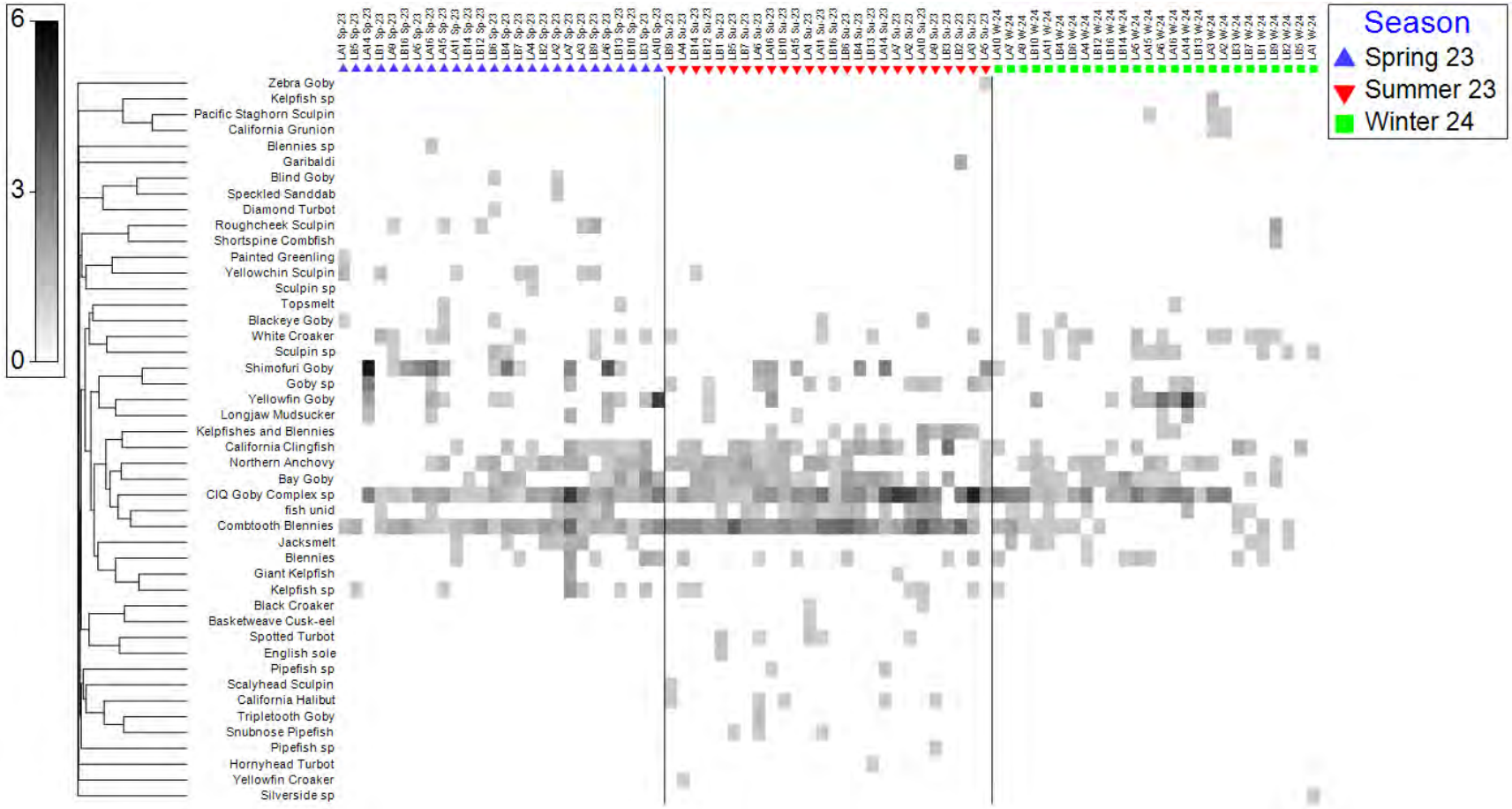


Figure 3-11. Multivariate nMDS Plot Showing the Relationship Among Larval Fish Populations Based on Season



The scale reflects abundance data that have been transformed and normalized

Figure 3-12. Shade Plot Showing the Relationship Among Larval Fish Populations Based on Season

3.2.2 HISTORICAL COMPARISONS

Prior ichthyoplankton surveys in the Port Complex (MEC, 2002; SAIC, 2010; MBC, 2016; Wood, 2021) used sampling gear and techniques similar to those used for the 2023 Biosurvey. There have been some differences in the number and location of stations and in laboratory sample processing, but when the data are standardized to number of larvae per water volume and to account for methodological differences, comparisons of results between Biosurveys are possible. Note that 2018 data have been revised to correct a calculation error in the egg and larvae density data.

Species richness has fluctuated across Biosurvey years (Table 3-4). During the 2023 Biosurvey, 44 unique taxa were collected, which is within the range of 42 to 58 species observed in past surveys. Mean station abundance has declined from the 2000 Biosurvey (1,653 larvae/100 m^3) to 2023 (435 larvae/100 m^3) (Table 3-4). This trend may reflect an overall regional decline in nearshore ichthyoplankton abundance, as was documented in a long-term monitoring program in nearby King Harbor (Pondella et al., 2012) in which results for surveys conducted from 1974 through 2009 showed steady declines in abundance, diversity, and total plankton sample volume. This gradual decline could possibly be due to numerous cumulative factors such as red tide, the strength of ENSO, and shifts in oceanographic conditions, including a transition to warmer, nutrient-deficient waters along the Southern California Bight since the 1970s (Parnell et al., 2010).

Table 3-4. Historical Comparison of Larval Fish Metrics per Biosurvey – Summation of All Seasons, Oblique and Epibenthic Tows

Metric	2000	2008	2013	2018	2023
	18 Stations	19 Stations	26 Stations	26 Stations	26 Stations
Total Larval Taxa Richness	42	55	58	45	44
Total # Larvae/100 m^3	29,753	15,610	22,400	17,758	11,315
Mean # Larvae/100 m^3 per Station	1,653	822	862	683	435
Total # Eggs/100 m^3 per Station	42,734	50,643	112,543	70,278	54,126

Many of the most abundant larvae have remained consistent over the four Biosurveys, including CIQ goby (the most abundant taxon in every Biosurvey), combtooth blenny, and bay goby (Table 3-5, Figure 3-13). The non-native Shimofuri goby and yellowfin goby were ranked third and fourth most abundant species in the 2023 Biosurvey, respectively, and yellowfin goby has appeared in the top 10 species in all Biosurveys. White croaker has been in the top 10 most abundant species from 2000 through 2018, but was no longer a top species in 2023. Adult anchovy and queenfish populations are well documented in trawl and lampara sampling, but larvae abundance has been variable; anchovy did not appear in the top 10 most collected in 2008, and queenfish was in the top 10 in 2000 and 2013 but was not collected at all in 2008, 2018, or 2023.

Within the Southern California Bight, fish larvae that prefer warm water have been very abundant since 2014 (Thompson, 2019), but abundances of species preferring cooler waters have declined (Parnell et al., 2010). In addition to rising larval anchovy abundance, goby and garibaldi larvae abundances have remained constant (Pondella, 2012). The increase in abundance of non-native species can be at least partly attributed to the high rainfall runoff that the Port Complex received from 2022 through 2024. Although most larval fish species populations have declined in Southern California recently, similar trends for both goby and anchovy identified in the 2023 Biosurvey have been observed in the other independent regional assessments described in this section, substantiating these observations for the Port Complex.

Table 3-5. Historical Comparison of the Top Ten Larval Fish Taxa Collected from 2000 to 2023, Summation of All Seasons, Oblique and Epibenthic Tows

2000	2008	2013	2018	2023
CIQ goby	CIQ goby	CIQ goby	CIQ goby	CIQ goby
Bay goby	Combtooth blenny	Anchovy sp.	Combtooth blenny	Combtooth blenny
Northern anchovy	Bay goby	Combtooth blenny	Northern anchovy	Shimofuri goby
California clingfish	Clingfish	White croaker	Tripletooth goby	Yellowfin goby
Queenfish	Unidentified fish	Northern anchovy	Bay goby	Bay goby
Combtooth blenny	Yellowfin goby	Bay goby	Blenny sp.	California clingfish
White croaker	White croaker	Unidentified yolk sac	Goby	Northern anchovy
Yellowfin goby	Roughcheek sculpin	Yellowfin goby	White croaker	Unidentified fish
Goby sp.	Snubnose sculpin	Queenfish	California clingfish	Goby sp.
California grunion	Fragmented larvae	Jacksmelt	Yellowfin goby	Blenny sp.

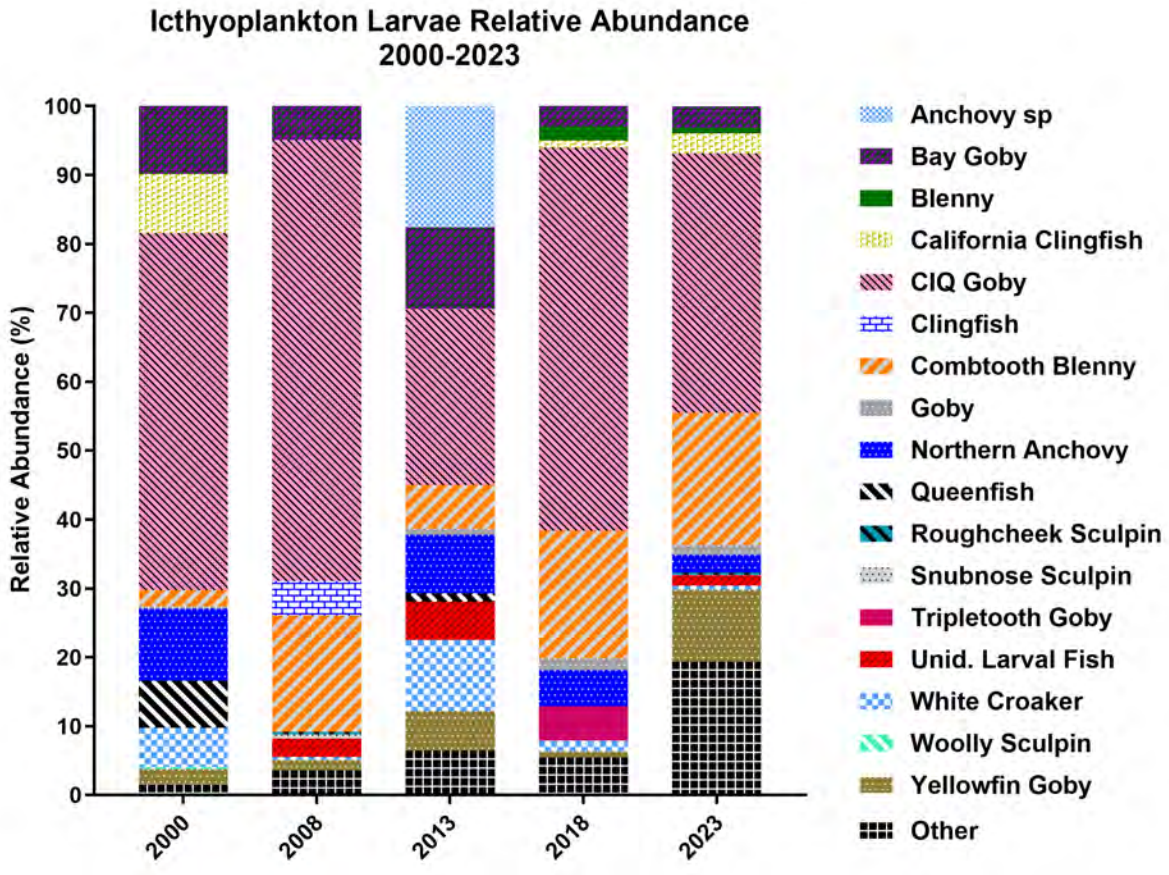


Figure 3-13. Historical Comparison of Relative Abundance of the Top 10 Larval Fish Taxa Collected from 2000 to 2023 – Summation of All Seasons, Oblique and Epibenthic Tows

3.3 PELAGIC FISH

Adult pelagic fishes were sampled using lampara nets in the spring and summer at 26 stations throughout the Port Complex (see Appendix C for map of net deployment locations in spring and summer). Day and night sampling was performed during each season for a total of 4 sampling events at each station throughout the Biosurvey period and a total of 104 individual sampling events. The overall diversity and biomass results from the two seasonal sampling events are combined in the results summary in this section because statistical analysis determined there was no significant difference among the seasons. Seasonal differences were noted, however, for certain individual species as highlighted in the following section that describes size class relationships for selected species.

3.3.1 SPECIES COMPARISONS

3.3.1.1 ABUNDANCE

Lampara sampling captured 22,184 fish composed of 22 species across all sampling events (Table 3-6). More fish were caught in the spring compared with the summer (14,793 individuals and 13 species versus 7,392 individuals and 20 species, respectively), although the differences in abundance and species numbers between the two seasons were not statistically significant. Nevertheless, notable differences between seasons were observed for topsmelt (*Atherinops affinis*; 4,801 in summer versus 2,793 in spring), California grunion (*Leuresthes tenuis*; 138 in summer versus 640 in spring), and northern anchovy (*Engraulis mordax*; 9,112 in summer versus 3,074 in spring). The seasonal difference for California grunion can be partially attributed to their annual spawning runs that begin in March and peak during June-September in Southern California.

A paired two-tailed t-test of natural-log-transformed abundance data identified a statistically significant difference between results for day and night sampling ($p<0.0001$). Day sampling captured 4,619 fish composed of 7 species, and night sampling captured 17,565 fish composed of 21 species. The most abundant species at each station during day versus night sampling in each season are shown in Figures 3-14 and 3-15. The species that showed the largest differences between day and night sampling were northern anchovy (*Engraulis mordax*; 65 day versus 12,121 night, respectively), Pacific sardine (172 day versus 853 night), jack mackerel (*Trachurus symmetricus*; 0 day versus 121 night), and shiner perch (*Cymatogaster aggregata*; 0 day versus 113 night). Topsmelt, California grunion, and Pacific sardine composed 97% of the 4,619 fish caught during the day; the other four species captured accounted for 139 individuals. Northern anchovy composed 69% of the 12,565 fish caught during the night. In addition, northern anchovy, topsmelt, California grunion, and Pacific sardine dominated the night catch, making up 97% of the total fish caught. There was more diversity at night, with an additional 17 species that added 528 individuals. The only species captured during the day that was not captured at night was a single Pacific chub mackerel (*Scomber japonicus*).



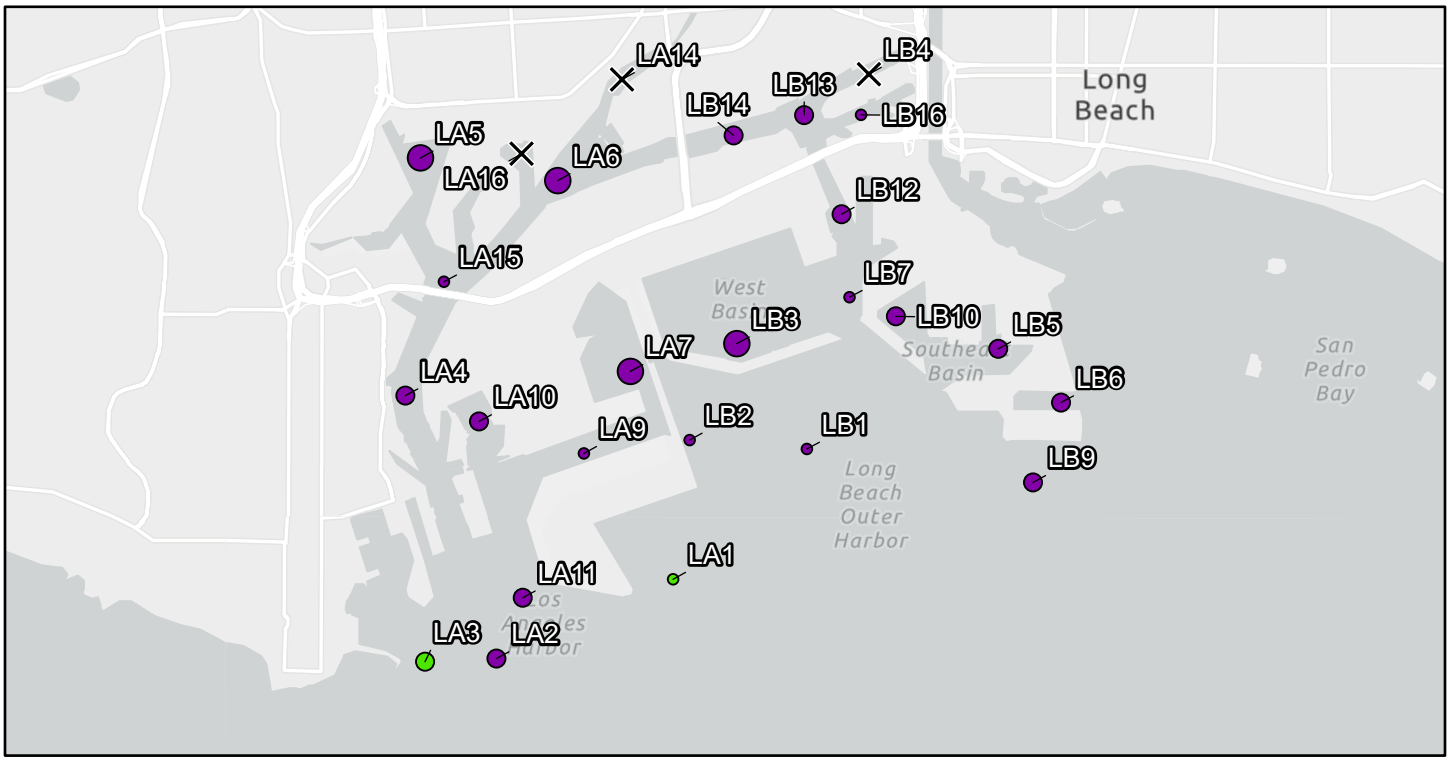
Northern anchovy (Engraulis mordax)

Fish captured at eight stations (LA3, LA7, LB13, LB14, LB2, LB3, LB5, and LB6) made up 74% of the total abundance across all sampling events. This value was driven primarily by large catches of northern anchovy and topsmelt at these stations (Figures 3-14 and 3-15). Of the 12,263 northern anchovy collected during the 2023 Biosurvey, 0.31% were collected near the bottom (using a trawl) during the day, and 98.8% were collected near the surface (using a lampara net) at night. Most (84.5%) of the northern anchovy collected with trawls during the day were from stations categorized in the Biosurvey as "Deep" stations (7.1–18 meters) (Figures 3-14 and 3-15). However, at night, 39% of fish collected with the lampara net (near the surface) were from Shallow stations (0–7 meters), 53% were from Deep stations, and only 8% were from Very Deep stations. These findings are consistent with a pattern observed for populations of adults in central Baja California (Robinson et al., 1995), Monterey, and Oregon (Kaltenberg and Benoit-Bird, 2009). During the day, northern anchovy seek deeper water and form compact, discrete shoals near the bottom, and then return to the surface at night in loosely associated schools to feed. This behavior is thought to help avoid predation during the day from avian and piscivorous fish and is also correlated with a high concentration of prey (euphausiids) near the surface at night (Robinson et al., 1995). In studies of visual thresholds for schooling in northern anchovy, Hunter and Nicholl (1985) suggest that light may not be necessary for successful filter feeding (the strategy used by anchovy), although the high ambient light levels in much of the Port Complex may increase their ability to locate food at night. In addition, as Figures 3-14 and 3-15 show, anchovies were far more abundant in the basins of the Outer Harbor than in the channels and slips of the Inner Harbor. Less than 1% of all northern anchovies were collected near the surface during the day and near the bottom at night.

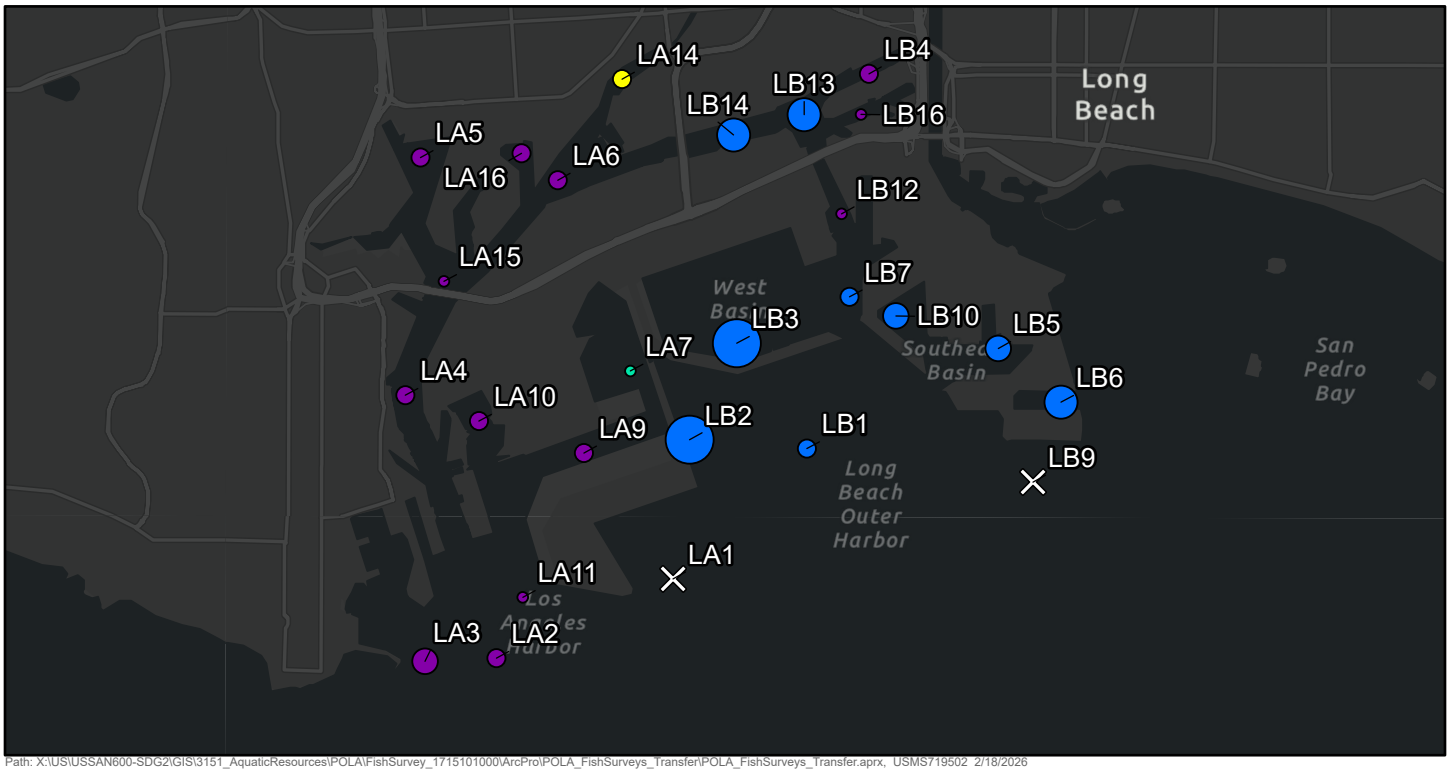
Similar patterns of significantly different day versus night catches between lampara (surface/midwater) and trawls (near-bottom) have been observed in the past four Biosurveys of the Port Complex (MEC, 2002; SAIC, 2010; MBC, 2016; Wood, 2021), although the link between spatial distribution and the behavior of the anchovy was made for the first time in 2018. This finding indicates that the behavior of northern anchovy described by Robinson et al. (1995) holds true in the Port Complex as well. That, in turn, indicates that northern anchovy – the lone Coastal Pelagic FMP species that used the Port Complex during the day – may avoid shallower Inner Harbor habitats to avoid predation and feed when prey is most abundant in the water column.

Service Layer Credits: Light Gray Reference: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Light Gray Base: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Spring 2023 - Day



Spring 2023 - Night



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Species Abundance (counts)

- 0 - 30
- 31 - 300
- 301 - 750
- 751 - 1500
- 1501 - 3145

Dominant Species

- Bat ray
- California grunion
- Jack mackerel
- Jacksmelt
- Northern Anchovy
- Pacific Butterfish
- Pacific sardine
- Topsmelt
- No Fish Caught

1:94,288

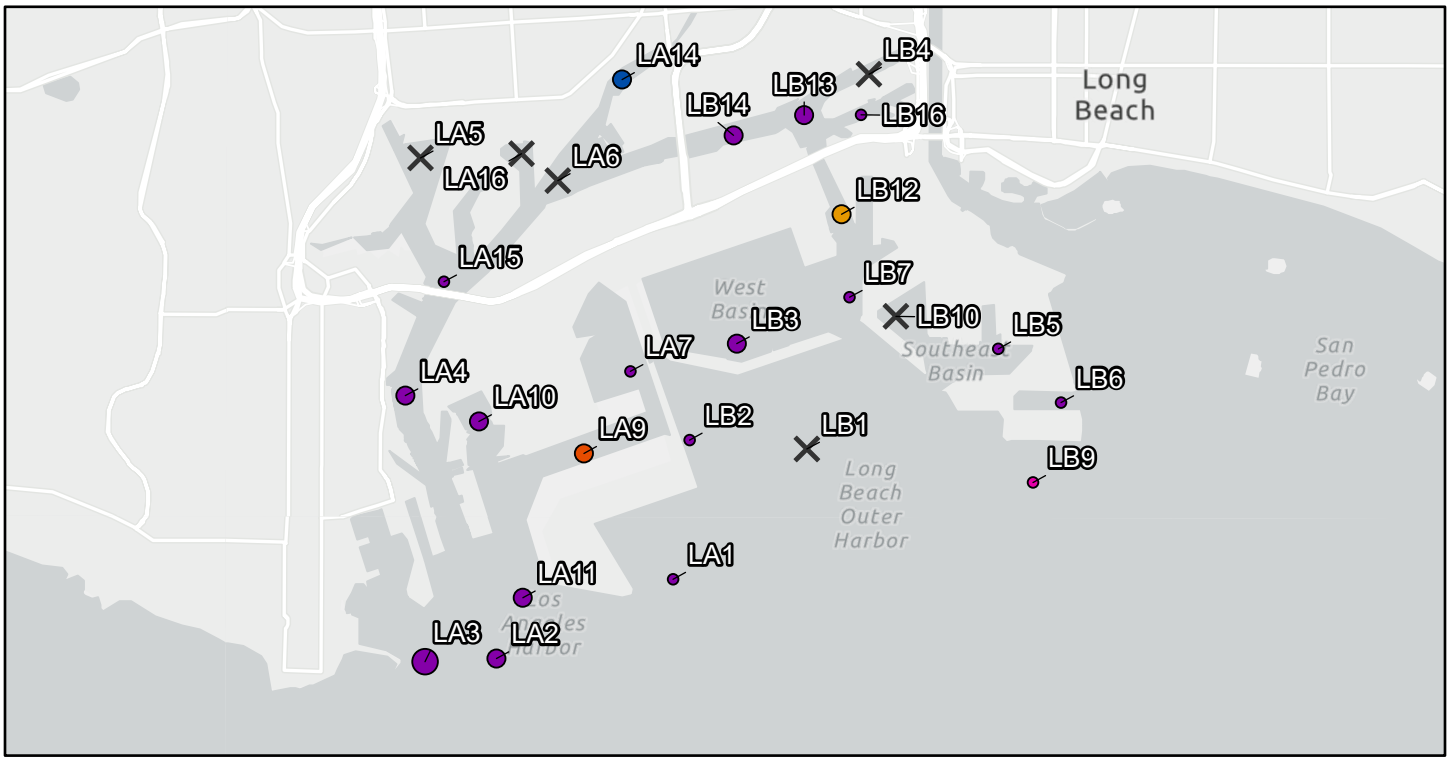
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FIGURE 3-14

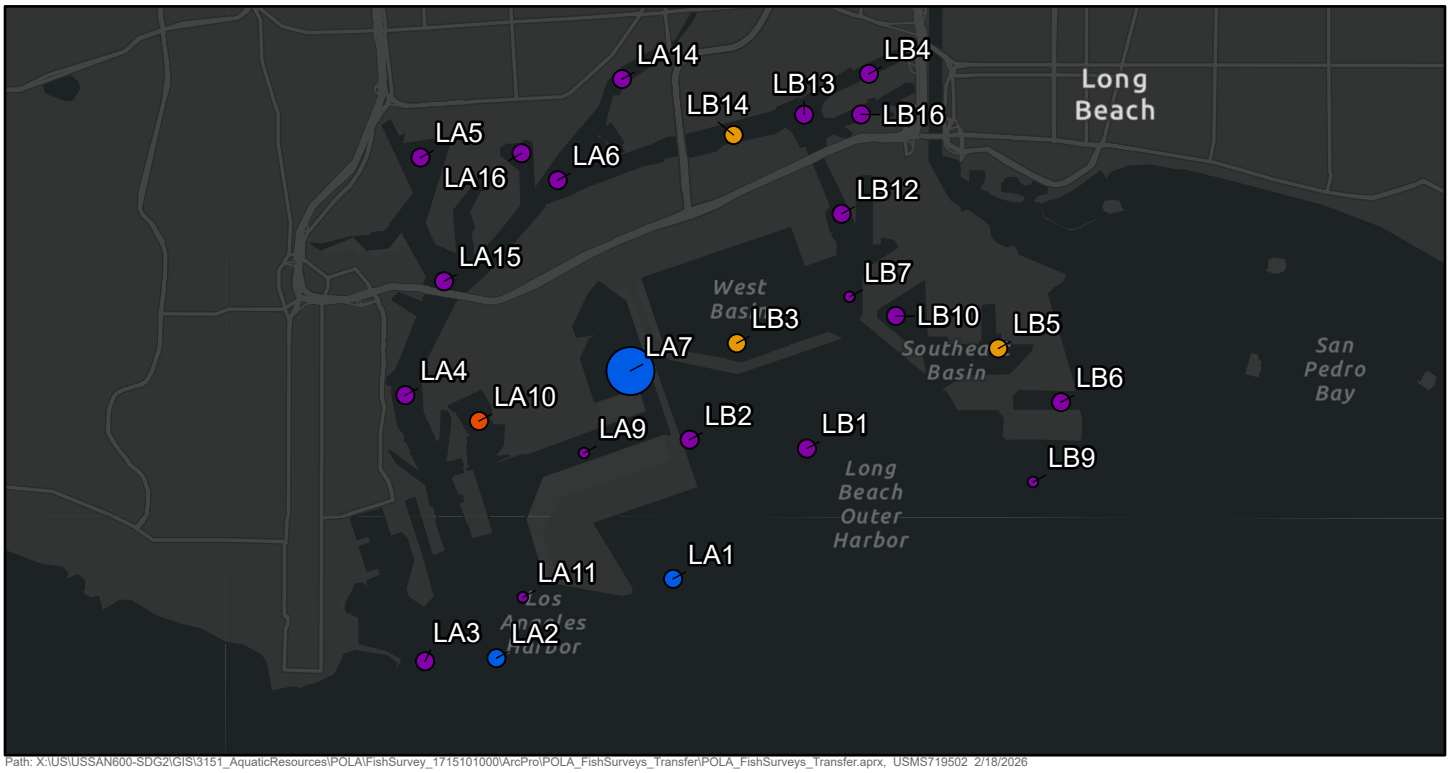
Most Abundant Pelagic Fish Species at Each Station During Daytime and Nighttime Lampara Sampling – Spring 2023

Service Layer Credits: Dark Gray Base: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community
Dark Gray Reference: Sources: Esri, TomTom, Garmin, (c) OpenStreetMap contributors, and the GIS User Community

Summer 2023 - Day



Summer 2023 - Night



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Species Abundance (counts)

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Dominant Species

- Bat ray
- California grunion
- Jack mackerel
- Jacksmelt
- Northern Anchovy
- Pacific Butterfish
- Pacific sardine
- Topsmelt
- No Fish Caught

1:94,288

0 1 2 Miles

FIGURE 3-15

Most Abundant Pelagic Fish Species at Each Station During Daytime and Nighttime Lampara Sampling – Summer 2023

3.3.1.2 BIOMASS

Lampara sampling captured 306.7 kilograms (kg) of fish biomass (Table 3-6): 215 kg in the spring and 91.4 kg in the summer. As with total abundance, results of a paired t-test indicated a statistically significant difference between total biomass collected during the day (68.0 kg) versus the night (238 kg).

Topsmelt accounted for the most biomass of any fish species (119 kg, 38.9% of total), followed by northern anchovy (97.9 kg, 31.9%) and Pacific sardine (44.1 kg, 14.4%). California grunion (*Leuresthes tenuis*; 1.5%), jack mackerel (*Trachurus symmetricus*; 2.1%), jacksmelt (*Atherinopsis californiensis*; 4.1%), and bat ray (*Myliobatis californica*; 4.8%) were the only other species that accounted for more than 1% of the total biomass.

Five stations (LA7, LA3, LB2, LB3, and LB14) accounted for 60.4% of the total fish biomass collected across all sampling events. These large biomass values were usually the result of one large individual or a large catch of a single species. The greatest total biomass value (46.9 kg) occurred at station LB3 as the result of a large catch of northern anchovy (33.1 kg). Although the highest diversity occurred at station LA3, most of that station's high biomass (34.3 kg) was the result of the large catch of topsmelt (1,200 individuals weighing 22.4 kg). Station LA7's biomass (37.60 kg) was dominated by a large catch of northern anchovy (9.9 kg) and topsmelt (13.5 kg) and one large individual bat ray (7.4 kg).

3.3.1.3 ECOLOGICAL INDEX

The EI is a metric that uses the percentage of total abundance, percentage of total biomass, and frequency of capture to calculate a unitless index value (Table 3-6; see discussion in Section 1.7 and Appendix A). This weighted approach emphasizes species that were abundant and caught at many stations, such as topsmelt and northern anchovy, but also gives weight to solitary larger species that were caught at only a few stations such as bat rays. The "rank" by EI determines the relative importance of each species to energy flows within the food web of the Port Complex ecosystem (Allen et al., 2002). Because the EI incorporates frequency of catch, this index provides a good measure of what the overall community looks like over time.

EI values for lampara sampling ranged from 0.02 for two small species (bay pipefish and giant kelpfish) occurring as single individuals to 7,312 for topsmelt, which was the overwhelmingly dominant species in terms of abundance and biomass; the species was also captured at all sampling stations. Northern anchovy (7,016) and Pacific sardine (877) were the next highest scoring species; they are also abundant and commonly encountered at most stations. An additional nine species had EI values above 1 (Table 3-6): California grunion (369), jack mackerel (124), jacksmelt (108), bat ray (56.0), Pacific butterfish (23.5), shiner perch (7.74), salema (7.25), queenfish (6.11), and Pacific barracuda (3.73).

Table 3-6. Pelagic Fish Caught by Lampara in Order of Ecological Index – All Seasons Combined

Species		Total Abundance per Taxa	% of Total Abundance	Total Biomass per Taxa (kg)	% of Total Biomass	Total Density (#/100 m^2)	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name							
Topsmelt	*Atherinops affinis*	7594	34.2	119	38.9	86.6	100	7312
Northern Anchovy	*Engraulis mordax*	12186	54.9	98.0	31.9	139	80.8	7017
Pacific Sardine	*Sardinops sagax*	1025	4.62	44.2	14.4	11.7	46.2	878
California Grunion	*Leuresthes tenuis*	778	3.51	4.74	1.55	8.87	73.1	369
Jack Mackerel	*Trachurus symmetricus*	121	0.55	6.44	2.10	1.38	53.8	143
Jacksmelt	*Atherinopsis californiensis*	131	0.59	12.6	4.10	1.50	23.1	108
Bat Ray	*Myliobatis californica*	5	0.02	14.8	4.81	0.06	11.5	55.7
Pacific Butterfish	*Peprilus simillimus*	78	0.35	2.67	0.87	0.89	19.2	23.5
Shiner Perch	*Cymatogaster aggregata*	113	0.51	0.50	0.16	1.29	11.5	7.74
Salema	*Haemulon californiensis*	81	0.37	0.81	0.26	0.92	11.5	7.25
Queenfish	*Seriphus politus*	41	0.19	0.65	0.21	0.47	15.4	6.11
Pacific Barracuda	*Sphyraena argentea*	7	0.03	1.39	0.45	0.08	7.69	3.73
White Croaker	*Genyonemus lineatus*	3	0.02	0.59	0.19	0.04	3.85	0.80
White Seaperch	*Phanerodon furcatus*	8	0.04	0.08	0.03	0.09	3.85	0.24
Slough Anchovy	*Anchoa delicatissima*	4	0.02	0.02	0.00	0.05	7.69	0.19
Halfmoon	*Medialuna californiensis*	2	0.01	0.00	0.00	0.02	7.69	0.07
Pacific Chub Mackerel	*Scomber japonicus*	1	0.00	0.04	0.01	0.01	3.85	0.07
California Lizardfish	*Synodus lucioceps*	1	0.00	0.03	0.01	0.01	3.85	0.05
Black Perch	*Embiotoca jacksoni*	1	0.00	0.02	0.00	0.01	3.85	0.04
Pile Surfperch	*Phanerodon vacca*	1	0.00	0.02	0.00	0.01	3.85	0.04
Bay Pipefish	*Syngnathus leptorhynchus*	1	0.00	0.00	0.00	0.01	3.85	0.02
Giant Kelpfish	*Heterostichus rostratus*	1	0.00	0.00	0.00	0.01	3.85	0.02
Total Abundance/Biomass		**22184**	**100**	**307**	**100**			
Total Species Richness		**22**						

kg = kilogram(s); m^2 = square meter(s)

3.3.1.4 SIZE CLASSES

Size class was analyzed for the top six pelagic species, chosen for a combination of high EI values and status as coastal pelagic species managed under NOAA EFH guidelines. Although the species discussed in this section were collected primarily through lampara sampling, some species such as topsmelt are considered pelagic and yet were also captured with benthic gear (i.e., otter trawling and beach seines), and those data are included in this size class analysis. Length at maturity information is provided for species for which this information is available.

Topsmelt (8,694 total across all gear types) ranged from 1 to 24 cm standard length (Figure 3-16). Topsmelt captured during the spring were generally larger: 98% of the 3,016 individuals were in the 9- to 18-cm range, whereas in the summer, 57% were in the 9- to 18-cm range. The largest individual topsmelt were also captured in the spring, with 9 individuals ranging from 18 to 19 cm, and only one topsmelt in the summer larger than 18 cm. Topsmelt captured by beach seine in the shallow subtidal zone were substantially smaller than those captured by lampara or trawls, ranging from 1 to 14 cm, with 39% in the 7- to 8-cm range. Maturity of Pacific topsmelt occurs when fish reach approximately 1 year of age (10 cm total length [TL]), and nearly all fish mature at 2 to 3 years of age, with a length of approximately 15 cm (Love, 2011). Based on the average of this range (12.5 cm), approximately 26% of the topsmelt caught during the spring could be considered mature adults, and 19% caught during the summer could be considered adults. Topsmelt individuals caught in beach seines were substantially different in their metrics: only approximately 1.7% were large enough to be considered mature, emphasizing the role of shallow subtidal habitat as a nursery for newly settled juvenile topsmelt compared with deeper habitats.

Northern anchovy was the most abundant pelagic species (12,262 total across all gear types, with most caught in the lampara nets because anchovy schools tend to occupy the entire water column). Anchovies ranged in size from 4 to 14 cm during the spring and from 4 to 13 cm in the summer (Figure 3-17). Size class distribution in both seasons was centered around 8 to 9 cm. Given that the length at maturity for females is 9.6 cm (Hunter and Macewicz, 1980), 10% of the total northern anchovies captured across both seasons were mature adults, and 87% of those adults were captured in the spring.

Pacific sardine (1,026 total) ranged in size from 11 to 19 cm (Figure 3-18) and had similar total abundance in both the spring and summer (42% captured in the spring and 58% in the summer). The population sampled in the spring ranged in size from 11 to 18 cm, with a normal distribution centered around 15 to 17 cm, whereas the population sampled in the summer was bimodal in distribution, with one peak around 13 to 14 cm and the other around 16 to 17 cm (Figure 3-18). Using the length at maturity of 14.5 cm (Butler et al., 1996), approximately 69% of the population across all seasons could be considered mature adults.

California grunion (778 total across all gear types) ranged in size from 3 to 17 cm standard length (Figure 3-19), and there was a marked difference in size classes between the spring and summer catches. The spring catch (138 individuals) was predominantly one size class group, with 94% of the measured fish in the 13- to 16-cm size class. The summer catch (640 individuals) had a bimodal distribution of size classes, with 95% of the fish in the 3- to 9-cm size class and 4% in the 12- to 16-cm size class. This finding was opposite of the 2018 Biosurvey findings, in which the spring catch had a bimodal distribution of size classes and the summer catch was predominantly one size class group. This difference may have to do with the timing of sampling events around grunion spawning events. This difference in size classes across seasons is notable when considering the length at maturity for female grunion is 11.9 cm (Shanks and Eckert, 2005). Although no information for length at maturity for males is currently available, if size at maturity is the same for both sexes, it would indicate that 94% of the California grunion caught during the spring could be considered mature adults, but only 4% caught during the summer could be considered adults (10% mature across both seasons).

Jack mackerel ranged in size from 13 to 22 cm (Figure 3-20). Most jack mackerel were captured during spring sampling (79 of 104 total captured) and ranged in size from 12.5 to 22 cm, with most of the individuals in the 15- to 18-cm range. The summer size class distribution ranged from 14 to 21 cm and was centered around 17 to 18 cm. Jack mackerel mature at approximately 1 year at 20 to 23 cm in length (Love, 2011). Based on the average of this range (21.5 cm), only one individual (approximately 1%) of the population captured in the Port Complex in 2023 may be considered mature.

Jacksmelt had a large range in standard length (10 to 28 cm), with both the smallest and largest individuals captured in the spring (Figure 3-21). Most of the individuals were captured during the spring (100 of the 124 total captured) and covered the whole size distribution, although over half of the individuals were in the 21 to 24 cm range. Jacksmelt

captured in the summer and in all beach seine samples made up approximately 20% of the population and ranged in size from 17 to 21 cm (although one individual captured in the summer was 27 cm long). Jacksmelt mature around 2 to 3 years of age at a length of 15 to 20 cm (Love, 2011). Based on the average of this range (17.5 cm), approximately 93% of the population captured in the Port Complex in 2023 may be considered mature.

A key observation from this analysis is that a high proportion of the fish captured use the Port Complex as a nursery ground prior to adulthood, at which time many will likely migrate to deeper offshore environments.

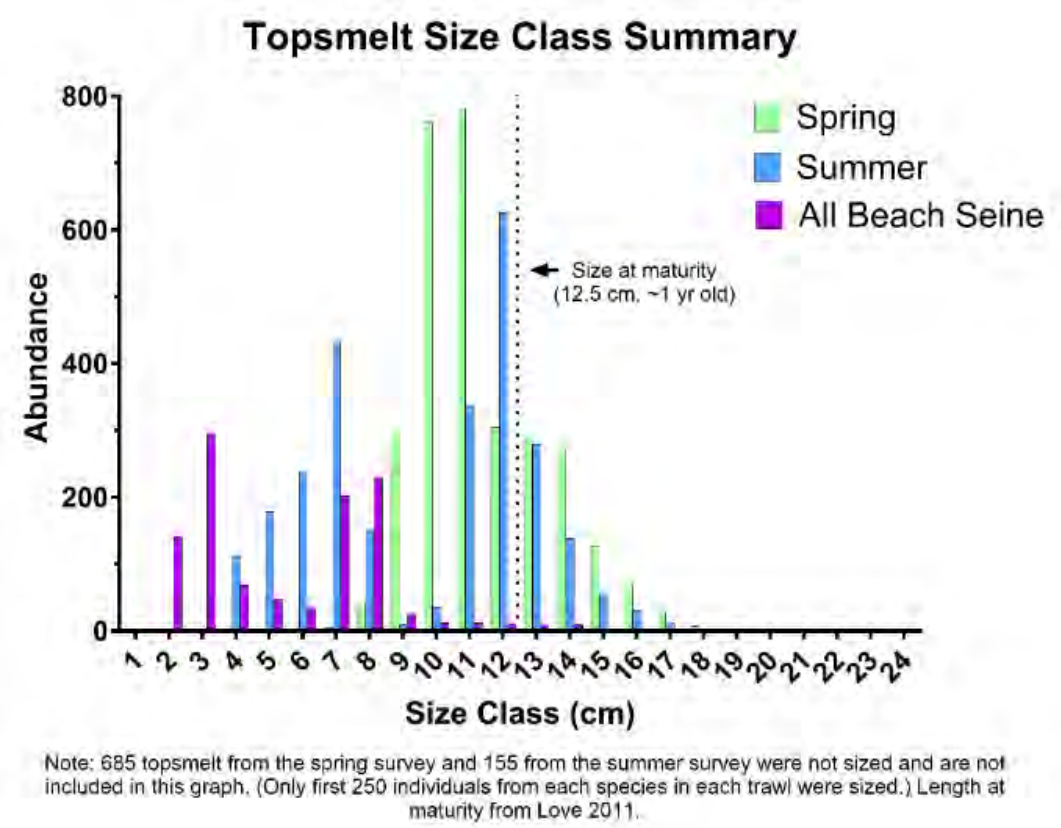


Figure 3-16. Topsmelt Size Class Distribution from Lampara, Trawl, and Beach Seine Sampling – Spring and Summer 2023

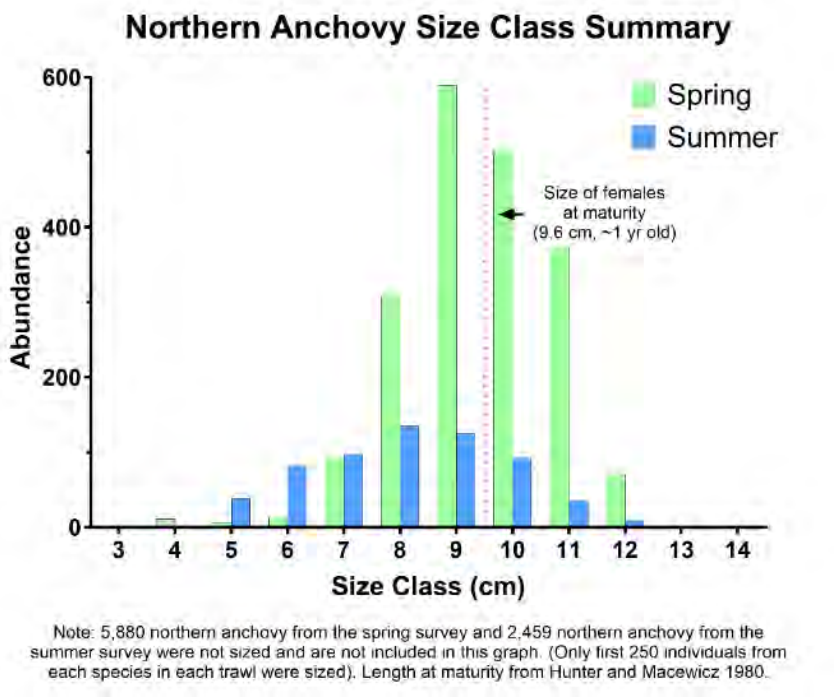


Figure 3-17. Northern Anchovy Size Class Distribution from Lampara, Trawl, and Beach Seine Sampling – Spring and Summer 2023

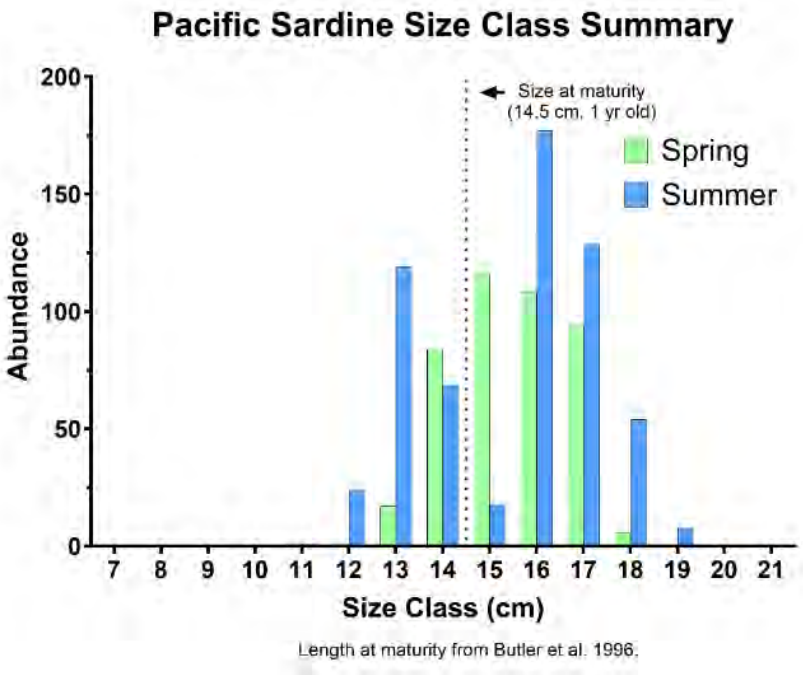


Figure 3-18. Pacific Sardine Size Class Distribution from Lampara, Trawl, and Beach Seine Sampling – Spring and Summer 2023

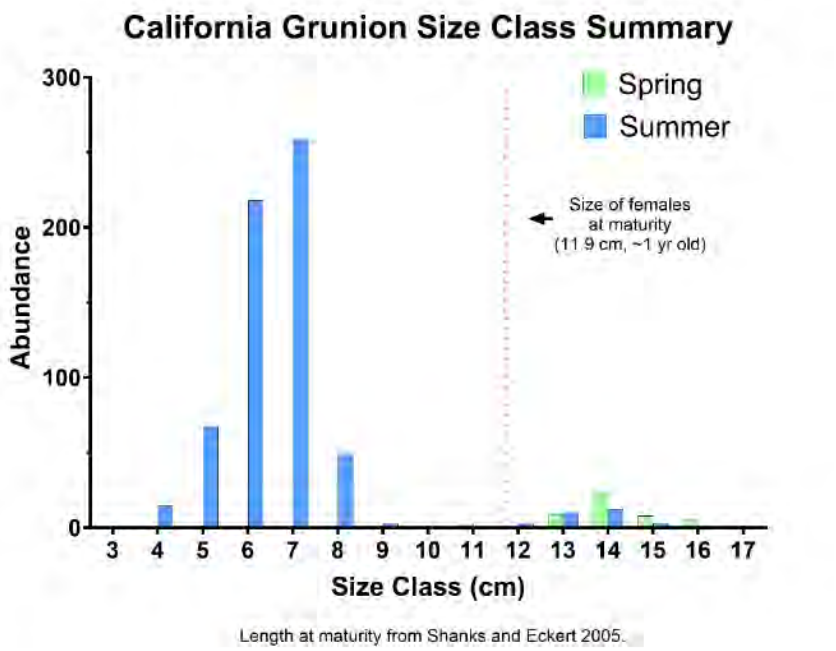


Figure 3-19. California Grunion Size Class Distribution from Lampara, Trawl, and Beach Seine Sampling – Spring and Summer 2023

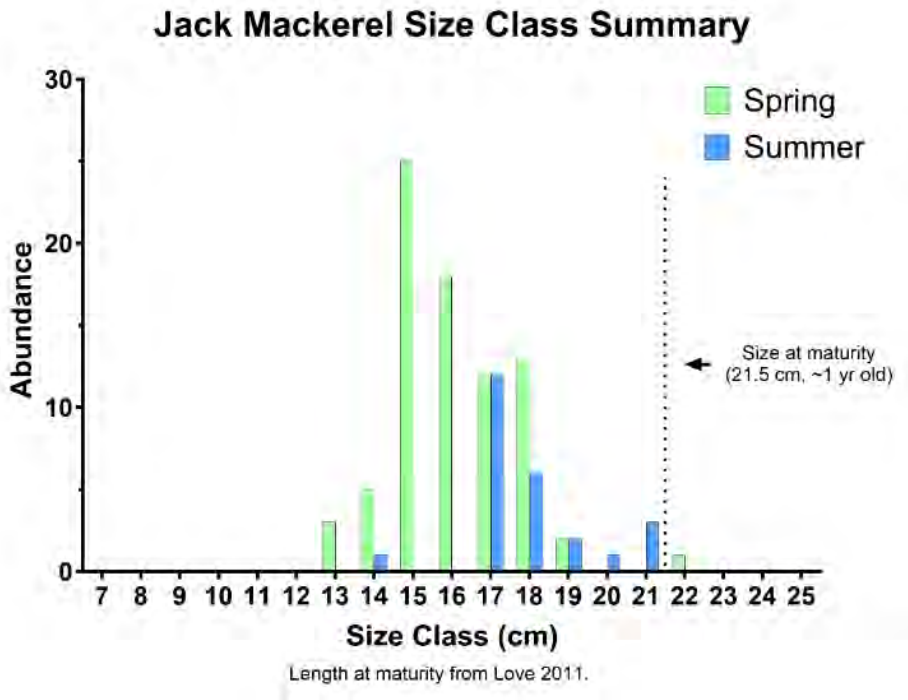


Figure 3-20. Jack Mackerel Size Class Distribution from Lampara, Trawl, and Beach Seine Sampling – Spring and Summer 2023

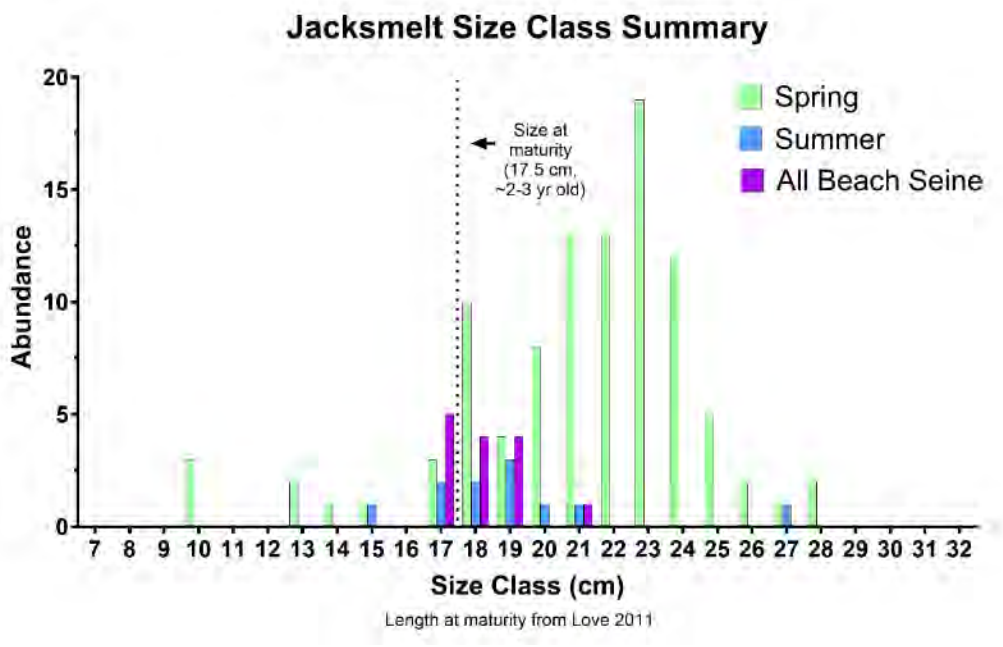


Figure 3-21. Jacksmelt Size Class Distribution from Lampara, Trawl, and Beach Seine Sampling – Spring and Summer 2023

3.3.2 STATION COMPARISONS

3.3.2.1 SPECIES RICHNESS

A total of 22 species were collected by lampara net sampling. Species richness was similar between spring and summer (13 and 20, respectively), but there was a marked contrast in species richness between day and night sampling (7 and 21, respectively). When all sampling events were combined (day/night and spring/summer) for each station, species richness among stations ranged from 2 to 14 (Table 3-7). Stations LA16 (Bannings Landing) and LA5 (West Basin) were the only stations where only two species were caught. The highest number of species (14) were caught at station LA3 (LA SWH West), followed by station LA7 (Seaplane Lagoon) with 10 and station LA2 (LA SWH East) with 9. In general, SWH stations as a group had the greatest species richness.

3.3.2.2 DIVERSITY AND EVENNESS INDICES

Overall, Shannon-Weiner Diversity Index values at individual stations ranged from 0.05 to 1.09, and Margalef Diversity Index values ranged from 0.16 to 1.75 (Table 3-7). Pielou's Evenness Index values ranged from 0 at station LA16, where only two species were captured, to 1.00 at station LA14, where although only three species were captured, their abundances were nearly equal (Table 3-7). Although individual index scores can describe the community at a single station, spatial variability is better described by station groups, as discussed in Section 3.3.3.

Table 3-7. Pelagic Fish Catch Summary by Station Using Lampara Nets – Both Seasons Combined

Station	Station Descriptor	Habitat	Location	Depth Stratum	Taxa Richness	Total Abundance per Station	Total Biomass per Station (kg)	Shannon-Wiener Diversity Index	Margalef Diversity Index	Pielou's Evenness Index
LA1	Outer Pier 400	Outer	Outer	Very Deep	4	70	0.98	0.89	0.71	0.64
LA2	POLA SWH East	SWH	SWH	Shallow	9	552	7.90	0.72	1.27	0.33
LA3	POLA SWH West	SWH	SWH	Shallow	14	1712	34.26	1.03	1.75	0.39
LA4	POLA Main Channel	Outer	Channel	Deep	3	262	3.14	0.33	0.36	0.30
LA5	West Basin	Inner	Basin	Deep	2	458	4.40	0.07	0.16	0.10
LA6	POLA East Basin	Inner	Basin	Deep	5	475	5.82	0.14	0.65	0.09
LA7	Seaplane Lagoon	SWH	SWH	Shallow	10	3567	37.60	0.81	1.10	0.35
LA9	Pier 300 Channel	Outer	Channel	Deep	4	485	3.71	0.79	0.49	0.57
LA10	Fish Harbor	Inner	Basin	Deep	6	710	5.63	0.95	0.76	0.53
LA11	POLA Outer Channel	Outer	Outer	Very Deep	3	293	3.07	0.05	0.35	0.04
LA14	Consolidated Slip	Inner	Slip	Deep	3	158	3.03	1.09	0.39	1.00
LA15	POLA Turning Basin	Outer	Basin	Deep	3	231	1.67	0.50	0.37	0.46
LA16	Bannings Landing	Inner	Slip	Deep	2	292	5.99	0.12	0.18	0.00
LB1	Outer Harbor Anchorages	Outer	Outer	Deep	5	155	2.54	0.96	0.79	0.60
LB2	POLB SWH	SWH	SWH	Shallow	6	2322	34.61	0.65	0.65	0.36
LB3	West Basin	Outer	Basin	Deep	6	3850	46.86	0.55	0.61	0.31
LB4	Channel 2	Inner	Slip	Deep	4	202	4.17	0.85	0.57	0.61
LB5	Southeast Basin East	Outer	Basin	Deep	5	1080	15.73	0.86	0.57	0.54
LB6	Pier J	Outer	Slip	Deep	6	1385	18.95	0.37	0.69	0.21
LB7	POLB Main Channel - Pilot Station	Outer	Channel	Very Deep	3	138	1.33	0.65	0.41	0.59
LB9	POLB Outer Main Channel	Outer	Outer	Very Deep	5	80	5.31	0.45	0.91	0.28
LB10	Southeast Basin West	Outer	Basin	Deep	6	611	5.47	0.84	0.78	0.47
LB12	Main Channel Police Station	Outer	Channel	Very Deep	3	389	7.78	0.71	0.34	0.65
LB13	POLB Inner Harbor Turning Basin	Outer	Basin	Very Deep	4	1105	13.10	0.75	0.43	0.54
LB14	Cerritos Channel	Inner	Channel	Deep	6	1481	31.96	0.97	0.68	0.54
LB16	Channel 3	Inner	Slip	Deep	3	122	1.71	0.13	0.42	0.12

kg = kilogram(s)

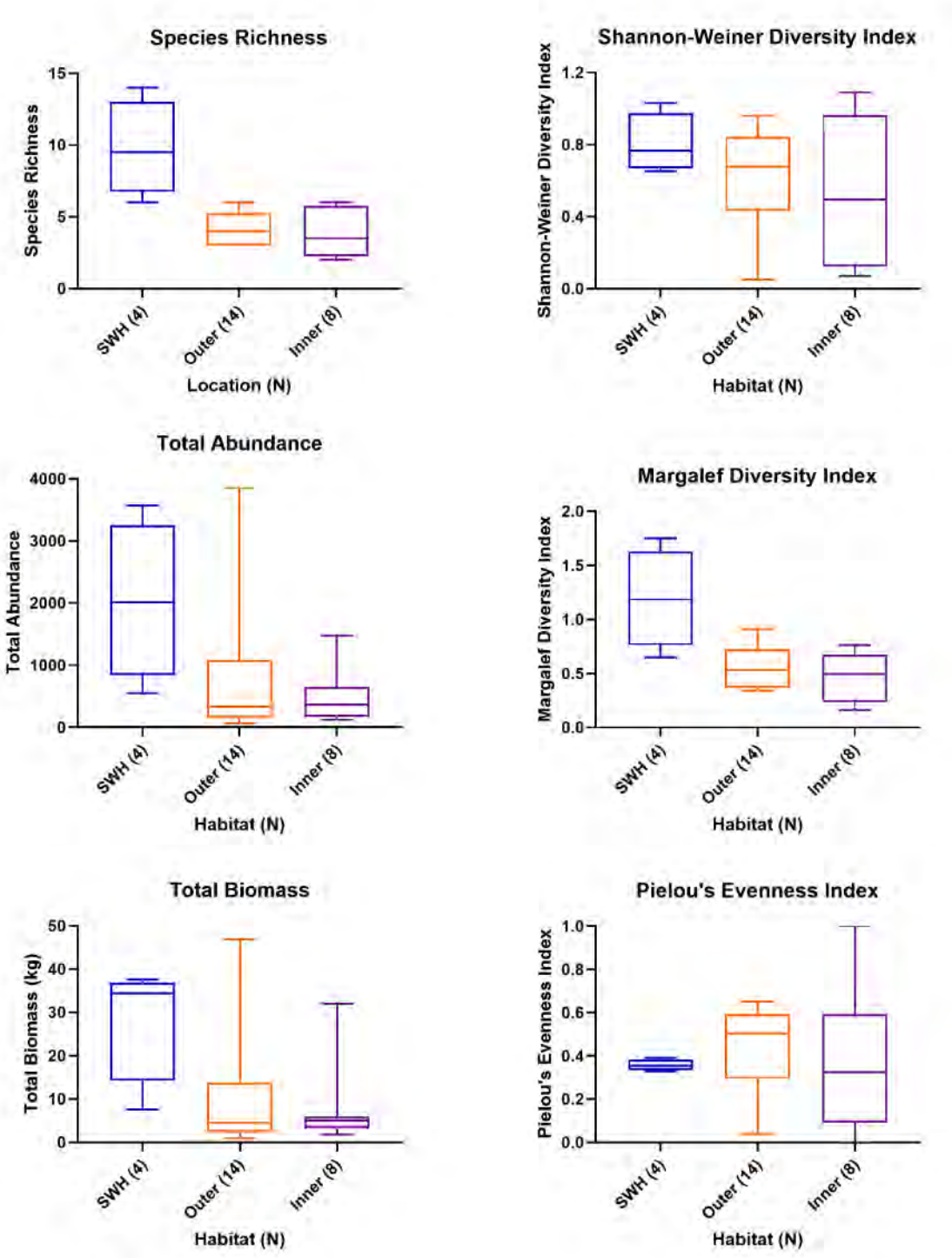
3.3.3 STATION GROUPS

Stations were grouped according to habitat (Inner Harbor, Outer Harbor, and SWH), location (Outer Harbor, SWH, channel, basin, and slip) and depth (Shallow [0–7 meters], Deep [7.1–18 meters], and Very Deep [18+ meters]) and compared using the metrics in the previous section.

For stations grouped according to habitat, the SWH stations, in general, had higher values of species richness, abundance, biomass, and diversity than either Inner Harbor or Outer Harbor stations (Figure 3-22).

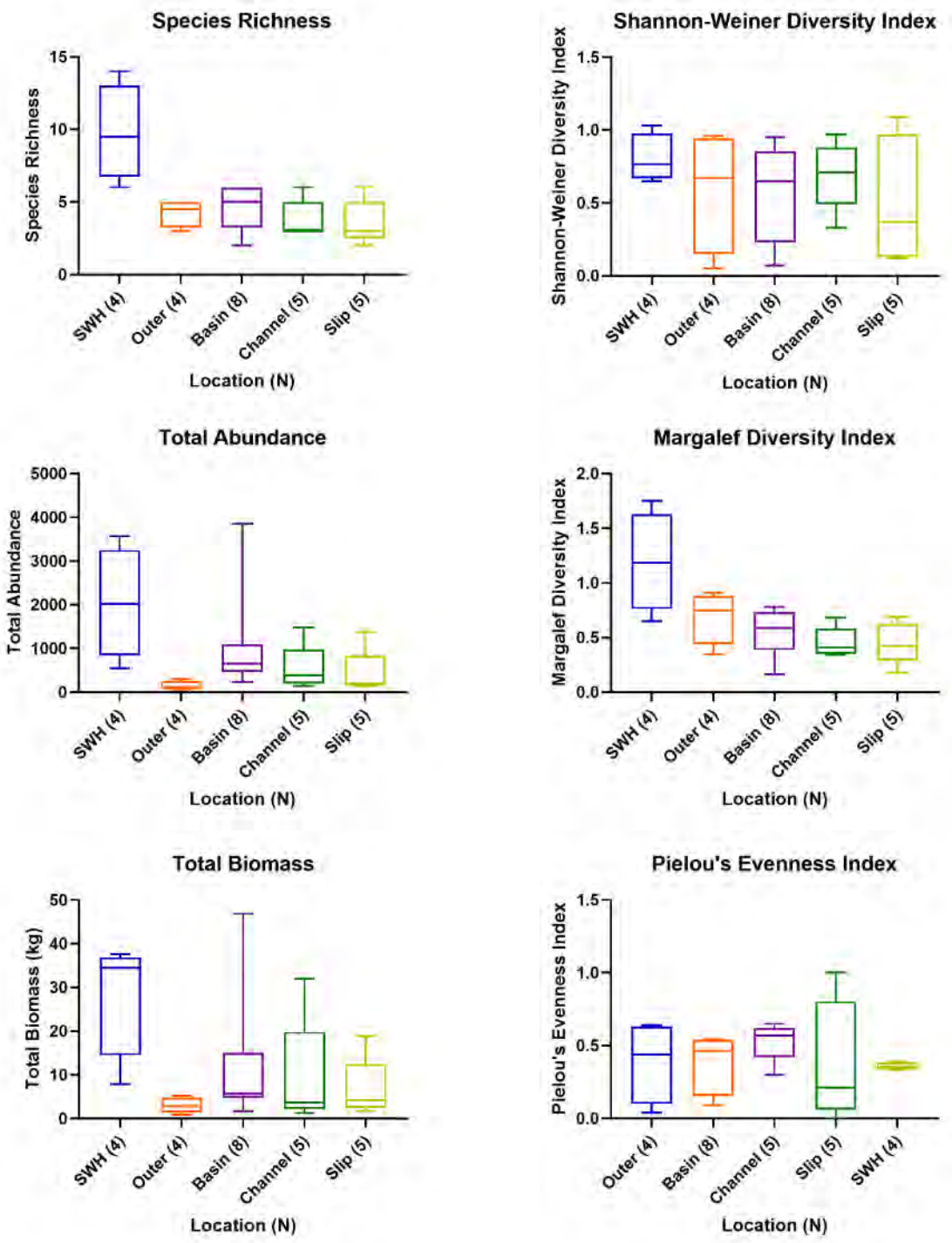
For stations grouped by location characteristics (SWH, Outer Harbor, basin, channel, and slip), SWH stations, on average, also had higher species richness, abundance, biomass, and diversity than other location types (Figure 3-23). Basin stations had a few outlier stations for abundance and biomass because of the high abundance of topsmelt and northern anchovy.

Stations grouped by depth followed a pattern similar to that during the 2018 Biosurvey, with the Shallow stations (made up entirely of SWH stations) having the highest average species richness, abundance, and biomass (Figure 3-24). There was little difference in these metrics between Deep and Very Deep station groups on average, although Deep stations had a few large catches that extended the ranges of values above those of the Shallow stations. Shallow stations had higher diversity scores than Deep and Very Deep stations, with the largest difference using the Margalef Diversity Index because of the higher number of species captured at Shallow stations.



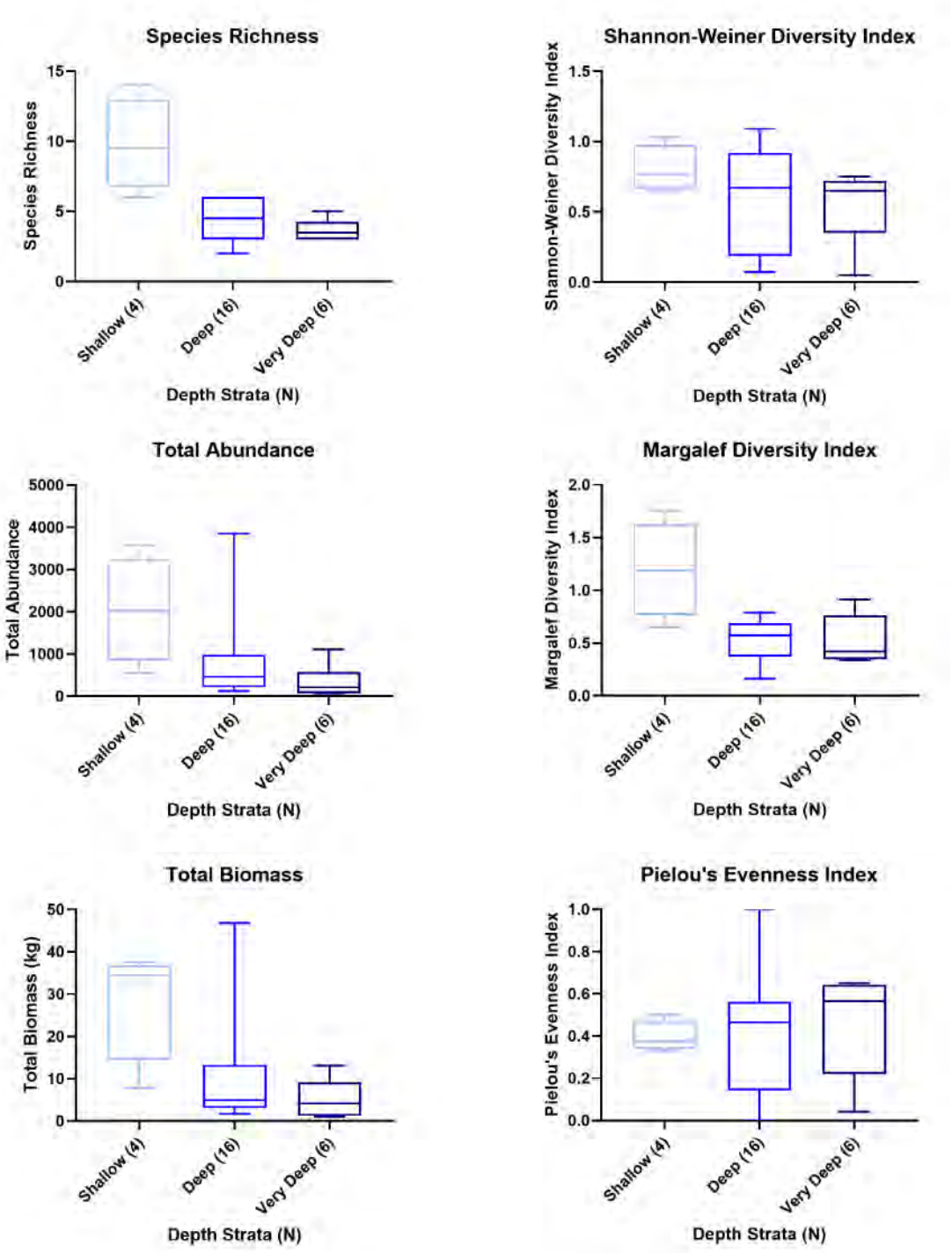
Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 3-22. Station Habitat Group Summaries for Pelagic Fish Captured Using Lampara Nets – All Seasons Combined



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 3-23. Station Location Group Summaries for Pelagic Fish Captured Using Lampara Nets – All Seasons Combined



Note: Shallow 0–7 meters, Deep 7.1–18 meters, and Very Deep 18+ meters. Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 3-24. Station Depth Strata Group Summaries for Pelagic Fish Captured Using Lampara Nets –All Seasons Combined

3.3.3.1 MULTIVARIATE ANALYSIS

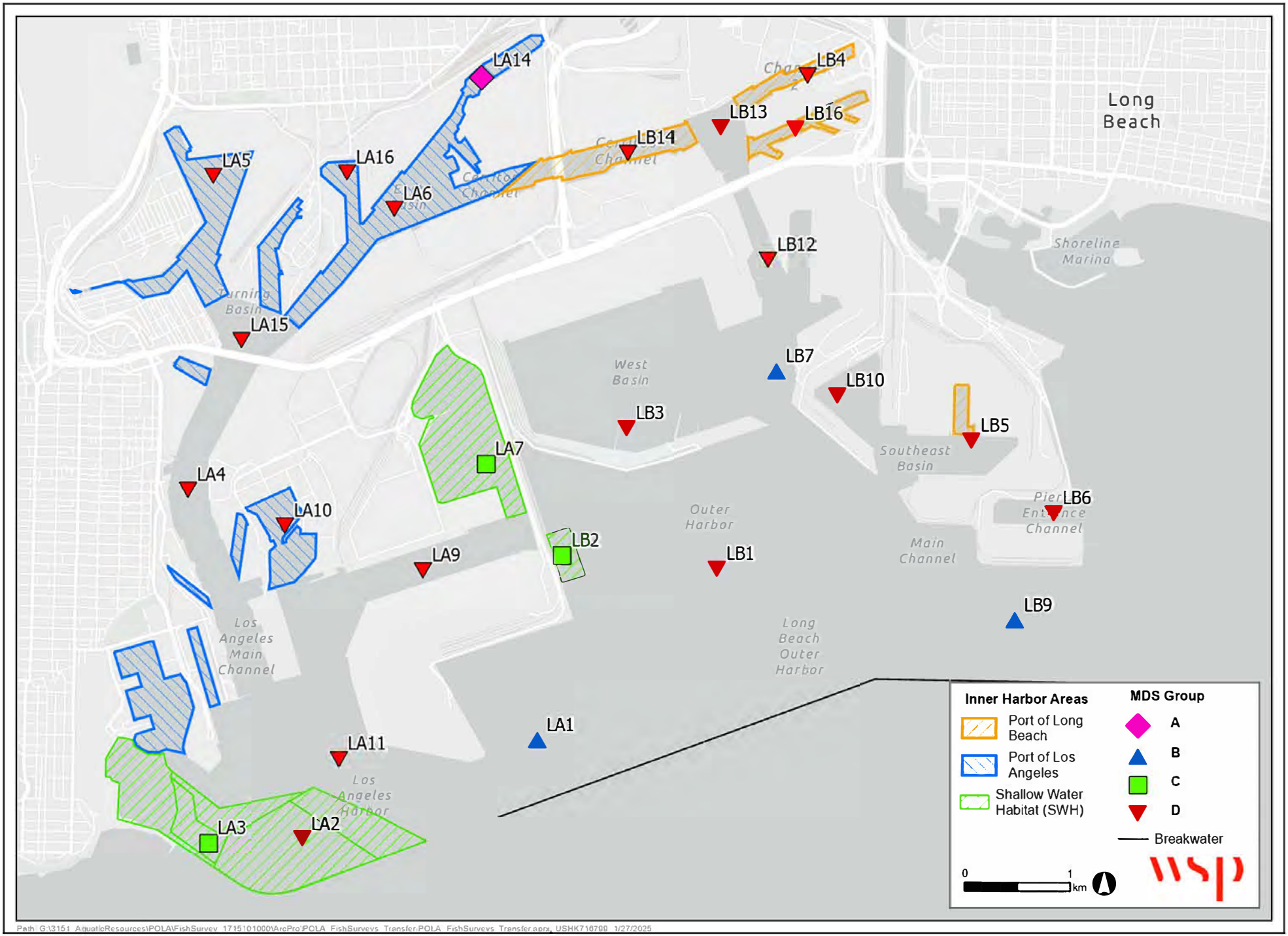
Multivariate analysis of pelagic fish abundance data combined across all sampling events was performed using Primer statistical software (see Section 1.7). This analysis provided an in-depth evaluation of station groups and patterns of pelagic fish communities across stations. Results for the 2018 Biosurvey indicated few statistical differences in pelagic fish communities, a finding that was attributed to the fact that pelagic species are highly mobile, can occur in large schools, and may not distribute according to habitat or location types. However, that analysis did not attempt to treat pelagic fish communities differently from benthic fish communities. Although benthic fish abundances are log transformed prior to analysis, this technique may be less appropriate for pelagic communities for which a transform will down-weight abundant species but also lose much of the quantitative information from mid- and low-abundance species, some of which may not exhibit the same schooling behavior (Clarke et al., 2014; Santana-Garcon et al., 2014). In the 2023 Biosurvey, however, the pelagic fish data were first dispersion-weighted before multivariate analysis was performed. Dispersion weighting divides all counts for a single species by a particular constant, the index of dispersion (ratio of the variance to the mean) within each group, to give a divisor for that species (Clarke et al., 2006). This step normalizes for the otherwise large contributions that schooling species (e.g., anchovy, topsmelt, etc.) would make to multivariate analyses, by down-weighting each species by its dispersion index. This technique is applied in pelagic fish assemblage studies to allow mid-range and low-abundance species to influence the calculation of similarity (Santana-Garcon et al., 2014; Miller et al., 2024).

Analysis of relationships among habitat and depth strata station groups (Figure 3-25) using ANOSIM (see Section 1.7) indicated significant differences. Habitat group pairwise tests showed that SWH stations were distinct from both Inner Harbor and Outer Harbor stations, but Inner Harbor and Outer Harbor stations were not statistically different from one another. All depth groups were significantly different from one another. The nMDS of location groups and a dendrogram showing the results of the cluster analysis are shown in Appendix C.

A similarity profile (SIMPROF) cluster analysis was used to identify unique station groups based on community composition (ignoring the *a priori* station groups), resulting in four station groups (Figure 3-25). The distribution of these station groups is shown overlaid on a map of sampling station locations in Figure 3-26, and the shadeplot in Figure 3-27 shows the relative abundance of each species across stations and groups. The largest group (Group D) consists of 19 stations that include primarily Deep Inner Harbor and Outer Harbor stations, but also the SWH station LA2 and two Very Deep channel stations (LA11 and LB12). This group represents the pelagic fish community most often encountered across the Port Complex, including topsmelt, Pacific sardine, northern anchovy, jack mackerel, and California grunion. Group C consists of the other three SWH stations, which generally had higher species richness that could be attributed to the lampara net potentially collecting some benthic species in addition to pelagic species because of the depth of the station and extension of the net all the way to the seafloor. Three Very Deep Outer Harbor stations (LA1, LB7, and LB9) made up Group B, which was most represented by the presence of topsmelt, northern anchovy, California grunion, and jacksmelt. Group A was represented by station LA14 (Consolidated Slip), which was unique in that Pacific butterfish was the most dominant species, followed by topsmelt and northern anchovy.

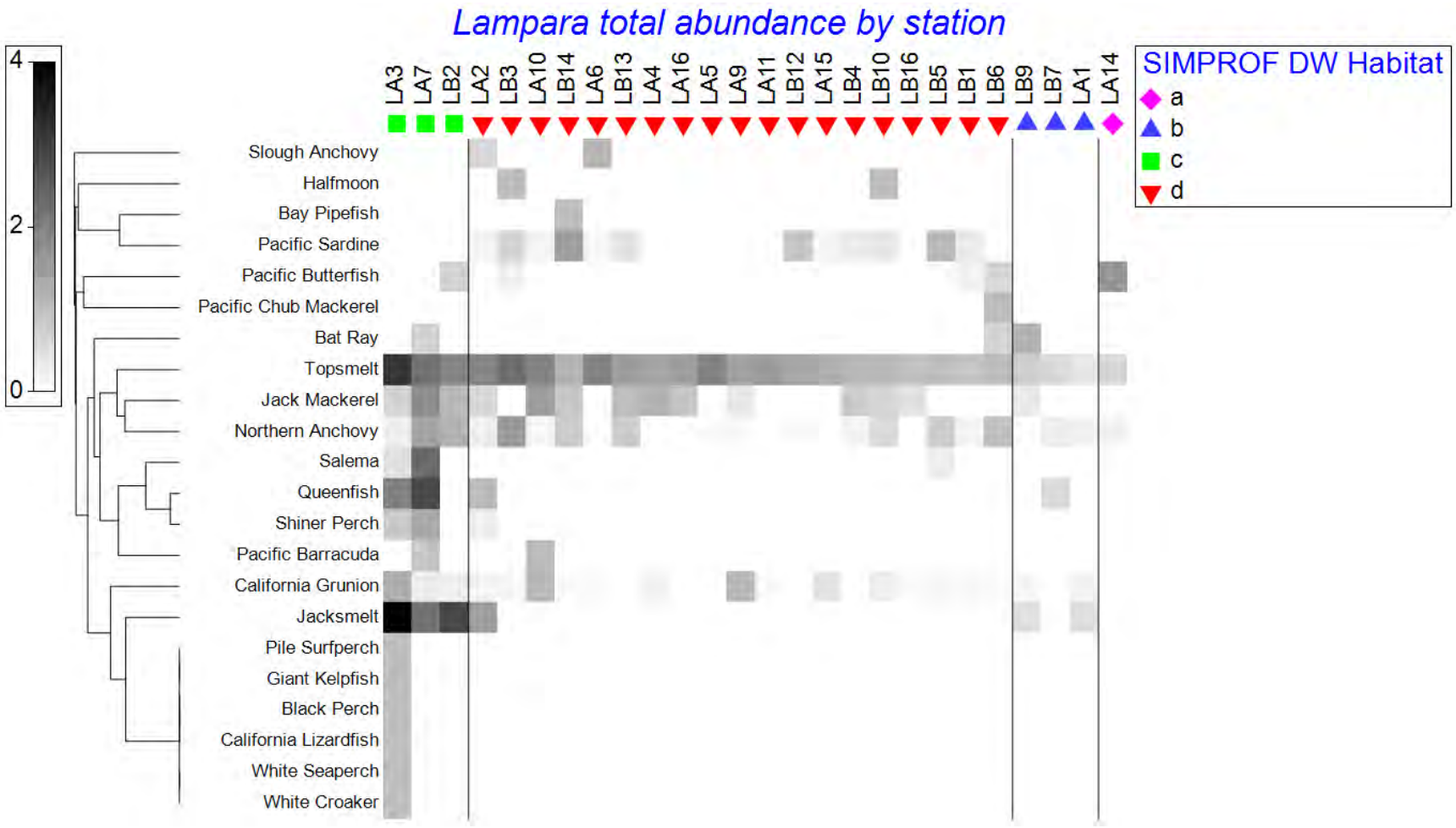


Figure 3-25. nMDS Plots for Pelagic Fish Captured Using the Lampara Nets Grouped by Habitat, Depth Strata, and Similarity Profile (SIMPROF) Analysis



Path: G:\3151_AquaticResources\POLA\FishSurvey_1715101000\ArcPro\POLA_FishSurveys_Transfer\POLA_FishSurveys_Transfer.aprx, USHK716799 1/27/2025

Figure 3-26. Similarity Profile Groups for Pelagic Fish – Spring and Summer 2023 Combined



The scale reflects abundance data that have been transformed and normalized

Figure 3-27. Shade Plot for Pelagic Fish Habitat Groups Assessed Using Lampara Nets

3.3.4 FISH HEALTH

Overall, the pelagic fishes captured appeared healthy, and most specimens had normal color and energy. External anomalies such as lesions, tumors, fin erosion, and spinal deformities were not observed in any of the fish captured in the lampara trawls.

3.3.5 HISTORICAL COMPARISONS

Lampara sampling across the 2000, 2008, 2013, 2018, and 2023 Biosurveys indicated considerable variability in the abundance, species numbers, and biomass of pelagic fishes in the Port Complex (Figure 3-28). The total number of species captured across all Biosurvey years is 63 and has ranged from 20 to 50 per year. Results for 2023 were similar to results in 2018 and 2008 (22, 23, and 20 species, respectively), whereas substantially more species were captured in 2000 (50) and 2013 (35). During the 2000 Biosurvey, a net was used that was deeper and heavier than the nets used in subsequent Biosurveys, which may have resulted in higher catch rates of benthic species such as white croaker and queenfish that skew the total species numbers. Unlike the 2018 Biosurvey, in which several species were captured for the first time, during the 2023 Biosurvey, no new pelagic species were captured. However, a number of species were captured in larger numbers in the 2023 Biosurvey than in the 2018 Biosurvey, including Pacific butterfish (*Peprilus simillimus),* salema (*Xenistius californiensis*), and shiner perch (*Cymatogaster aggregate*).

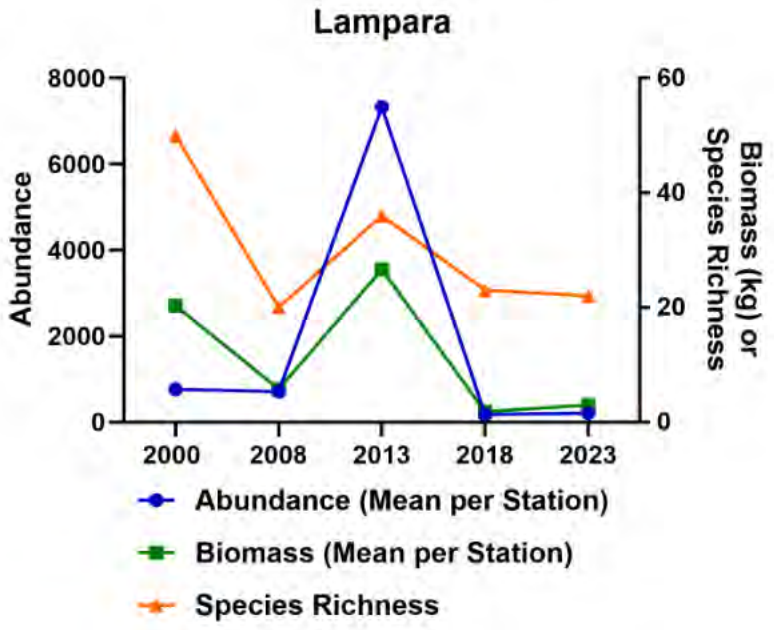


Figure 3-28. Mean Abundance, Mean Biomass, and Total Pelagic Species Captured by Lampara Sampling – 2000–2023

The results for the 2023 and 2018 Biosurveys indicated similar mean abundances (213 and 176, respectively) and mean biomass values (2.95 and 1.80 kg, respectively) per station. However, these values are lower than those of the 2000 through 2013 Biosurveys. Some of this variability can be attributed to differences in sampling equipment used across Biosurveys because past Biosurveys have used heavier lampara nets that captured some benthic fishes in addition to pelagic fishes despite similar mesh size. This effect can be observed in the larger number of benthic species caught by lampara nets in earlier Biosurveys, such as white croaker (6,612 in 2000, 25 in 2008, 284 in 2013, 1 in 2018, and 3 in 2023) and queenfish (6,577 in 2000, 159 in 2008, 629 in 2013, 20 in 2018, and 41 in 2023). The lighter sampling equipment used during the 2018 and 2023 Biosurveys more effectively limited the sampling effort to the intended targeted pelagic communities, although some benthic species such as queenfish and bay pipefish were still captured at Shallow stations, albeit in very low numbers. Although differences in gear types such as weight on the bottom of the net have not been quantified across Biosurveys, historical comparisons across years does require this factor to be considered because it greatly influences abundance, biomass, and number of species captured. The number

of stations and the seasons sampled are also factors that have changed across Biosurvey years. Although in the 2013 through 2023 Biosurveys, sampling occurred at the same number of stations (26) and during the same seasons (spring and summer), during the 2008 Biosurvey, 19 stations were sampled across three seasons, and during the 2000 Biosurvey, 14 stations were sampled across four seasons. The number of stations and their coverage of different habitat types likely have some unquantified impact on the species sampled during the past Biosurveys, and therefore on the analysis of historical trends in the data.

Results for the five Biosurveys were compared in terms of the composition of their pelagic fish species assemblages by identifying the top 10 species (by abundance or biomass) across Biosurveys, combining all other species in an "other" category, and calculating the percent composition of each of the 11 species categories (Figures 3-29 and 3-30). In the 2000 through 2013 Biosurveys, northern anchovy dominated the catch, accounting for 68% to 97% of abundance; no other single species totaled more than 6% of the catch. The catch in 2018 had a more balanced profile among the top three species: topsmelt (43%), northern anchovy (27%), and California grunion (26%). The catch in 2023 was dominated by two species: northern anchovy (55%), and topsmelt (34%). Four species (northern anchovy, Pacific sardine, queenfish, and topsmelt) were among the 10 most abundant species across all Biosurveys.

Percent composition by biomass was more variable across Biosurveys because large, less numerous species such as bat ray and barracuda had an influence on biomass that was out of proportion with their abundance. Of all the Biosurveys, the 2000 Biosurvey captured the most bat rays (332) and barracudas (646), and the biomass of the 2000 Biosurvey was dominated by those two species (24% and 22% of total biomass, respectively). Despite their small individual size, the large number of northern anchovy captured in 2008 and 2013 also led to them dominate biomass (57% and 66%, respectively). During the 2023 Biosurvey, topsmelt was the dominant biomass species (39%), followed by northern anchovy (32%) and Pacific sardine (14%). Only three species (bat ray, northern anchovy, and topsmelt) were in the top 10 species by biomass across all Biosurveys.

The EI was chosen as a comparative method that might sufficiently overcome the variability in stations, sampling gear, and seasons to compare the structure of pelagic fish communities over the past 23 years of biological monitoring in the Port Complex. The top 15 species captured with lampara nets in each Biosurvey year and ranked by EI are shown in Table 3-8, with species managed under the Coastal Pelagic FMP highlighted. Except for Pacific mackerel in 2023 and 2008 (ranked #17 and #16, respectively), the four managed species occurred in the top 15 species across all years. Northern anchovy was consistently among the highest ranked species, and Pacific sardine was never ranked lower than #9. Other pelagic species that consistently ranked in the top 10 were topsmelt, bat ray, and queenfish. Of the 63 species captured with lampara nets over the five different Biosurveys (a full table with abundances is provided in Appendix C), 9 pelagic species were captured during every Biosurvey (Table 3-9). Note that demersal fishes captured at shallow stations such as white croaker and queenfish were excluded from the count of recurring pelagic species.

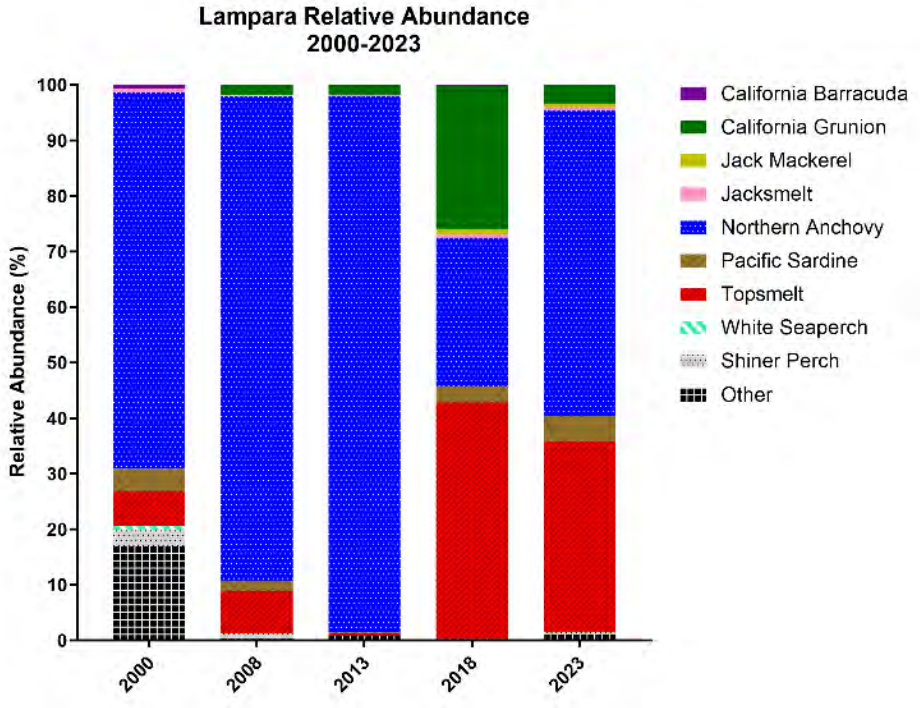


Figure 3-29. Historical Comparison of Species Composition by Abundance of Pelagic Fish Captured Using Lampara Nets

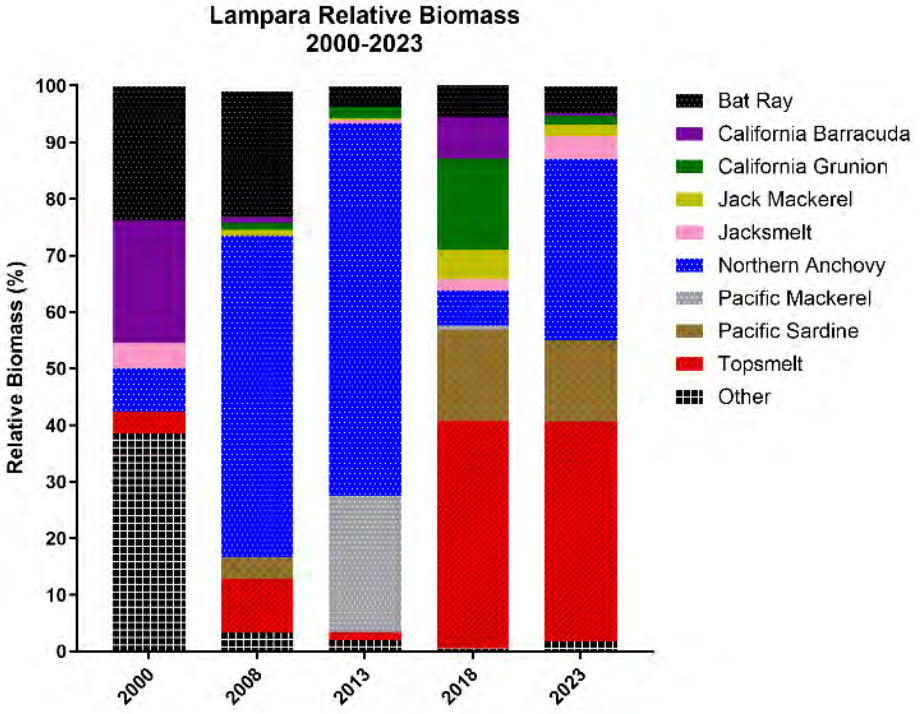


Figure 3-30. Historical Comparison of Species Composition by Biomass of Pelagic Fish Captured Using Lampara Nets

Table 3-8. Historical Summary of Fish Captured Using Lampara Nets – Top 15 Species Ranked by the Ecological Index

2023 Lampara Fish Ecological Index — **22 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
Topsmelt	*Atherinops affinis*	34.2	38.9	100	7312
Northern Anchovy	*Engraulis mordax*	54.9	31.9	81	7017
Pacific Sardine	*Sardinops sagax*	4.62	14.4	46	878
California Grunion	*Leuresthes tenuis*	3.51	1.55	73	369
Jack Mackerel	*Trachurus symmetricus*	0.55	2.10	54	143
Jacksmelt	*Atherinopsis californiensis*	0.59	4.10	23	108
Bat Ray	*Myliobatis californica*	0.02	4.81	12	55.7
Pacific Butterfish	*Peprilus simillimus*	0.35	0.87	19	23.5
Shiner Perch	*Cymatogaster aggregata*	0.51	0.16	12	7.74
Salema	*Haemulon californiensis*	0.37	0.26	12	7.25
Queenfish	*Seriphus politus*	0.19	0.21	15	6.11
Pacific Barracuda	*Sphyraena argentea*	0.03	0.45	8	3.73
White Croaker	*Genyonemus lineatus*	0.02	0.19	4	0.80
White Seaperch	*Phanerodon furcatus*	0.04	0.03	4	0.24
Slough anchovy	*Anchoa delicatissima*	0.02	0.00	8	0.19

2018 Lampara Fish Ecological Index — **23 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
Topsmelt	*Atherinops affinis*	42.6	40.2	100	8280
California Grunion	*Leuresthes tenuis*	25.8	16.2	69	2907
Northern Anchovy	*Engraulis mordax*	26.6	6.23	73	2402
Pacific Sardine	*Sardinops sagax caeruleus*	2.95	16.1	23	440
Jack Mackerel	*Trachurus symmetricus*	0.82	5.17	54	323
Jacksmelt	*Atherinopsis californiensis*	0.71	1.95	35	92.0
California Barracuda	*Syphyraena argentea*	0.25	7.39	12	88.1
Bat Ray	*Myliobatis californica*	0.01	5.46	4	21.0
Pacific Mackerel	*Scomber japonicus*	0.07	0.73	23	18.4
Queenfish	*Seriphus politus*	0.11	0.29	12	4.61
Slough Anchovy	*Anchoa delicatissima*	0.04	0.01	8	0.35
California Lizardfish	*Synodus lucioceps*	0.01	0.03	8	0.32
White Croaker	*Genyonemus lineatus*	0.01	0.07	4	0.28
Pacific Butterfish	*Peprilus simillimus*	0.01	0.03	4	0.13
Salema	*Xenistus californiensis*	0.01	0.03	4	0.13

Note: Managed species under the Coastal Pelagic FMP are in BOLD. Pacific mackerel ranked # 17 in 2023 and #16 in 2008. Values of 0.00 are <0.005. “Frequency of capture” is the percentage of sampling stations at which the species was captured.

Table 3-8. Historical Summary of Fish Captured using the Lampara– Top 15 Species Ranked by the Ecological Index (Continued)

2013 Lampara Fish Ecological Index — **35 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
Northern Anchovy	*Engraulis mordax*	96.6	65.8	100	16244
Pacific Mackerel	*Scomber japonicus*	0.68	24.0	54	1331
California Grunion	*Leuresthes tenuis*	1.69	1.96	88	322
Topsmelt	*Atherinops affinis*	0.54	1.36	96	183
Bat Ray	*Myliobatis californica*	0.00	3.76	31	116
Jacksmelt	*Atherinopsis californiensis*	0.27	0.61	92	81.9
Queenfish	*Seriphus politus*	0.08	0.31	88	35.1
White Croaker	*Genyonemus lineatus*	0.04	0.46	62	30.4
Pacific Sardine	*Sardinops sagax*	0.02	0.28	73	22.1
Pacific Butterfish	*Peprilus simillimus*	0.03	0.35	50	18.8
Jack Mackerel	*Trachurus symmetricus*	0.02	0.34	50	17.7
California Lizardfish	*Synodus lucioceps*	0.01	0.24	69	17.4
Diamond Turbot	*Pleuronichthys guttulatus*	0.001	0.06	12	0.72
Barred Sand Bass	*Paralabrax nebulifer*	0.002	0.03	19	0.68
White Surfperch	*Phanerodon furcatus*	0.003	0.03	19	0.54

2000 Lampara Fish Ecological Index — **51 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
Northern Anchovy	*Engraulis mordax*	67.9	7.65	100	7551
White Croaker	*Genyonemus lineatus*	5.68	11.1	100	1682
California Barracuda	*Sphyraena argentea*	0.59	21.7	72	1611
Queenfish	*Seriphus politus*	5.97	7.16	100	1314
Bat Ray	*Myliobatis californica*	0.30	23.7	50	1198
Topsmelt	*Atherinops affinis*	6.07	3.74	100	981
Salema	*Xenistius californiensis*	2.85	5.41	72	597
Pacific Sardine	*Sardinops sagax*	4.11	1.73	83	487
Jacksmelt	*Atherinopsis californiensis*	0.70	4.41	89	454
Shiner Surfperch	*Cymatogaster aggregata*	2.96	1.56	78	351
White Surfperch	*Phanerodon furcatus*	0.82	1.98	78	218
California Halibut	*Paralichthys californicus*	0.05	1.88	67	129
Jack Mackerel	*Trachurus symmetricus*	0.15	0.84	89	87.6
Barred Sand Bass	*Paralabrax nebulifer*	0.10	0.76	61	52.8
Pacific Mackerel	*Scomber japonicus*	0.11	0.67	67	52.2

2008 Lampara Fish Ecological Index — **20 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
Northern Anchovy	*Engraulis mordax*	87.1	56.9	100	46034
Topsmelt	*Atherinops affinis*	7.65	9.45	100	6966
Bat Ray	*Myliobatis californica*	0.03	22.2	21	3072
Pacific Sardine	*Sardinops sagax*	1.86	3.74	74	1944
California Grunion	*Leuresthes tenuis*	1.89	1.17	89	858
Jack Mackerel	*Trachurus symmetricus*	0.13	1.09	74	538
Queenfish	*Seriphus politus*	0.20	0.87	63	373
California Barracuda	*Syphyraena argentea*	0.02	1.06	21	147
Shiner Surfperch	*Cymatogaster aggregata*	0.94	0.50	32	134
White Croaker	*Genyonemus lineatus*	0.03	0.58	16	60.3
Brown Smoothhound Shark	*Mustelus henlei*	0.00	1.54	5	53.2
White Surfperch	*Phanerodon furcatus*	0.07	0.14	21	20.8
White Seabass	*Atractoscion nobilis*	0.00	0.25	11	17.2
Jacksmelt	*Atherinopsis californiensis*	0.01	0.14	16	14.7
Spotfin Croaker	*Roncador stearnsii*	0.00	0.30	5	10.3

Note: Managed species under the Coastal Pelagic FMP are in BOLD. Pacific mackerel ranked # 17 in 2023 and #16 in 2008. Values of 0.00 are <0.005. “Frequency of capture” is the percentage of sampling stations at which the species was captured

Table 3-9. Historical Abundance of Pelagic Fish Species Caught During All Biosurvey Years to Date Using Lampara Nets

Common Name	Scientific Name	2023	2018	2013	2008	2000
Bat Ray	*Myliobatis californica*	5	1	28	28	332
California Barracuda	*Sphyraena argentea*	7	45	4	19	646
California Grunion	*Leuresthes tenuis*	778	4727	12610	1531	411
Jack Mackerel	*Trachurus symmetricus*	121	151	115	106	161
Jacksmelt	*Atherinopsis californiensis*	131	130	2036	7	770
Northern Anchovy	*Engraulis mordax*	12186	4884	722008	70658	74720
Pacific Mackerel	*Scomber japonicus*	1	12	5104	2	124
Pacific Sardine	*Sardinops sagax caeruleus*	1025	540	177	1509	4520
Topsmelt	*Atherinops affinis*	7594	7802	4049	6205	6688

3.4 DISCUSSION

Fish eggs and larval fish in the Port Complex have shown variability in both abundance and diversity, consistent with observations for nearshore environments in the Southern California Bight. Changes in oceanographic conditions, especially sea surface temperature, have been shown to affect the abundance and diversity of nearshore ichthyoplankton communities (Duke et al., 2018; Thompson, 2019; Choi et al., 2021; Chen et al., 2025). The California Current, including the Southern California Bight, experienced the fourth-largest marine heatwave on record over from 2022 through 2024 (Harvey et al., 2023; Leising et al., 2024; Leising et al., 2025) in addition to El Niño conditions (see Section 2.1) and record rainfall over that period. Higher sea surface temperatures in the winter at Scripps Pier have been shown to negatively correlate with fish egg abundance and diversity during the following summer (Duke et al., 2018; Choi et al., 2021), although the lag between peak temperatures and the lowest abundance is not as well defined, indicating that factors such as reproductive failure or range shifts can also contribute to annual variability. Warm sea surface temperatures may affect the timing of spawning in species, such as earlier spawning for Pacific chub mackerel and delayed spawning for Pacific butterfish (Chen et al., 2025), and prolonged exposure to high temperatures may reduce the survival of fish eggs (Choi et al., 2021). The strength of coastal upwelling, which is usually weaker in warmer years, can affect nutrient availability that fuels planktonic food webs and may also affect how nearshore egg and larvae are transported between coastal habitats (Leising et al., 2025; Chen et al., 2025).

Within the Southern California Bight, fish larvae that prefer warm water have been very abundant since 2014, but species preferring cooler waters have been in decline (Thompson, 2019). Record high larval anchovy abundance has been recorded in the Southern California Bight from 2015 through 2024 (Thompson, 2019; Leising et al., 2025) as warm water circumstances persisted, which may help explain why this species remains dominant within the Port Complex. Gobies and blennies have been among the most abundant larval fish across all Biosurveys to date, despite declining abundance for other species seen across other regional monitoring efforts related to changing environmental conditions. For instance, results for long-term monitoring of ichthyoplankton in nearby King Harbor from 1974 through 2009 (Pondella et al., 2012) noted that goby and garibaldi larvae abundance was constant despite widespread declines in other species that were correlated with sea surface temperatures over that time period. This gradual decline could possibly be due to numerous cumulative factors such as red tide, the strength of ENSO, and shifts in oceanographic conditions, including a transition to warmer, nutrient-deficient waters along the Southern California Bight since the 1970s (Parnell et al., 2010; Pondella et al., 2012). Ichthyoplankton abundance, species richness, and diversity were all highest in shallower areas of the Port Complex compared with deeper areas, most likely because of the increased diversity of pelagic and demersal fishes in the area that may spawn in these areas, as well as the potential for increased predation on larval fishes in open-water areas compared with shallow areas that contain eelgrass that may provide shelter and protection from predators (Heck and Orth, 1980).

Lampara sampling results did not indicate a seasonal difference between the spring and summer pelagic fish communities, but there was a marked difference between day and night sampling in the number of species and abundance of fish collected. This difference could be attributed to several factors, such as gear avoidance during the day, increased prey (e.g., plankton) abundance in the water column at night, and behavioral patterns of some pelagic fishes using the Port Complex only at night. The results for the 2000 and 2008 Biosurveys indicated a similar pattern, with 28,422 fish (42 species) captured during the day versus 81,667 (46 species) at night in 2000 and 8,043 fish (12 species) captured during the day versus 73,041 (19 species) at night in 2008. In 2013, the opposite pattern was observed; however, this result was driven by one abnormally large catch of northern anchovy during the day. The 2013 Biosurvey Report (MBC 2016) stated that, excluding results for that one station, the number of northern anchovy captured was 30 times greater at night than in the daytime, and fewer species were captured during day sampling than during night sampling (23 versus 33, respectively).

Changes in fish community composition across all Biosurveys appear to be largely influenced by gear type and the number of stations and seasons sampled. Other likely factors include continued harbor development (e.g., completion of the SWH areas in 2013), regional fisheries management actions, and broader regional climate trends that have occurred. An example of the latter is the marine heat wave from 2014 through 2016 (Jacox et al., 2019) that affected coastal fish populations and led to mass marine mammal strandings across southern California (Cavole et al., 2016).

Pacific sardines have a long history of large fluctuations in abundance and distribution that appear closely linked to environmental conditions, although the mechanisms driving these boom-and-bust dynamics remain unclear (Smith et al., 2021). The population of sardines off the West Coast has been steadily declining over the past 2 decades (Kuriyama et al., 2024; Figure 3-31), a regional trend potentially attributed primarily to overexploitation

by the commercial fishery. Abundances were so low in 2014 that a moratorium was placed on fisheries in Washington and Canada that is still in effect (Hill et al., 2019). The live bait fishery for Pacific sardine on the West Coast is currently still open in southern California; it supports a recreational fishery that added over $500 million to the local economy in 2022 (Pacific Fisheries Management Council [PFMC], 2024) with vessels based in the Port of Los Angeles representing the largest live bait fleet in southern California. NOAA Fisheries has implemented annual harvest specifications and management measures for the Pacific sardine with the goals of conserving, managing, and rebuilding the Pacific sardine stock off the coasts of Washington, Oregon, and California (PFMC, 2024). Pacific sardine abundance within the Port Complex from 2000 through 2018 mirrored this decline (4,520 individuals in 2000, 1,509 in 2008, and 177 in 2013), although there have been signs of modest recovery, with 540 individuals captured in 2018 and 1,025 in 2023. Although regional management of the Pacific sardine may limit fishing pressure on this species and lead to additional recovery, environmental stressors such as warming ocean temperatures from climate change threaten to shift the distribution of this species, with some models indicating that future live bait landings in San Pedro could decrease by 30 to 50% by 2080 (Smith et al., 2021).

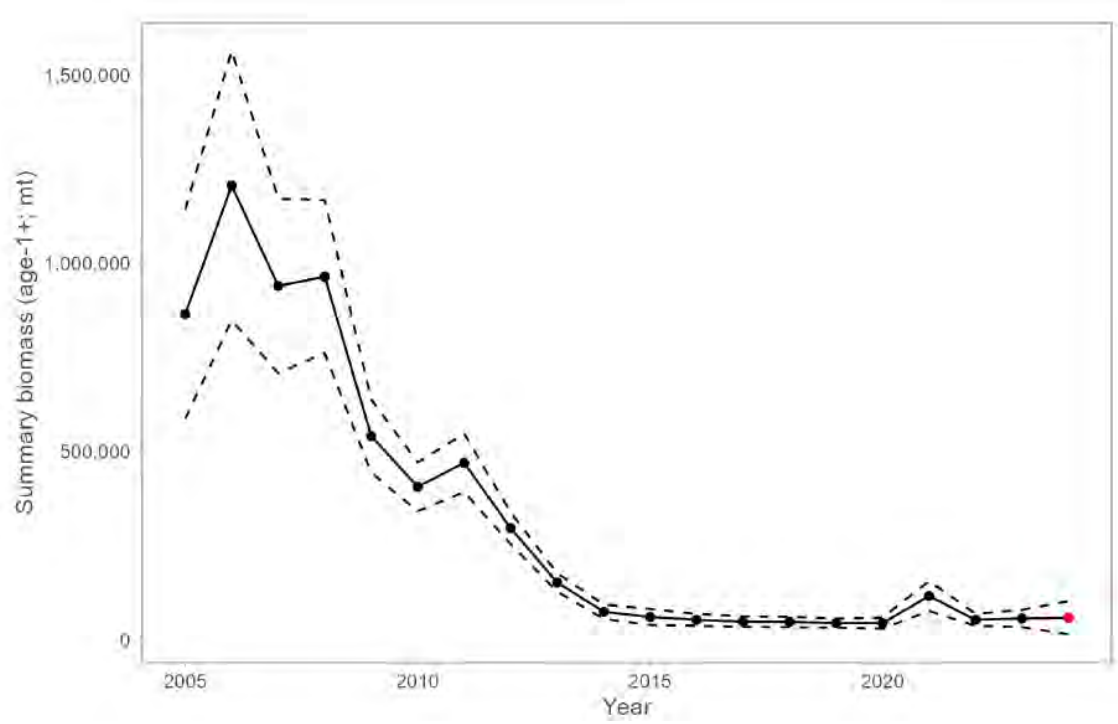


Figure 3-31. Modeled Biomass (in metric tons) for Pacific Sardine on the West Coast of the U.S. from 2005–2024 (Kuriyama et al., 2024)

Although northern anchovy abundance is typically higher during cooler periods (Cavole et al., 2016), the largest catch of northern anchovy during any Biosurvey to date occurred in 2013 when water temperatures were higher than normal because of the beginning of the marine heat wave. The increase in abundance of anchovy adults and larvae in 2013 could also have been a lagging response to the strong coastal upwelling that resulted in cooler temperatures and high productivity in the Southern California Bight from 2012 through early 2013 (Leising et al., 2014), before the shift to warmer waters began in fall 2013. There is also the element of chance when sampling for schooling fish species, as evidenced in the 2013 Biosurvey, when one extremely large catch of northern anchovy from one station had a large influence on the historical comparisons.

A distinct and key observation as described above was the high prevalence of sub-adult pelagic fish species captured, indicating use of the Port Complex by the species as a critical and productive nursery habitat prior to moving toward deeper offshore environments.

3.4.1.1 MANAGED SPECIES

Several species managed under the Coastal Pelagic FMP were captured during the 2023 Biosurvey (Table 3-10). Northern anchovy was the most abundant and widespread Coastal Pelagic FMP species, followed by Pacific sardine, jack mackerel, and pacific mackerel. As described in Section 3.3.1, northern anchovy was the only Coastal Pelagic FMP species captured in the Port Complex during daytime sampling, notably collected closer to the

seafloor with trawls during the day compared with nighttime, when they follow their prey to the surface (Robinson et al., 1995; Kaltenberg and Benoit-Bird, 2009). The other three species were caught in the Port Complex only at night, indicating that these species are likely to move offshore during the day but may return to the Port Complex at night to feed. All of the Coastal Pelagic FMP species were more common across the Outer Harbor compared with the Inner Harbor

Table 3-10. Coastal Pelagic FMP Species Caught in the 2023 Biosurvey – All Gear Types)

Common Name	Scientific Name	Abundance (# of individuals caught)
Northern Anchovy	*Engraulis mordax*	12,263
Pacific Sardine	*Sardinops sagax*	1,026
Pacific Mackerel	*Scomber japonicus*	1
Jack Mackerel	*Trachurus symmetricus*	130

During the 2023 Biosurvey, 45,582 fish were caught using otter trawls, lampara nets, and beach seine sampling throughout the Port Complex.

3.4.1.2 NON-NATIVE SPECIES

Two non-native species were detected in the ichthyoplankton: the yellowfin goby (*Acanthogobius flavimanus*) and Shimofuri goby (*Tridentiger bifasciatus*). Figure 3-32 shows the total abundance across all seasons combined for Shimofuri and yellowfin goby larvae, as well as a comparison with the abundance of the native CIQ goby. The Shimofuri goby is a species native to Asia that prefers fresh and brackish water. It has a very wide range of thermal and salinity tolerance (USFWS, 2019), although it is suggested that the species spawning is limited to waters with salinities up to 19 practical salinity units (PSU). The species was first introduced in the San Francisco Bay estuary circa 1985, and has spread more than 500 km through the aqueducts of the California State Water Project into lakes and coastal drainages in Southern California. The 2023 Biosurvey is the first time that the Shimofuri goby has been positively identified, and it was observed at a much higher density (1,727/100 m^3, 15.3% across all seasons) than *Tridentiger* sp. previously. *Tridentiger* sp. larvae were first observed at low densities at similar stations only in the spring of the 2018 Biosurvey (428/100 m^3, or 5% of all larvae across all seasons) and were thought to be *T. trigonocephalus* (chameleon goby; Wood, 2021). Given their preference for fresh and brackish waters, it is likely that the adults of this species are now present in the watersheds and tributaries that feed into the Inner Harbor and that heavy rainfall may have helped to distribute larvae into local watersheds that drain into Inner Harbor areas.

Because the lowest salinity measured by the CTD in winter 2024 (March), a rainy season with 17.99 inches of rainfall, was 22 PSU, it does not appear likely that the adult population of Shimofuri goby would become established further into the Outer Harbor from the nearby watersheds, although it bears monitoring in future efforts. For example, dive surveys in the spring and summer of 2023 at Inner Harbor stations identified what are thought to be adult non-native chameleon gobies (*Tridentiger trigonocephalus*; see Section 5.5.4) at five Inner Harbor stations. The morphological differences between chameleon and Shimofuri gobies are minute, and it is impossible to differentiate between the species during visual surveys. However, the salinity preferences of both species are thought to be well enough understood that a positive identification was made after discussion with local ichthyologists during a Southern California Association Ichthyological Taxonomists and Ecologists meeting in March 2024. Given the planktonic nature of larval fish, the presence of Shimofuri goby larvae in Outer Harbor areas at low densities (Figure 3-32) is likely the result of tidal and wind-driven currents and the influence of a strong pulse of freshwater (see Section 2.1, Table 2-1) from the substantial rainfall amounts preceding and during the sampling seasons (Robins et al., 2013).

The non-native yellowfin goby (*Acanthogobius flavimanus*) has been observed during Biosurveys since 2000, and the adults are caught infrequently in the trawl sampling (two captured in 2023). Their larval distribution has been relatively well documented throughout the Port Complex, with high abundances in 2023 at station LA10 (Fish Harbor) in the spring and stations LA14 and LA16 (Inner Harbor) in the winter. There was a notable increase in larvae captured in 2023 (1,183/100 m^3, or 10.5% of all larvae across all seasons) compared with 2018 (158/100 m^3, 0.89% of all larvae across all seasons). Given that the adults are rarely captured, it is hard to assess whether this increase is linked to an increasing adult population or whether the sampling in 2023 coincided with optimal conditions or timing of the sampling around a peak spawning period.

No non-native adult pelagic fish species were caught during lampara net sampling.

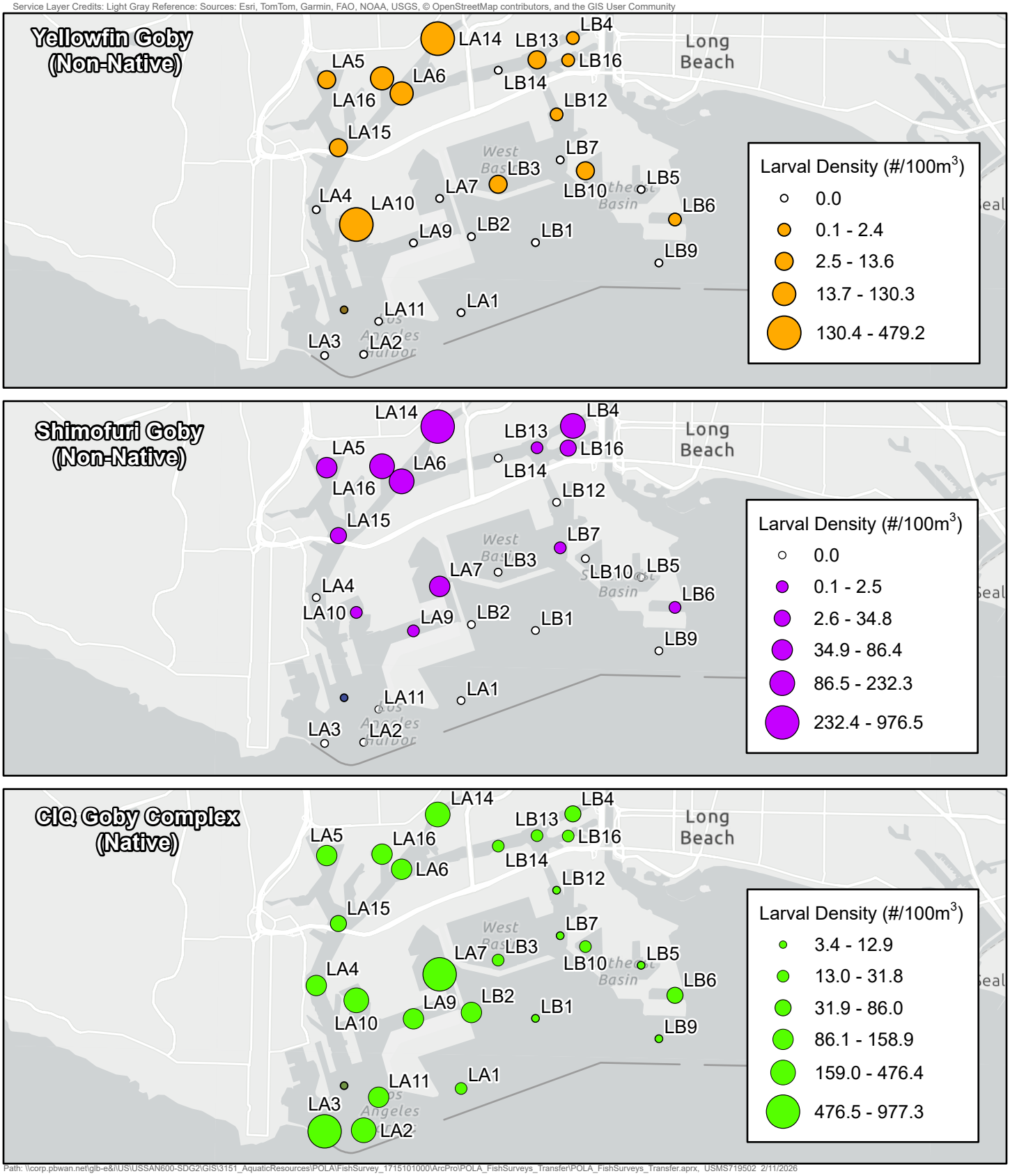


Figure 3-32. Non-Native and Native Goby Larvae Distribution in the Port of Los Angeles and Port of Long Beach During the 2023 Biosurvey

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4 SOFT-BOTTOM HABITAT

Most of the water area of the Port Complex – nearly 8,000 acres – consists of soft-bottom habitat: silty sediments of the deep channels, basins, and open-water anchorage and maneuvering areas; sandy sediments of shallow nearshore areas and a small amount of beach; and sandy-silt in nearshore eelgrass beds. This section describes the plants, fishes, and invertebrates that live just above, on, and in the sediments of the soft-bottom habitat of the Port Complex. The distribution and composition of eelgrass beds in soft-bottom habitat throughout the Port Complex are discussed in Section 4.2. The benthic infauna – the organisms living in the sediments – are discussed in Section 4.3; epibenthic invertebrates – organisms living on the sediment surface – are discussed in Section 4.4; shallow subtidal fish near beaches in Los Angeles Harbor are discussed in Section 4.5; and demersal fish living just above the bottom in deep waters throughout the Port Complex are discussed in Section 4.6.

Sediments in the Port Complex support a diverse array of invertebrates with differing life histories and feeding strategies that respond uniquely to various habitat conditions. These organisms vary in their tolerance to physical and chemical stressors from both natural and anthropogenic sources, including changes in habitat conditions such as sediment particle size and organic content. Benthic organisms are an important link between primary producers and higher trophic levels of the food web (e.g., fish and birds) and perform crucial ecological functions such as water filtration, nutrient cycling, and bioturbation of sediments. Multiple indices have been developed (e.g., the BRI) that can provide an integrated measure of the overall condition of the benthic infaunal community. Although there are no similar established indices for epibenthic marine invertebrates in southern California, commonly used metrics such as taxa richness, abundance, dominance, diversity, and biomass can be used to assess the relative health of this community across Biosurvey years and among different areas within the Port Complex.

4.1 HABITAT CHARACTERISTICS

Soft-bottom habitat supports several different biological communities. This habitat is found in open-water areas that are predominantly sandy and influenced by tidal currents and wave action, and in more protected areas that are more prone to sedimentation and have a higher proportion of fine-grained material (i.e., mud/silt) and a higher total organic carbon content. The assemblage of soft-bottom species at a given location varies based on the site's physical characteristics and the species' adaptations to those conditions that allow them successfully to forage for food, find shelter from predators, and reproduce.

Soft-bottom habitats are also important for a wide variety of adult and juvenile fishes, especially those managed by NOAA under the Pacific Coast Groundfish (PCG) Fishery Management Plan (FMP) through the Magnuson-Stevens Act. Several of those managed species were captured during the 2023 Biosurvey, including California scorpionfish, vermillion rockfish, chilipepper rockfish, bocaccio, English sole, and Pacific sanddab. Those species and others observed during the 2023 Biosurvey are discussed in more detail in this section.

Data on these communities were collected using a variety of methods, including side-scan sonar to map eelgrass, otter trawls to sample benthic fishes and epibenthic invertebrates, and sediment grabs for benthic infaunal organisms. Details of the field sampling and laboratory and data analysis are presented in Appendix A. For comparative analysis, stations were grouped according to habitat (Inner Harbor, Outer Harbor, and SWH), location (Outer Harbor, SWH, channel, basin, and slip), and depth stratum (Shallow [0–7 meters], Deep [7.1–18 meters], and Very Deep [18+ meters]). Station designations and the grouping of stations for analysis are shown in Tables 4-1 and 4-2.

Table 4-1. Station Analysis Groups and Location Characteristics for Demersal Fishes and Epibenthic Invertebrates

Station	Port	Habitat	Location	Station Description	Station Depth (meters)	Depth Stratum
LB1	POLB	Outer	Outer	Outer Harbor Anchorages	13	Deep
LB2	POLB	SWH	SWH	POLB SWH	7	Shallow
LB3	POLB	Outer	Basin	West Basin	15.5	Deep
LB4	POLB	Inner	Slip	Channel 2	14	Deep
LB5	POLB	Outer	Basin	Southeast Basin East	17.5	Deep
LB6	POLB	Outer	Slip	Pier J South Slip	16.5	Deep
LB7	POLB	Outer	Channel	POLB Main Channel – Pilot Station	24.5	Very Deep
LB9	POLB	Outer	Outer	POLB Outer Main Channel	24.5	Very Deep
LB10	POLB	Outer	Basin	Southeast Basin West	18	Deep
LB12	POLB	Outer	Channel	POLB Main Channel – Police Station	23	Very Deep
LB13	POLB	Outer	Basin	POLB Inner Harbor Turning Basin	20	Very Deep
LB14	POLB	Inner	Channel	Cerritos Channel	18	Deep
LB16	POLB	Inner	Slip	Channel 3	16.5	Deep
Cabrillo Beach	POLA	SWH	SWH	Cabrillo Beach	2	Shallow
LA1	POLA	Outer	Outer	Outer Pier 400	24	Very Deep
LA2	POLA	SWH	SWH	POLA SWH East	6	Shallow
LA3	POLA	SWH	SWH	POLA SWH West	6	Shallow
LA4	POLA	Outer	Channel	POLA Main Channel	18	Deep
LA5	POLA	Inner	Basin	West Basin	16.5	Deep
LA6	POLA	Inner	Basin	POLA East Basin	17.5	Deep
LA7	POLA	SWH	SWH	Seaplane Lagoon	3.5	Shallow
LA9	POLA	Outer	Channel	Pier 300 Channel	18	Deep
LA10	POLA	Inner	Basin	Fish Harbor	7.5	Deep
LA11	POLA	Outer	Outer	POLA Outer Channel	25	Very Deep
LA14	POLA	Inner	Slip	Consolidated Slip	7.5	Deep
LA15	POLA	Outer	Basin	POLA Turning Basin	17.5	Deep
LA16	POLA	Inner	Slip	Banning's Landing	14	Deep
Pier 300	POLA	SWH	SWH	Seaplane Lagoon Beach	2	Shallow

POLA = Port of Los Angeles; POLB = Port of Long Beach; SWH = shallow water habitat

Table 4-2. Station Analysis Groups and Location Characteristics for Benthic Infauna

Station	Port	Habitat	Location	Station Descriptor	CTD Bottom Depth (meters)	Depth Stratum
LB1	POLB	Outer	Outer	Outer Harbor Anchorages – Navy Mole	14	Deep
LB2	POLB	SWH	SWH	POLB SWH	5	Shallow
LB3	POLB	Outer	Basin	POLB West Basin – Navy Mole	15	Deep
LB4	POLB	Inner	Slip	Channel 2	14	Deep
LB5	POLB	Outer	Basin	Southeast Basin East	18	Deep
LB6	POLB	Outer	Slip	Pier J South Slip	17	Deep
LB7	POLB	Outer	Channel	POLB Main Channel – Pilot Station	22	Very Deep
LB8	POLB	Outer	Slip	Outer Pier J Breakwater	12	Deep
LB9	POLB	Outer	Outer	POLB Outer Main Channel	24	Very Deep
LB10	POLB	Outer	Basin	Southeast Basin West	18	Deep
LB11	POLB	Outer	Basin	POLB West Basin	17	Deep
LB12	POLB	Outer	Channel	POLB Main Channel – Police Station	17	Deep
LB13	POLB	Outer	Basin	Inner Harbor Turning Basin	20	Deep
LB14	POLB	Inner	Channel	Cerritos Channel	15	Deep
LB15	POLB	Outer	Outer	Outer Harbor Anchorages – Breakwater	17	Deep
LB16	POLB	Inner	Slip	Channel 3	14	Deep
LA1	POLA	Outer	Outer	Outer Pier 400	21	Very Deep
LA2	POLA	SWH	SWH	Cabrillo SWH Phase 1	5	Shallow
LA3	POLA	SWH	SWH	Cabrillo SWH Phase 3	6	Shallow
LA3-ALT	POLA	SWH	SWH	Cabrillo SWH Phase 4	6	Shallow
LA4	POLA	Outer	Channel	POLA Main Channel	18	Deep
LA5	POLA	Inner	Basin	POLA West Basin	16	Deep
LA6	POLA	Inner	Channel	POLA East Basin Channel	13	Deep
LA7	POLA	SWH	SWH	Pier 300 SWH	4	Shallow
LA8	POLA	SWH	SWH	Seaplane Lagoon SWH	4	Shallow
LA9	POLA	Outer	Channel	Pier 300 Channel	17	Deep
LA10	POLA	Inner	Basin	Fish Harbor	7	Shallow
LA11	POLA	Outer	Outer	POLA Outer Channel	18	Deep
LA12	POLA	Inner	Basin	Cabrillo Marina	3	Shallow
LA13	POLA	Inner	Slip	Berth 118	15	Deep
LA14	POLA	Inner	Slip	Consolidated Slip	6	Shallow
LA15	POLA	Outer	Basin	POLA Turning Basin	17	Deep
LA16	POLA	Inner	Slip	POLA Slip 5	11	Deep

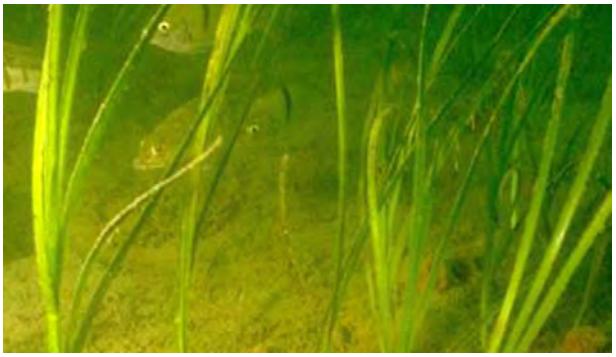
CTD = conductivity, temperature, and depth; POLA = Port of Los Angeles; POLB = Port of Long Beach;
SWH = shallow water habitat

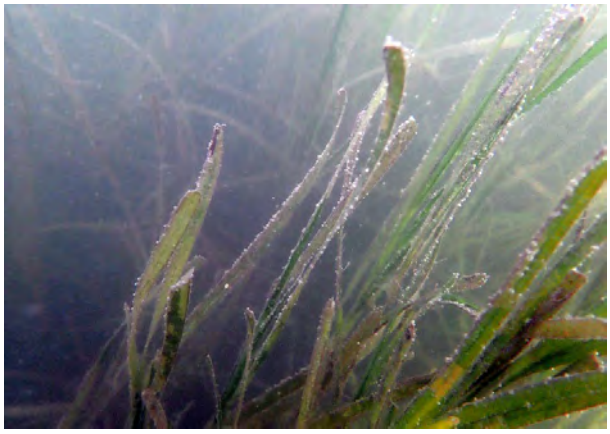
4.2 EELGRASS

Seagrasses are recognized as one of the most productive ecosystems worldwide, and eelgrass is the most abundant and productive seagrass species in the northern hemisphere. Eelgrass (genus *Zostera*) is often referred to as a "foundation species" or "habitat architect" because of its role as a habitat-forming species. Eelgrass beds perform a multitude of ecosystem services (Orth et al., 2012; Waycott et al., 2009) and have been recognized and valued highly for their physical, chemical, and biological functions (Cole and Moksnes, 2016).

Zostera is a community-structuring seagrass that in recent years has become abundant in shallow areas of the Port Complex, particularly within the generally shallower Port of Los Angeles. *Zostera* is a vascular monocot flowering plant that spreads by rhizomatous clonal growth and seedling recruitment. It can form expansive meadows or small beds in both subtidal and intertidal habitats of shallow coastal bays and estuaries, as well as within semi-protected, shallow, soft-bottom environments of the open coast. Eelgrass in Southern California is typically limited to low intertidal elevations along its upper margin by desiccation stress and along its lower margin of growth by limitations on available photosynthetically active light. The elevation range of eelgrass is highly variable and depends on a number of factors, including available soft-bottom habitat, water clarity, suspended sediment load, bottom slope, wave energy and circulation, summer temperatures, and biotic factors of epiphytic loading, bioturbation, and disease.

Eelgrass is widespread in distribution but is highly restricted in abundance both worldwide and within California. It is presently estimated that eelgrass covers approximately 16,000 acres along the California coastline, with approximately 80% of the state's eelgrass occurring in just five coastal systems: Humbolt Bay, Tomales Bay, San Francisco Bay, Mission Bay, and San Diego Bay (NMFS, 2014). Documented eelgrass within the Southern California Bight (i.e., from Point Concepcion south to Punta Colonet in Baja California) totals slightly over 5,000 acres (Bernstein et al., 2011).







Eelgrass beds function as habitat and nursery areas for marine fish and invertebrates, providing cover, forage opportunities, habitat complexity, and enhanced productivity. The photosynthesis within large eelgrass beds contributes to high oxygen levels during daylight hours, and respiration at night can reduce oxygen in proximity to beds. Eelgrass dampens wave energy and stabilizes sediment along the shoreline interface, while concurrently contributing to nutrient cycling, habitat structure, and a complex food web.

4.2.1 REGULATORY CONTEXT OF EELGRASS

Because of the important ecosystem functions it provides, eelgrass has special-status designations under federal and state environmental laws and regulations. The United States Environmental Protection Agency (EPA) has designated eelgrass beds as special aquatic sites under the Clean Water Act, affording them a higher level of protection under federal regulation and policy.

Under the Magnuson-Stevens Act, eelgrass is recognized as a Habitat Area of Particular Concern (HAPC). Although HAPCs are not afforded additional protections, they aid in prioritizing conservation efforts by the NMFS and focusing coordination and consultation concerns under EFH consultations among federal agencies. Under the California Coastal Act, eelgrass is recognized as an Environmentally Sensitive Habitat Area (ESHA).

In 1991, the NMFS adopted the Southern California Eelgrass Mitigation Policy (SCEMP). After 23 years of successful application and 11 revisions, the NMFS replaced the SCEMP 2014 by formal adoption of the California Eelgrass Mitigation Policy (CEMP; NMFS, 2014) that retained many of the elements of the SCEMP. The CEMP has been subsequently used by most state and federal agencies, including the Port Complex, as a standard for eelgrass management needs in California.

Common eelgrass (*Zostera marina*) is the most widespread of the three eelgrass species occurring in California (NMFS, 2014) and the only eelgrass species known to occur in the Port Complex. The open coastal Pacific eelgrass (*Z. pacifica*) occurs near the Port Complex in scattered shoreline beds in East San Pedro Bay. *Z. marina* typically grows in low-energy, shallow-water, soft-bottom environments ranging from silts to fine gravels; however, the optimal growth medium is considered to be silty sands. Within the Port Complex, the distribution of shallow-water soft-bottom habitat is limited (see Eelgrass Depth Distribution discussion in Section 4.2.2), and thus the distribution of eelgrass is similarly restricted.

In addition to their critical resource values and ecosystem functions, eelgrass beds are uniquely suited to serve as a sentinel indicator of overall ecosystem health and condition (Costanza et al., 1997). Eelgrass is easily monitored and widely distributed, and responds in a predictable way to natural and anthropogenic stressors that are chronic in nature. Despite seasonal fluctuations in environmental conditions, eelgrass is relatively consistent during its primary growing season in spring and summer and is resistant to changes driven by short-term environmental fluctuations within normal or near normal ranges. However, eelgrass is vulnerable to stressors that manifest over longer periods, such as persistently elevated water temperature and/or turbidity (e.g., ENSO events and marine heatwaves). Eelgrass may also respond rapidly to physical damage, episodic pollution, and disease, which itself may be facilitated by other stressors that can weaken the natural immunity of the eelgrass bed (Orth et al., 2006).

In the 2023 Biosurvey, eelgrass surveys were conducted throughout the Port Complex in May and September 2023 using a combination of acoustic techniques (i.e., interferometric sidescan sonar), diver surveys, and ROV surveys. The surveys were conducted at both the beginning (spring) and the height (summer) of the growing season to assess potential short-term changes in eelgrass distribution and density. Sonographic surveys were undertaken in the navigable waters of the Port Complex using an interferometric sidescan sonar system.

4.2.2 EELGRASS DISTRIBUTION AND DENSITY

Eelgrass within the Port Complex was identified at discrete locations during both the spring 2023 (Figure 4-1) and summer 2023 (Figure 4-2) survey periods. In Figures 4-1 and 4-2, eelgrass is plotted with a 25-meter locator buffer around all beds to make very small beds more readily apparent, but it is important to note that this presentation results in a visual suggestion of substantially more eelgrass than actually exists in small patches. The broad distribution of eelgrass was generally consistent with distribution identified during prior Biosurvey years, including one location of eelgrass in Slip 1 in the Port of Los Angeles Inner Harbor first noted in 2018 that persisted into 2023. More detailed maps of the eelgrass beds in the Port Complex are provided in Appendix D.

Note that throughout the eelgrass discussion, the terms density and bottom cover have explicit meanings and are not used interchangeably. Density relates to the density of leaf shoot bundles (turions), and bottom coverage is described in terms of acreage that the bed covers across the seafloor.

4.2.2.1 SEASONAL COMPARISONS

Eelgrass in the Port Complex covered approximately 164 acres in spring and 165 acres in summer (Table 4-3). Over 99% of the eelgrass occurred on the Los Angeles side of the Port Complex in both spring and summer, a function of the much greater extent of shallow water on the Port of Los Angeles side than on the Port of Long Beach side. Two sites – the Cabrillo Beach area and the Pier 300 Basin (including Seaplane Lagoon) – contained more than 94% of all the eelgrass within the Port Complex during both seasons of the 2023 Biosurvey. This spatial pattern of occurrence has been consistent throughout past Biosurveys starting in year 2000.

Table 4-3. Distribution of Eelgrass Within Port Complex by Survey Season

Location of Eelgrass Bed	May 2023		September 2023	
	Acres	Percentage of Total	Acres	Percentage of Total
Port of Los Angeles				
Consolidated Slip	1.48	0.9	2.04	1.2
Fish Harbor	0.37	0.2	0.50	0.3
Cabrillo Marina	0.39	0.2	0.72	0.4
POLA Turning Basin	0.73	0.4	0.98	0.6
Slip 1	0.72	0.4	0.67	0.4
East Basin Yacht Marina	3.93	2.4	4.68	2.8
South Cabrillo Beach	0.42	0.3	0.44	0.3
North Cabrillo Beach	33.92	20.8	34.91	21.3
Pier 300 Basin	120.95	74.2	119.17	72.
POLA Channel	0.17	0.1	0.15	0.1
Port of Los Angles Total	*163.07*	*100.0*	*164.24*	*100.0*
Port of Long Beach				
Cerritos Channel	0.42	66.0	0.58	71.7
Navy Mole	0.21	34.0	0.23	28.3
Back Channel	<0.01	<0.01	<0.01	<0.01
Port of Long Beach Total	*0.63*	*100.0*	*0.81*	*100.%*
Total Port Complex (2023)	163.70		165.05	

POLA = Port of Los Angeles



Note that the 25-meter buffer results in a visual suggestion of substantially more eelgrass than actually exists in small patches.

Figure 4-1. Spring Eelgrass Distribution Within the Port Complex – May 2023



Note that the 25-meter buffer results in a visual suggestion of substantially more eelgrass than actually exists in small patches.

Figure 4-2. Summer Eelgrass Distribution Within the Port Complex – September 2023

Seasonal differences in the overall acreage of individual eelgrass beds provide a good indicator of the stability of an eelgrass bed throughout a year and help identify factors affecting eelgrass growth in different areas of the Port Complex. The change in the extent of eelgrass from May through September 2023 is shown graphically in Figure 4-3 for the Pier 300 area; figures for the other areas are included in Appendix D. The areas of change were determined by subtracting the area occupied by eelgrass in September 2023 from that in May 2023. The percentage changes in eelgrass beds between sampling seasons is illustrated in Figure 4-4.

As shown in Figure 4-3, a single bed may exhibit both increases and decreases in eelgrass acreage between the seasons. Note that for even the most stable beds within the Port Complex, only approximately 30 to 50% of their total area remained unchanged with respect to the presence of eelgrass from spring to summer, although the sites occupied by eelgrass remained consistent between seasons. In the most dynamic bed (North Cabrillo Beach), less than 10% of the bed remained unchanged between seasons as a result of dramatic expansion in the beds from May through September 2023.

In general, the largest changes in the area of the larger beds occurred as the beds withdrew at the shallow margins and expanded at their deeper margins, although for smaller and patchy beds, the changes occurred throughout the depth range. Some beds almost doubled in area between spring and summer (e.g., Fish Harbor and Cabrillo Marina), although these increases were somewhat offset by patchy areas of decreased eelgrass within the beds. In all cases except three locations in the Port of Los Angeles (Slip 1, Pier 300 Basin, and Port of Los Angeles Channel), the net eelgrass coverage increased between the spring and summer surveys (Table 4-3, Figure 4-4).

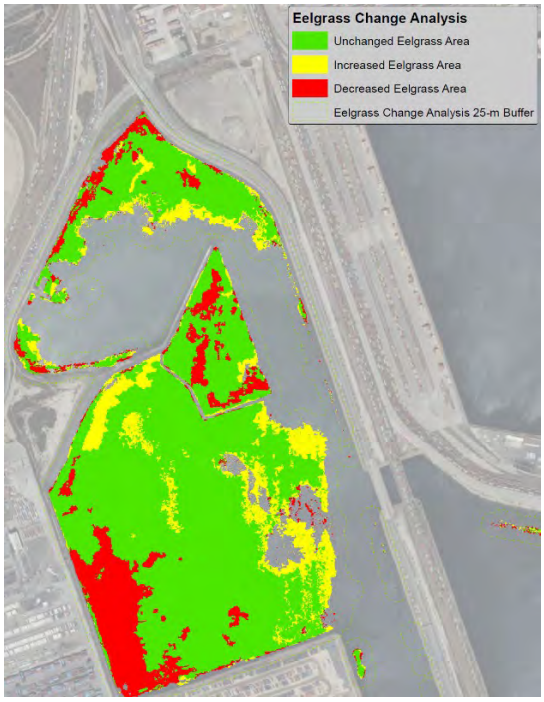
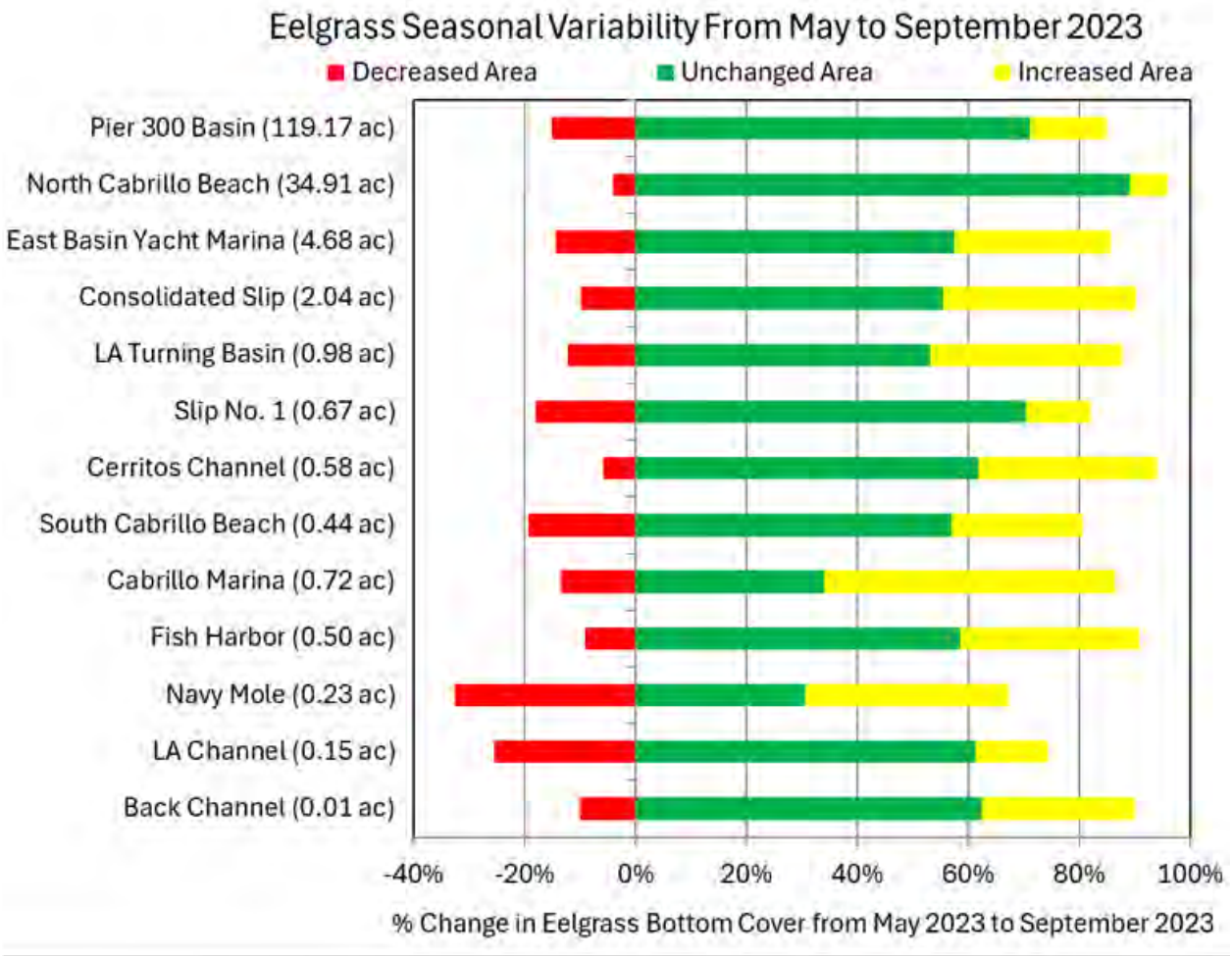


Figure 4-3. Change in Eelgrass Distribution From May 2023 Through September 2023 Pier 300 Basin



Acreage shown is for September 2023. ac = acre(s).

Figure 4-4. Change in Eelgrass Distribution Between May and September 2023

4.2.2.2 EELGRASS DEPTH DISTRIBUTION

During the winter, eelgrass typically experiences a reprieve from high summer temperatures and intense sunlight, and the upper margin of the bed moves higher into the intertidal and shallow subtidal margin (MBC, 2016). In spring and summer, eelgrass is pushed down from the intertidal margin, but more sunlight at depth allows the lower margin of the bed to expand downward. In addition, during the spring, eelgrass seedlings may germinate and grow at depths below those typically suited for long-term support of eelgrass. This occurs as a result of a combination of early-season high water clarity, supplemental energy stores in the seed, and seasonally enriched sediment nutrient levels. As a result, early growing season surveys often demonstrate deeper bed margins made up of plants that typically do not survive through the entire growing season. Within the Pier 300 Basin, early-season shallow eelgrass was replaced with deeper eelgrass as the temperatures rose and the season progressed (Figure 4-3).

Almost 99% of the eelgrass in the Port Complex occurs from +0.5 to -15 feet MLLW. This is a slight decrease from conditions in 2018 and 2013, when 99.5% of the eelgrass occurred within this same depth range. Eelgrass thus is restricted to a very small proportion of the Port Complex because most of the water at the Port Complex is considerably deeper than -15 feet MLLW.

4.2.2.3 EELGRASS DENSITY

Eelgrass beds are characterized by the density of leaf shoot bundles (turions) arising from meristematic tissue at the rhizome tip. Turion density provides information on the overall bed condition and is useful in characterizing differences across beds and seasonally within beds. The raw density sampling data are presented in Appendix D. In southern California, eelgrass turion densities in established beds typically range from 100 to 300 turions/m^2 with deviations from this norm typically occurring in stressful environments that either restrict turion count and increase plant height (e.g., light limitation) or increase turion count and reduce canopy height and leaf width (e.g., increased hydrodynamic energy). In the 2023 Biosurvey, mean density across all samples was 112±66 turions/m^2 (±1 standard deviation [SD], n=240) in spring and 145±63 turions/m^2 (±1 SD, n=200) in summer.

Eelgrass density increased between spring and summer at 8 of the 12 stations (Figure 4-5). No eelgrass was sampled in the summer at the Navy Mole. The order in which the stations are presented in Figure 4-5 generally reflects the most-flushed (i.e., replacement of water as result of tidal flow) to the least-flushed environments in the Port Complex, and as such, tend to reflect Outer Harbor sites followed by Inner Harbor sites. The highest densities occurred in Slip 1, which has relatively poor tidal exchange, and the lowest densities occurred in areas of more moderate exchange such as the Pier 300 Basin, the Navy Mole, and Consolidated Slip (Figure 4-6). The greatest increase in density (269%) was observed at the Fish Harbor site.

Overall, the greatest eelgrass densities occurred in uniformly shallow areas in the Outer Harbor that are more open to tidal exchange and experience higher wave energy; lower densities occurred in deeper areas with sloped embankments and lower circulation and/or less hydrodynamic energy. This is a typical density distribution pattern for eelgrass beds.

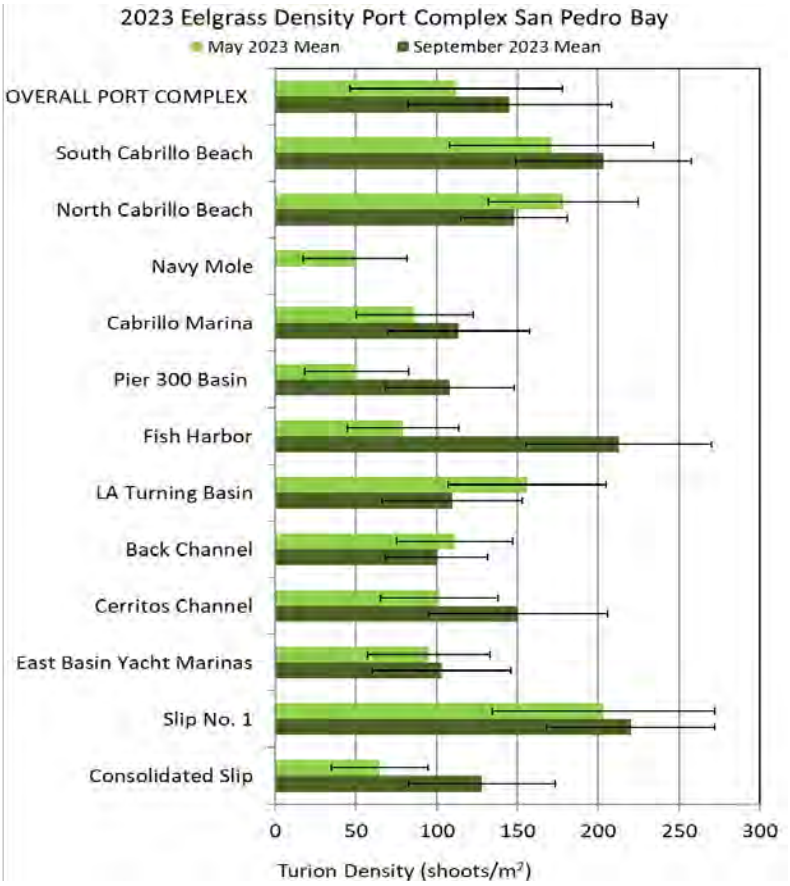


Figure 4-5. Mean Turion Density of Eelgrass in Spring (May 2023) and Summer (September 2023) (±1 Standard Deviation)



Figure 4-6. Eelgrass Turion Density Observed in Spring and Summer 2023

4.2.3 EELGRASS HEALTH AND VIGOR

The health and vigor of eelgrass beds in the Port Complex were assessed on the basis of observations of canopy height, leaf color and turgidity, and stressors that limit photosynthetic potential (Drake et al., 2003), including epiphytic/sediment loading of leaves as an estimated percentage of the leaf surface area. In addition, the percentage of the plants exhibiting signs of wasting disease was noted (where evidence of disease was observed only on dead leaf tissues, the percentage of disease was reported as zero because this is a natural pattern of decay of dead eelgrass). Finally, the characteristics of the surface sediments supporting eelgrass were noted (e.g., silt, mud, sand, and shell hash). The observations are presented in Appendix D.

Canopy height in spring (0.1 to 0.9 meter) was typically lower than in summer (0.2 meter to 1.1 meters), which is typical in California eelgrass beds (Carr et al., 2011). Eelgrass color ranged from the bright green and yellow green of rapidly growing tissues in May 2023 to a typically darker solid green in September 2023.

Epiphytic loading of eelgrass leaves, usually a sign of eutrophication or lack of grazers in estuarine systems (Drake et al., 2003), varied substantially across beds and seasons. The lightest loading ranged from 20 to 40% (North Cabrillo Beach, Pier 300 Basin, Fish Harbor, and Consolidated Slip), with most beds in the 30 to 70% range and a few beds with heavy epiphytic loading (East Basin Yacht Marinas 50 to 80%, Port of Los Angeles Turning Basin 70 to 80%, and Slip 1 90 to 100%). During both sampling periods, macroalgae, composed principally of *Ulva* sp., *Chaetomorpha* sp., and *Gracilaria* sp., were abundant along the margins of eelgrass beds and were also common within the interior of several beds, particularly beds that were sparse and shallow.

Sediment loading of eelgrass leaves is noted as cover of sediment over visible green plant tissue. It is important because heavy sediment loading precludes adequate light reaching the leaves to support photosynthesis (Drake et al., 2003). Little sediment loading was noted during spring and summer 2023 in most eelgrass beds throughout the Port Complex, with only light sediment loading noted in the Port of Los Angeles Turning Basin in spring and East Basin Yacht Marinas in the summer. None of the sediment loading was high enough to be judged substantively detrimental to the health of the eelgrass.

Eelgrass in the Port Complex did not exhibit strong blemish and leaf erosion patterns of wasting disease in 2023, although limited disease blemishes were noted on plants in some of the beds (Appendix D).

4.2.4 HISTORICAL COMPARISONS

The earliest known efforts to quantify eelgrass in the Port Complex were undertaken in 1996 and 1999 by the Southern California Marine Institute. These studies surveyed eelgrass within specific portions of the Port of Los Angeles where eelgrass was known to exist. The 1996 survey assessed only the Cabrillo Beach area, and the 1999 survey addressed both Cabrillo Beach and the Pier 300 SWH (Gregorio, 1999). Survey methods included visual observations, fathometer readings, and diver transects. Although these investigations provided insights into the distribution of the primary eelgrass within the Port Complex, the methods applied provided less detailed and comprehensive data than provided by the sidescan sonar method in the surveys in spring and summer months during 2000, 2008, 2013, 2018, and 2023 Biosurveys.

The previous five Biosurveys have included nine seasonal surveys of eelgrass in the Port Complex, making it possible to examine the recent history of the occurrence of eelgrass. Although methodological differences between the Biosurveys – aggregated density classes in 2000 and 2008 versus discrete bed mapping limits starting in 2013 and continuing in 2018 and 2023 – limit the overall accuracy of numeric area comparison, it is nevertheless possible to evaluate the long-term stability of eelgrass beds within a given area by digitally overlaying the spatial data layers from each survey and determining how often eelgrass was reported for that area as a percentage of the survey intervals. Accordingly, when eelgrass was present during only one of nine surveys, the occurrence frequency would be 11%; the presence of eelgrass during six of nine surveys would result in a 67% occurrence frequency. Because of a lack of comparability, data from the 1996 and 1999 surveys were omitted from this analysis.

The analytical results confirm the persistence of eelgrass beds in the shallows of North and South Cabrillo Beach and in the Pier 300 Basin since 2000 (the darkest areas in Figure 4-7). Eelgrass has persisted within portions of these three stations across all historical surveys, although the deeper margins of these areas exhibit dynamic conditions, with the frequency of occurrence ranging from 11 to 44% over much of the overall bed area. The occurrence frequency of

eelgrass within the Pier 300 SWH has been limited to no more than 78% because eelgrass was planted at the site as mitigation for the Pier 300 fill after the completion of the first two surveys in 2000. Similarly, a low-occurrence frequency is shown within the Pier 300 fill footprint because that area was filled following the 2000 surveys. Similarly, a low occurrence frequency has been documented at the southeastern margin of Cabrillo Beach where eelgrass habitat was developed for mitigation purposes subsequent to the 2013 Biosurvey. Because of the mapping scale, it is hard to see small patches of eelgrass with low frequency of occurrence that are scattered throughout the Port Complex. However, note that, in most instances, few eelgrass beds outside the Cabrillo Beach and the Pier 300 Basin (including Seaplane Lagoon) exceeded a 56% occurrence frequency because of the non-persistence of individual plants and the relatively recent emergence of many of those beds.

The current Port Complex-wide Biosurvey noted eelgrass in core areas and areas where eelgrass has not previously been observed. However, eelgrass has been observed to be developing in small patches throughout the Port Complex during recent 2018 and 2023 Biosurveys. The first substantial expansion of eelgrass into areas not previously noted was in the mid-2000s, when eelgrass was documented in the Consolidated Slip and the East Basin Yacht Marinas while investigating potential locations for positioning flow sensors for the Dominguez Channel Hydrodynamic and Water Quality Study (K. Merkel, pers. obs., 2005), in the Cabrillo Marina Basin, and in 2011 along the Cerritos Channel east of the Heim Lift Bridge (MBC, 2011). During the 2023 Biosurvey, eelgrass was noted to be expanding within Slip 1, following its earliest detection during the 2018 Biosurvey.

Although the frequency of eelgrass occurrence map (Figure 4-7) provides a valuable tool to explore the persistence of eelgrass in the Port Complex, numeric comparisons of the present and prior eelgrass mapping efforts have been intentionally avoided in this report because of the methodological inconsistencies noted above. The mapping methodologies have evolved from a three-class bottom coverage with a lower limit threshold at 5% bottom cover (2000), to a simplified two-class bottom coverage mapping classification without range definition (2008), to discrete plant boundary-mapping methods applied from 2013 through the 2023 Biosurvey. These differences in methodology do not permit meaningful numeric interpretation of eelgrass extent; the application of the broader cover classes in 2000 and 2008 resulted in overestimating eelgrass relative to the discrete mapping applied in more recent survey periods.

In 2023, eelgrass beds grew at deeper depths in Inner Harbor areas, such as along Cerritos Channel and within marina basins, as opposed to Outer Harbor areas, as one might expect because of more oceanic influence and greater water clarity and flushing. Similar observations of deep eelgrass beds have been made within the industrialized portions of San Diego Bay where it is believed that water clarity is enhanced by an inability to suspend sediment through wind waves, relatively slow water turn-over and thus continued settlement of suspended particulates, and trapping and removal of sediment by filter-feeders as the water circulates through. This observation may point to greater average water clarity in the Inner Harbor than in the Outer Harbor, as shown in the turbidity and transmissivity data presented in Section 2.

Although the locations of eelgrass distribution within the Port Complex have remained similar over many years, there has been clear and accelerating shift in the average depth of eelgrass. To explore trends in the depth distribution of eelgrass within the Port Complex, the eelgrass area across a depth gradient was plotted for each of the past five summer season surveys in the Biosurveys, and the average depth of eelgrass during each survey was plotted (Figure 4-8). The plot indicates a notable pattern of the average depth of eelgrass increasing over the past 15 years due to an expansion of eelgrass into deeper areas of the Port Complex, with the most significant expansion occurring from 2018 through 2023. The shift in average bed depth is related principally to expansion of eelgrass into deeper waters within the Pier 300 Basin and on the sloping bottom at Cabrillo Beach. However, throughout the Port Complex, eelgrass is growing in deeper waters than it has historically.



Figure 4-7. Frequency of Eelgrass Occurrence During Nine System-wide Biosurveys in 2000, 2008, 2013, 2018, and 2023

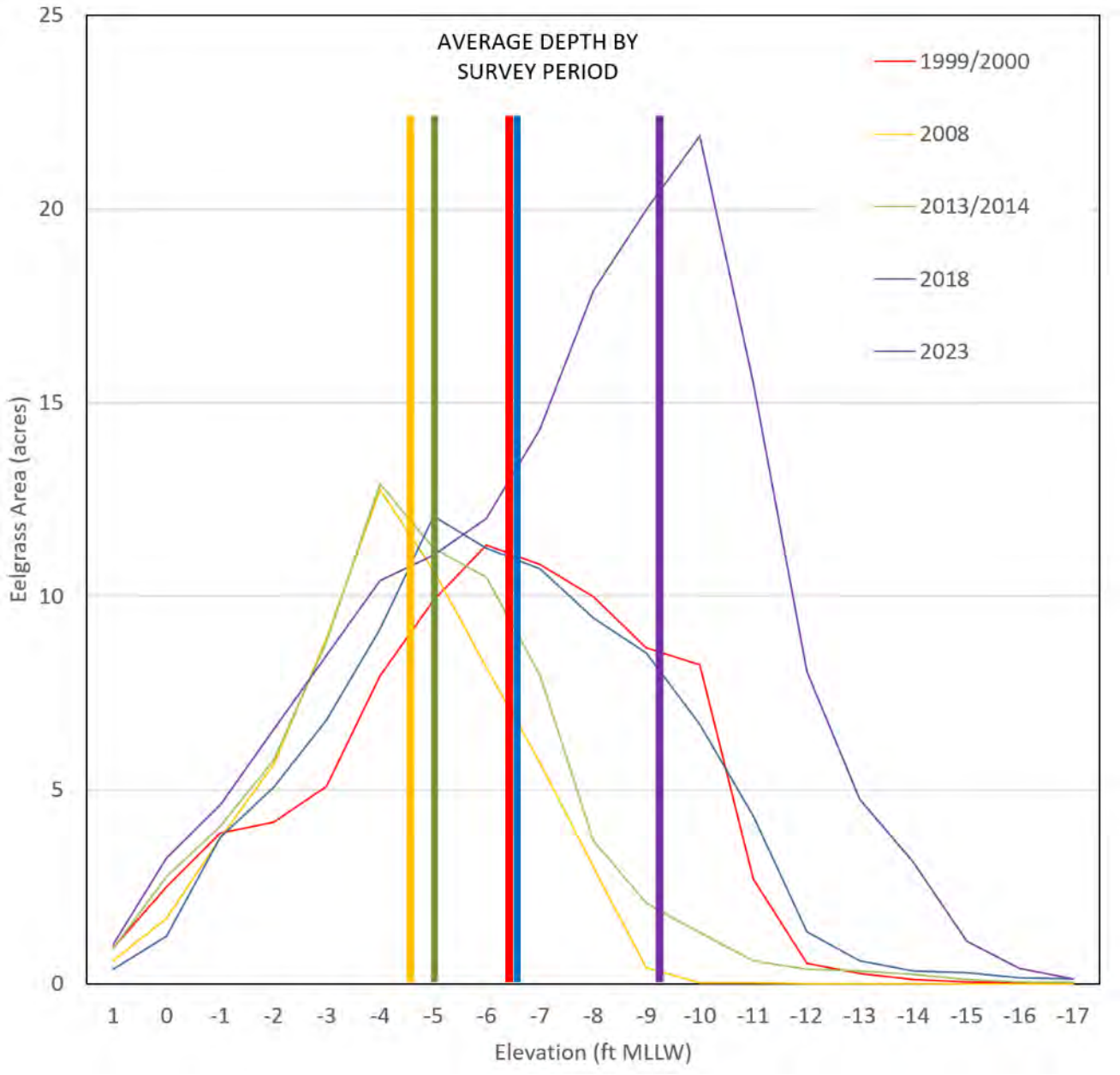


Figure 4-8. Summer Eelgrass Depth Distribution and Mean Elevation – 1999–2023

The apparent shift in mean elevation between the 2000 survey (-6.4 feet MLLW) and the 2008 survey (-4.8 feet MLLW) was predominantly driven by construction of a 14.5 -acre shallow water eelgrass mitigation site for Pier 300. This site composed nearly 17% of the eelgrass in the Port Complex when constructed and thus had a substantive effect on raising the average depth distribution of the beds. Subsequent Biosurveys have shown a steady increase in the average depth of the eelgrass beds, despite the construction of a 3-acre shallow water (-3 to -6 feet MLLW) eelgrass mitigation site at Inner Cabrillo Beach in 2016. This small mitigation site likely had little effect on the Port Complex-wide trend observed between the 2013 and 2018 surveys because the South Cabrillo kelp bed in represents less than 1% of the total eelgrass in the Port Complex.

4.2.5 DISCUSSION

Approximately 94% of the eelgrass in the Port Complex occurs in two areas: the Pier 300 Basin and the Cabrillo Beach area, including 14.5 acres planted in 2003 and 3.05 acres planted as mitigation in 2016 (Merkel and Associates, 2008, 2020). As a result of those plantings and natural recruitment, these core areas have supported most of the eelgrass throughout the five Port Complex-wide Biosurveys. Considerable expansion of eelgrass has occurred within the Port Complex as water clarity has increased, and eelgrass is growing in deeper waters than it has in prior years. The eelgrass beds in the Port Complex appear healthy, with limited sediment loading and no eelgrass wasting disease noted.

Changes in mapping methodologies over the past 2 decades limit the ability to make robust numerical comparisons of eelgrass acreage over time prior to the consistent explicit mapping methods adopted in 2013. However, the changes in eelgrass distribution throughout the Port Complex clearly indicate the improving suitability of the Port Complex to support eelgrass. In 2000, eelgrass was limited to beds at Cabrillo Beach and Pier 300 Basin and a very small bed, probably a single plant, reported along the shoreline of Pier A (Berth A88) within the Cerritos Channel (MEC, 2002).

In March 2000, a single floating leaf in the Port of Long Beach Back Channel indicated the presence of Pacific eelgrass (*Z. pacifica*) in the area; however, to date, this species has not been identified in the Port Complex, and the leaf was likely derived from one of the small beds known to occur in eastern San Pedro Bay, east of the Port Complex. Opportunity may exist for natural recruitment to establish Pacific eelgrass adjacent to the Cabrillo Beach Pier on the SWH fills constructed in this region by the Port of Los Angeles because these areas have more connectivity to the ocean and *Z. pacifica* is more commonly found in coastal shelf habitats and at the Channel Islands.

In 2008, eelgrass beds were again mapped only within the two core areas, but a small number of other beds were reported to exist based on referenced reports by other researchers (SAIC, 2010). By 2013, eelgrass was well represented as scattered plants in the limited shallow soft-bottom habitat areas of the Port Complex (MBC, 2016). Finally, during the 2018 Biosurvey, eelgrass became well represented in persistent beds distributed widely through the suitable habitats of the Port Complex. From 2018 through 2023, the amount of eelgrass in the Port Complex continued to grow, increasing by 79% to as much as 165 acres of eelgrass. This is an increase of approximately 100 acres from the low extent of eelgrass mapped during earlier Biosurveys and reflects a continuous increase in the extent of eelgrass since 2008.

The notable expansion of eelgrass throughout the Port Complex over the past several years is likely a result of many factors, but primarily improving water clarity conditions. The increased water clarity is likely due largely to prolonged drought conditions that have persisted over recent years until the 2022–2023 water year (Table 2-2, Section 2) but also to some extent by the effects of increasing control of upland runoff. Another likely important factor is the increase in suitable eelgrass habitat as areas become shallower because of sediment accretion. Although periods of favorable conditions have likely contributed to expansion, long-term stressors such as warm water anomalies, ENSO events, and outbreaks of wasting disease have also resulted in eelgrass declines on timescales shorter than the historical Biosurvey recurrence frequency. These events have adversely affected eelgrass in many systems along the southern California coast, and all these types of events have had detectable effects on eelgrass dynamics within the Port Complex. These periodic stressors create instability within eelgrass habitat and can lead to localized extirpation of eelgrass from marginal environments. As a result, some of the smaller stands of eelgrass within the Inner Harbor may disappear over time, and others may emerge because of random recruitment events. Concurrently, larger core areas may fluctuate substantially in area and intra-site distribution, but these beds are unlikely to disappear as a result of climatic instability, and they will be important sources of seed for natural recolonizations of eelgrass stands following extirpations.

The bed dynamics observed in the Port Complex in 2023 underscore the relative plasticity of eelgrass between survey years and seasons. The seasonal patterns of eelgrass change are consistent with recurrent patterns of vegetated and seedling recruitment events and plant mortality drivers. During winter months, it is not uncommon to observe bed declines along the lower margins and expansions higher up on the shoreline. As summer progresses, beds decline along the shallow margin and expand into deeper areas. Changes in eelgrass beds follow a natural cycle as a consequence of seasonal variations in temperature, light availability, and other physical stressors such as winter storm events.

It is anticipated, however, that in the future, with changing climate conditions, eelgrass will recede along the deeper margins as a result of sea level rise. Increased sea surface temperatures are also a risk to eelgrass beds because temperatures above 25°C are known to be stressful to *Z. marina,* and temperatures above 30°C are lethal (Lee et al.,

2007; Kaldy, 2014). Eelgrass beds may also act as a local buffer against ocean acidification (Ricart et al., 2021a) and can be beneficial to species that may be sensitive to rising pH levels, such as oysters (Ricart et al., 2021b).

4.3 BENTHIC INFAUNA

The benthic infauna community is made up of organisms living in the sediments of the seafloor. Benthic infauna sampling was performed by Anchor QEA in coordination with the RMC Program and the Bight 2023 Regional Monitoring Program. Samples were collected during the spring (April) and summer (August) of 2023. Sediment samples were collected using a VanVeen grab sampler and filtered through a 1.0-mm sieve onboard the vessel. The organisms were sorted by the taxonomy laboratory to the lowest taxonomic group. A total of 33 samples were analyzed.

To determine the overall condition of benthic infaunal communities, the Biosurvey used multiple lines of evidence, including the BRI for bays and harbors (Smith et al., 2003), which is an established multi-metric indicator. The BRI is one of three types of benthic indices recognized for biocriteria development by the EPA. Others include the standard biological community metrics also used in Section 3 of this report, such as abundance, taxa richness, biomass, and various diversity indices. The individual metrics are useful to understand the characteristics of the benthic community, and the BRI provides a measure of overall biotic integrity.

4.3.1 SPECIES COMPARISONS

4.3.1.1 BENTHIC INFAUNA SURVEY AREA SUMMARY METRICS

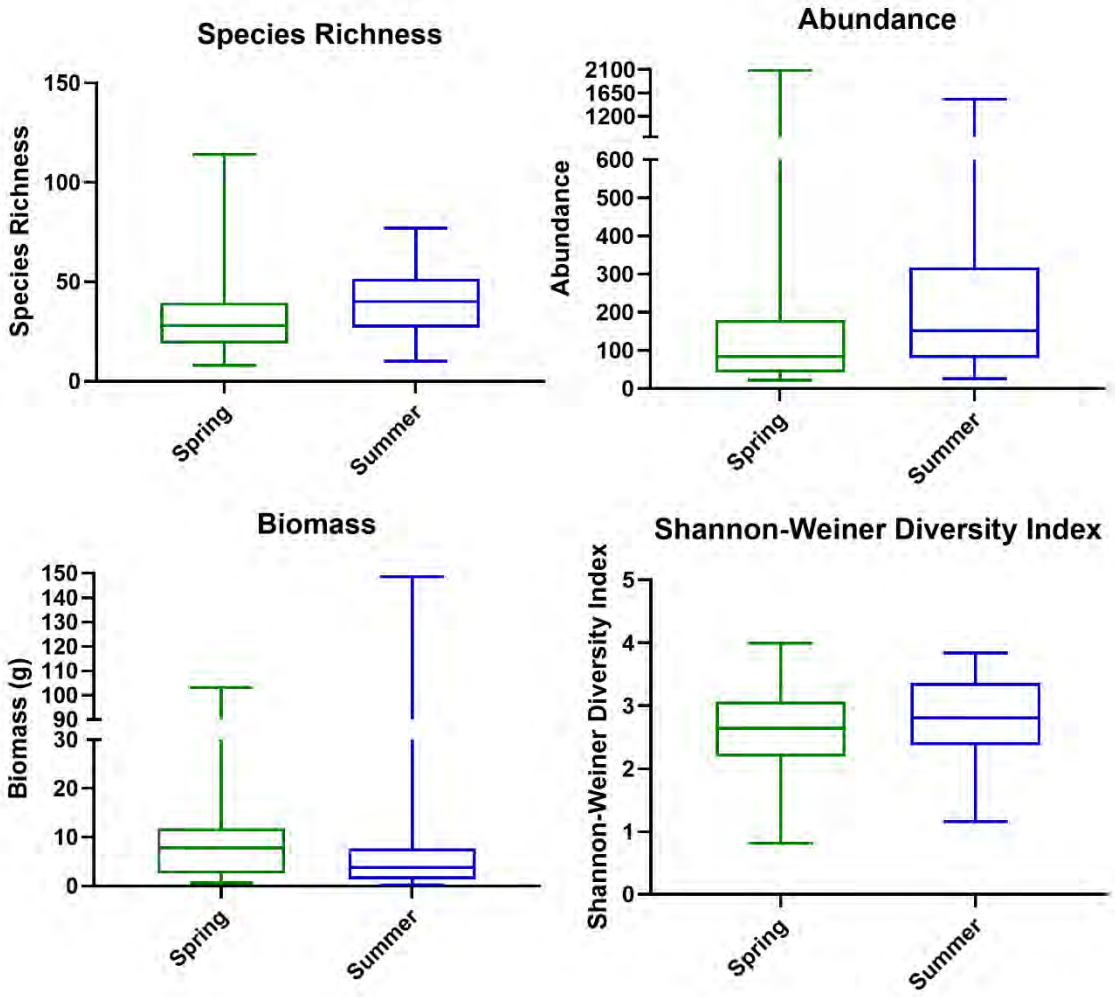
Summing all samples, stations, and seasons, 18,848 organisms representing 372 unique taxa were identified (Appendix D). Total abundance and richness were very similar between seasons, with 9,062 organisms (332 unique taxa) collected in the spring and 9,786 organisms (321 unique taxa) collected in the summer.

Abundance per station in spring ranged from 22 (station LA15) to 2,085 (station LA10) organisms per sample; in summer, it ranged from 26 (station LB6) to 1,531 (station LA2) organisms per sample (Figure 4-9; Appendix D). Species richness per station in spring ranged from 8 (station LB10) to 114 (station LB9) and in summer from 10 (station LA11) to 77 (stations LB10 and LB13).

Infaunal biomass for all stations and surveys combined totaled 711 grams, with 377 grams in the spring and 334 grams in summer. Per-station biomass in spring ranged from 0.64 grams (station LB5) to 103.3 grams (station LB16) and in summer from 0.25 grams (station LA11) to 148.6 g (station LB13), as shown in Figure 4-9.

Shannon-Wiener Diversity Index scores ranged from 0.82 (station LA10) to 4.00 (station LA1) in the spring and from 1.16 (station LA10) to 3.84 (station LB13) in the summer (Figure 4-9).

When evaluating all samples and stations, the only statistically significant difference between the two seasons was for species richness, which was higher in the summer (mean of 40.0 species per station) compared with spring (31.8 species per station; Figure 4-9).



Whiskers represent the range, the line represents the median, and boxes represent the first quartile above and below the median.

Figure 4-9. Median and Range of Benthic Infauna Community Metrics (per Station) in Spring and Summer – All Stations Combined

4.3.1.2 TAXONOMIC COMPOSITION BY MAJOR PHYLA

Annelida (primarily polychaete worms) was the most abundant phylum, composing 74.5% of the total abundance in the spring and 53.4% of the total abundance in the summer (Figure 4-10, Appendix D). Arthropoda (crustaceans) was the second most abundant phylum, comprising 15.4% and 32.6% of the total abundance in spring and summer, respectively.

Biomass of major phyla showed somewhat different results than abundance in that there was a different dominant phylum group in each season. Mollusca had the highest biomass in spring and summer, with 46.4% and 39.3% of the total, respectively. Occasionally, one or a few large organisms can dominate the biomass in a single sample. Larger individuals of both Annelida and Mollusca were captured in a few samples, resulting in substantially greater biomass than average. This was particularly evident in the station LB16 sample collected in spring in which one individual mollusk accounted for 57% of the sample biomass. The summer taxa contained more mollusk biomass (20.4%) compared to the spring taxa (11.9%). Echinodermata (primarily brittle stars) contributed the least biomass across both seasons, with 0.1% and 0.03% of the total biomass in spring and summer, respectively.

Taxonomic richness varied little from spring to summer (Figure 4-10). Annelida was the most diverse major phylum and composed 60.5% and 53.1% of the total taxa collected in spring and summer, respectively. Arthropoda had similar diversity values among the seasons, with each composing roughly 16% of the taxa for both surveys. Echinodermata were represented by the lowest number of taxa, 2.6% and 2.4% of the total in spring and summer, respectively, and were primarily Ophiuroidea (brittle stars).

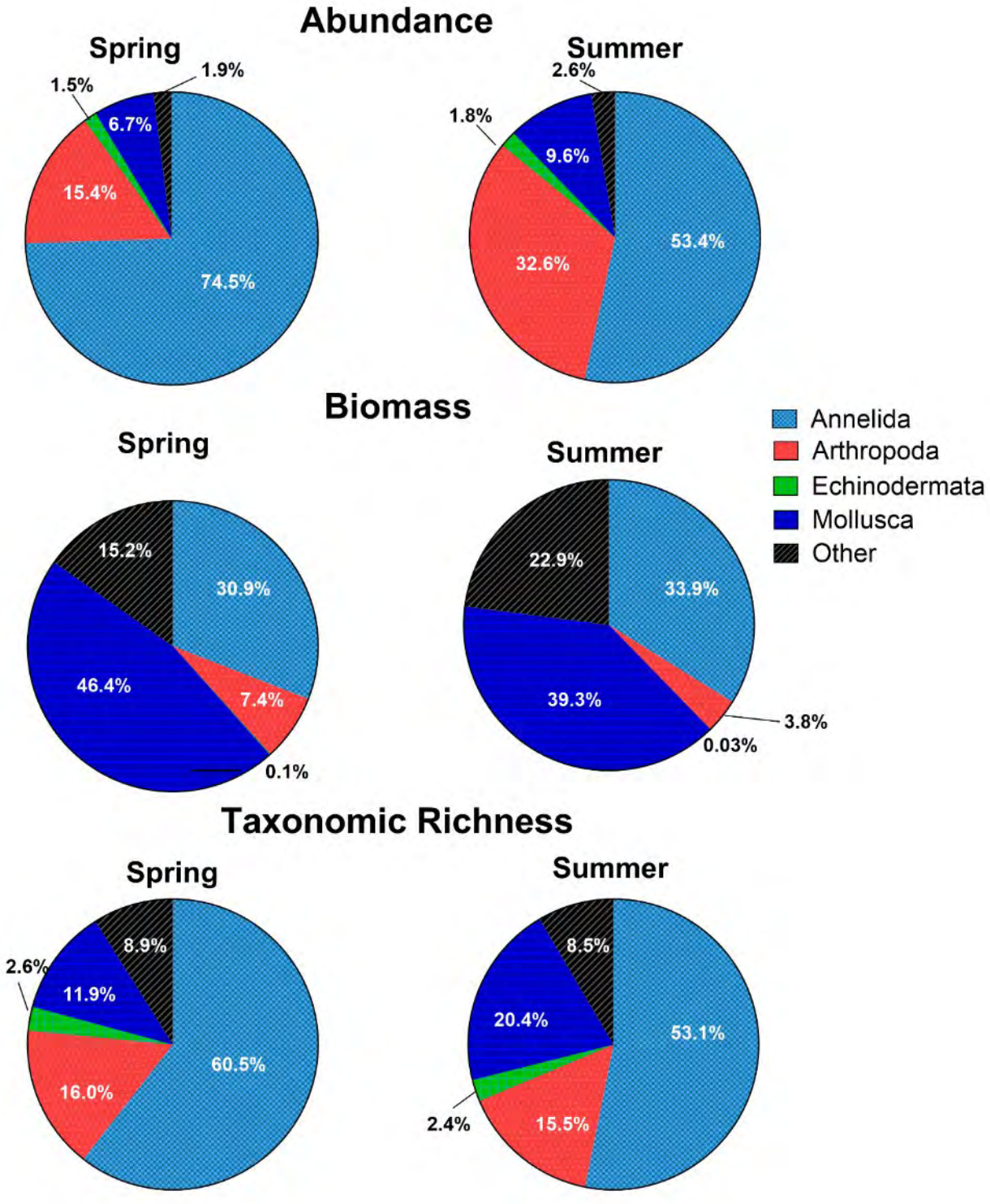


Figure 4-10. Relative Major Taxa Group Percentages for Benthic Infauna Abundance, Biomass, and Richness in Spring and Summer Among All Stations Combined

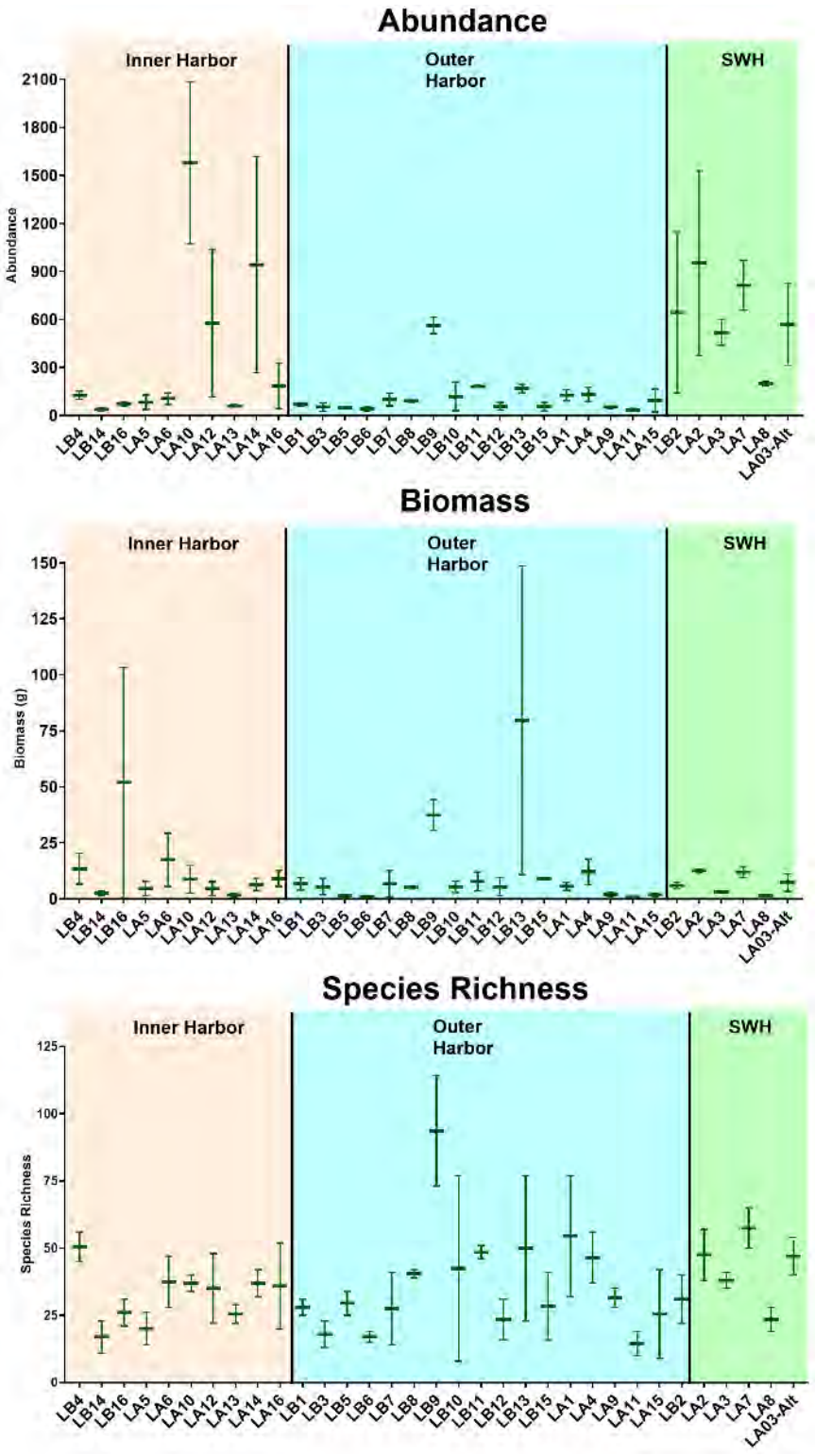
4.3.2 STATION COMPARISONS

4.3.2.1 INFAUNA ABUNDANCE, BIOMASS AND RICHNESS BY STATION

Figure 4-11 shows the mean and range of abundance, biomass, and species richness separated by station and grouped by habitat. In general, the SWH stations had greater mean abundances than the Inner Harbor and Outer Harbor stations. The exception was Inner Harbor station LA10, which had substantially greater abundance in the spring than all other stations in both spring and summer. That pattern was largely accounted for by the abundance of the non-native polychaete *Pseudopolydora paucibranchiata* in both spring and summer (84% and 77%, respectively) of the abundance at that station.

Other than outlier stations in the Inner Harbor (station LB16) and Outer Harbor (station LB13), biomass was generally consistent throughout the Port Complex, ranging from 3 grams to 18 grams per station, and no habitat group exhibited consistently greater biomass. However, biomass at some stations was quite variable between seasons. For example, station LB13 in the summer had 82.6 grams of mollusks, but the spring sample had only 2.1 grams of mollusks. The occurrence of shell-forming species had a large influence on the total biomass of infauna at each station.

Richness was similar to biomass in that it was generally consistent across stations, with a few stations in the Outer Harbor (stations LB9, LB10, LB13, and LA1) and SWH (station LA7) having above-average richness in both seasons. There was also large variability at some stations, particularly station LB10, which had eight species in the spring and 77 species in the summer.



Vertical line represents range of sample values; horizontal bar represents the mean value.

Figure 4-11. Mean and Range of Benthic Infauna Abundance, Biomass, and Species Richness in Spring and Summer, Separated by Station

4.3.2.2 DOMINANT BENTHIC INFAUNA

In both the spring and summer surveys across all stations combined, the dominant taxon was the non-native annelid *Pseudopolydora paucibranchiata*, which composed 31.4% and 21.3% of infaunal community abundance in spring and summer, respectively (Table 4-4). The second most abundant taxa were the annelid *Capitella capitata Cmplx* in the spring and the sensitive, pollution-intolerant arthropod *Amphideutopus oculatus* in the summer; the third most abundant was the polychaete *Cossura* sp. A in both seasons. Many of the most abundant taxa were unevenly distributed throughout the Port Complex. For example, in the spring survey, 96.2% of *Pseudopolydora paucibranchiata* individuals were collected from two stations (LA7 and LA10), and 97.0% of *Capitella capitata Cmplx* were collected from a single station (LB14). In the summer survey, 97.1% of *Amphideutopus oculatus* were collected from three stations (LA2, LA3, and LB2). All but 1 of the 10 most abundant taxa were either annelids or arthropods; the clam *Theora lubrica* was particularly abundant in spring. Note that 3 of the top 10 species in spring and summer were non-natives.

Table 4-4. Ten Most Abundant Benthic Infauna Collected Across all Stations – Spring and Summer, 2023

Spring 2023		Summer 2023	
Taxon	Percent Composition	Taxon	Percent Composition
Pseudopolydora paucibranchiata[2]	31.4	*Pseudopolydora paucibranchiata*[2]	21.3
Capitella capitata Cmplx	11.7	*Amphideutopus oculatus*[1]	11.1
Cossura sp. A	3.5	*Cossura* sp. A	2.8
Theora lubrica[2]	3.0	*Caprella simia*[2]	2.4
Amphideutopus oculatus[1]	2.7	*Photis brevipes*	2.1
Aphelochaeta petersenae	2.5	*Monocorophium acherusicum*[2]	2.1
Oligochaeta	2.1	*Caprella* sp.	2.1
Grandidierella japonica[2]	2.1	*Aphelochaeta petersenae*	2.0
Mediomastus sp.	2.0	*Leitoscoloplos pugettensis*	1.8
Chondrochelia dubia Cmplx	1.7	*Paramicrodeutopus schmitti*	1.6

1. Denotes sensitive, pollution-intolerant species.
2. Denotes non-native species

4.3.2.3 RELATIVE ABUNDANCE, BIOMASS, AND TAXONOMIC RICHNESS BY STATION

Figure 4-12 shows the relative proportions for abundance, biomass, and richness of each major phylum, separated by station (both seasons combined). Annelida, Anthropoda, and Mollusca were the most abundant taxa at the Inner Harbor and Outer Harbor stations; SWH stations generally had greater abundance of Arthropoda (primarily amphipods) relative to other taxa. Echinoderms (primarily brittle stars) were the least abundant of the four main phyla and were found in greatest numbers at stations LA8 and LA11. Inner Harbor and Outer Harbor stations had more taxa that fit into the "Other" category than SWH stations did. These included ribbon worms (Nemertea), horseshoe worms (Phoronida), tunicates (Chordata) and sea pens, and anemones (Cnidaria).

Biomass was dominated by Annelida at most of the Outer Harbor stations, and biomass was dominated by a mix of mollusks and annelids at the Inner Harbor stations. Biomass at the SWH stations was more balanced among annelids, arthropods, and mollusks. Echinoderm biomass was very low at all stations. Stations such as LB16, with several large bivalves (mussels, clams) compared with many other animals, show how the relative biomass contribution of Mollusca can be so high while the relative abundance is low.

Although abundance and biomass of the major benthic infauna categories varied among stations and habitat type within the Port Complex, the relative taxonomic richness remained fairly consistent across all stations except the SWH stations. Annelid taxa composed the largest percentage of the total diversity at all stations except SWH stations LA8 and LA2, at which arthropods contributed the most taxa.

4.3.2.4 BENTHIC INFAUNA CHARACTERISTICS BY HABITAT TYPE, LOCATION, AND DEPTH

To further assess spatial patterns of benthic infauna distribution within the Port Complex, stations were grouped according to habitat type (SWH, Outer Harbor, and Inner Harbor), location (SWH, Outer Harbor, basin, channel, and slip) and depth (Shallow 0–7 meters, Deep 7.1–18 meters, and Very Deep 18+ meters). Data from both sampling seasons (spring and summer) were combined for this evaluation. Differences in diversity (taxonomic richness), abundance, and biomass were then assessed across these station groups. The results are shown in Figure 4-13 (habitat), Figure 4-14 (location), and Figure 4-15 (depth).

Mean species richness and biomass were similar across habitat types, and mean abundance was on average highest at the SWH stations. Outer Harbor and Inner Harbor stations had similar mean abundance, but Inner Harbor stations had the highest range across all stations (Figure 4-13). All three diversity indicators showed a similar pattern, with the Outer Harbor stations consistently exhibiting the highest diversity index values. This reflects the fact that both the SWH and Inner Harbor habitats exhibited greater dominance by a few species; for example, three of the six SWH stations were dominated by the amphipod *Amphideutopus oculata* and three stations in the Inner Harbor were dominated by *Capitella capitata Cmplx* and the non-native *Pseudopolydora paucibranchiata*.

By location, species richness was similar everywhere, although particularly high species richness occurred at three Outer Harbor stations (LA1, LB9, and LB14; Figure 4-14). Mean abundance was similar at all location groups except the SWH stations, which had greater mean abundance. Mean biomass was not distinctly different across location groups, with large ranges in Outer Harbor, basin, and slip stations where mollusks may skew the patterns observed as just a few large individuals can heavily influence the range and means.

Mean evenness and diversity index scores were highest at Outer Harbor and channel stations compared with other stations despite those stations having the lowest mean abundances (Figure 4-14). As with habitat types, the SWH stations exhibited the lowest mean diversity index scores, particularly with Pielou's Evenness Index, which is more sensitive for samples dominated by one or two taxa.

When sorted by depth, species richness was highest at the Very Deep stations, mean total abundance was highest at Shallow stations, and biomass varied little with depth, although the abundance of mollusks at Deep and Very Deep stations resulted in higher ranges at those stations (Figure 4-15). The diversity and evenness index scores indicate that diversity and evenness increase with depth.

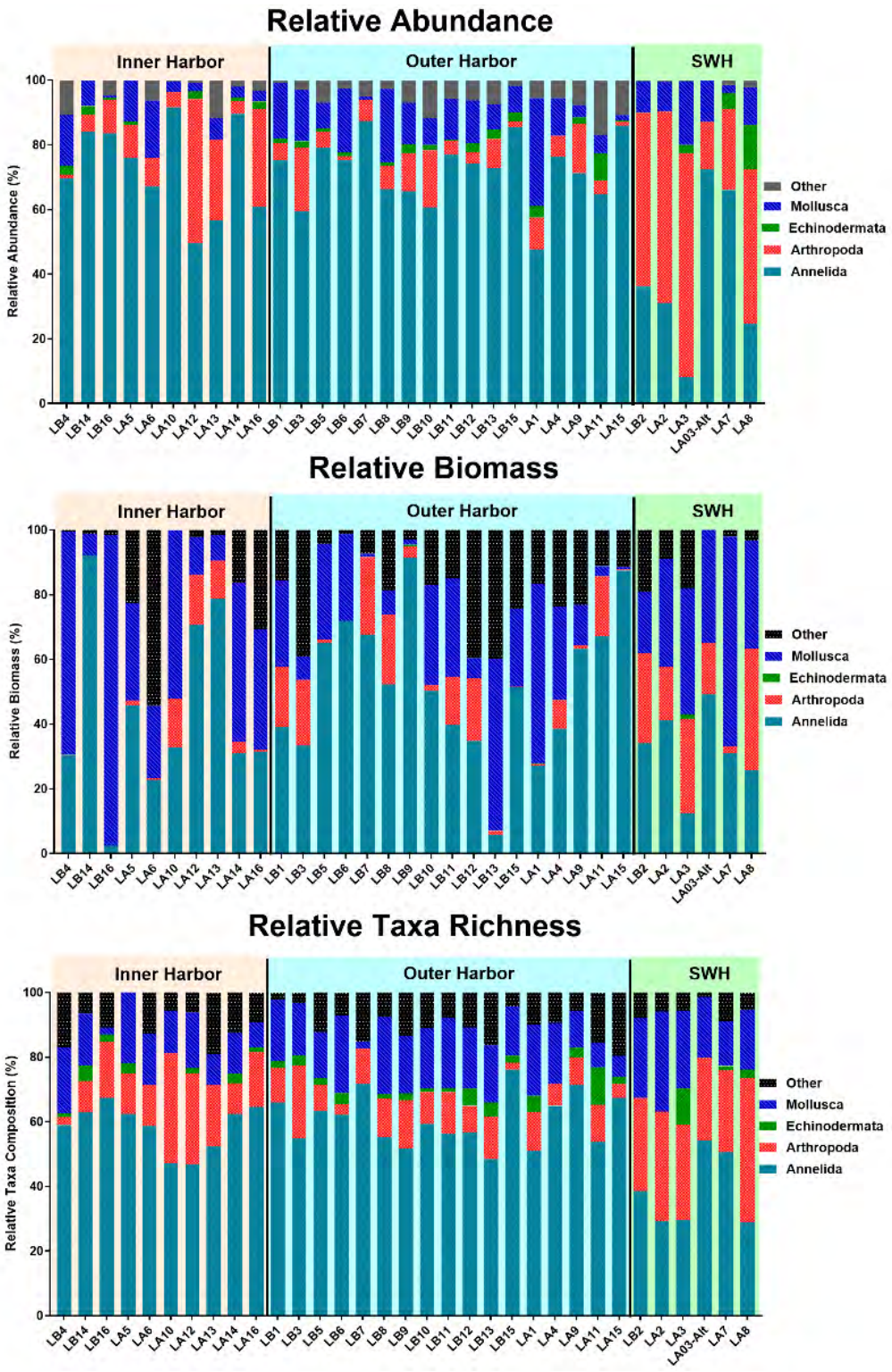
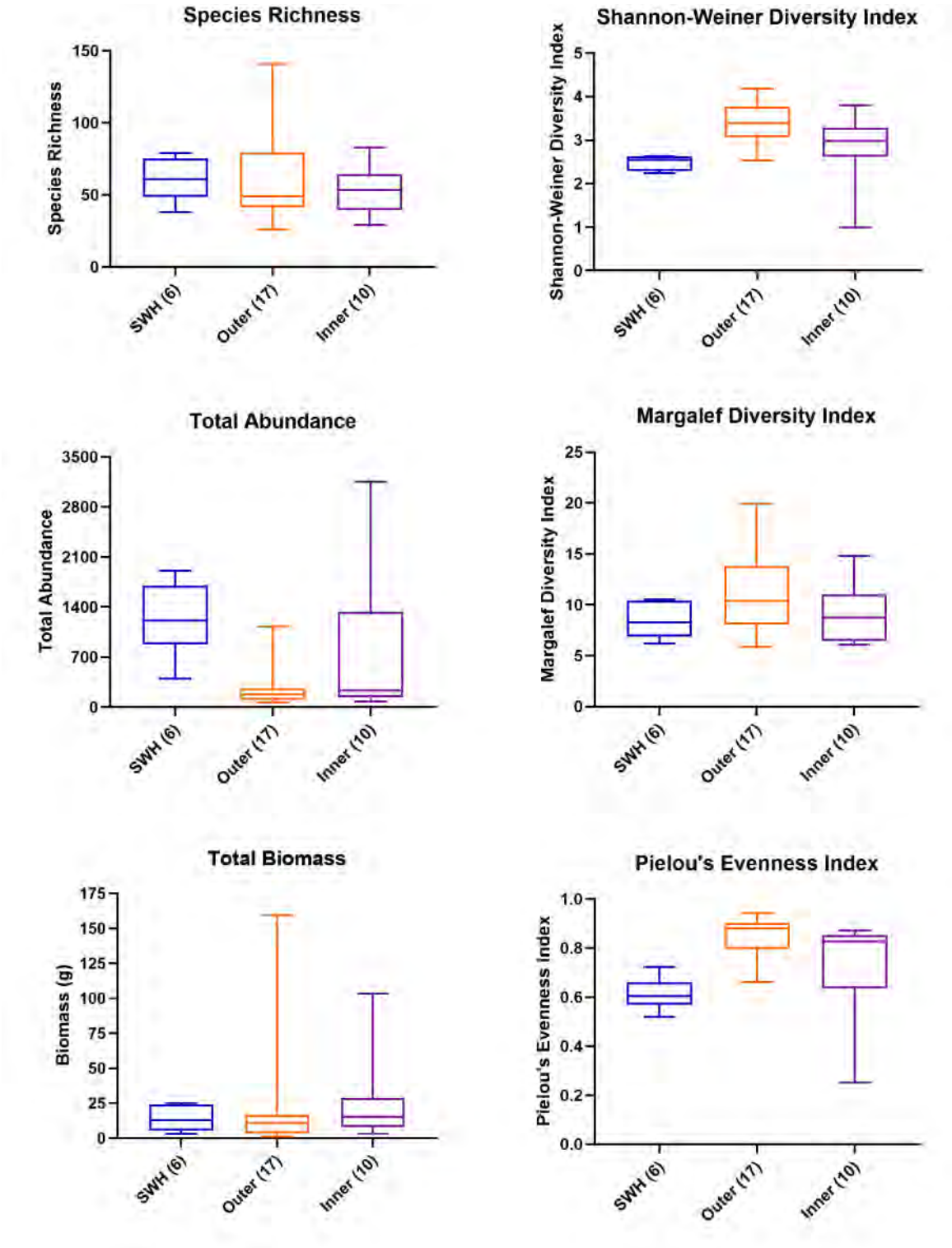
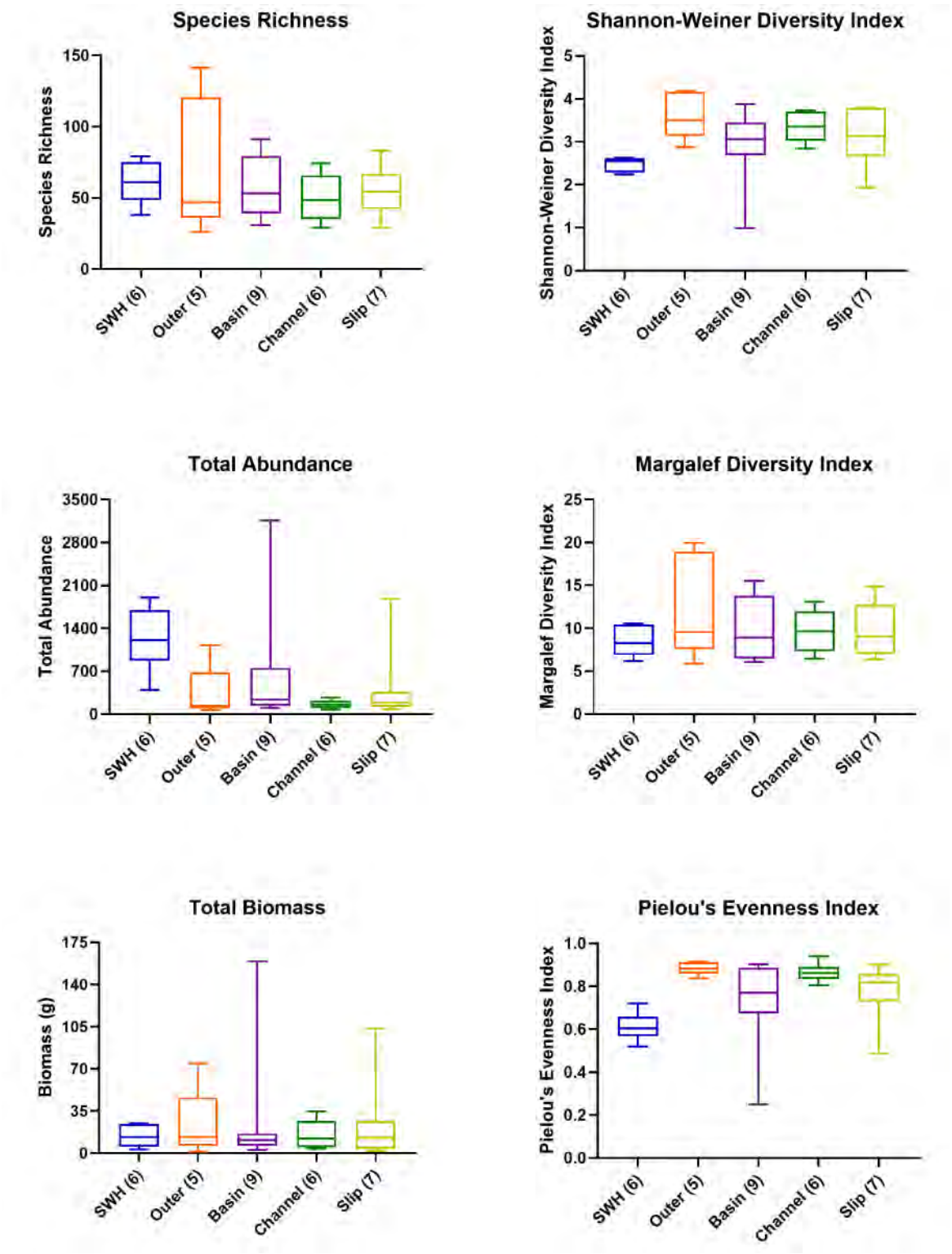


Figure 4-12. Relative Contribution by Major Phyla for Abundance, Biomass, and Taxonomic Richness in Spring and Summer Combined



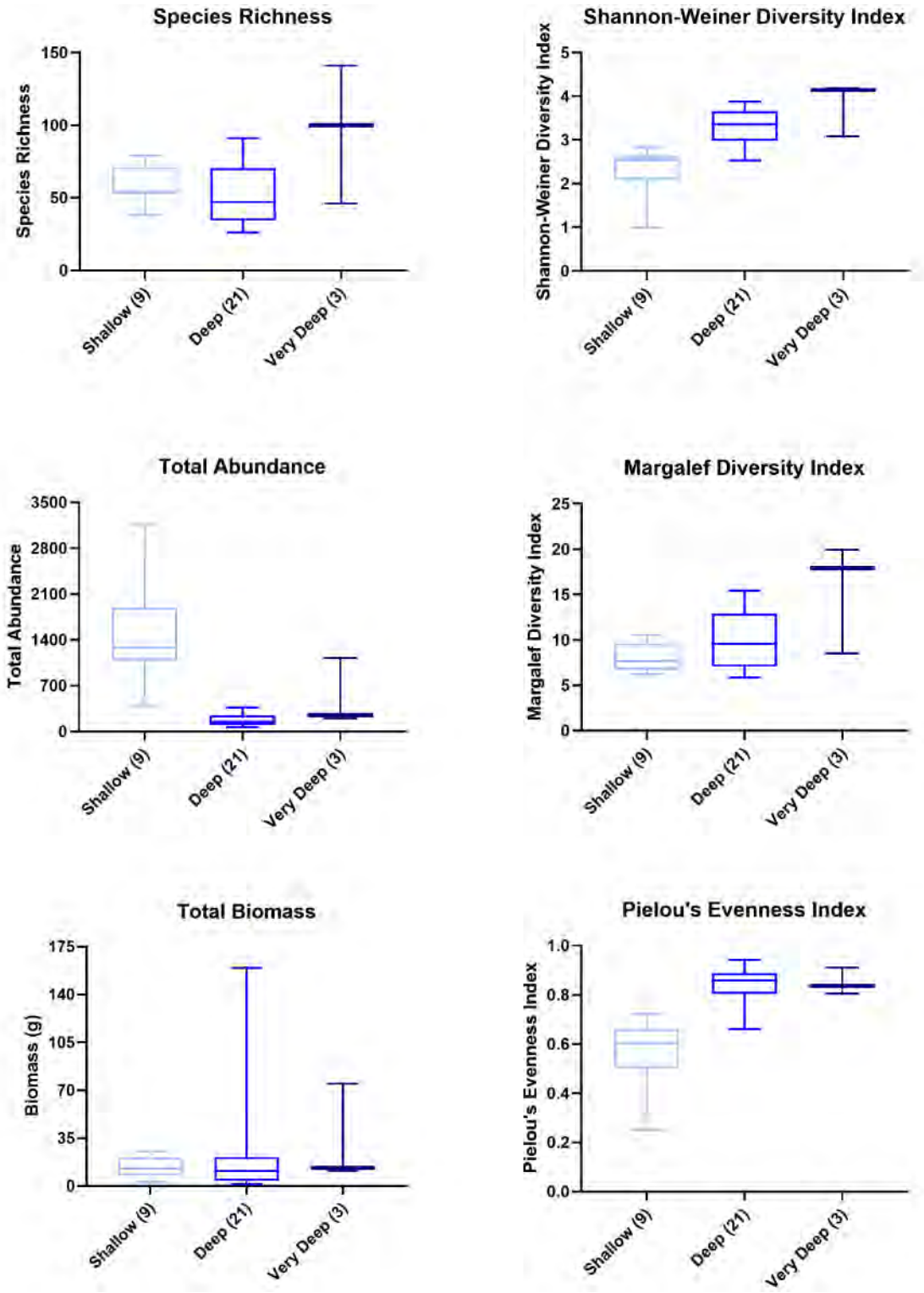
Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 4-13. Benthic Infauna Summary Metrics by Station Habitats



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median (N)= number of stations.

Figure 4-14. Benthic Infauna Summary Metrics by Station Locations



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median (N)= number of stations.

Figure 4-15. Benthic Infauna Summary Metrics by Station Depths

4.3.2.5 DISTRIBUTIONAL PATTERNS OF INFAUNA USING MULTIVARIATE ANALYSES

Multivariate analysis of benthic infauna abundance data was performed by combining data across the spring and summer sampling events to assess potential differences in community composition patterns throughout the Port Complex (see Appendix A for a description of the analytical methodology). Additional nMDS plots and dendrograms with cluster analysis results are provided in Appendix D.

Distribution patterns in the benthic infaunal communities were compared by habitat type (Outer Harbor, Inner Harbor, and SWH), depth strata (Shallow, Deep, and Very Deep) and location group (Outer Harbor, SWH, channel, basin, and slip). Infauna communities by habitat type were all significantly different from one another (Figure 4-16); SWH stations composed the only location group that was significantly different from all other location groups (Appendix D). There was a limited degree of resolution overall in part because of smaller sample sizes (i.e., number of stations) for each location group. Among depth strata, benthic infaunal communities at Shallow stations were significantly different from those of the Deep and Very Deep stations (Figure 4-16), which were not significantly different from one another. These patterns generally agree with those in the abundance, richness, and biomass discussion, and indicate that the benthic infauna assemblages within the Port Complex are influenced more by habitat type and water depth than by location in the Port Complex.

To examine how the infauna community differs across stations beyond the predetermined groups above, cluster analysis using SIMPROF grouping (see Appendix A for a description of the methodology) was performed on combined station abundance data from both spring and summer, and the resulting nMDS plot (Figure 4-16) was overlaid on the station map (Figure 4-17) to examine spatial patterns. The resulting seven station groups indicate a number of habitats within the Harbor Complex that have statistically different community composition, although the ecological implications of these groups are not well established. The shade plot (Figure 4-18) and bar chart of relative phyla abundance and grain size (Figure 4-19) are useful tools for identifying community differences between these groups.

All but one of the SWH stations (LA7) formed two cluster groups (Groups C and D), but the benthic infauna community at station LA7 was more similar to several Inner Harbor stations at the Port of Los Angeles (LA10, LA12, LA14, and LA16; Group B) than to the other SWH stations. The high degree of separation for Group B, Group C, and Group D from all the others is due to the dominance of Arthropoda, including pollution-sensitive *Amphideutopus oculatus* and *Monocorophium insidiosum*. These groups also have among the highest abundances of several negative indicator species, including the pollution-tolerant amphipod *Capitella capitata cmplx*, the non-native amphipod *Grandidierella japonica*, and the pollution-tolerant polychaete *Pseudopolydora paucibranchiata*. Depth and grain size (Figure 4-19) likely influence the different communities present in these groups because all stations in these three groups are relatively sandy and shallow.

Group G was the largest with 20 stations primarily representing Deep stations in both the Inner Harbor and Outer Harbor. These stations included core community species observed across all stations such as the annelids *Leitoscoloplos pugettensis* and *Cossura* sp. A and non-native bivalve *Theora lubrica*, as well as species more common only among this group of stations, including the polychaetes *Streblosoma crassibranchia* (spaghetti worm), *Aphelochaeta petersenae*, *Kirkegaardia siblina*, and the pollution-sensitive *Chaetozone corona*.

Groups A, E, and F all consisted of a single station and separated out because of unique benthic communities. Station LB9 (Group F) was among the most diverse; because it is one of the deepest stations and is in the Port of Long Beach Main Channel closest to the outer portions of east San Pedro Bay, it may encounter unique conditions (e.g., lower temperatures near the seafloor, less disturbance from waves and prop blast, etc.) that shape its benthic community. Station LA11 (Group A) is also in a deep, outer main channel location (the Port of Los Angeles Main Channel) and had a unique community dominated primarily by annelids, including the bioluminescent *Polycirrus perplexus*. Station LA15 is in the Port of Los Angeles Turning Basin, and the very high gravel content in the spring sample at this station likely influenced the community composition. The seafloor at station LA15 has rocky areas and is subject to disturbance from prop blast from tug boat and oceangoing vessel activity in the basin.

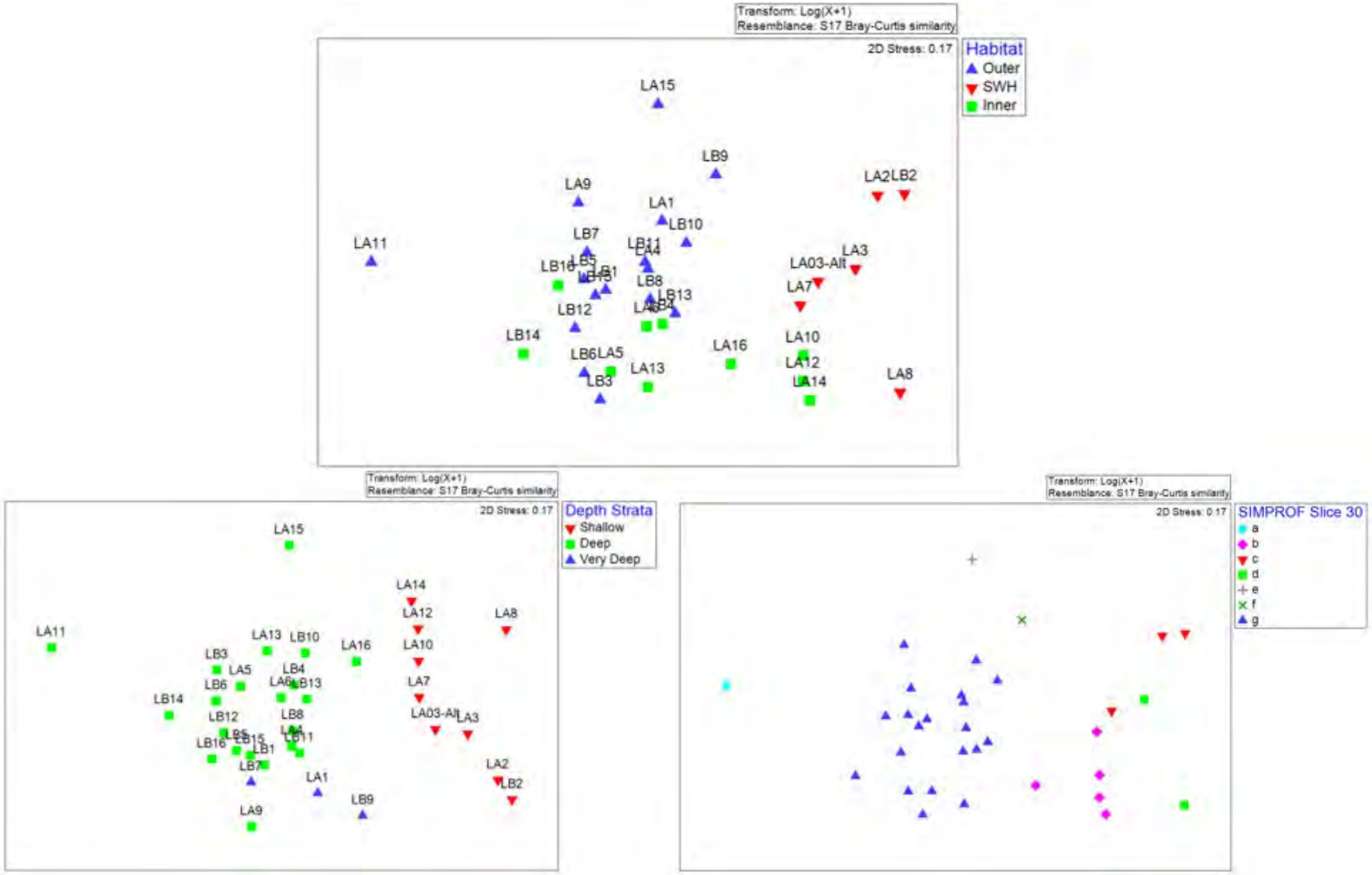
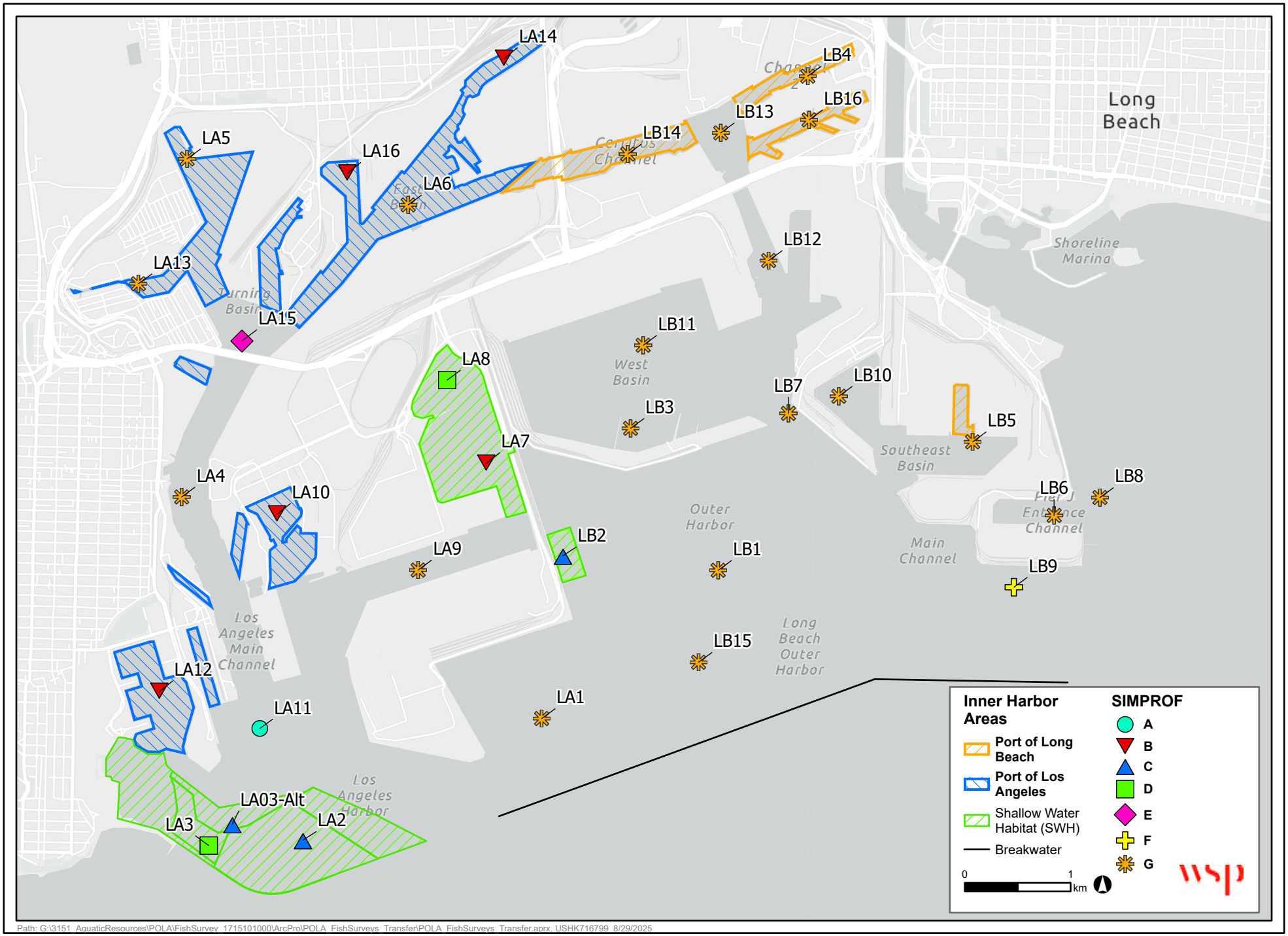
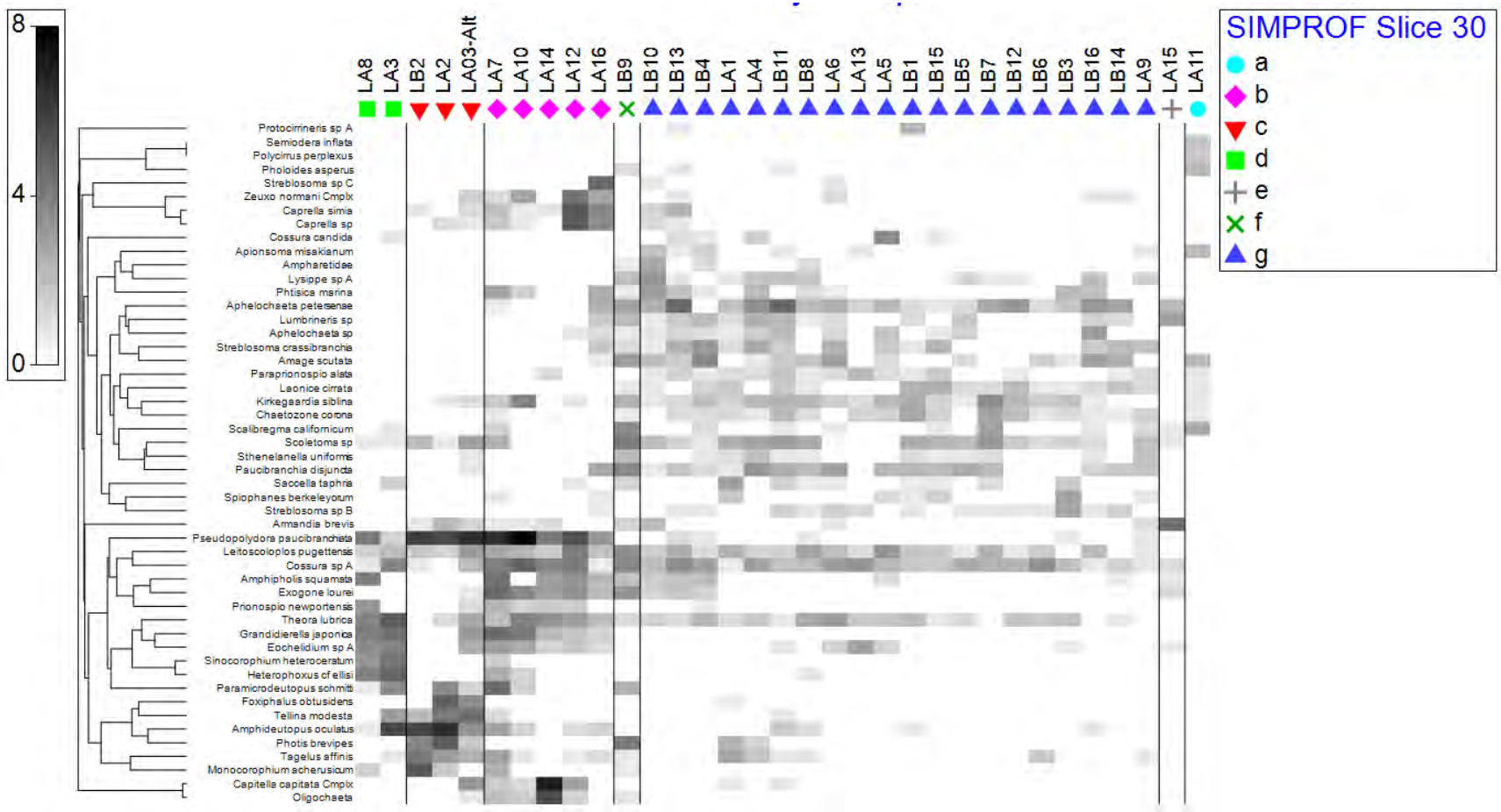


Figure 4-16. Benthic Infauna nMDS Plots by Habitat (Top), Depth Strata (Bottom Left), and SIMPROF (Bottom Right)



Path: G:\3151_AquaticResources\POLA\FishSurvey_1715101000\ArcPro\POLA_FishSurveys_Transfer\POLA_FishSurveys_Transfer.aprx, USHK716799, 8/29/2025

Figure 4-17. Benthic Infauna SIMPROF Analysis Groups – Both Seasons Combined



The scale reflects abundance data that have been transformed and normalized.

Figure 4-18. Benthic Infauna Community Shade Plot by SIMPROF Group – Top 50 Species – Both Seasons Combined

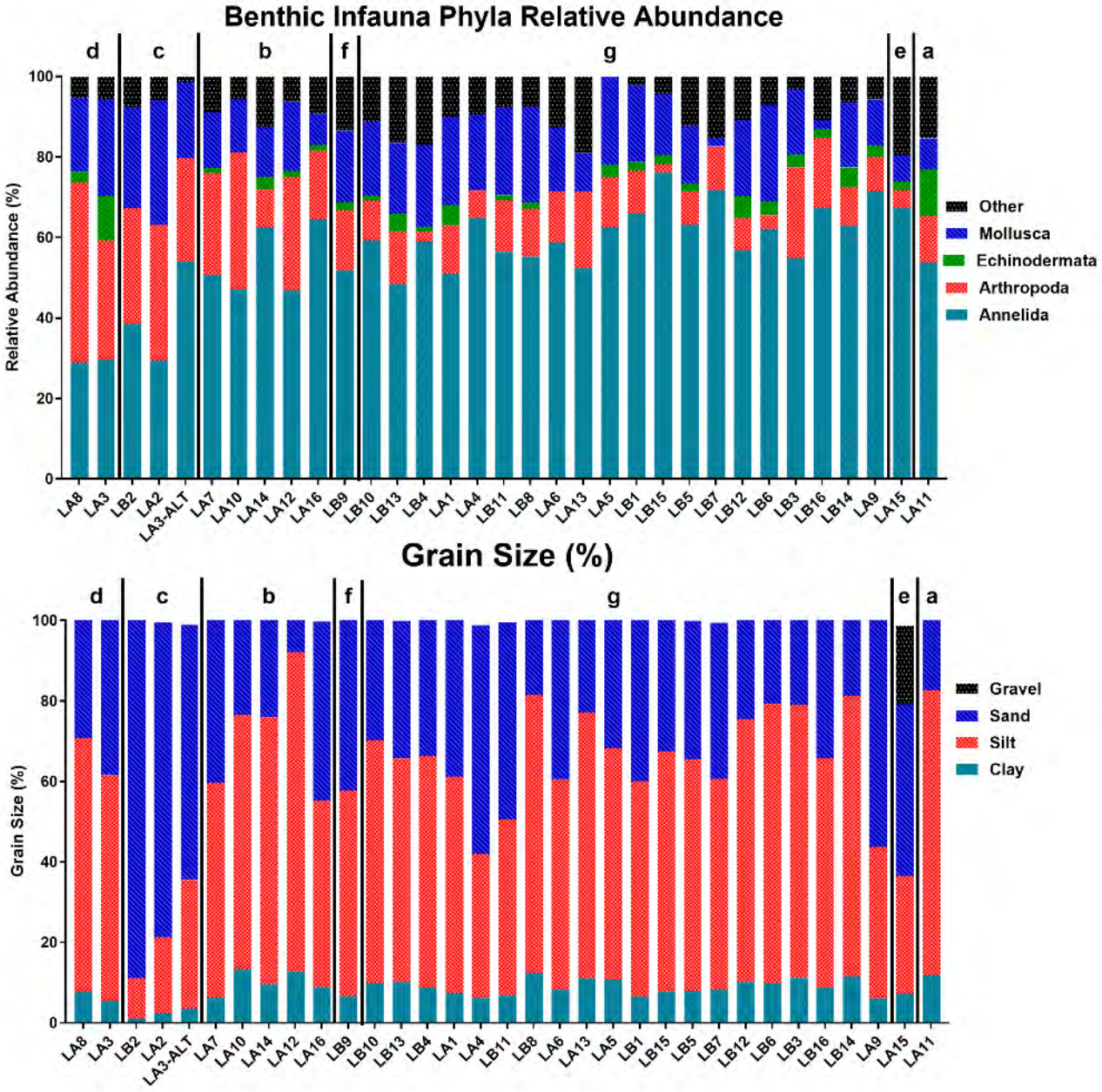


Figure 4-19. Benthic Infauna Phyla Relative Abundance and Grain Size by SIMPROF Group

4.3.3 SEDIMENT BENTHIC RESPONSE INDEX FOR BAYS

The BRI (Smith et al., 2003) has assigned pollution tolerance values to 322 individual taxa collected from 33 sites in bays and harbors from Point Conception, California, to the United States–Mexico international border. These tolerance values are based on individual species frequency of abundance along a gradient between the most and least disturbed (primarily pollution) sites. Species for which insufficient data were available (e.g., collected at only one site) were not assigned a pollution tolerance value. The BRI score is based on abundance-weighted pollution tolerance values of the organisms present in a benthic sample. The higher the BRI score, the more degraded the benthic community represented by the sample. Two types of data are needed to calculate the BRI score: (1) the abundance of each species,

and (2) its pollution tolerance value (P). A final BRI score was then defined as the abundance-weighted average tolerance value for all taxa in the sample (species without an associated pollution tolerance value are not included in the calculation). This average tolerance score is then compared to a set of thresholds that separate the conditions of the benthic community into four categories:

- Reference (BRI <39.96) – A community that would occur at a site in a similar habitat that is not pollution-stressed.
- Low Disturbance (BRI >39.96 to <49.15) – A community that may show signs of some stress but is within expected natural variability of the reference condition.
- Moderate Disturbance (BRI >49.15 to <73.27) – A community that shows clear signs of physical, chemical, natural, or anthropogenic stress.
- High Disturbance (BRI >73.27) – A clearly impacted community exhibiting a high magnitude of stress.

In the 2023 Biosurvey, the BRI was calculated for data collected at the 33 Port Complex stations during each of the spring and summer surveys, although the index was developed with the recommendation that in southern California, sampling should occur in summer (July 1 through September 30; Smith et al., 2003). The benthic infaunal communities at most of the stations in the Port Complex were categorized as "Reference" (79% of stations in spring and 85% in summer, respectively). A few stations were categorized as "Low Disturbance" (12% in spring and 15% in summer), 9% of stations in the spring and none of the stations in summer were categorized as "Moderate Disturbance," and no stations were characterized as "High Disturbance" (Table 4-5). The ranges of BRI scores in the two seasons were fairly similar, with spring scores ranging from 6.9 (station LA9) to 65.7 (station LB10) and summer scores ranging from -5.52 (station LA11) to 48.5 (station LA10). Only at two stations (LA12 and LA16) did BRI categories increase between spring and summer, moving from "Reference" to "Low Disturbance." At all other stations, BRI scores either remained in the same category or decreased to a lower (i.e., improved) category between spring and summer (Table 4-6).

The three highest BRI scores (at stations LB10, LA14, and LA15) occurred during the spring, and the stations were categorized as "Moderate Disturbance.". In the summer, these three stations' BRI scores decreased, and the stations changed categories to "Low Disturbance" or "Reference.". During the spring sampling, station LB10 (Southeast Basin West) had relatively low species diversity, with only eight species. The polychaete *Cossura* sp. A, a pollution-tolerant species with a high abundance-weighted pollution tolerance value (49.8), was captured at the station and contributed to a higher BRI score. During the summer at station LB10, the species diversity was greater, at 77 species, and the presence of additional species with lower p-scores than *Cossura* sp. A resulted in a lower station BRI score. A similar pattern was observed at station LA15 (Port of Los Angeles Turning Basin), which also had a lower diversity of species during the spring compared with the summer and the presence of *Cossura* sp. A. During the spring, station LA14 (Consolidated Slip) had a high abundance of the pollution-tolerant polychaete *Capitella capitata Cmplx,* (1,024, over 60% of the total abundance) at the station; the high abundance-weighted pollution tolerance value (130.8) for that species likely heavily influenced the "Moderate Disturbance" BRI category. The low species diversity and presence of pollution-tolerant species in the spring underscore the use of the BRI in the designated summer index period because the community in the spring may still be recovering from winter disturbances and physical conditions (e.g., low temperature, low salinity, and scouring from storms) that result in higher disturbance categories.

Table 4-5. Summary of BRI Scores and Condition Categories

Parameter	Spring	Summer
BRI Mean Score	27.8	24.1
BRI Score Range	6.9 to 65.7	-5.5–48.5
Categorical Ratings (% of stations)		
Reference	78.8	84.8
Low Disturbance	12.1	15.2
Moderate Disturbance	9.09	0
High Disturbance	0	0

BRI = Benthic Response Index

Table 4-6. Summary of Site Categorization

Station	Port	Habitat	Depth Stratum	Spring		Summer	
				BRI Score	BRI Category	BRI Score	BRI Category
LB1	POLB	Outer	Deep	15.46	Reference	7.79	Reference
LB2	POLB	SWH	Shallow	14.06	Reference	23.32	Reference
LB3	POLB	Outer	Deep	27.79	Reference	27.93	Reference
LB4	POLB	Inner	Deep	12.28	Reference	24.08	Reference
LB5	POLB	Outer	Deep	24.84	Reference	17.91	Reference
LB6	POLB	Outer	Deep	30.17	Reference	8.38	Reference
LB7	POLB	Outer	Very Deep	14.10	Reference	16.21	Reference
LB8	POLB	Outer	Deep	21.24	Reference	18.22	Reference
LB9	POLB	Outer	Very Deep	17.13	Reference	15.99	Reference
LB10	POLB	Outer	Deep	65.74	Moderate Disturbance	25.66	Reference
LB11	POLB	Outer	Deep	11.88	Reference	20.65	Reference
LB12	POLB	Outer	Deep	28.87	Reference	20.41	Reference
LB13	POLB	Outer	Deep	41.33	Low Disturbance	27.48	Reference
LB14	POLB	Inner	Deep	25.83	Reference	27.87	Reference
LB15	POLB	Outer	Deep	9.88	Reference	15.50	Reference
LB16	POLB	Inner	Deep	27.91	Reference	38.39	Reference
LA1	POLA	Outer	Very Deep	22.18	Reference	2.28	Reference
LA2	POLA	SWH	Shallow	16.23	Reference	17.23	Reference
LA3	POLA	SWH	Shallow	29.29	Reference	19.65	Reference
LA3-ALT	POLA	SWH	Shallow	30.46	Reference	25.04	Reference
LA4	POLA	Outer	Deep	11.71	Reference	22.14	Reference
LA5	POLA	Inner	Deep	44.81	Low Disturbance	22.61	Reference
LA6	POLA	Inner	Deep	21.71	Reference	17.09	Reference
LA7	POLA	SWH	Shallow	36.26	Reference	36.81	Reference
LA8	POLA	SWH	Shallow	46.35	Low Disturbance	47.25	Low Disturbance
LA9	POLA	Outer	Deep	6.88	Reference	13.08	Reference
LA10	POLA	Inner	Shallow	47.73	Low Disturbance	48.48	Low Disturbance
LA11	POLA	Outer	Deep	18.87	Reference	-5.52	Reference
LA12	POLA	Inner	Shallow	38.33	Reference	47.56	Low Disturbance
LA13	POLA	Inner	Deep	35.57	Reference	29.00	Reference
LA14	POLA	Inner	Shallow	49.79	Moderate Disturbance	46.34	Low Disturbance
LA15	POLA	Outer	Deep	49.90	Moderate Disturbance	28.26	Reference
LA16	POLA	Inner	Deep	22.92	Reference	42.79	Low Disturbance

POLA = Port of Los Angeles; POLB = Port of Long Beach; SWH = shallow water habitat

4.3.4 HISTORICAL COMPARISONS

Benthic infauna communities have been sampled in the Port Complex periodically since 1954 (Reish, 1959), although the configuration of the Port Complex and the scope and sampling methodologies of the various studies have changed substantially over time. The initial surveys from the 1950s found that healthier areas were characterized by the polychaetes *Tharyx parvus*, *Cossura* sp. A, and *Nereis procera*, and polluted areas were dominated by large numbers of the pollution-tolerant polychaete *Capitella capitata*. The most heavily polluted areas in the Inner Harbor had DO levels near zero at the bottom, and no infauna present. Only 70 species of benthic infaunal organisms were collected, most of which (45 species) were polychaetes.

In the five most recent Biosurveys (2000 through 2023), from 258 to 445 species of benthic infauna have been identified within the Port Complex. The mean abundance across all stations over time has declined from 4,100 individuals/m^2 in 2000 to 1,860 individuals/m^2 in 2008, and to 1,215 individuals/m^2 in 2013. Then, mean abundance increased to 2,568 individuals/m^2 in 2018 and 2,862 individuals/m^2 in 2023. Mean biomass has been quite

variable, ranging from 49.7 grams/m^2 in 2000 to 121 grams/m^2 in 2008, 37 grams/m^2 in 2013, 50.5 grams/m^2 in 2018, and 107 grams in 2023.

Table 4-7 shows the 10 most abundant species of benthic infauna over 11 historical surveys within the Port Complex, with results for the five most recent Biosurveys also indicating species richness and highlighting species that appear in the top 10 for at least 3 of 5 survey years. Studies from 1954 through 1996 do not include species richness because of substantial differences between studies in terms of sampling gear and taxonomic identification methods (MEC, 1988). The 2000, 2013, and 2018 Biosurveys identified numbers of species (366 to 389) similar to the 372 species identified in the 2023 Biosurvey; the 2008 Biosurvey, however, identified only 261 species. However, the top 10 species have remained fairly consistent over all five recent Biosurveys, with *Amphideutopus oculatus*, *Cossura* sp. A, and *Theora lubrica* in the top 10 species in all 5 Biosurveys and *Pseudopolydora paucibranchiata* in in the top 10 species in 4 of the 5 Biosurveys.

Pseudopolydora paucibranchiata and *Theora lubrica*, which are considered non-native, have been among the most abundant benthic infauna species dating back as far as 1954 and 1986, respectively (Table 4-7). The annelid species *Capitella capitata*, a generalist feeder that has been noted to be tolerant of pollution (Dean, 2008) and organic content enrichment (Thompson and Lowe, 2004; Reish, 1955), has been observed to colonize opportunistically in areas with frequent disturbance (e.g., harbor turning basins and areas subject to regular maintenance dredging). This species was among the most abundant in studies from 1954, 1973 to 1974, and 1983, but its abundance across all seasons decreased steadily thereafter, from 325 in 2000, 23 in 2008, 27 in 2013, and only 16 individuals in 2018. Total abundance increased dramatically in 2023, with 1,076 individuals Port Complex-wide, making it one of the 10 most abundant species. However, 1,025 of those individuals occurred at station LA14 (Consolidated Slip), and only 51 individuals were collected at the remaining stations.

An important note when looking at the population trends of *Capitella capitata* is to consider that the vast majority (98%) were captured in the spring at station LA14 (Consolidated Slip), an area with the highest total organic carbon content across all stations, which is consistent with preferred habitat for *Capitella capitata* (see Section 2.5.2). The wet season that preceded the 2023 Biosurvey had more rainfall (16+ inches from January through March) than any of the previous Biosurvey years, with the next highest rainfall amount (8+ inches) prior to the 2008 Biosurvey. Station LA14 receives drainage from the Dominguez Channel watershed, indicating that the spike in *Capitella capitata* in 2023 is not unexpected because heavy rainfall and urban discharges from the watershed may have locally disturbed sediments at station LA14 in a manner that presented ideal conditions for a boom in their population. By summer 2023, only one *Capitella capitata* individual was captured at station LA14, with 20 individuals in total across all stations, indicating that this large fluctuation in the population is less indicative of degradation in Port Complex conditions but instead is evidence that (1) the timing of benthic infauna sampling is an important consideration in trend analysis, and (2) localized responses in the benthic community to disturbance can confound trend analysis without considering additional context about location and environmental conditions at the time of sampling.

BRI evaluations for Biosurvey stations began in 2013 and have consistently shown most stations categorized as "Reference" across all three Biosurveys (Table 4-8), although the percentage has slightly declined across the last three surveys. Only 4 stations in spring (stations LB13, LA5, LA8, and LA10) and five stations in summer (stations LA8, LA10, LA12, LA14, and LA16) were categorized as "Low Disturbance" in 2023. The 2018 survey was the first to have stations categorized as "Moderate Disturbance", with a similar percentage of stations in 2023 in the same category. The Bight Regional Monitoring program collcted benthic infuana in the summer and calculated BRI scores for numerous stations throughout the Port Complex in 2003 (n=17), 2008 (n=33), and 2013 (n=25) and found 0-6% of stations categorized as Low Disturbance and 3-6% as Moderate Disturbance over that time period. These historical ranges are consistent with summer results from the 2023 Biosurveys which had 0% Moderate Disturbance, although the 2023 Biosurvey had a higher percentage of Low Disturbance (15%) stations than has been observed historically. Although the BRI was not calculated prior to 2013, results for both the 2000 (MEC, 2002) and 2008 Biosurveys (SAIC, 2010) indicate that stations LA10 and LA14 were dominated by pollution-tolerant taxa, and cluster analysis showed that these two stations would often form their own single-station group or be grouped together. In the 2023 Biosurvey, the higher disturbance categories at these stations appear to be consistent with the historical trends driven by low species diversity and/or presence and high abundance of pollution-tolerant species.

Table 4-7. Historical Comparison of the Ten Most Abundant Benthic Infauna Taxa in the Port Complex, in Descending Order of Dominance

Year	1954	1973–1974	1978	1983	1986–1987	1994 and 1996	2000	2008	2013	2018	2023
Source	Reish, 1959	HEP, 1976	HEP, 1980	MBC, 1984	MEC, 1988	SAIC/MEC, 1997	MEC, 2002	SAIC, 2010	MBC, 2016	Wood, 2021	2023 Biosurvey
1	*Pseudopolydora paucibranchiata*	*Tharyx parvus*	*Cossura candida*	*Cossura candida*	*Cossura candida*	*Cossura candida*	*Pseudopolydora paucibranchiata*	*Theora lubrica*	*Amphideutopus oculatus***	*Amphideutopus oculatus***	*Pseudopolydora paucibranchiata*
2	*Tharyx parvus*	*Capitita ambiseta*	*Mediomastus californiensis*	*Prinospio cirrifera*	*Prionospio lighti***	*Leitoscoloplos pugettensis*	*Amphideutopus oculatus***	*Nebalia pugettensis-complex*	*Cossura* sp. A	*Pseudopolydora paucibranchiata*	*Amphideutopus oculatus***
3	*Cossura candida*	*Cossura candida*	*Tharyx* sp.	*Capitella capitata*	*Mediomastus* spp.	*Aphelochaeta multifilis Type 2*	*Cossura* sp. A	*Cossura* sp. A	*Theora lubrica*	*Cossura* sp. A	*Capitella capitata Cmplx*
4	*Capitella capitata*	*Capitella capitata*	*Prionospio cirrifera*	*Pseudopolydora paucibranchiata*	*Levinsenia gracilis*	*Chaetozone corona***	*Theora lubrica*	*Streblosoma* sp. B	*Sinocorophium heteroceratum*	*Theora lubrica*	*Cossura* sp. A
5	*Cirriformia luxuriosa*	*Paraonis gracilis oculata*	*Capitella capitata*	*Polydora ligni*	*Euchone limnicola*	*Amphideutopus oculatus***	*Euphilomedes carcharodonta***	*Monticellina siblina*	*Euchone limnicola*	*Kirkegaardia siblina*	*Theora lubrica*
6	*Dorvillea articulata*	*Euchone limnicola*	*Paraonis gracilis oculata*	*Tharyx* sp.	*Theora lubrica*	*Mediomastus* sp.	*Monticellina siblina*	*Amphideutopus oculatus***	*Paramage scutata***	*Oligochaeta*	*Aphelochaeta petersenae*
7	*Phoronids*	*Chaetozone corona***	*Euchone limnicola*	*Mediomastus ambiseta*	*Tharyx* sp. C	*Monticellina tesselata*	*Euchone limnicola*	*Scleroplax granulata*	*Aphelochaeta monilaris*	*Mediomastus* sp.	*Grandidierella japonica*
8	*Nereis procera*	*Sigambra tentaculata*	*Haploscoloplos elongatus*	*Carinomella lactea*	*Nematoda*	*Monticellina* sp. 1	*Mediomastus* spp.	*Pista agassizi*	*Scleroplax granulata*	*Zeuxo normani Cmplx*	*Mediomastus* sp.
9	*Capitita ambiseta*	*Prionospio cirrifera*	*Sigambra tentaculata*	*Mediomastus californiensis*	*Tharyx* sp. A	*Paraprionospio pinnata*	*Spiophanes berkeleyorum*	*Pseudopolydora paucibranchiata*	*Neotrypaea* spp.**	*Eochelidium* sp. A	*Oligochaeta*
10	*Macoma nasuta*	*Schistomeringos longicornis*	*Nephtys cornuta franciscana*	*Paraprionospio pinnata*	*Tharyx tesselata*	*Euclymene grossanewporti*	*Chaetozone corona***	*Pista wui*	*Pista wui*	*Euchone limnicola*	*Leitoscoloplos pugettensis*
Species Richness	-	-	-	-	-	-	366 species	261 species	389 species	369 species	372 species
# Top 10 Sensitive Taxa	0	1	0	0	1	2	3	1	3	1	1

Species richness not provided for 1954–1996 because of inconsistent sampling and taxonomy methods between studies. Colors are provided for 2000–2023 to highlight species that appear in the top 10 species in at least 4 of the 5 Biosurveys. Species in **bold** are classified by the California Department of Fish and Wildlife (CDFW) National Exotic Marine and Estuarine Species Information System (NEMESIS) database as non-native. Species followed by ** are considered relatively sensitive, pollution-intolerant taxa.

Table 4-8. Percentage of Station BRI Infauna Condition Categorical Ratings for Biosurvey Since 2013

BRI Condition Category	Biosurvey 2013	Biosurvey 2018	Biosurvey 2023
	Percentage of Stations Sampled		
Reference	96	88	82
Low Disturbance	4	6	14
Moderate Disturbance	0	6	5
High Disturbance	0	0	0

BRI = Benthic Response Index

4.3.5 DISCUSSION

In general, resuls for overall abundance, biomass, and diversity were similar between the spring and summer surveys, and average species richness was higher in summer than in spring. The most abundant species across the Port Complex in the 2023 Biosurvey were the polychaete *Pseudopolydora paucibranchiata* and the amphipod *Amphideutopus oculatus*; however, the vast majority of these individuals were captured in only a few locations. *A. oculatus*, a pollution-sensitive species, was identified almost exclusively at stations LA2, LA3 and LB2, and *Pseudopolydora paucibranchiata*, a pollution-tolerant species, was identified predominantly at station LA10. However, *Pseudopolydora paucibranchiata* also occurred in relatively high abundance in the summer at stations LA2 (284 individuals) and LB2 (375 individuals) that the BRI categorized as "Reference." This finding indicates that although some species can be considered pollution-tolerant or pollution-sensitive, habitat conditions such as depth and sediment characteristics (e.g., grain size and TOC) may influence the distribution of a particular species in a way that does not correlate well with disturbance indices.

It was apparent when evaluating the data by habitat, location, and depth strata, that depth (Shallow, Deep, and Very Deep) and habitat (Inner Harbor, Outer Harbor, and SWH) were the key factors influencing the benthic community's characteristics. The SWH stations typically exhibited higher abundance but reduced diversity relative to other stations, and results of nMDS analysis indicated different community composition among the three habitat types. Among the depth strata, Very Deep stations had significantly greater species richness, biomass, and diversity, and Shallow stations had significantly greater abundance than Deep and Very Deep stations. These results are similar to the 2018 Biosurvey results in that SWH stations had lower diversity with higher abundance and Inner Harbor and Outer Harbor stations had higher diversity with lower abundance.

Cluster analysis of the benthic infauna communities showed that stations tended to group by location within the Port Complex, with groups consisting of the Back Channel of Port of Long Beach, outer anchorages, Main Channel of the Port of Los Angeles, Seaplane Lagoon, Port of Los Angeles West Basin, and Port of Long Beach West Basin. Six groups each contain a single station (LA11, LA15, LA9, LB10, LB9, and LA8) based upon that station's unique combination of pollution-tolerant taxa. Stations LA14 (Consolidated Slip) and LA12 (Cabrillo Marina), although not near each other, were within the same cluster group, indicating that they have closely related communities dominated by several pollution-tolerant taxa.

Overall, the results of the 2023 Biosurvey reaffirmed the findings of the 2018 Biosurvey, in that the overall conditions of the benthic infaunal communities in the Port Complex have substantially improved in recent decades; both Biosurveys showed a general increase in species diversity and a continued high percentage of stations categorized as "Reference" or "Low Disturbance" according to the BRI.

4.4 EPIBENTHIC INVERTEBRATES

Epibenthic invertebrates were captured during otter trawling for demersal fish (see Section 4.6) at 26 stations and at 2 beach seine stations in spring and summer 2023 (Figure 4-20, Table 4-9). Detailed maps of trawl locations are provided in Appendix C and tables that compare stations, species captured, day versus night sampling, and spring versus summer sampling are provided in Appendix D.

4.4.1 SPECIES COMPARISONS

4.4.1.1 SPECIES RICHNESS

During otter trawl and beach seine sampling across all seasons, 83 epibenthic invertebrate species were collected. Otter trawls collected 66 species not captured in beach seines, beach seines collected another 10 species not collected in trawls, and 7 species were collected using both otter trawl and beach seines.

Otter trawls collected 65 species in daytime sampling and 60 at night, and 64 species in the spring compared with 63 in the summer; none of these differences were statistically significant. Across both seasons, station LB9 (Outer Channel) had the lowest number of species (5); station LB16 (Channel 3) had the highest species richness (26).

Species richness of invertebrates collected at the two beach seine stations was similar: 10 species at Pier 300 and 7 at Cabrillo Beach. However, the species assemblages at the two locations were almost entirely different, and no species were captured at both stations.

4.4.1.2 ABUNDANCE

Across all seasons and stations, 12,763 epibenthic invertebrates were captured using otter trawls (Table 4-9, Appendix D), and 1,312 were captured using beach seines (Table 4-10). The one bryozoan species collected (*Thalamoporella californica*) could not be quantified for abundance in the field and has been excluded from the abundance data.



Target shrimp (Sicyonia penicillata)

The most abundant species captured by otter trawls was the target shrimp (*Sicyonia penicillata;* 59.5% of total abundance), followed by Pacific rock shrimp (*Sicyonia ingentis*; 12.34%), and tunicates (*Ascidiella aspersa*; 8.08%). Invertebrates in otter trawls were more abundant at night than during the day (7,564 and 5,199, respectively) and more abundant in spring than in summer (8,434 and 4,329, respectively). Both the day and night and seasonal differences were significantly different. Differences between day and night abundance were largely driven by increased capture rate across many species (e.g., Xantu's swimming crabs, target shrimp, and blacktail shrimp), which may be the result of increased foraging at night by these more mobile species. The difference between spring and summer abundance was in large part due to differences in the abundance of the two most common shrimp species, target shrimp and Pacific rock shrimp. Combined, the two species accounted for 6,414 individuals captured in the spring but only 2,752 in the summer.

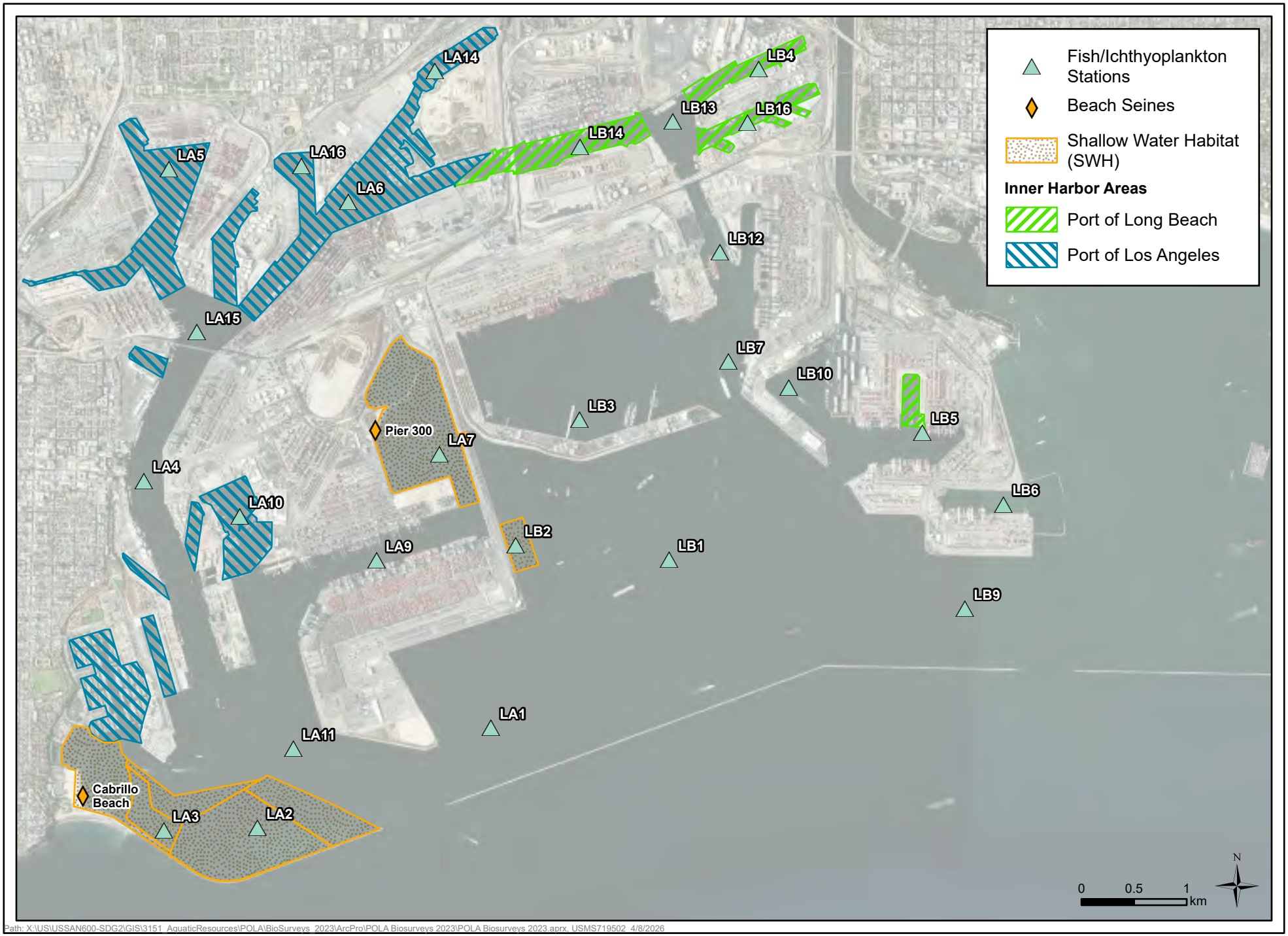
The abundance of invertebrates collected by beach seines was variable across seasons and may also have been influenced by sampling occurring during different tidal heights and in somewhat different portions of the shallow eelgrass habitats. In total, 1,260 invertebrates were collected at Pier 300 compared with 52 at Cabrillo Beach. Pier 300 was dominated by green shrimp (37% of the total abundance) and the Sitka shrimp (*Heptacarpus sitchensis*; 22%). Cabrillo Beach was dominated by a single species, hermit crab (*Pagurus samuelis*; 52% of total abundance).

4.4.1.3 BIOMASS

A total of 224.7 kg of epibenthic invertebrates were captured using otter trawls (Table 4-9, full table in Appendix D), and 10.1 kg were captured using beach seines (Table 4-10). All species were weighed upon capture, making biomass the most representative metric for comparisons among the results for day versus night and spring versus summer sampling because biomass includes species that could not be enumerated such as bryozoans and sponges.

The species with the highest total biomass in otter trawls were target shrimp (46% of the total biomass), California spiny lobster (*Panulirus interruptus*; 8.9%), and California sea hare (*Aplysia californica*; 7.5%). Total biomass was greater during the day than the night (65 kg and 60.0 kg, respectively, a statistically significant difference), and greater in the spring than the summer (135.7 kg and 88.9 kg, respectively, not statistically different). Across both seasons (Table 4-9), biomass per station ranged from 1.75 kg at station LA 5 (West Basin) to 28.71 kg at station LB 9 (Outer Channel). There was no significant difference in invertebrate biomass between spring and summer, but there was a significant difference between invertebrate biomass collected during the day and night.

Total invertebrate biomass collected in beach seines (Table 4-10) was greater at Cabrillo Beach (9,579 grams) than at Pier 300 (567 grams). Pier 300 biomass was dominated by the snail western mud nassa (25% of total biomass) and Sitka shrimp (20%). At Cabrillo Beach, nine California spiny lobsters were captured and made up nearly all (97%) of the total biomass. Yellow rock crab (1.4%) was the only other species to make up more than 1% of the total biomass.



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Table 4-9. Top 25 Epibenthic Invertebrate Species Collected with Otter Trawl – Summary Statistics – Spring and Summer Events Combined and Species Ranked by Ecological Index

Species			Total Abundance per Taxa	% of Total Abundance	Total Biomass per Taxa (kg)	% of Total Biomass	Total Density (#/100 m^2)	Frequency of Trawl Capture (%)	Ecological Index
Phylum	Common name	Scientific Name							
Arthropoda	Target shrimp	*Sicyonia penicillata*	7,591	59.5	104.3	46.4	80.8	88.5	9,368
Arthropoda	Xantu's swimming crab	*Achelous xantusii*	967	7.34	15.4	6.84	10.3	88.5	1,275
Chordata	European ascidian	*Ascidiella aspersa*	1,031	5.80	15.6	6.93	11.0	84.6	1,269
Arthropoda	Pacific rock shrimp	*Sicyonia ingentis*	1,575	16.5	10.3	4.60	16.8	57.7	977
Arthropoda	California spiny lobster	*Panulirus interruptus*	24	0.18	20.1	8.93	0.26	38.5	350
Chordata	Sea vase ascidian	*Ciona robusta*	398	2.90	5.11	2.27	4.24	61.5	331
Mollusca	California sea hare	*Aplysia californica*	15	0.11	16.9	7.50	0.16	26.9	205
Mollusca	Gould's bubble snail	*Bulla gouldiana*	244	1.84	2.80	1.25	2.60	30.8	97.2
Arthropoda	Blackspot shrimp	*Crangon nigromaculata*	113	0.56	0.17	0.07	1.20	73.1	70.2
Mollusca	Navanax	*Navanax inermis*	39	0.37	3.12	1.39	0.42	34.6	58.7
Mollusca	Mediterranean mussel	*Mytilus galloprovincialis*	148	1.35	1.78	0.79	1.58	23.1	45.0
Arthropoda	Blacktail shrimp	*Crangon alaskensis*	100	0.85	0.08	0.04	1.06	42.3	37.9
Echinodermata	Western spiny brittle star	*Ophiothrix spiculata*	73	0.36	0.09	0.04	0.78	50.0	30.5
Arthropoda	Tuberculate pear crab	*Pyromaia tuberculata*	31	0.08	0.04	0.02	0.33	57.7	16.2
Chordata	Warty tunicate	*Styela clava*	33	0.09	0.38	0.17	0.35	34.6	14.8
Mollusca	Festive murex	*Pteropurpura festiva*	36	0.15	0.25	0.11	0.38	34.6	13.6
Arthropoda	Kellet's whelk	*Kelletia kelletii*	11	0.08	1.02	0.45	0.12	19.2	10.4
Arthropoda	Sheep crab	*Loxorhynchus grandis*	1	0.00	4.30	1.91	0.01	3.85	7.39
Chordata	Blunt-spined microcosmus	*Microcosmus squamiger*	33	0.31	0.16	0.07	0.35	19.2	6.32
Mollusca	Lesser two-spot octopus	*Octopus bimaculoides*	6	0.05	0.62	0.28	0.06	19.2	6.20
Chordata	Solitary tunicate	*Mogula ficus*	21	0.08	0.14	0.06	0.22	26.9	6.12
Chordata	Pleated tunicate	*Styela plicata*	19	0.11	0.32	0.14	0.20	19.2	5.58
Chordata	Common camellia	*Corella japonica*	26	0.01	0.07	0.03	0.28	23.1	5.43
Mollusca	White bubble snail	*Philine auriformis*	18	0.11	0.03	0.01	0.19	23.1	3.53
Arthropoda	Yellow leg shrimp	*Penaeus californiensis*	7	0.02	0.333	0.15	0.07	15.4	3.08

kg = kilogram(s); m^2 = square meter(s)

Table 4-10. Epibenthic Invertebrates Collected with Beach Seine Summary – Spring and Summer Events Combined

Common Name	Species Name	Abundance			Biomass (grams)		
		Pier 300	Cabrillo Beach	Total Abundance	Pier 300	Cabrillo Beach	Total Biomass
Calico Scallop	*Argopecten gibbus*	2	0	2	19	0	19
California Bubble Snail	*Bulla gouldiana*	8	0	8	8	0	8
Purple Olivella	*Callianax biplicata*	0	2	2	0	3	3
Swimmer Crab	*Callinectes arcuatus*	2	0	2	27	0	27
California Coastal Shrimp	*Heptacarpus paludicola*	270	0	270	108	0	108
Sitka Shrimp	*Heptacarpus sitchensis*	280	0	280	112	0	112
California Green Shrimp	*Hippolyte californiensis*	465	0	465	48	0	48
Yellow Rock Crab	*Metacarcinus anthonyi*	0	10	10	0	138	138
Graceful Rock Crab	*Metacarcinus gracilis*	0	1	1	0	38	38
Nassa Mud Snail	*Nassarius fossatus*	220	0	220	142	0	142
Navanax	*Navanax inermis*	1	0	1	56	0	56
Hermit Crab	*Pagurus samuelis*	0	27	27	0	44	44
Oriental Glass shrimp	*Palaemon californiensis*	1	0	1	5	0	5
California Spiny Lobster	*Panulirus interruptus*	0	9	9	0	9,333	9,333
Tuberculate Pear Crab	*Pyromaia tuberculata*	0	2	2	0	3	3
Southern Kelp Crab	*Taliepus nuttallii*	0	1	1	0	20	20
By-the-Wind Sailor	*Velella velella*	11	0	11	42	0	42
Total		1,260	52	1,312	567	9,579	10,146
Species Richness		10	7	17			
Shannon-Weiner Diversity		1.44	1.36	-			

4.4.2 STATION COMPARISONS

To assess patterns of epibenthic invertebrate distribution within the Port Complex, stations were grouped according to habitat type (SWH, Outer Harbor, and Inner Harbor), location (SWH, Outer Harbor, basin, channel, and slip) and depth (Shallow, Deep, and Very Deep). Differences in invertebrate diversity, abundance, and biomass were then assessed across these station groups (Table 4-11).

Species richness and total biomass were greater in the Outer Harbor habitats than in the Inner Harbor and SWH habitats (Figure 4-21). Diversity indices were highest at Inner Harbor stations and similar at Outer Harbor and SWH stations. Although these patterns were not statistically significant, abundance was significantly different, i.e., significantly higher in the Outer Harbor than in the Inner Harbor (abundance at SWH areas was not significantly different from abundance at either of the other habitats). Comparing total biomass and relative biomass by phylum (Table 4-11, Figure 4-22), SWH was dominated by arthropods and mollusks with only minor contributions from other phyla; this pattern likely contributed to the low diversity index scores. Most Outer Harbor stations were also dominated by arthropods, although at several stations, other phyla such as Chordata (station LB13), Mollusca (station LB12), and porifera (station LA15) were among the most dominant. The Inner Harbor habitat was the most variable in terms of composition, with most stations dominated by chordates and arthropods, with a few stations at Inner Harbor slips dominated by porifera (station LA13) and mollusks (station LB16).

By location type, basin and slip stations had the greatest species richness, and Outer Harbor stations had the greatest abundance and biomass (Figure 4-23). The abundance at Outer Harbor stations was significantly different from the abundance at basin and slip stations, and the Shannon-Weiner Diversity Index values were significantly different at Outer Harbor stations compared with SWH and slip stations. Outer Harbor stations had slightly lower diversity index scores compared with other location types because they were generally dominated by a single species. Slip stations scored high on the diversity indices, although this pattern was driven by stations LA16 (Bannings Landing) and LB16 (Channel 3), which had high species richness and evenness values despite having among the lowest total abundance and biomass; that degree of evenness heavily influences the diversity indices.

Species richness was relatively even across all depth strata, and abundance and biomass were higher at Deep and Very Deep stations than at Shallow stations (Figure 4-24). Total abundance was significantly higher at Very Deep stations compared with all others, and total biomass was significantly higher at Very Deep stations compared with Deep stations (total biomass at Shallow stations was not significantly different from total biomass at either Deep or Very Deep stations). Shallow and Deep stations generally scored higher for the diversity indices than the Very Deep stations, likely because Very Deep stations were more often dominated by a single or small group of species such as target shrimp.

Table 4-11. Otter Trawl Invertebrates Station Summary – Spring and Summer Events Combined

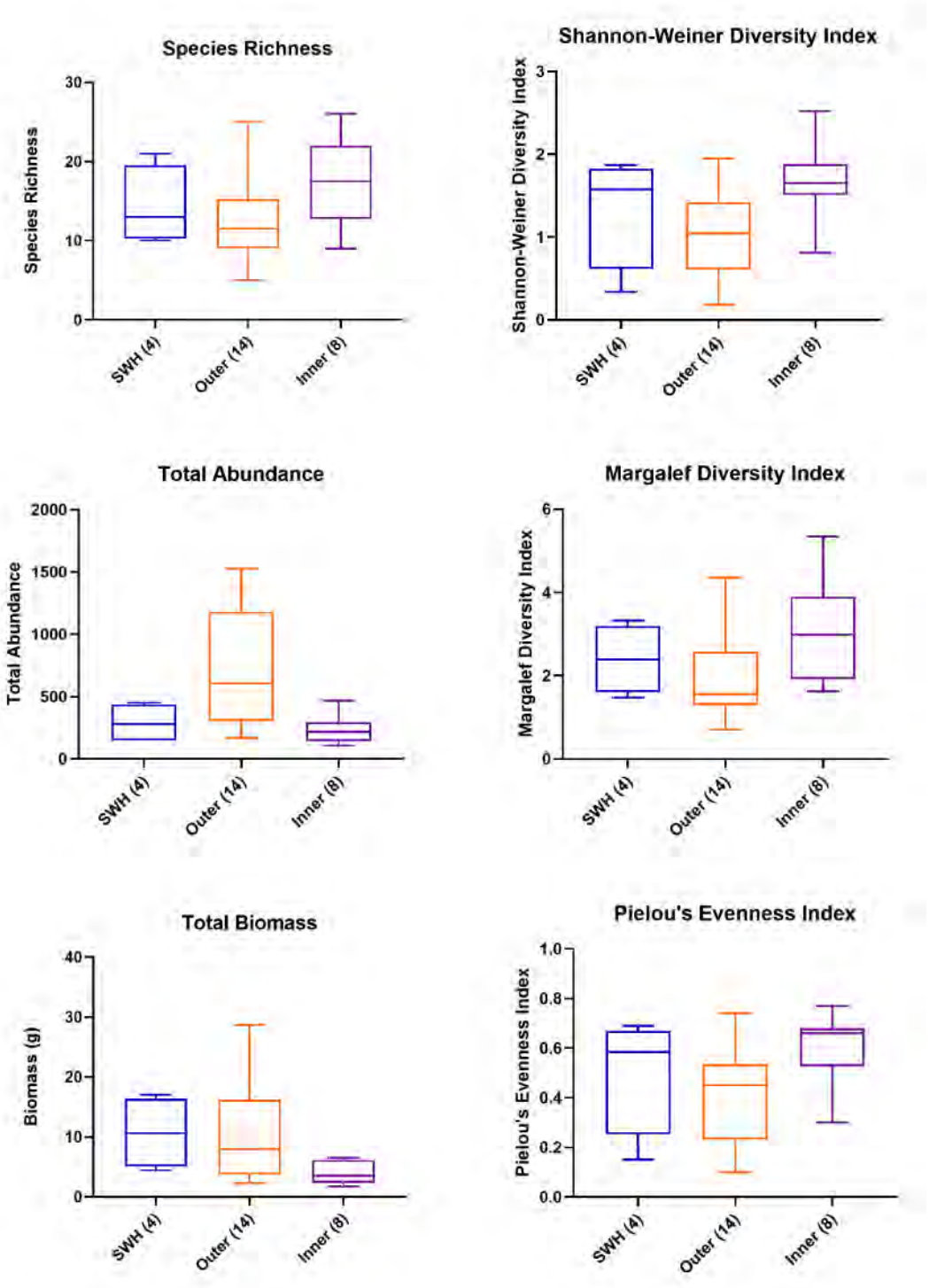
Station	Station Descriptor	Habitat	Location	Depth Strata	Taxa Richness	Total Abundance per Station	Total Biomass per Station (kg)	Shannon-Weiner Diversity Index	Margalef Diversity Index	Pielou's Evenness Index
LA1	Outer Pier 400	Outer	Outer	Very Deep	10.0	1,181	13.5	0.69	1.27	0.30
LA2	POLA SWH East	SWH	SWH	Shallow	11.0	151	4.49	1.46	1.99	0.61
LA3	POLA SWH West	SWH	SWH	Shallow	21.0	409	14.3	1.70	3.33	0.56
LA4	POLA Main Channel	Outer	Channel	Deep	9.00	167	5.50	1.63	1.56	0.74
LA5	West Basin	Inner	Basin	Deep	22.0	152	1.75	1.68	3.98	0.55
LA6	POLA East Basin	Inner	Basin	Deep	12.0	260	3.14	1.62	1.80	0.68
LA7	Seaplane Lagoon	SWH	SWH	Shallow	15.0	155	17.1	1.87	2.78	0.69
LA9	Pier 400	Outer	Slip	Deep	14.0	347	8.69	1.24	2.56	0.45
LA10	Fish Harbor	Inner	Basin	Shallow	19.0	260	5.89	1.90	3.24	0.65
LA11	POLA Outer Channel	Outer	Outer	Very Deep	12.0	1,188	24.0	0.37	1.55	0.15
LA14	Consolidated Slip	Inner	Slip	Shallow	9.00	140	2.16	1.47	1.62	0.67
LA15	POLA Turning Basin	Outer	Basin	Deep	19.0	619	19.8	1.35	2.64	0.47
LA16	Bannings Landing	Inner	Slip	Deep	16.0	172	6.23	1.83	2.72	0.68
LB1	Outer Anchorages	Outer	Outer	Deep	14.0	595	5.59	0.69	2.03	0.26
LB2	POLB SWH	SWH	SWH	Shallow	10.0	450	6.97	0.34	1.47	0.15
LB3	West Basin	Outer	Basin	Deep	10.0	672	8.98	0.31	1.38	0.14
LB4	Channel 2	Inner	Slip	Deep	22.0	306	3.15	1.61	3.67	0.52
LB5	Southeast Basin East	Outer	Basin	Deep	12.0	275	2.35	1.12	1.78	0.47
LB6	Pier J	Outer	Slip	Deep	9.00	469	3.83	0.99	1.30	0.45
LB7	Main Channel Pilot Station	Outer	Channel	Very Deep	11.0	1,528	15.0	0.86	1.36	0.36
LB9	Outer Channel	Outer	Outer	Very Deep	5.00	1,323	28.7	0.18	0.70	0.10
LB10	Southeast Basin West	Outer	Basin	Deep	8.00	810	7.21	1.10	1.05	0.53
LB12	Main Channel Police Station	Outer	Channel	Very Deep	22.0	312	3.49	1.70	3.66	0.55
LB13	POLB Turning Basin	Outer	Basin	Deep	25.0	246	2.34	1.95	4.36	0.61
LB14	Cerritos Channel	Inner	Channel	Deep	15.0	468	3.96	0.81	2.28	0.30
LB16	Channel 3	Inner	Slip	Deep	26.0	108	6.53	2.52	5.34	0.77

POLA = Port of Los Angeles; POLB = Port of Long Beach; SWH = shallow water habitat

Table 4-11. Otter Trawl Invertebrates Station Summary – Spring and Summer Events Combined (continued)

Station	Station Descriptor	Habitat	Location	Depth Strata	Percentage of Total Biomass							
					Arthropoda	Bryozoa	Chordata	Cnidaria	Ctenophora	Echinodermata	Mollusca	Porifera
LA1	Outer Pier 400	Outer	Outer	Very Deep	98.48	0	0.29	0.14	0	0.16	1.06	0
LA2	POLA SWH East	SWH	SWH	Shallow	76.83	0	0	0	0.02	0	23.2	0
LA3	POLA SWH West	SWH	SWH	Shallow	36.15	0	3.93	0	0	2.86	56.6	0
LA4	POLA Main Channel	Outer	Channel	Deep	85.30	0	14.7	0	0	0.02	0	0
LA5	West Basin	Inner	Basin	Deep	34.61	0	16.6	2.57	0	3.72	12.9	32.2
LA6	POLA East Basin	Inner	Basin	Deep	66.89	0	16.7	0.13	0	0.03	0.16	16.3
LA7	Seaplane Lagoon	SWH	SWH	Shallow	59.76	0	8.75	0	0	0.02	31.5	0
LA9	Pier 400	Outer	Slip	Deep	76.35	0	23.6	0	0	0	0.02	0
LA10	Fish Harbor	Inner	Basin	Shallow	19.40	0	47.9	0.03	0	0	32.2	0
LA11	POLA Outer Channel	Outer	Outer	Very Deep	99.73	0	0	0	0	0.03	0.10	0
LA14	Consolidated Slip	Inner	Slip	Shallow	0	0	82.0	0	0	0	18.0	0
LA15	POLA Turning Basin	Outer	Basin	Deep	9.08	0	24.0	0.01	0	0.60	7.05	59.3
LA16	Bannings Landing	Inner	Slip	Deep	6.96	0	16.5	0.37	0	0.03	1.43	75.1
LB1	Outer Anchorages	Outer	Outer	Deep	94.52	0	4.08	0.29	0	0	1.18	0
LB2	POLB SWH	SWH	SWH	Shallow	99.91	0	0	0	0	0	0.09	0
LB3	West Basin	Outer	Basin	Deep	99.55	0	0.13	0	0	0.01	0.30	0
LB4	Channel 2	Inner	Slip	Deep	13.32	0	81.3	0	0	3.11	2.26	0
LB5	Southeast Basin East	Outer	Basin	Deep	65.73	2.25	23.1	0	0	0	8.89	0
LB6	Pier J	Outer	Slip	Deep	97.00	0	1.83	0	0	0	1.10	0
LB7	Main Channel Pilot Station	Outer	Channel	Very Deep	95.99	0	3.30	0	0	0.03	0.68	0
LB9	Outer Channel	Outer	Outer	Very Deep	99.97	0	0	0	0	0	0.03	0
LB10	Southeast Basin West	Outer	Basin	Deep	99.88	0	0.12	0	0	0	0	0
LB12	Main Channel Police Station	Outer	Channel	Very Deep	46.47	0	1.72	0.29	0	0.83	50.9	0
LB13	POLB Turning Basin	Outer	Basin	Deep	49.04	0	24.0	0	0	0.73	26.0	0
LB14	Cerritos Channel	Inner	Channel	Deep	85.16	0	11.6	0	0	0.23	0.05	2.95
LB16	Channel 3	Inner	Slip	Deep	3.75	0	9.43	1.06	0	1.58	83.3	1.93

POLA = Port of Los Angeles; POLB = Port of Long Beach; SWH = shallow water habitat



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median (N)= number of stations.

Figure 4-21. Epibenthic Invertebrate Summary Metrics by Station Habitats – Spring and Summer Events Combined

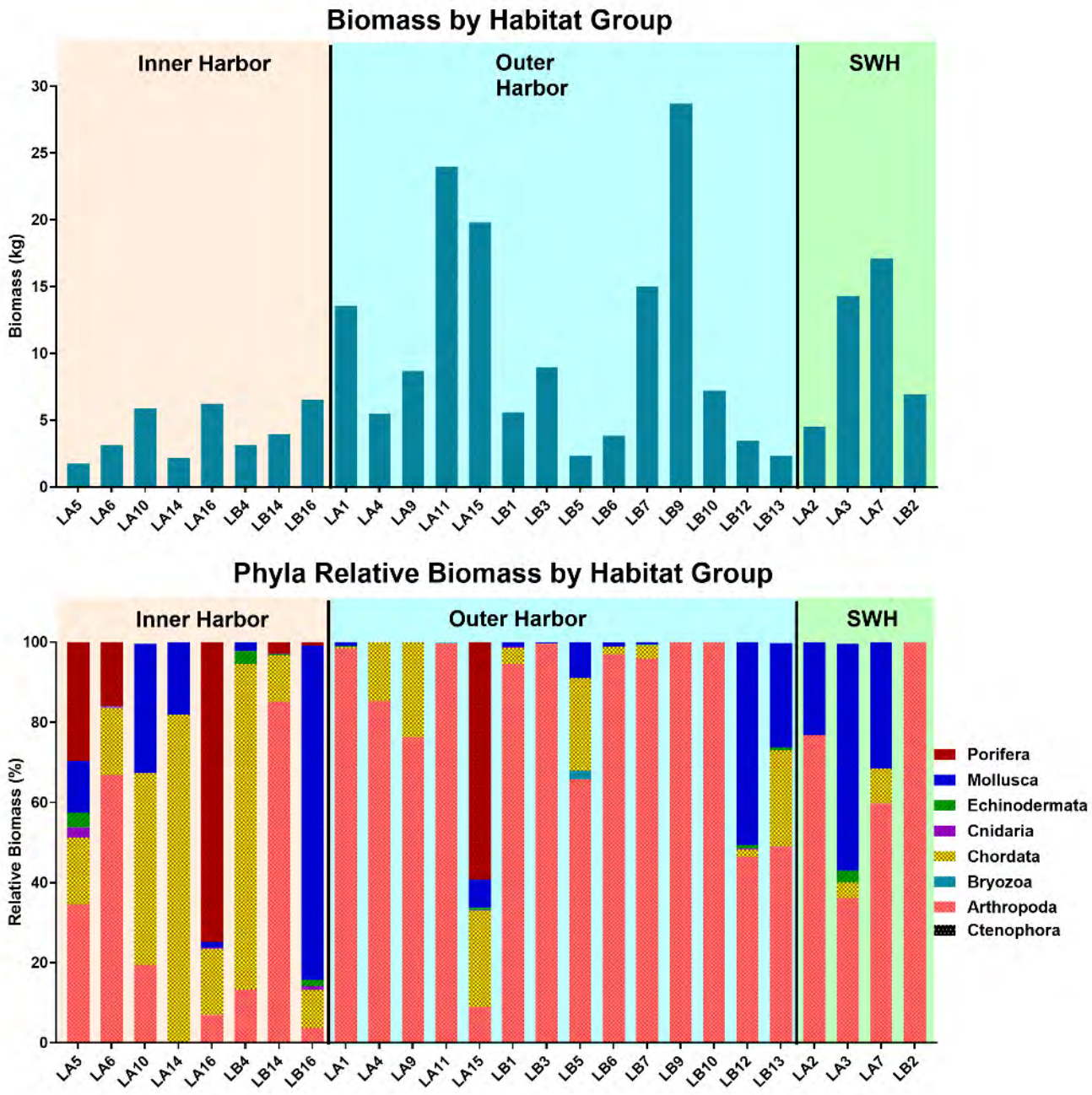
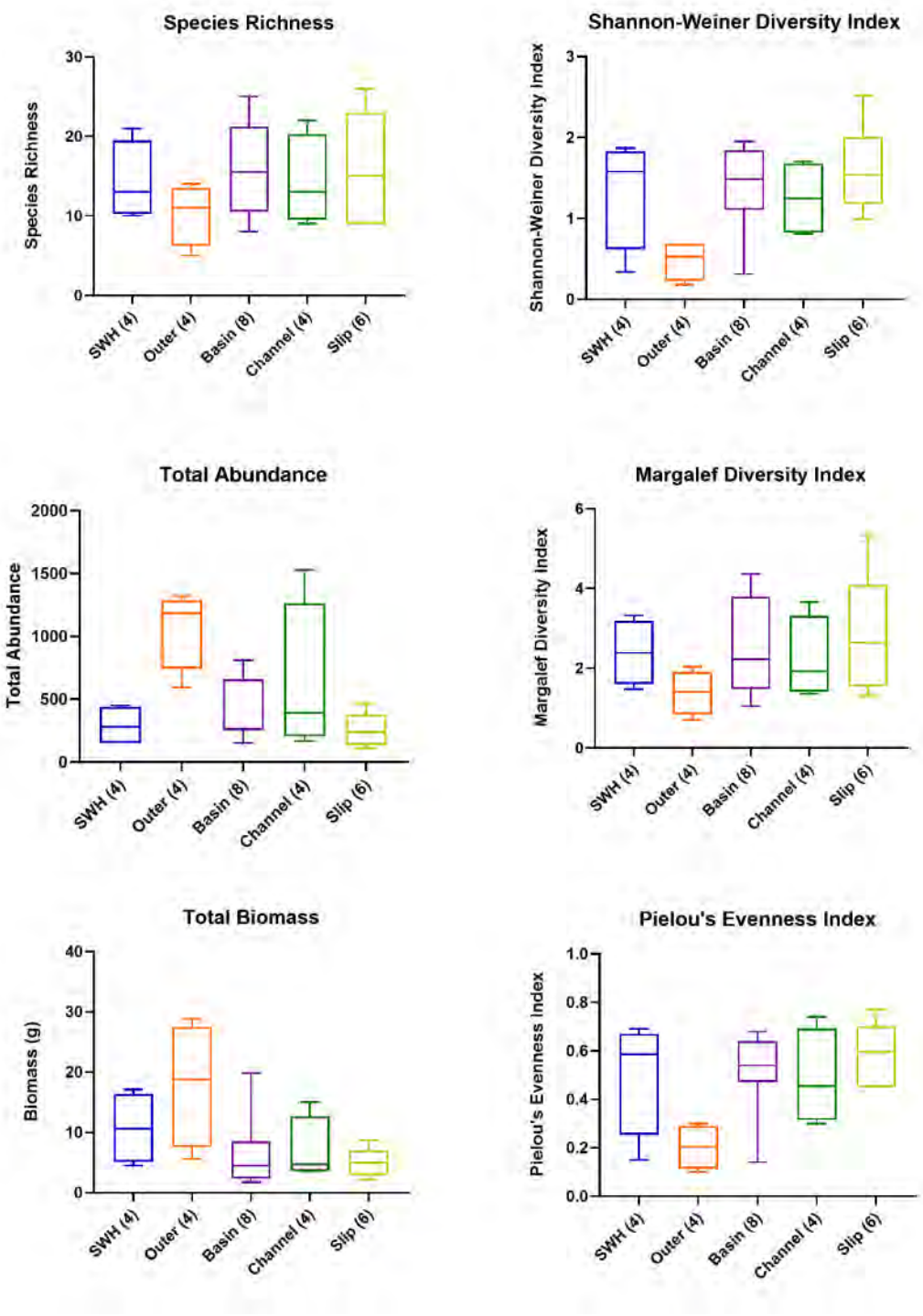
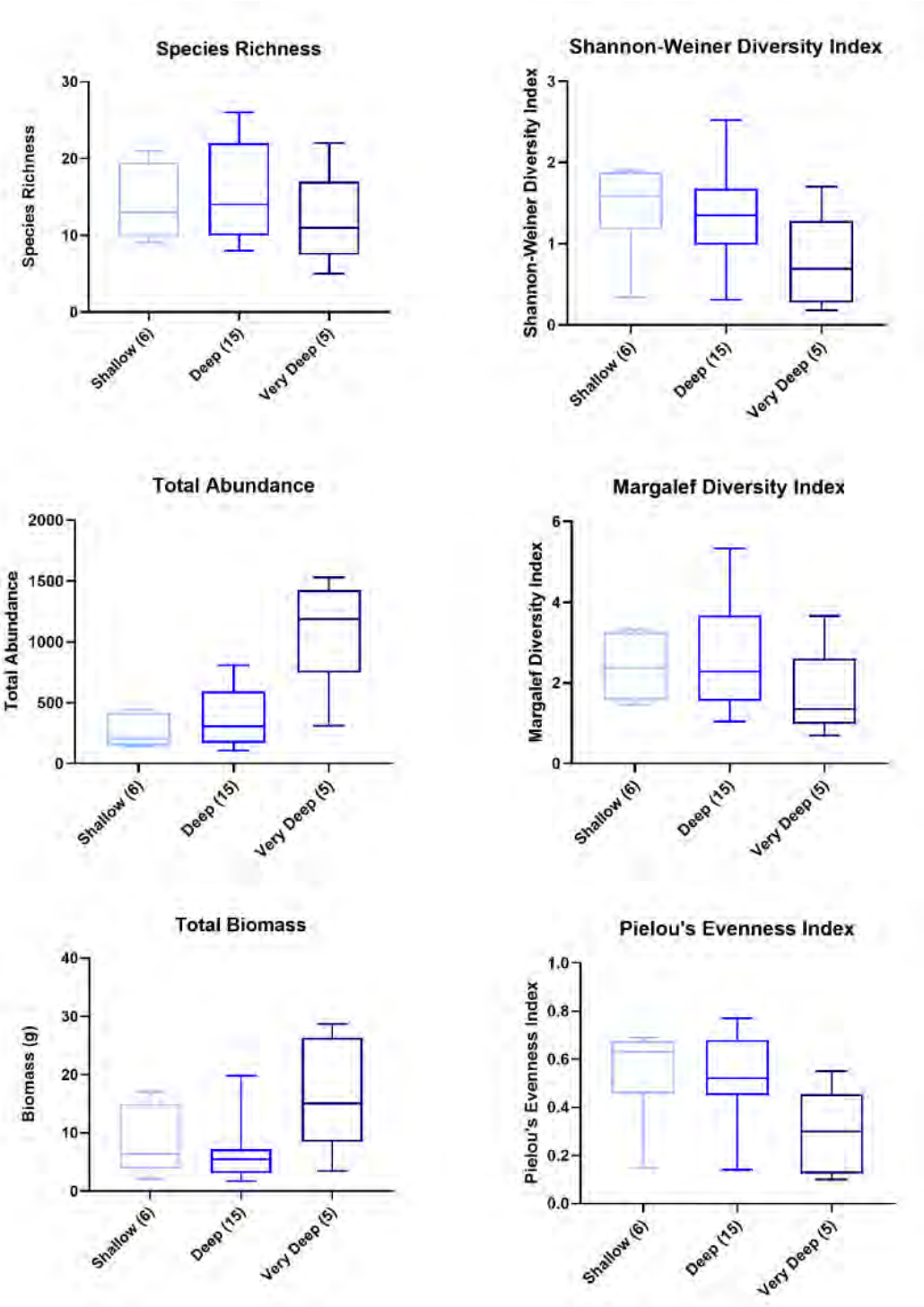


Figure 4-22. Epibenthic Invertebrate Station Biomass – Total and Relative Biomass by Phyla – Spring and Summer Events Combined



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median (N)= number of stations.

Figure 4-23. Epibenthic Invertebrate Summary Metrics by Station Locations – Spring and Summer Events Combined



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median (N)= number of stations.

Figure 4-24. Epibenthic Invertebrate Summary Metrics by Station Depths – Spring and Summer Events Combined

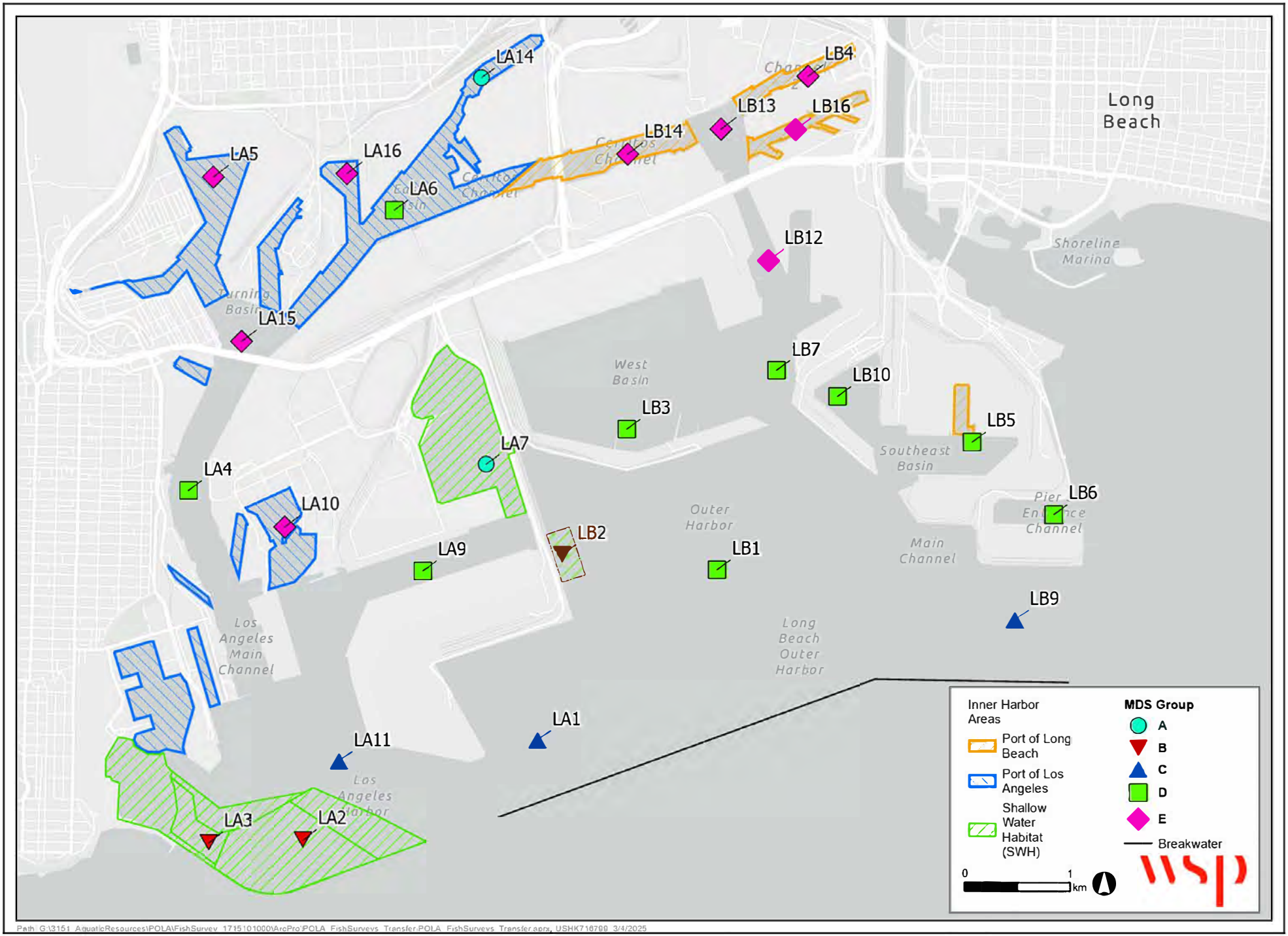
4.4.2.1 MULTIVARIATE ANALYSIS

Multivariate analysis of epibenthic invertebrate abundance data combined across the spring and summer sampling events assessed community patterns throughout the Port Complex (Appendix A provides a description of the multivariate analytical methodology). Note that for species that could not be enumerated such as Bryozoa and sponges, biomass was substituted for abundance for the analysis. Group nMDS plots and the dendrogram showing cluster analysis results are provided in Appendix D. The analytical results indicated the following primary patterns:

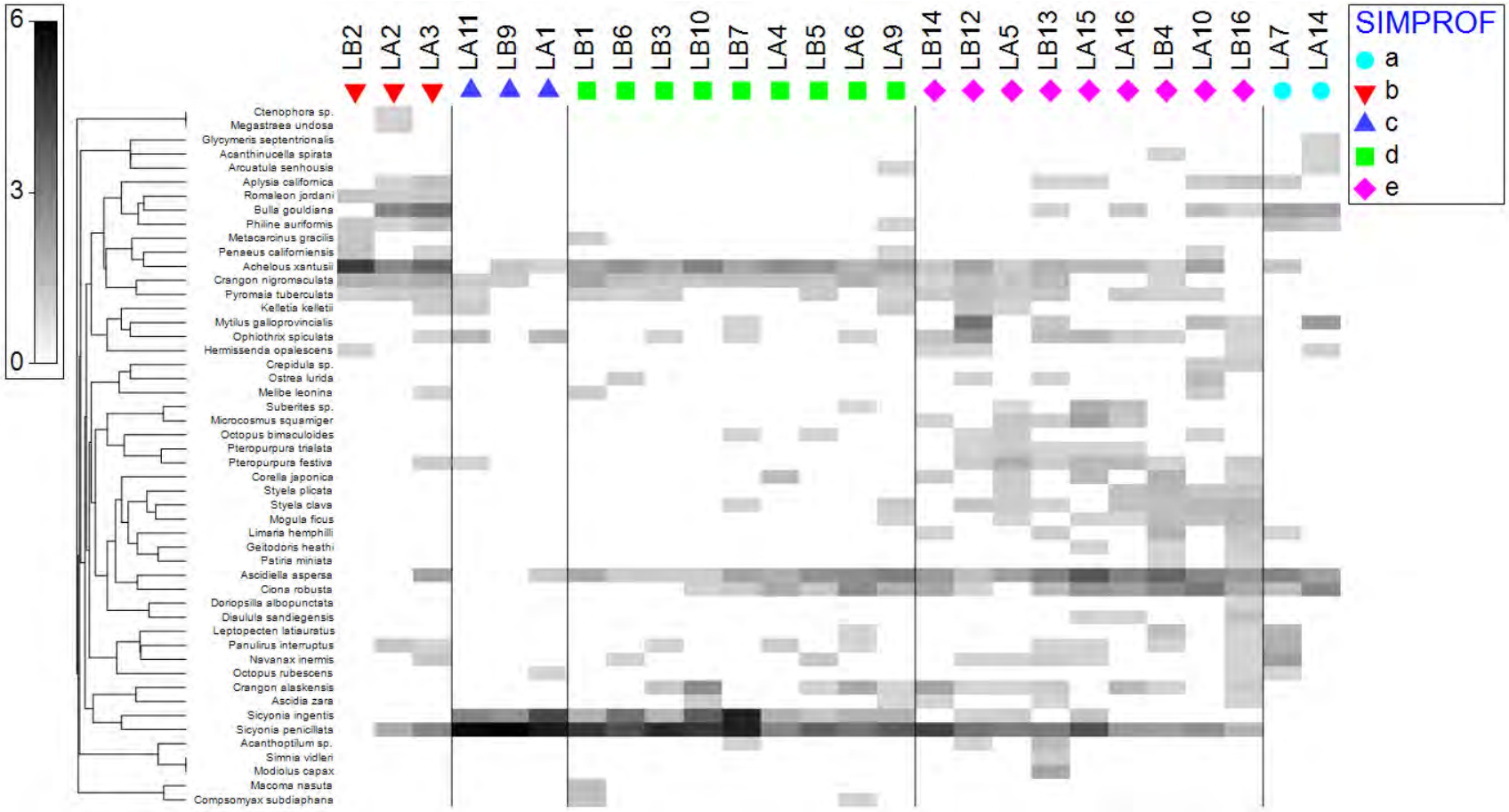
- Habitat group analyses showed that all groups were significantly different from one another.
- Location group analyses indicated that Outer Harbor and SWH stations were statistically different from all other location types. There was no significant difference between channel, basin, and slip stations.
- Depth strata group analyses showed that Shallow stations were significantly different from Deep and Very Deep stations, but Deep stations were not significantly different from Very Deep stations.

The station groups resulting from the SIMPROF analysis were overlaid on the station map (Figure 4-25); the analysis also produced a heatmap of the 50 species that best resolve the groups (Figure 4-26).

Group A consisted of two stations (LA14 [Consolidated Slip] and LA7 [Seaplane Lagoon SWH]) with similarly high abundances of snails (Gould's bubble snail and the non-native white bubble snail) and non-native tunicates (*Ascidiell aspersa* and *Ciona robusta*). The remaining SWH stations (LA2, LA3, and LB2) clustered together in Group B and were dominated by crabs (swimming crab *Achelous xantusii* and tuberculate pear crabs) and shrimp (target shrimp and blacktail shrimp). Group C consisted of the deepest Outer Harbor stations (LA11, LA1, and LB9) that were dominated by target shrimp and ridgeback prawn with few other major species. All of the Inner Harbor stations except station LA6 in the West Basin clustered together in Group E, and the remaining slip, channel, and basin stations clustered in Group D. These two groups were similar in their core community (target shrimp, swimming crabs, and tunicate *Ascidiella aspersa*), with the main difference between the groups the abundance of the core community species (more target shrimp and swimming crabs in Group D, more *Ascidiella aspersa* in Group E) and the presence of more secondary species such as the California sea hare (*Aplysia californica*), three-winged murex (*Pteropurpura trialata*), and festive murex (*Pteropurpura festiva*) in Group E than in Group D.



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The scale reflects abundance data that have been transformed and normalized

Figure 4-26. Epibenthic Similarity Profile Group Heatmap – Top 50 Species

4.4.3 HISTORICAL COMPARISONS

Despite differences in the number of stations and the seasons sampled across Biosurvey years, epibenthic invertebrate communities in the 2023 Biosurvey showed patterns consistent with those of the past four Biosurveys, especially increased abundance during night relative to daytime surveys. For the 2023, 2018, and 2013 Biosurveys, sampling was conducted during two seasons (spring and summer) at 26 stations. During the 2008 Biosurvey, sampling was conducted during three seasons at 19 stations, and during the 2000 Biosurvey, sampling was conducted during all four seasons at 14 stations. This discrepancy makes direct comparisons difficult, but measures such as mean biomass and mean abundance per trawl can be used for meaningful comparisons.

These comparisons (Table 4-12) are made on the basis of the 10 most abundant epibenthic invertebrate species from the past four Biosurveys. The 2013 and 2018 Biosurveys documented a marked increase in the number of invertebrates per trawl – approximately 2.5 times more than the previous two Biosurveys (2000 and 2008) — and the trend continued in the 2023 Biosurvey. This trend held true for biomass as well (Table 4-12). Species richness, however, did not increase; during the 2023 Biosurvey, 83 species of epibenthic invertebrates were captured, compared with 116 species in 2018 and 110 in 2013.

The changes in average biomass and abundance over the past four Biosurveys were driven largely by a shift in capture of a few key shrimp species, principally the target shrimp (*Sicyonia penicillata*), which became the most abundant epibenthic invertebrate from 2013 through 2023 (146 individuals per trawl in 2023). The center of distribution for *Sicyonia penicillata* has historically been in southern Baja California and the Gulf of California, but the species range expansion northward in western Baja California was noted as early as 1986 (Estrada-Ramirez and Calderon-Aguilera, 2001). The species was first identified off Palos Verdes in 1998 (Montagne and Cadien, 2001) and was first captured in the Port Complex in 2000 (although only four individuals). This range expansion into San Pedro Bay was attributed to strong El Niño events in 1997 and 1998, but regional monitoring results for the Southern California Bight in embayment and coastal shelf habitats (Wisenbaker et al., 2021) and within the Port Complex did not indicate substantially increased populations until at least 2008 (Figure 4-27). Within the Port Complex, the increased abundance of *Sicyonia penicillata* was most defined from 2008 through 2013, which may be a result of the warm water event that was underway in the years leading up to 2013. Subsequent survey results have indicated that *Sicyonia penicillata* has persisted and increased its abundance within the Port Complex, with the highest abundance per trawl documented in 2023.

Results of regional studies indicated that the abundance of ridgeback prawn (*Sicyonia ingentis)* declined from 1998 to 2003 (Wisenbaker et al., 2021) but has since has remained relatively stable; abundance of blackspot shrimp (*Crangon nigromaculata*) is less and has been more variable, with the lowest average catch of all Biosurveys to date within the past 2 years (Figure 4-27). The same pattern has been observed in the Port Complex. *Sicyonia ingentis* abundance (average per trawl) has remained relatively stable and in 2023 was the highest to date (30 individuals per trawl). *Crangon nigromaculata* has decreased in abundance since 2000, with the lowest average abundance occurring in 2023 (two individuals per trawl).

The substantially increased biomass in recent Biosurveys (Table 4-12) is likely the result of changing patterns of dominance in the epibenthic fauna. *Sicyonia penicillata* is considerably larger than *Crangon nigromaculata*, and is larger than the other two most abundant species in 2000 and 2008, Xantu's *s*wimming crab (*Portunus xantusii*) and the tuberculate pear crab (*Pyromaia tuberculata*), so the increased biomass from 2013 through 2023 is likely attributable to the dominance of the larger species in the three most recent Biosurveys.

In total, during the past five Biosurveys, 241 species have been collected, with 18 of them collected in all five Biosurveys (Table 4-13). A total of 28 species were recorded in trawls for the first time in 2023, including the non-native sea squirts *Corella japonica*, *Ascidiella aspersa*, *Ciona robusta*, and *Ascidia zara* (see Section 4.7). This observation is consistent with results for previous Biosurveys: 24 species were captured in only 2000; 27 species were captured in in only 2008; 37 species were captured in only 2013; and 48 species were captured in only 2018. This demonstrates the high variability in the epibenthic invertebrate community over the temporal scale of the Biosurveys. For example, some species that were identified in all the Biosurveys from 2000 through 2018 were absent in 2023, such as the California sea cucumber (*Apostichopus californicus*), spiny sand star (*Astropecten armatus*), and four species of shrimp, most notably the blacktail shrimp (*Crangon nigricauda*). The blacktail shrimp was relatively abundant (800+ individuals caught) from 2008 through 2013, but fewer than 12 individuals were caught in 2000 and 2018, and none were caught in 2023.

Epibenthic invertebrates were not captured using beach seines during the 2000 or 2008 Biosurveys, so comparisons can be made only with the results for the 2013 and 2018 Biosurveys. The 2023 Biosurvey results indicated an increase in overall abundance and diversity at beach seine sites compared with results in 2018 and 2013. A total of 1,260 individuals were collected in 2023 across two seasons compared with 1,039 individuals collected in 2018 across three seasons and only 74 collected in 2013 across two seasons. At Cabrillo Beach, a similar number of species was caught in 2023 (7) compared with 2018 (5) and 2013 (6), with diversity ranging from 0.24 in 2018 to 1.48 in 2013 and 2023 within that range at 1.44. At Pier 300, there has been a steady increase in species captured, from 1 in 2013, to 6 in 2018, to 10 in 2023. The increased diversity is reflected in the diversity results at Pier 300, which increased from 0 in 2013, to 0.24 in 2018, to 1.44 in 2023, and from 0.63 in 2018 to 1.36 in 2023 at Cabrillo Beach.

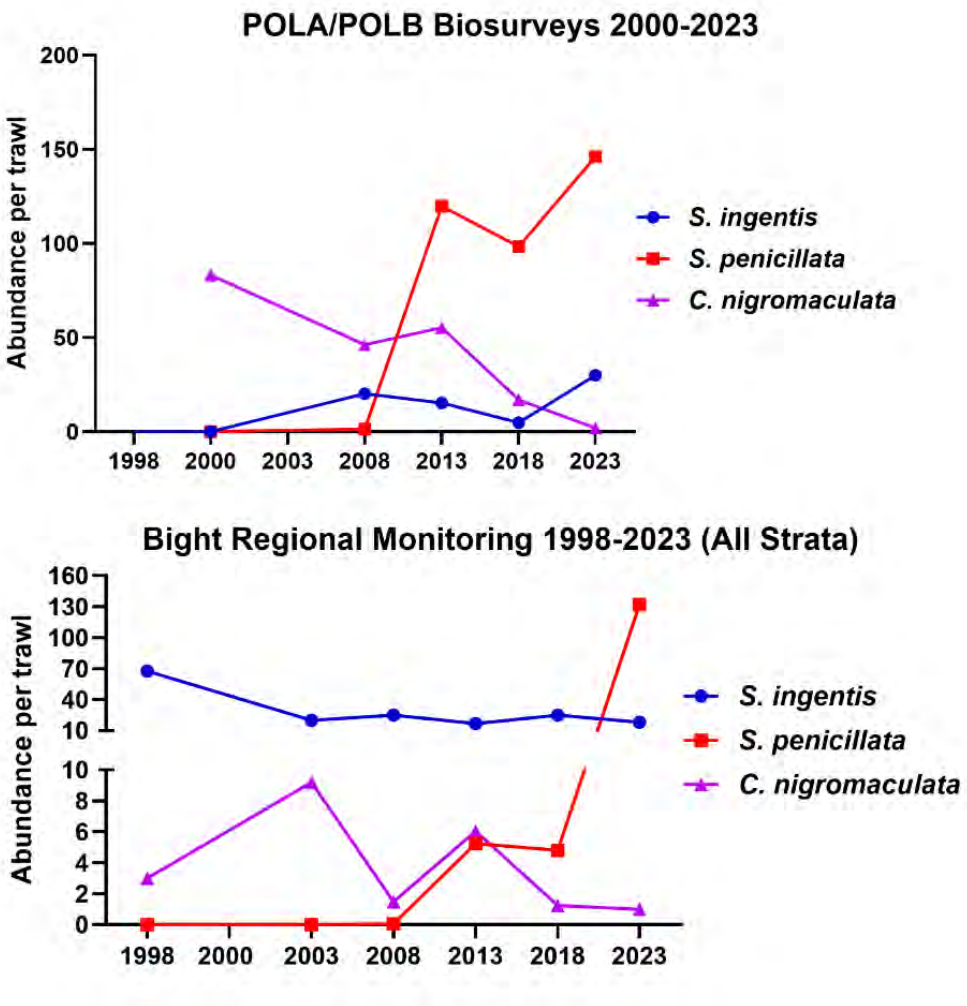


Figure 4-27. Abundance of Three Shrimp Species Measured by the Biosurveys and in All Strata (Bays and Harbors, Shelf, and Slope Strata) of the Regional Bight Monitoring Program

Table 4-12. Historical Top Ten Epibenthic Invertebrates

Year	2000		2008		2013		2018		2023	
Rank	Species	% Total Abundance	Species	% Total Abundance	Species	% Total Abundance	Species	% Total Abundance	Species	% Total Abundance
1	*Crangon nigromaculata*	50.8	*Crangon nigromaculata*	38.4	*Sicyonia penicillata*	37.5	*Sicyonia penicillata*	39.4	*Sicyonia penicillata*	59.5
2	*Pyromaia tuberculata*	27.9	*Sicyonia ingentis*	16.7	*Crangon nigromaculata*	17.3	*Ciona* sp.*	7.98	*Sicyonia ingentis*	12.3
3	*Portunus xantusii*	10.2	*Crangon nigricauda*	13.1	*Portunus xantusii*	10.3	*Alia carinata*	7.57	*Ascidiella aspersa**	8.08
4	*Philine auriformis*	4.45	*Portunus xantusii*	10.9	*Pyromaia tuberculata*	6.60	*Crangon nigromaculata*	6.77	*Achelous xantusii*	7.58
5	*Pagurus spilocarpus*	1.42	*Heptacarpus* sp.	7.62	*Sicyonia ingentis*	4.80	*Tunicate* sp.	5.77	*Ciona robusta**	3.12
6	*Cancer gracilis*	0.48	*Pyromaia tuberculata*	3.35	*Crangon nigricauda*	5.60	*Portunis xantusii*	3.50	*Bulla gouldiana*	1.91
7	*Bulla gouldiana*	0.36	*Crangon alaskensis*	3.15	*Heptacarpus* sp.	2.89	*Styela clava**	2.93	*Mytilus galloprovincialis**	1.16
8	*Penaeus californiensis*	0.34	*Sicyonia penicillata*	1.14	*Crangon* sp.	3.81	*Pyromaia tuberculata*	2.59	*Crangon nigromaculata*	0.89
9	*Navanax inermis*	0.32	*Penaeus californiensis*	0.70	*Philine auriformis*	1.20	*Stylatula elongata*	2.59	*Crangon alaskensis*	0.78
10	*Crangon alaskensis*	0.30	*Styela* sp.*	0.69	*Cancer productus*	0.98	*Leptopecten latiauratus*	2.49	*Ophiothrix spiculata*	0.57
Total # of Trawls	56		57		52		52		52	
Species Richness	61		61		110		116		83	
Total Abundance	9,182		6,861		16,615		12,989		12,763	
Average Abundance per Trawl	164		120		320		250		245	
Average Biomass per Trawl (kg)	1.03		0.52		3.63		3.22		4.32	

* = Genus contains species in NEMESIS database known to be non-native in California.
Shading follows species that appear in at least three Biosurvey years.
kg = kilogram(s)

Table 4-13. Epibenthic Invertebrate Species Captured During All Five Biosurvey Years

Phylum	Common Name	Scientific Name	2000	2008	2013	2018	2023
Arthropoda	Alaska Bay Shrimp	*Crangon alaskensis*	28	216	1	39	100
	Blackspot Shrimp	*Crangon nigromaculata*	4,660	2,632	2,877	880	113
	Yellowleg Shrimp	*Farfantepenaeus californiensis*	31	48	101	20	7
	Sheep Crab	*Loxorhynchus grandis*	5	2	10	3	1
	California Spiny Lobster	*Panulirus interruptus*	26	43	28	25	24
	Xantu's Swimming Crab	*Portunus xantusii*	933	747	1,706	454	967
	Tuberculate Pear Crab	*Pyromaia tuberculata*	2,561	230	1,096	337	31
	Ridgeback Prawn	*Sicyonia ingentis*	1	1,148	797	250	1,575
	Target Shrimp	*Sicyonia penicillata*	4	78	6,230	5,115	7,591
Echinodermata	Warty Sea Cucumber	*Apostichopus parvimensis*	8	8	27	10	2
	Red Urchin	*Mesocentrotus franciscanus*	1	2	2	8	6
	Bat Star	*Patiria miniata*	16	2	29	6	2
	Purple Urchin	*Strongylocentrotus purpuratus*	6	3	7	6	3
Mollusca	California Sea Hare	*Aplysia californica*	21	4	9	2	15
	Milky Venus	*Compsomyax subdiaphana*	5	1	16	4	5
	Giant Nudibranch	*Dendronotus iris*	5	2	98	1	4
	Navanax	*Navanax inermis*	29	12	56	31	39
	Two Spot Octopus	*Octopus bimaculoides*	1	1	18	5	6

4.4.4 DISCUSSION

Sampling results for epibenthic invertebrates collected using beach seines indicated that each station was largely dominated by a few species, although the species at each location and the relative abundance of the animals indicate the different habitat characteristics at each station. Pier 300 has a gradually sloping beach, extensive eelgrass beds that extend far into the subtidal zone, and generally calm conditions, which provide a favorable habitat for the small shrimps and snails that are common in the area. In contrast, Cabrillo Beach slopes more quickly to subtidal habitats that receive more wave energyfrom its proximity to Angel's Gate that mixes the water and results in sandier sediments, and the proximity to kelp habitats creates favorable habitat for crabs and lobsters. During the 2023 Biosurvey, sampling also occurred when nearshore conditions carried by-the-wind sailors (*Velella velella*, a colonial hydroid) into Pier 300, where they were blown up against the beach and captured in the beach seine. Although these animals are found regularly on the beaches in southern California each year, they are not often identified in these surveys because they are generally found in the open ocean.

Epibenthic invertebrate communities sampled using trawls were most distinct across station habitat groups and depths: Deep, Outer Harbor stations exhibited greater abundance and biomass compared with Inner Harbor and SWH stations. The Outer Harbor stations were most commonly dominated by a single species or a few species, most often the target shrimp *Sicyonia penicillata*, and the Inner Harbor stations were more typically dominated by the tunicate *Ascidiella aspersa*. Multivariate analysis identified two major groups that shared the same core community, mostly Inner Harbor and Outer Harbor stations; SWH stations and Deep stations in the main channels of both the Port of Los Angeles and the Port of Long Beach clustered into their own groups with unique community compositions.

The composition of the epibenthic community has shifted over the course of the past four Biosurveys. In the 2000 and 2008 Biosurveys, the community was dominated by the blackspotted shrimp (*Crangon nigromaculata*), and the tuberculate pear crab (*Pyromaia tuberculata*), before shifting dramatically in 2013, 2018, and 2023 to dominance by the target shrimp (*Sicyonia penicillata*). This shift appears to be in part a result of the target shrimp shifting its distribution northward in response to warm water events that occur regularly in Southern California, and recent strong El Niño events in 1997 and 1998 and the warm water event from 2013 through 2015 may have facilitated the persistence of a northern population (Estrada-Ramirez and Calderon-Aguilera, 2001; Montagne and Cadien, 2001). Although these regional events may be landmarks of large-scale shifts, other oceanographic and climatic forces facilitate the establishment of southern species such as *Sicyonia penicillata* in the Port Complex.

4.5 SHALLOW SUBTIDAL FISHES

Shallow subtidal habitat was sampled at two sandy beach and eelgrass locations: Cabrillo Beach and Pier 300. At each location, two stations were sampled using a beach seine during the spring and summer, with sampling conducted as close to low tide as possible. The two sampling events were combined in these analyses because statistical analysis determined no significant differences in fish abundance across replicates and seasons based on total number of species and biomass.

4.5.1 SPECIES COMPARISONS

4.5.1.1 ABUNDANCE

A total of 1,875 fish composed of 23 species were collected using beach seines across all sampling events (Tables 4-14 and 4-15, Figure 4-28). Notable differences were identified in the fish communities at the two stations, with more species and higher abundance at Pier 300 compared with Cabrillo Beach. Similar to the results for epibenthic invertebrates at each location, the composition of the fish community reflects the particular characteristics of each location. Pier 300's shallow, sloping beach and extensive subtidal eelgrass beds provide favorable habitat for species such as shiner perch, pipefish, gobies, rays, sculpins, and juvenile bass. Cabrillo Beach's sheltered coastal conditions and proximity to kelp beds favor species such as leopard sharks, black perch, dwarf perch, and jacksmelt.

Five taxa made up 84% of the total abundance of all fish collected across both stations (Table 4-16): topsmelt (*Atherinops affinis*; 51.1%), shiner perch (*Cymatogaster aggregate;* 16%), Atherinopsis (7.5%), yellowchin sculpin *(Icelinus quadriseriatus;* 5%), and bay pipefish (*Syngnathus leptorhynchus*; 4.4%). Only four other species made up 1% or more of the remaining total abundance.

Table 4-14. Fish Catch Summary by Station Using Beach Seines Across All Seasons

Common Name	Scientific Name	Cabrillo Beach	Pier 300	Total Abundance
Arrow Goby	*Clevelandia ios*	0	14	14
Barred Sand Bass	*Paralabrax nebulifer*	0	51	51
Bat Ray	*Myliobatis californica*	0	9	9
Bay Blenny	*Hypsoblennius gentilis*	0	17	17
Bay Pipefish	*Syngnathus leptorhynchus*	3	80	83
Black Perch	*Embiotoca jacksoni*	7	1	8
California Corbina	*Menticirrhus undulatus*	0	1	1
California Halibut	*Paralichthys californicus*	2	2	4
CIQ Goby (larval)	*Gobiidae*	1	23	24
Diamond Turbot	*Pleuronichthys guttulatus*	0	9	9
Dwarf Perch	*Micrometrus minimus*	61	0	61
Giant Kelpfish	*Heterostichus rostratus*	29	25	54
Jacksmelt	*Atherinopsis californiensis*	14	0	14
Kelp Pipefish	*Syngnathus californiensis*	0	1	1
Leopard Shark	*Triakis semifasciata*	6	0	6
Round Stingray	*Urobatis halleri*	1	9	10
Shiner Perch	*Cymatogaster aggregata*	2	299	301
Smelt sp.	*Atherinopsis sp.*	0	141	141
Spotted Kelpfish	*Gibbonsia elegans*	1	3	4
Spotted Sand Bass	*Paralabrax maculatofasciatus*	3	1	4
Topsmelt	*Atherinops affinis*	445	514	959
White Croaker	*Genyonemus lineatus*	0	7	7
Yellowchin Sculpin	*Icelinus quadriseriatus*	0	93	93
Total Abundance		**575**	**1,300**	**1,875**
Species Richness		**13**	**20**	**23**

4.5.1.2 BIOMASS

During beach seine sampling, 42.2 kg of fish biomass were collected across all sampling events (Table 4-15), with the large biomass primarily due to nine bay rays captured in the summer at Pier 300, which made up nearly 60% (24.94 kg) of the total biomass. Other than the bat rays, the two locations were very similar in terms of biomass, with a total of 9.49 kg at Pier 300 and 7.77 kg at Cabrillo Beach.

Other than the bat rays, 11 other species accounted for more than 1% of the remaining total biomass (Table 4-16): round stingray (9.1%), topsmelt (8%), leopard shark (5.3%), spotted sand bass (3.1%), dwarf perch (2.4%), shiner perch (2.2%), California corbina (1.9%), barred sand bass (1.9%), black perch (1.7%), jacksmelt (1.7%), and yellowchin sculpin (1.2%).

4.5.1.3 SIZE CLASSES

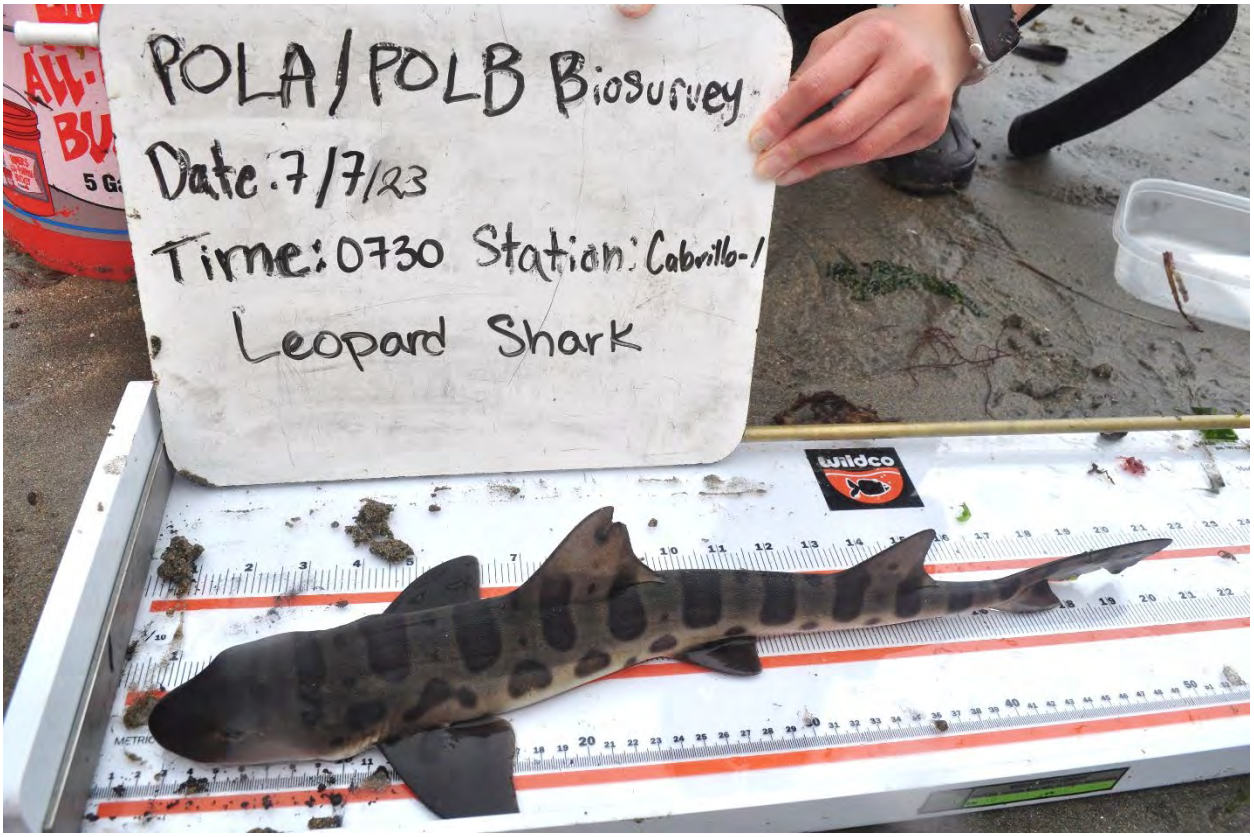
To supplement otter trawl data, size class was analyzed for the white croaker, topsmelt, barred sand bass, and California halibut collected in the beach seines (Section 4.6.1). Shiner perch and bay pipefish were not analyzed because of their small size range. Although topsmelt individuals were caught in the beach seines, their size class distribution is presented with the rest of the pelagic species in Section 3.3.1.

Table 4-15. Fish Index Summary by Station Using Beach Seines – Across all Seasons

Location	Species Richness	Total Abundance	Total Biomass (kg)	Shannon Weiner Diversity Index	Margalef Diversity Index	Pielou's Evenness Index
Pier 300	20	1300	34.4	1.86	2.65	0.62
Cabrillo Beach	13	575	7.77	0.91	1.89	0.36

kg = kilogram(s)

The results for the size class analysis indicate that juveniles of all three species use the shallow beach and eelgrass habitat as nursery habitats. Their size distributions indicate that smaller individuals use these habitats compared with the population sampled in deeper pelagic and soft-bottom habitat. Based on published length at maturity information, no mature white croaker or halibut were caught in the beach seines because all individuals caught were less than 16.5 cm in size, and only one barred sand bass (26 cm) was caught that could potentially be mature; the rest caught were juveniles.



Leopard shark captured in beach seines at Cabrillo Beach

4.5.1.4 DIVERSITY AND EVENNESS INDICES

Diversity and evenness index values differed for Pier 300 and Cabrillo Beach (Figure 4-28) because of differences in total abundance and species richness at the two locations. This was a change from the previous Biosurvey (2018) for which the diversity and evenness index values were very similar for Pier 300 and Cabrillo Beach. Pier 300 scored slightly higher than Cabrillo Beach using all three indices.

4.5.1.5 ECOLOGICAL INDEX

Fish species with the top five EI scores collected using beach seines included topsmelt, bat ray, shiner perch, round stingray, and bay pipefish, as shown in Table 4-16.

Table 4-16. Fish Catch Summary by Species using Beach Seines, in Order of Ecological Index – All Seasons Combined

Common Name	Scientific Name	Total Abundance	% of Total Abundance	Total Biomass (kg)	% of Total Biomass	Frequency of Occurrence (%)	Ecological Index
Topsmelt	*Atherinops affinis*	959	51.2	3.41	8.09	86	5,078
Bat Ray	*Myliobatis californica*	9	0.5	24.9	59.2	14	852
Shiner Perch	*Cymatogaster aggregata*	301	16.1	0.92	2.19	43	782
Round Stingray	*Urobatis halleri*	10	0.53	3.84	9.10	71	688
Bay Pipefish	*Syngnathus leptorhynchus*	83	4.40	0.09	0.21	86	397
Yellowchin Sculpin	*Icelinus quadriseriatus*	93	4.96	0.52	1.22	57	353
Giant Kelpfish	*Heterostichus rostratus*	54	2.88	0.41	0.97	71	275
Barred Sand Bass	*Paralabrax nebulifer*	51	2.72	0.78	1.9	57	262
Smelt sp.	*Atherinopsis sp.*	141	7.52	0.06	0.13	29	219
Dwarf Perch	*Micrometrus minimus*	61	3.25	1.02	2.42	29	162
Leopard Shark	*Triakis semifasciata*	6	0.32	2.24	5.31	29	161
Spotted Sand Bass	*Paralabrax maculatofasciatus*	4	0.21	1.32	3.13	29	95
Black Perch	*Embiotoca jacksoni*	8	0.43	0.70	1.67	43	90
CIQ Goby (larval)	*Gobiidae*	24	1.28	0.02	0.06	43	57
Bay Blenny	*Hypsoblennius gentilis*	17	0.9	0.17	0.39	43	56
Jacksmelt	*Atherinopsis californiensis*	14	0.75	0.70	1.66	14	34
Diamond Turbot	*Pleuronichthys guttulatus*	9	0.48	0.10	0.23	43	30
California Corbina	*Menticirrhus undulatus*	1	0.05	0.80	1.89	14	28
Arrow Goby	*Clevelandia ios*	14	0.70	0.01	0.01	29	22
California Halibut	*Paralichthys californicus*	4	0.21	0.10	0.24	43	20
White Croaker	*Genyonemus lineatus*	7	0.37	0.01	0.02	29	11
Spotted Kelpfish	*Gibbonsia elegans*	4	0.21	0.01	0.03	29	7
Kelp Pipefish	*Syngnathus californiensis*	1	0.05	0.004	0.01	14	1
Total Abundance/Biomass		**1875**		**42.2**			
Total Species Richness		**23**					

kg = kilogram(s)

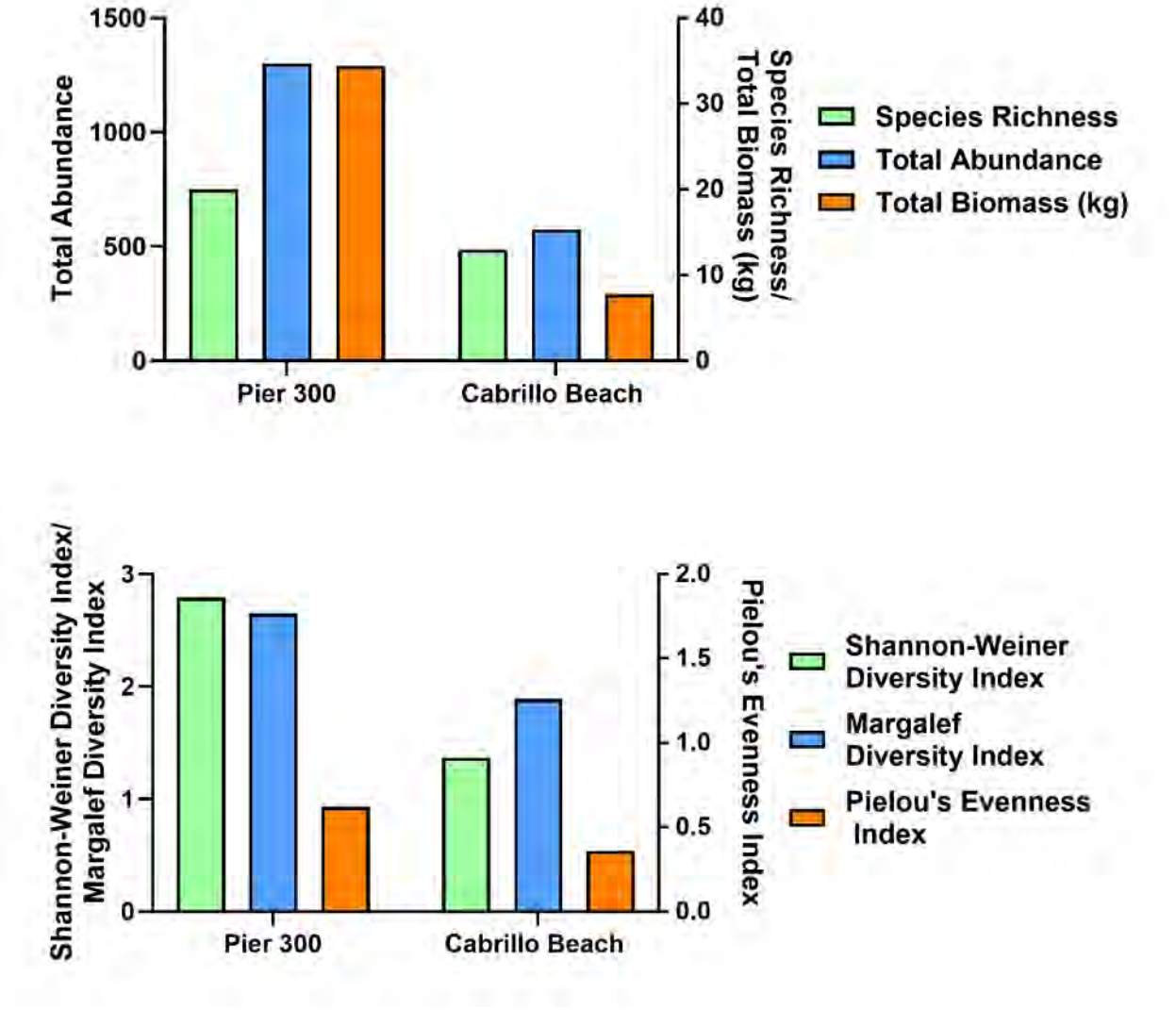


Figure 4-28. Fish Community Summaries for Pier 300 and Cabrillo Beach Captured Using Beach Seines

4.5.2 HISTORICAL COMPARISONS

Species richness has been consistent over four of the five Biosurveys for 20 to 24 species (Figure 4-29); only in 2008 was the number of species caught markedly lower. The mean abundance of fish per station was similar in all Biosurveys except for the 2013 Biosurvey, which had double the next highest abundance (the change was attributable to unusually large catches of queenfish, *Seriphus politus*, and northern anchovy, *Engraulis mordax*). The mean biomass per station was low in the 2000 and 2008 Biosurveys (0.37 kg and 0.17 kg, respectively) relative to the results for the 2013, 2018, and 2023 Biosurveys (6.5 kg, 4.5 kg, and 7.0 kg respectively), likely due to the capture of a few large individual species such as guitarfish, leopard sharks, and bat rays in some years but not others.

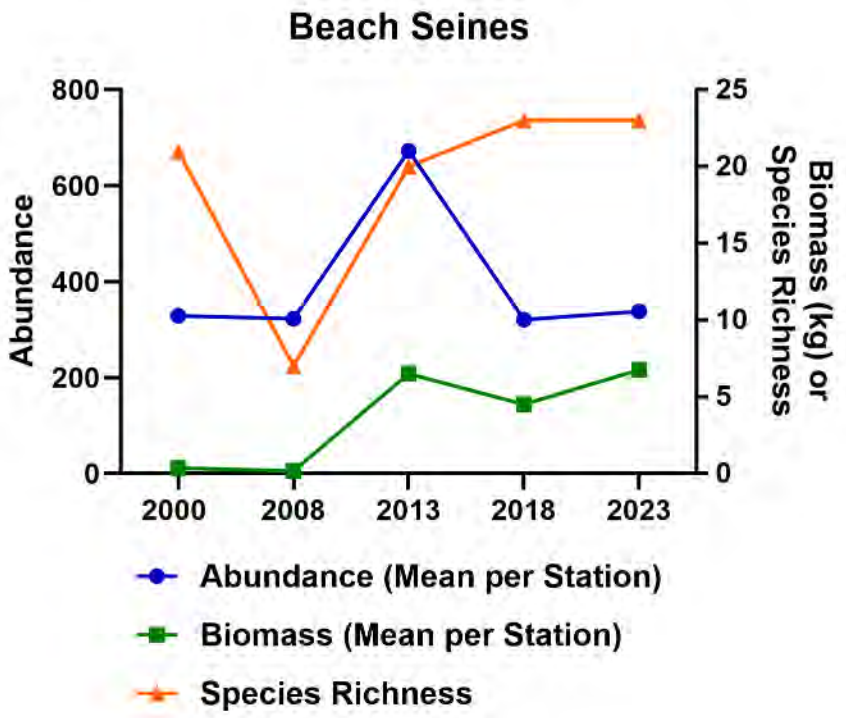


Figure 4-29. Historical Comparison of Fish Species Richness, Mean Abundance, and Mean Biomass Captured Using Beach Seines at Pier 300 and Cabrillo Beach

4.6 DEMERSAL FISH

Demersal fish, those living on or near the ocean bottom, were sampled in the spring and summer at 26 stations throughout the Port Complex (see Appendix C for map of trawl tracks in spring and summer). Day and night sampling used an otter trawl during each season for 4 trawls at each station throughout the period and 104 individual trawl events.

4.6.1 SPECIES COMPARISONS

4.6.1.1 ABUNDANCE

During otter trawl sampling, 56 species composed of 21,523 fish were collected across all sampling events (Table 4-17). More fish were caught during the day (13,669) than at night (7,853). Across all sampling events, seven species made up 94.5% of the total abundance of the fish collected (Table 4-17): white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), shiner perch (*Cymatogaster* aggregate), speckled sanddab (*Citharichthys stigmaeus*), specklefin midshipmen (*Porichthys myriaster*), salema (*Haemulon californiensis*), and barred sand bass (*Paralabrax nebulifer*). The remaining 49 species represented only 5.4% of the total abundance.

Ten stations (LB9, LB7, LB12, LA11, LA1, LB6, LB1, LB10, LA7, and LB3) accounted for 90% of the total abundance of fish captured across the stations (see Appendix D). Large numbers of white croaker, queenfish, and shiner perch were the main drivers of this pattern. All but station LA7 are Outer Harbor stations that were classified as either Deep or Very Deep, with depths ranging from 15.4 to 26.7 meters. Station LA7 (Pier 300), classified as Shallow, with depths of 4.1 to 4.9 meters, had a large number of shiner perch that accounted for 90% of the total abundance of fish captured at that station.

Table 4-17. Summary of Demersal Fish Captured Using the Otter Trawl by Species in Order of Ecological Index

Common Name	Scientific Name	Total Abundance per Taxa	% of Total Abundance	Total Biomass per Taxa (kg)	% of Total Biomass	Total Density (#/100 m^2)	Frequency of Trawl Capture (%)	Ecological Index
White Croaker	*Genyonemus lineatus*	11,475	53.32	367	66.54	122.16	73.1	8,758
Queenfish	*Seriphus politus*	5,322	24.73	37.6	6.81	56.65	96.2	3,032
Shiner Perch	*Cymatogaster aggregata*	1,497	6.95	12.9	2.33	15.93	92.3	857
California Halibut	*Paralichthys californicus*	97	0.45	49.4	8.95	1.03	84.6	795
Speckled Sanddab	*Citharichthys stigmaeus*	985	4.58	7.37	1.34	10.49	61.5	364
Specklefin Midshipman	*Porichthys myriaster*	538	2.50	5.36	0.97	5.73	88.5	307
Barred Sand Bass	*Paralabrax nebulifer*	261	1.21	10.7	1.93	2.78	88.5	278
Salema	*Haemulon californiensis*	281	1.31	1.40	0.25	2.99	50.0	78.0
Round Stingray	*Urobatis halleri*	21	0.10	8.25	1.49	0.22	46.2	73.5
Fantail Sole	*Xystreurys liolepis*	60	0.28	4.49	0.81	0.64	57.7	63.0
Pacific Butterfish	*Peprilus simillimus*	188	0.87	4.87	0.88	2.00	26.9	47.2
California Tonguefish	*Symphurus atricaudus*	144	0.67	1.13	0.20	1.53	50.0	43.7
Spotted Turbot	*Pleuronichthys ritteri*	47	0.22	1.87	0.34	0.50	65.4	36.4
Bat Ray	*Myliobatis californica*	7	0.03	14.7	2.66	0.07	11.5	31.0
Vermilion Rockfish	*Sebastes miniatus*	87	0.40	1.17	0.21	0.93	46.2	28.4
Northern Anchovy	*Engraulis mordax*	77	0.36	0.85	0.15	0.82	42.3	21.6
California Scorpionfish	*Scorpaena guttata*	12	0.06	3.93	0.71	0.13	26.9	20.7
Hornyhead Turbot	*Pleuronichthys verticalis*	29	0.13	1.71	0.31	0.31	42.3	18.8
California Lizardfish	*Synodus lucioceps*	41	0.19	0.75	0.14	0.44	50.0	16.3
Longspine Combfish	*Zaniolepis latipinnis*	70	0.33	1.69	0.31	0.75	23.1	14.6
California Skate	*Raja inornata*	7	0.03	1.39	0.25	0.07	26.9	7.67
Longfin Sanddab	*Citharichthys xanthostigma*	30	0.14	1.83	0.33	0.32	15.4	7.24
Plainfin Midshipman	*Porichthys notatus*	20	0.09	0.27	0.05	0.21	42.3	6.02
White Seaperch	*Phanerodon furcatus*	27	0.13	0.55	0.10	0.29	23.1	5.18
Bocaccio	*Sebastes paucispinis*	19	0.09	0.16	0.03	0.20	38.5	4.52
Chilipepper Rockfish	*Sebastes goodei*	36	0.17	0.36	0.07	0.38	15.4	3.57
Yellowchin Sculpin	*Icelinus quadriseriatus*	17	0.08	0.08	0.01	0.18	38.5	3.56
Basketweave Cusk-Eel	*Ophidion scrippsae*	19	0.09	0.38	0.07	0.20	19.2	3.03
Pacific Electric Ray	*Tetronarce californica*	1	0.00	4.24	0.77	0.01	3.85	2.97
Black Perch	*Embiotoca jacksoni*	20	0.09	0.24	0.04	0.21	15.4	2.11

kg = kilogram(s); m2 = square meter(s)

Table 4-17. Summary of Demersal Fish Captured Using the Otter Trawl by Species in Order of Ecological Index (continued)

Common Name	Scientific Name	Total Abundance per Taxa	% of Total Abundance	Total Biomass per Taxa (kg)	% of Total Biomass	Total Density (#/100 m^2)	Frequency of Trawl Capture (%)	Ecological Index
Jack Mackerel	*Trachurus symmetricus*	9	0.04	0.43	0.08	0.10	15.4	1.83
Giant Kelpfish	*Heterostichus rostratus*	11	0.05	0.14	0.03	0.12	19.2	1.47
Horn Shark	*Heterodontus francisci*	1	0.00	2.01	0.36	0.01	3.85	1.41
Pacific Sanddab	*Citharichthys sordidus*	12	0.06	0.13	0.02	0.13	15.4	1.40
English Sole	*Parophrys vetulus*	6	0.03	0.11	0.02	0.06	19.2	0.90
Shovelnose Guitarfish	*Psuedobatos productus*	1	0.00	1.26	0.23	0.01	3.85	0.90
Jacksmelt	*Atherinopsis californiensis*	5	0.02	0.49	0.09	0.05	7.69	0.87
Thornback	*Platyrhinoidis triseriata*	2	0.01	0.38	0.07	0.02	7.69	0.61
Pacific Staghorn Sculpin	*Leptocottus armatus*	7	0.03	0.08	0.01	0.07	11.5	0.53
Spotted Sand Bass	*Paralabrax maculatofasciatus*	4	0.02	0.02	0.00	0.04	7.69	0.17
California Clingfish	*Gobiesox rhessodon*	3	0.01	0.00	0.00	0.03	11.5	0.17
Bay Blenny	*Hypsoblennius gentilis*	3	0.01	0.04	0.01	0.03	7.69	0.16
Bay Pipefish	*Syngnathus leptorhynchus*	2	0.01	0.01	0.00	0.02	7.69	0.08
Barcheek Pipefish	*Syngnathus exilis*	2	0.01	0.00	0.00	0.02	7.69	0.08
Cheekspot Goby	*Ilypnus gilberti*	2	0.01	0.00	0.00	0.02	7.69	0.08
Shadow Goby	*Quietula y-cauda*	4	0.02	0.00	0.00	0.04	3.85	0.07
Arrow Goby	*Clevelandia ios*	3	0.01	0.00	0.00	0.03	3.85	0.06
Yellowfin goby	*Acanthogobius flavimanus*	2	0.01	0.02	0.00	0.02	3.85	0.05
Pacific Sardine	*Sardinops sagax*	1	0.00	0.05	0.01	0.01	3.85	0.05
Spotted Kelpfish	*Gibbonsia elegans*	2	0.01	0.01	0.00	0.02	3.85	0.04
Pink Surfperch	*Zalembius rosaceus*	1	0.00	0.01	0.00	0.01	3.85	0.02
Kelp Pipefish	*Syngnathus californiensis*	1	0.00	0.01	0.00	0.01	3.85	0.02
Black Croaker	*Cheilotrema saturnum*	1	0.00	0.01	0.00	0.01	3.85	0.02
Blackeye Goby	*Rhinogobiops nicholsii*	1	0.00	0.00	0.00	0.01	3.85	0.02
Pygmy Poacher	*Odontopyxis trispinosa*	1	0.00	0.00	0.00	0.01	3.85	0.02
Roughback Sculpin	*Chitonotus pugetensis*	1	0.00	0.00	0.00	0.01	3.85	0.02
Total Abundance/Biomass		21,523		552				
Total Species Richness								

kg = kilogram(s); m2 = square meter(s)

4.6.1.2 BIOMASS

The total biomass of demersal fish collected using otter trawl sampling across both seasons was 552 kg (Table 4-17). There was little difference in biomass between day (298 kg) and night (254 kg) sampling and between spring (270 kg) and summer (282 kg) sampling among all fish combined.

Across all sampling events, white croaker made up 66.5% of the total biomass. California halibut (*Paralichthys californicus*; 8.9%) and queenfish (*Seriphus politus;* 6.8%) were the only other species that made up more than 5% of the total biomass collected.

Eight stations in the Outer Harbor (LB9, LB7, LB12, LA11, LA1, LB6, LB1, and LB3) accounted for 75% of the total biomass of fish captured across all stations.

4.6.1.3 ECOLOGICAL INDEX

The EI values for trawl species ranged from 0.02 for a single roughback sculpin to 8,758 for white croaker, which was nearly ubiquitous across Port Complex (Table 4-17). The top five species based on the EI values were white croaker (8,758), queenfish (3,032), shiner perch (857), California halibut (795), and speckled sanddab (364). The "rank" by EI determines the relative importance of each species to the flow of energy within the food web of the Port Complex ecosystem (Allen et al., 2002). Because the EI incorporates frequency of catch and size (biomass) of the fish, this index provides a good measure of the overall community over time and across multiple trophic levels.



White croaker (Genyonemus lineatus)

4.6.1.4 SIZE CLASSES

The five benthic fish species with the highest EI values (white croaker, queenfish, shiner perch, barred sand bass, and California halibut) and the most abundant PCG FMP species (vermillion rockfish) were analyzed by size class. Beach seine data were incorporated into the size class analysis for white croaker, barred sand bass, shiner perch, and California halibut because those species were abundant in shallow subtidal habitats, and white croaker and queenfish captured in the lampara (see Chapter 3) were added to this analysis. Length at maturity information is provided for species when available.

White croaker (11,482 total across all gear types) had the highest EI value of any species collected and ranged in size from 1 to 25 cm (Figure 4-30). Both spring and summer populations showed normal distributions. The spring population had a smaller size class centered around 6 to 8 cm and a larger size class from 9 to 12 cm. In the summer, the smaller size class was longer than in spring (10 to 13 cm range) and more abundant (2,619 individuals), and the larger size class was also longer than in spring (14 to 19 cm). Maturity of 50% of the white croaker population occurs when fish reach approximately 1 year of age (14 cm total length [TL] male and 15 cm TL female, respectively), and 100% of fish are mature at 3 to 4 years of age, with a length of approximately 19 cm (Love, 2011). Based on the average of this range (16.5 cm), approximately 10% of the population captured in the Port Complex in 2023 may be considered mature.

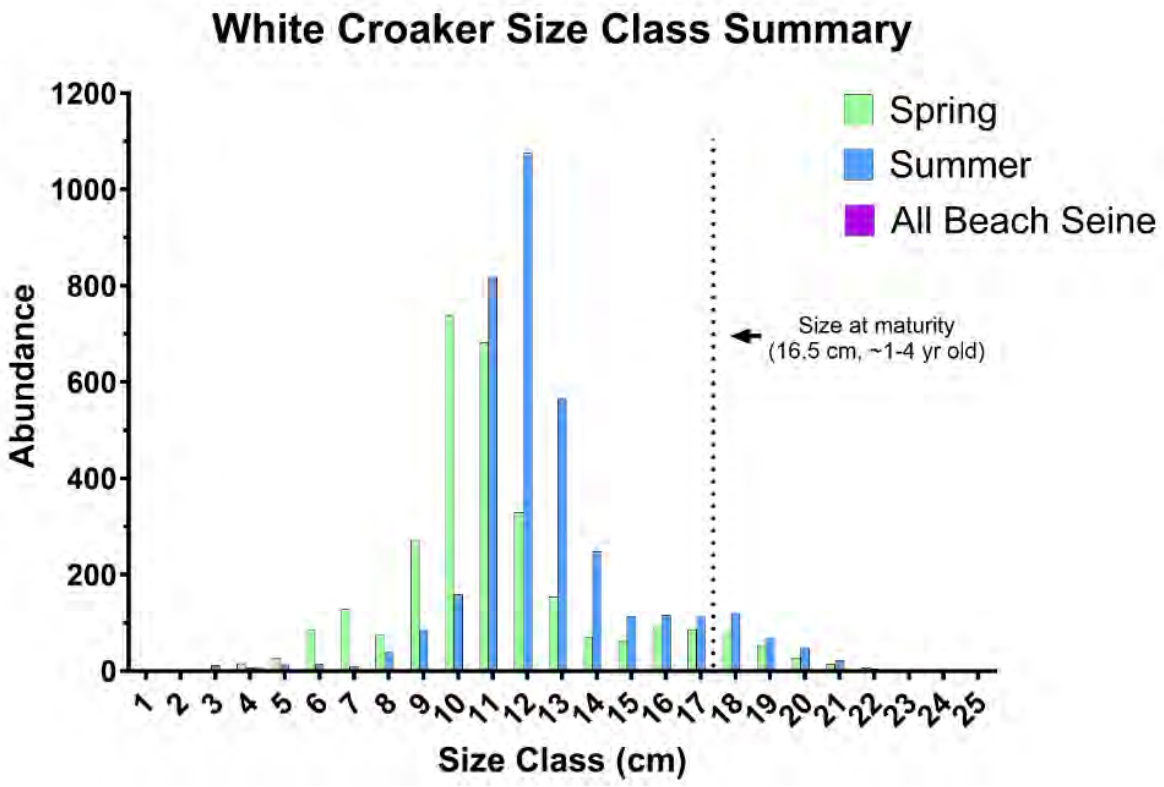
Queenfish (5,360 total) captured with trawls and lampara nets ranged in size from 1 to 20 cm and had a bimodal size distribution across both seasons (Figure 4-31). The spring population had a smaller size class centered around 6 to 8 cm and a larger size class from 13 to 16 cm. The summer population had a smaller size class around 7 to 10 cm and a larger size class from 14 to 17 cm. Length-at-age studies using San Clemente and Oceanside populations indicated that females are mature at approximately 10 to 10.5 cm standard length (DeMartini and Fountain, 1981), which would mean that approximately 14% of the total catch in the 2023 Biosurvey would be considered mature.

Shiner perch collected in trawls (1,230 total) ranged in size from 3 to 14 cm, with similar abundances of fish greater than 9 cm in length across both seasons (Figure 4-32). Shiner perch were captured only in summer using beach seines, and ranged in size from 3 to 11 cm. Maturity for males usually occurs within the first year by the time they are 6.5 to 9.5 cm TL, and females mature within their first year or two at approximately 9 cm TL (Love, 2011). Of the shiner perch captured across both seasons in 2023, from 19 to 22% were mature, although nearly all of the shiner perch captured in the spring (size range from 8 to 14 cm) were mature. There was a notable spike in abundance of shiner perch sized at 4 to 8 cm TL in the summer, which likely represents the young of the year because females in southern California generally give birth (the species is viviparous) from May through August in nearshore environments (Love, 2011), and growth is rapid within the first year of life.

Barred sand bass (312 total) ranged in size from 4 to 31 cm, and in both seasons the modal size class was centered around 4 to 11 cm (Figure 4-33). Only 16 individuals sized over 24 cm were captured, and the largest fish, at 31 cm TL, was smaller than the recreational fishing limit size of 14 inches total length (35.5 cm TL). Maturity of 50% of the male and female barred sand bass population occurs when fish reach approximately 3 years of age (22 cm and 24 cm TL, respectively), and 100% of fish are mature at 4 to 5 years of age, with a length of approximately 26 to 27 cm (Love, 2011). Based on the average of this range (24.5 cm), approximately 0.3% of the population captured in the Port Complex in 2023 may be considered mature.

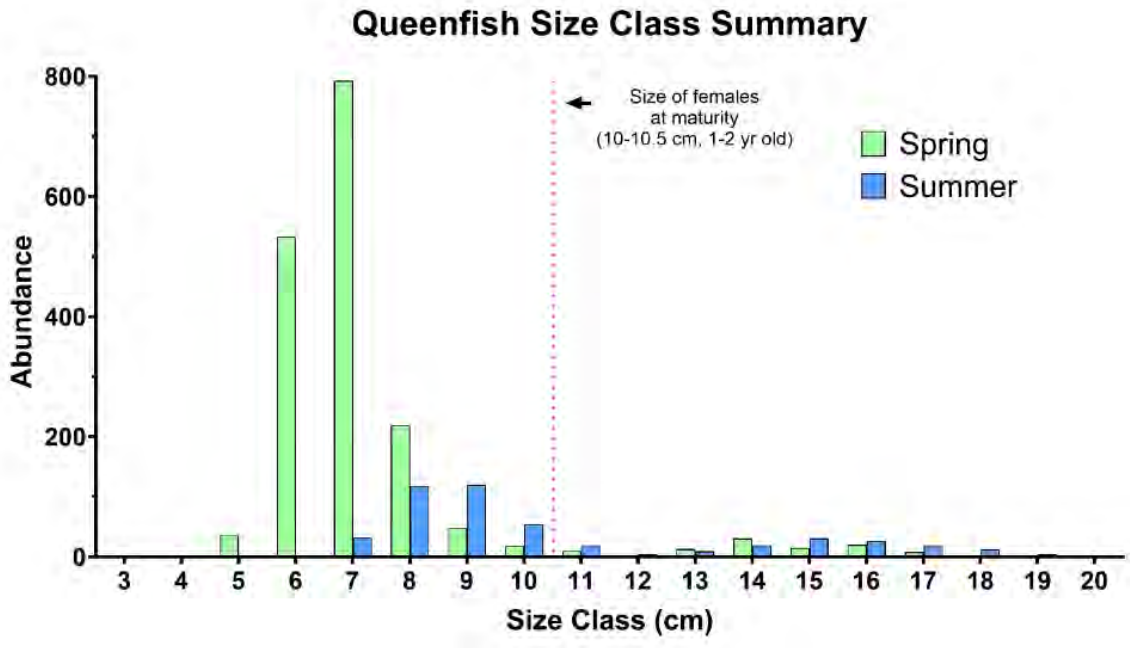
California halibut caught using trawls (97 total) ranged in size from 6 to 72 cm in spring and from 9 to 64 cm in summer. California halibut caught using beach seines (4 total) ranged in size from 10 to 14 cm (Figure 4-34). This trend was notable because it is well established that halibut use bays and estuaries as nursery habitats (Lopez-Rasgado and Herzka, 2009), with adults moving into shallow protected habitats from April through July to spawn. In the summer, the largest halibut caught were sized at 60 cm and 64 cm, and in the spring, four halibut from 54-72 cm in size were caught. The CDFW considers California halibut a high-priority species for life history research to help manage the fishery for long-term sustainability (Lesyna and Barnes, 2016) and has established length- and age-at-maturity for California halibut in central and southern California. In southern California, 50% of males are mature at approximately 22.7 cm long (fork length) and at approximately 1 year old, and 50% of females reach maturity at 45.5 cm (fork length) and approximately 4 years old. Although for the 2023 Biosurvey fish were measured in standard length, these lengths can be used to conservatively estimate the juvenile and mature reproductive population of halibut within the Port Complex. A total of 44% of the California halibut captured across all seasons with otter trawls and beach seines were from 2 to 22 cm in standard length, or what could be considered a first-year juvenile (Lesyna and Barnes, 2016). A total of 42 individuals (42% of the total caught) were from 23 to 44 cm, which is a 1- to 4-year-old cohort that is likely a mix of juvenile and adult halibut, with most males in this size class already at maturity. There were 10 individuals (10% of total abundance) larger than 45 cm, which represents a 4+ year old cohort that was almost entirely mature adults. The two individuals captured in the spring that were from 60 to 72 cm were likely adults that had moved from offshore into shallower waters to spawn within the Port Complex.

Vermillion rockfish (87 caught) ranged in size from 4 to 16 cm in the spring and 5 to 10 cm in the summer (Figure 4-35). The length at maturity for vermillion rockfish is 37 to 38 cm TL (4-7 years old; Love, 2011), meaning that all of the fish captured were juveniles. Vermillion rockfish are long-lived (maximum age 60+ years) and slow growing. The distinct peak in size class at approximately 5 to 9 cm potentially represents a cohort that is the result of a few favorable spawning and recruitment years since the 2018 Biosurvey. The fact that no adult vermillion rockfish were captured using trawls or lampara nets indicates that the adults reside in nearby rocky reef environments (or near the breakwaters), and their pelagic larvae are carried into the Outer Harbor where they settle and reside during their long juvenile stage.



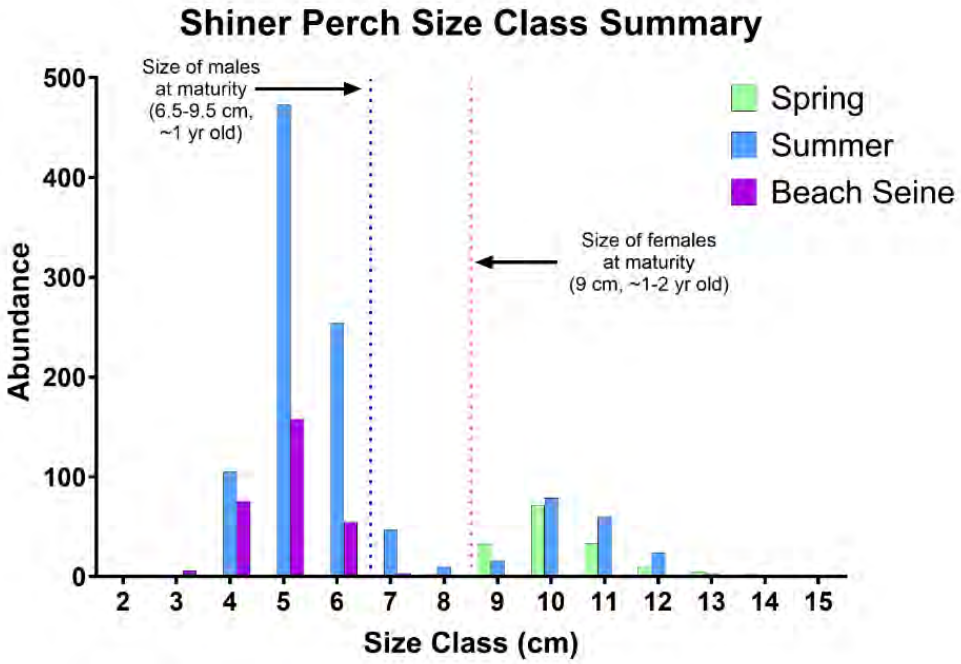
3,100 white croaker from the spring and 1,711 white croaker from the summer surveys were not sized and are not included in this graph (only first 250 individuals from each species in each trawl were sized). Length at maturity from Love, 2011.

Figure 4-30. White Croaker Size Class Summary



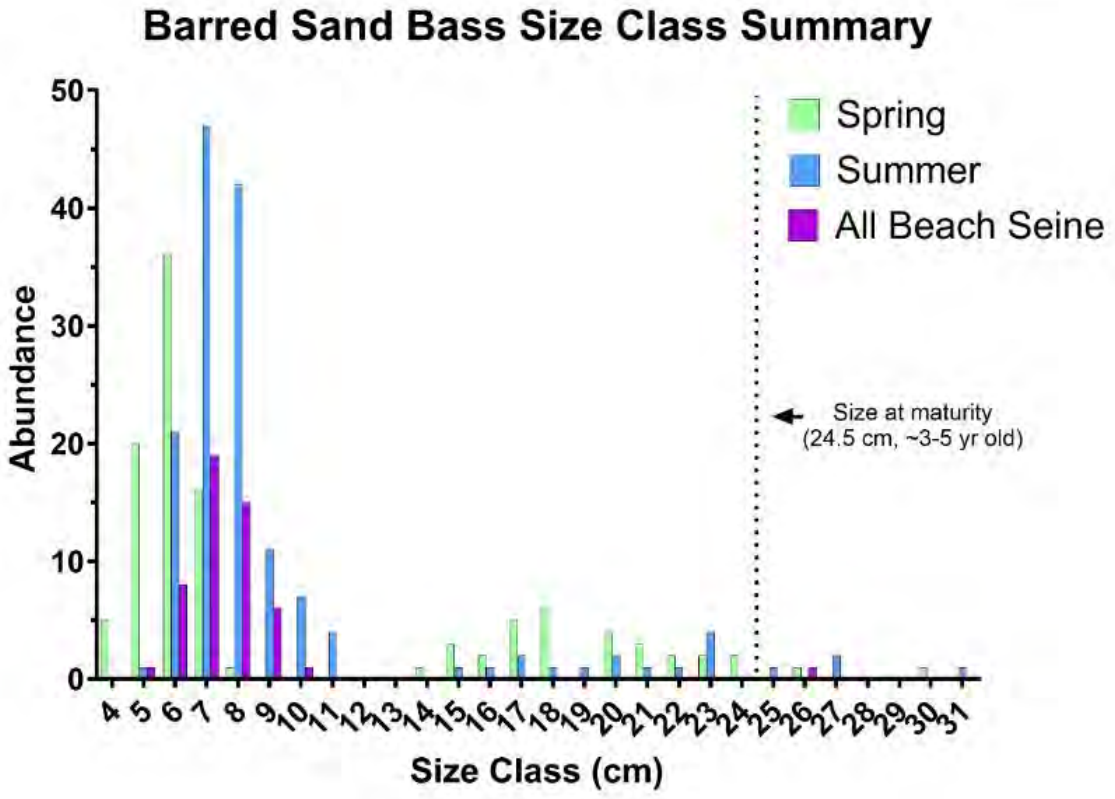
3,135 queenfish from the spring trawl survey were not sized and are not included in this graph (only first 250 individuals from each species in each trawl were sized). Length at maturity from DeMartini and Fountain, 1981.

Figure 4-31. Queenfish Size Class Summary



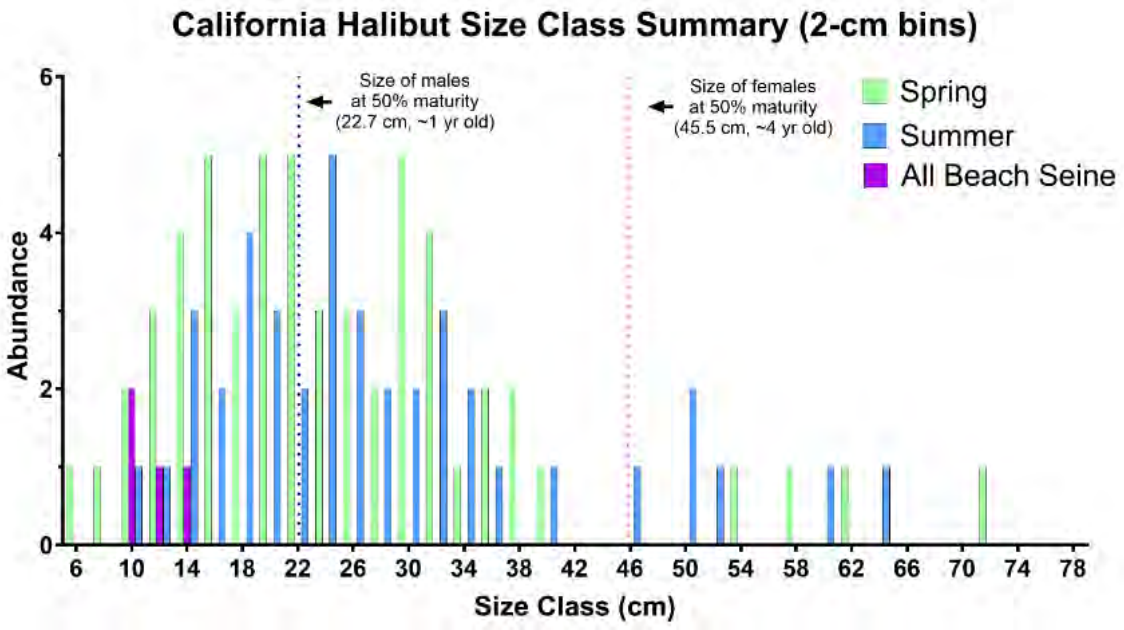
Length at maturity from Love, 2011.

Figure 4-32. Shiner Perch Size Class Summary



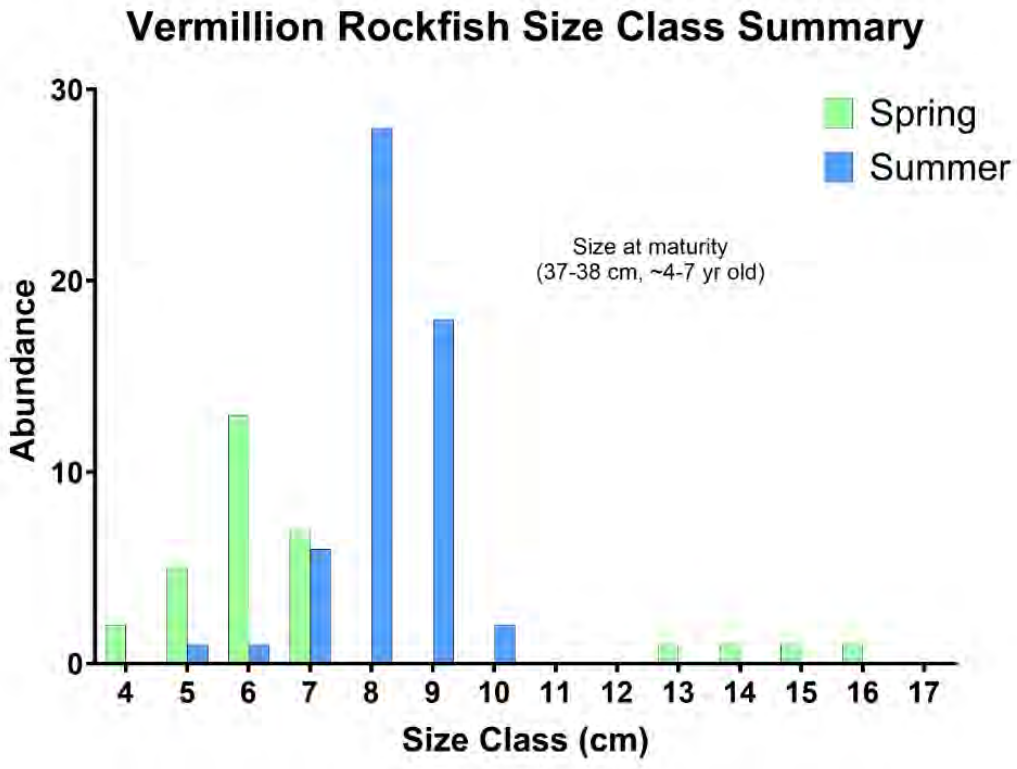
Length at maturity from Love, 2011.

Figure 4-33. Barred Sand Bass Size Class Summary



Length at maturity from Lesyna and Barnes, 2016, which used fork length. Standard length is reported in the Biosurvey. Therefore, these estimates can be considered conservative for the number of mature halibut because the standard length at maturity is shorter than fork length.

Figure 4-34. California Halibut Size Class Summary



Length at maturity from Love, 2011

Figure 4-35. Vermillion Rockfish Size Class Summary

4.6.2 STATION COMPARISONS

4.6.2.1 SPECIES RICHNESS

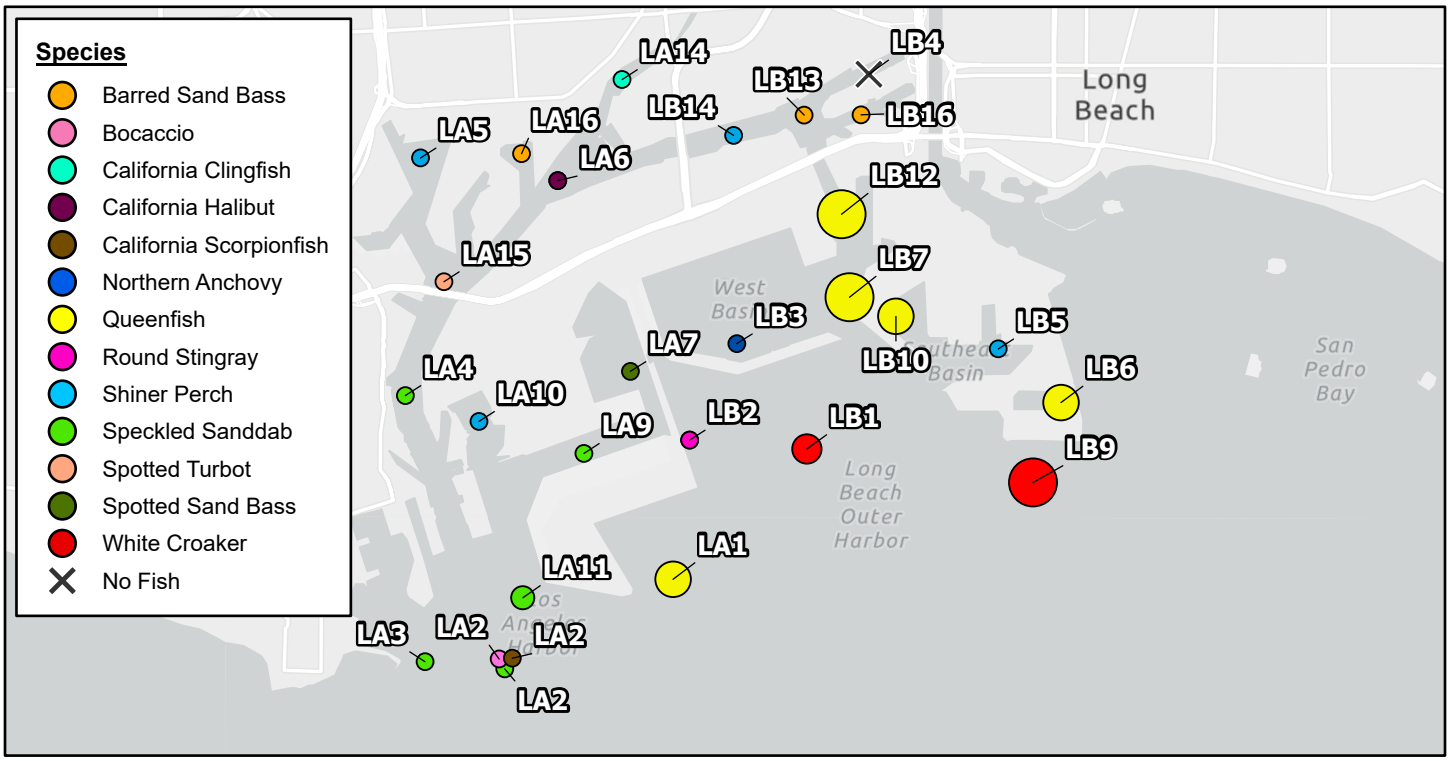
During otter trawl sampling, 56 species were collected over all sampling events; 45 species were captured during day sampling, and 47 species were captured during night sampling (Appendix D). Spring sampling captured 48 species while summer sampling captured 44 species (Appendix D). The most abundant species captured during daytime and nighttime trawls in spring and summer 2023 are shown in Figures 4-36 and 4-37. When all sampling events were combined, Inner Harbor Station LB4 (Channel) had the fewest species captured (n=5), and Outer Harbor Station LA11 (Outer Channel) had the most species captured (n=28; Table 4-18).

4.6.2.2 DIVERSITY AND EVENNESS INDICES

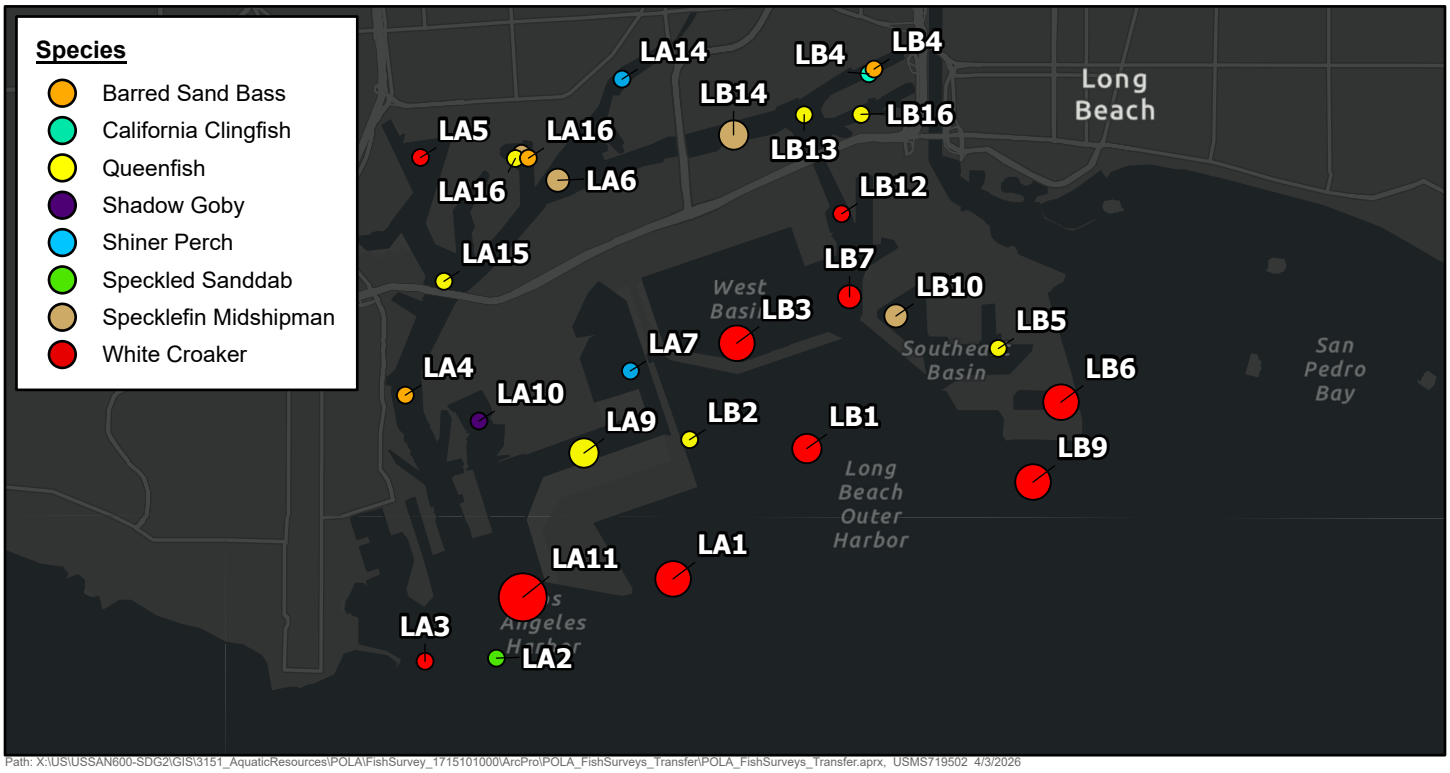
Shannon-Weiner Diversity Index values ranged from 0.49 to 2.21, and Margalef Diversity Index values ranged from 1.24 to 3.62 (Table 4-18). Although both indices identify generally similar patterns, there are some notable differences. Both indices identified Outer Harbor station LA9 as having the highest diversity, which differs from results for previous Biosurveys in which SWH stations LA2 and LA3 had the highest diversity. However, differences between the indices were evident when factoring in the evenness of the community. Although the Shannon-Weiner Diversity Index and Pielou's Evenness Index identified station LA7 as having the lowest values because shiner perch composed 90% of the total abundance, the Margalef Diversity Index value of 2.02 for this station was in the center of the observed range for all stations. The station with the most even distribution of fish based on Pielou's Evenness Index (0.96) was station LB4, which was the 12th ranked station according to the Shannon-Weiner Diversity Index and the 21st ranked station based on the Margalef Diversity Index.

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Light Gray Base: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Spring 2023 - Day



Spring 2023 - Night



Path: X:\US\USSAN600-SDG2\GIS\3151_AquaticResources\POLA\FishSurvey_1715101000\ArcPro\POLA_FishSurveys_Transfer\POLA_FishSurveys_Transfer.aprx, USMS719502 4/3/2026

Abundance
- 1 - 29
- 30 - 50
- 51 - 180
- 181 - 683
- 684 - 1579

1:94,288

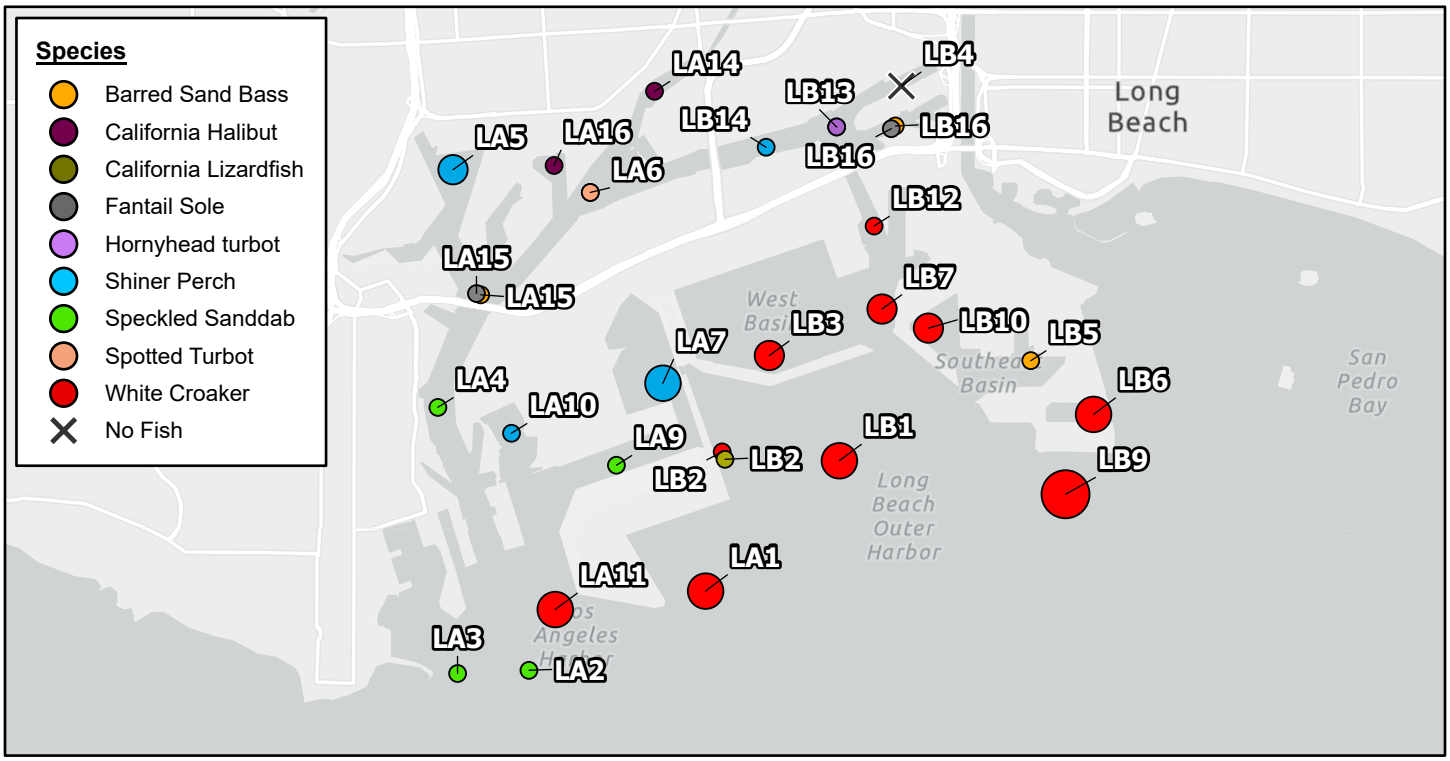
0 1 2 Miles

FIGURE 4-36

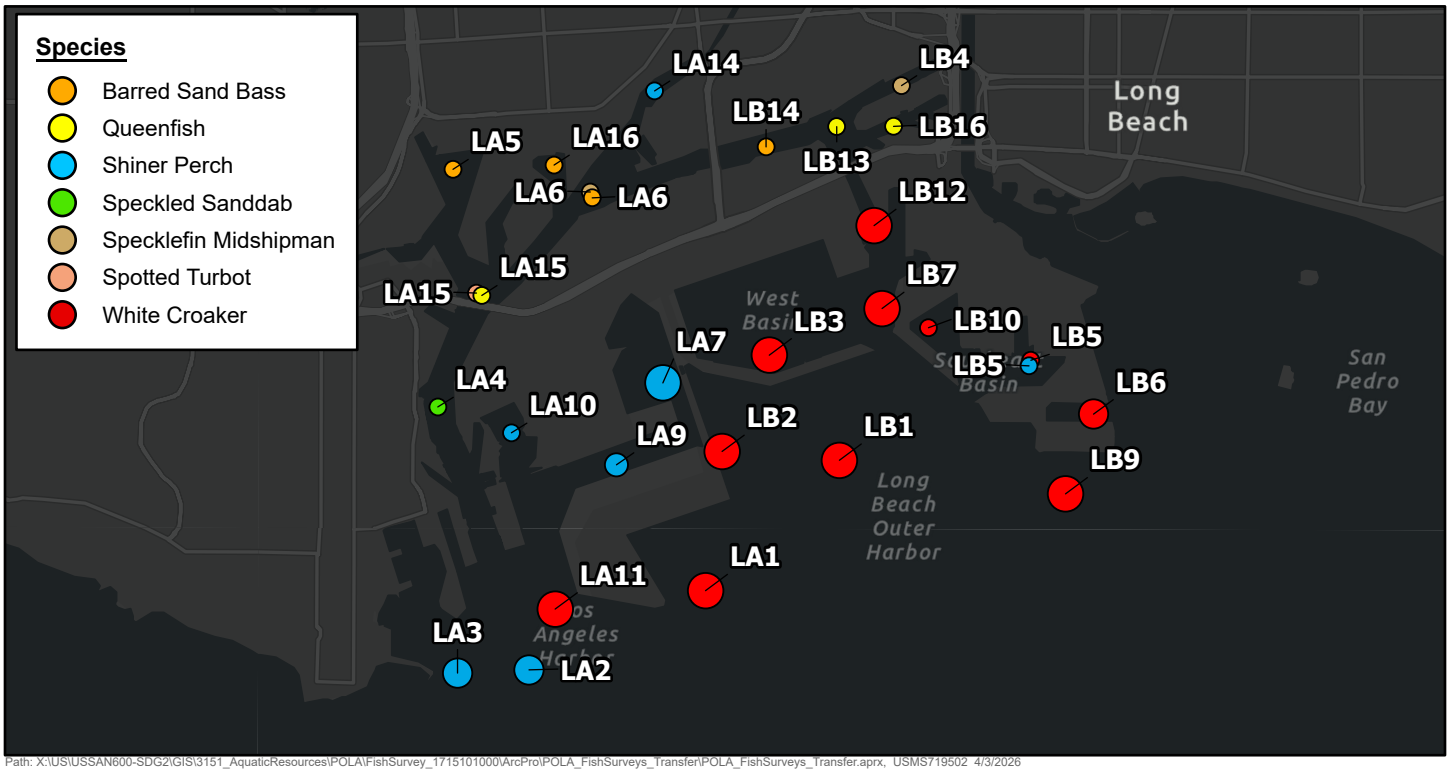
Most Abundant Species Captured at Each Station in Spring 2023 During Daytime (top) and Nighttime Trawls (bottom)

Service Layer Credits: Light Gray Reference: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Light Gray Base: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Summer 2023 - Day



Summer 2023 - Night



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Abundance
- 1 - 29
- 30 - 50
- 51 - 180
- 181 - 683
- 684 - 1579

1:94,288

0 1 2 Miles

FIGURE 4-37

Most Abundant Species Captured at Each Station in Summer 2023 During Daytime (top) and Nighttime Trawls (bottom)

Table 4-18. Demersal Fish Catch Summary by Station Captured using the Otter Trawl (All Seasons Combined)

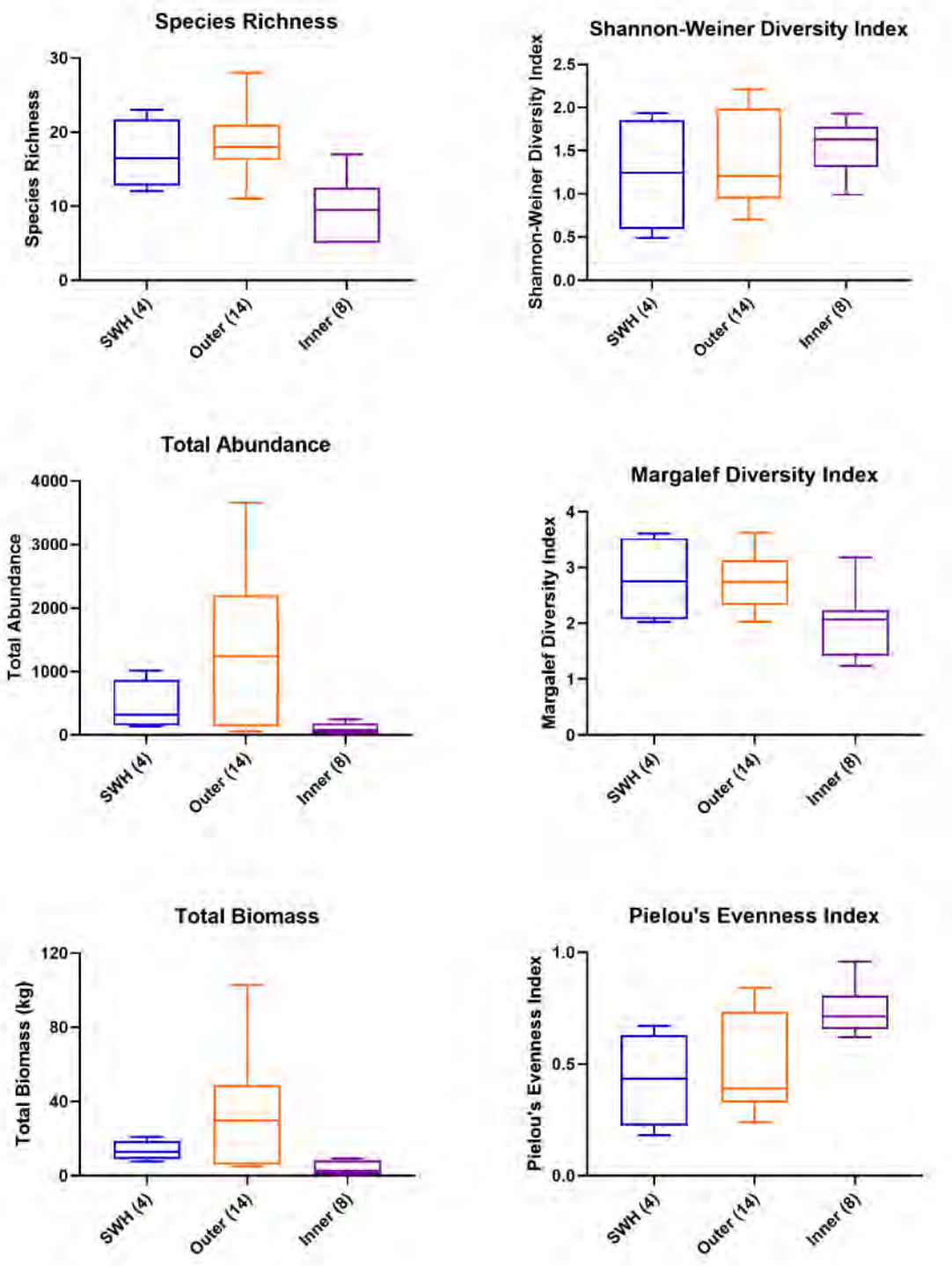
Station	Station Descriptor	Habitat	Location	Depth Strata	Taxa Richness	Total Abundance per Station	Total Biomass per Station (kg)	Shannon-Wiener Diversity Index	Margalef Diversity Index	Pielou's Evenness Index
LA1	Outer Pier 400	Outer	Outer	Very Deep	25	2,112	44.5	1.34	3.13	0.42
LA2	POLA SWH East	SWH	SWH	Shallow	12	137	12.9	0.89	2.24	0.36
LA3	POLA SWH West	SWH	SWH	Shallow	18	182	7.68	1.94	3.27	0.67
LA4	POLA Main Channel	Outer	Channel	Deep	14	91	5.47	1.33	2.88	0.50
LA5	West Basin	Inner	Basin	Deep	11	241	9.32	1.57	1.82	0.65
LA6	POLA East Basin	Inner	Basin	Deep	11	120	3.41	1.75	2.09	0.73
LA7	Seaplane Lagoon	SWH	SWH	Shallow	15	1013	13.1	0.49	2.02	0.18
LA9	Pier 400	Outer	Channel	Deep	21	249	6.27	2.21	3.62	0.73
LA10	Fish Harbor	Inner	Basin	Deep	17	152	6.85	1.93	3.18	0.68
LA11	POLA Outer Channel	Outer	Outer	Very Deep	28	2,148	63.7	1.07	3.39	0.33
LA14	Consolidated Slip	Inner	Slip	Deep	5	22	0.88	0.99	1.29	0.62
LA15	POLA Turning Basin	Outer	Basin	Deep	11	54	5.71	2.02	2.51	0.84
LA16	Bannings Landing	Inner	Slip	Deep	5	25	0.60	1.23	1.24	0.77
LB1	Outer Anchorages	Outer	Outer	Deep	21	1,398	46.2	1.09	2.76	0.36
LB2	POLB SWH	SWH	SWH	Shallow	23	446	20.8	1.60	3.61	0.51
LB3	West Basin	Outer	Basin	Deep	17	863	33.6	0.95	2.37	0.33
LB4	Channel 2	Inner	Slip	Deep	5	7	0.19	1.55	2.06	0.96
LB5	Southeast Basin East	Outer	Basin	Deep	17	158	5.06	2.12	3.16	0.75
LB6	Pier J	Outer	Slip	Deep	21	1,996	57.4	0.91	2.63	0.30
LB7	Main Channel Pilot Station	Outer	Channel	Very Deep	17	2,699	42.3	0.97	2.03	0.34
LB9	Outer Channel	Outer	Outer	Very Deep	18	3,661	103	0.70	2.07	0.24
LB10	Southeast Basin West	Outer	Basin	Deep	20	1,090	17.9	1.33	2.72	0.44
LB12	Main Channel Police Station	Outer	Channel	Very Deep	18	2,355	25.7	0.93	2.19	0.32
LB13	POLB Turning Basin	Outer	Basin	Very Deep	14	84	9.64	1.98	2.93	0.75
LB14	Cerritos Channel	Inner	Channel	Deep	13	193	8.60	1.79	2.28	0.70
LB16	Channel 3	Inner	Slip	Deep	8	28	1.88	1.69	2.10	0.82

4.6.3 STATION GROUPS

Grouping stations according to habitat (Inner Harbor, Outer Harbor, and SWH) indicated some patterns that have already been discussed, such as those for Outer Harbor stations (Figure 4-38), which had the highest average species richness, abundance, and total biomass of the three habitats. Station LB9 in the Outer Harbor (Outer Channel) had the greatest abundance and biomass, and was near the top for species richness. Inner Harbor stations overall had the lowest average species richness, abundance, and total biomass, but had the highest mean values for the Shannon-Weiner Diversity Index and Pielou's Evenness Index. SWH and Outer Harbor stations had similar mean values for species richness and diversity and evenness indices.

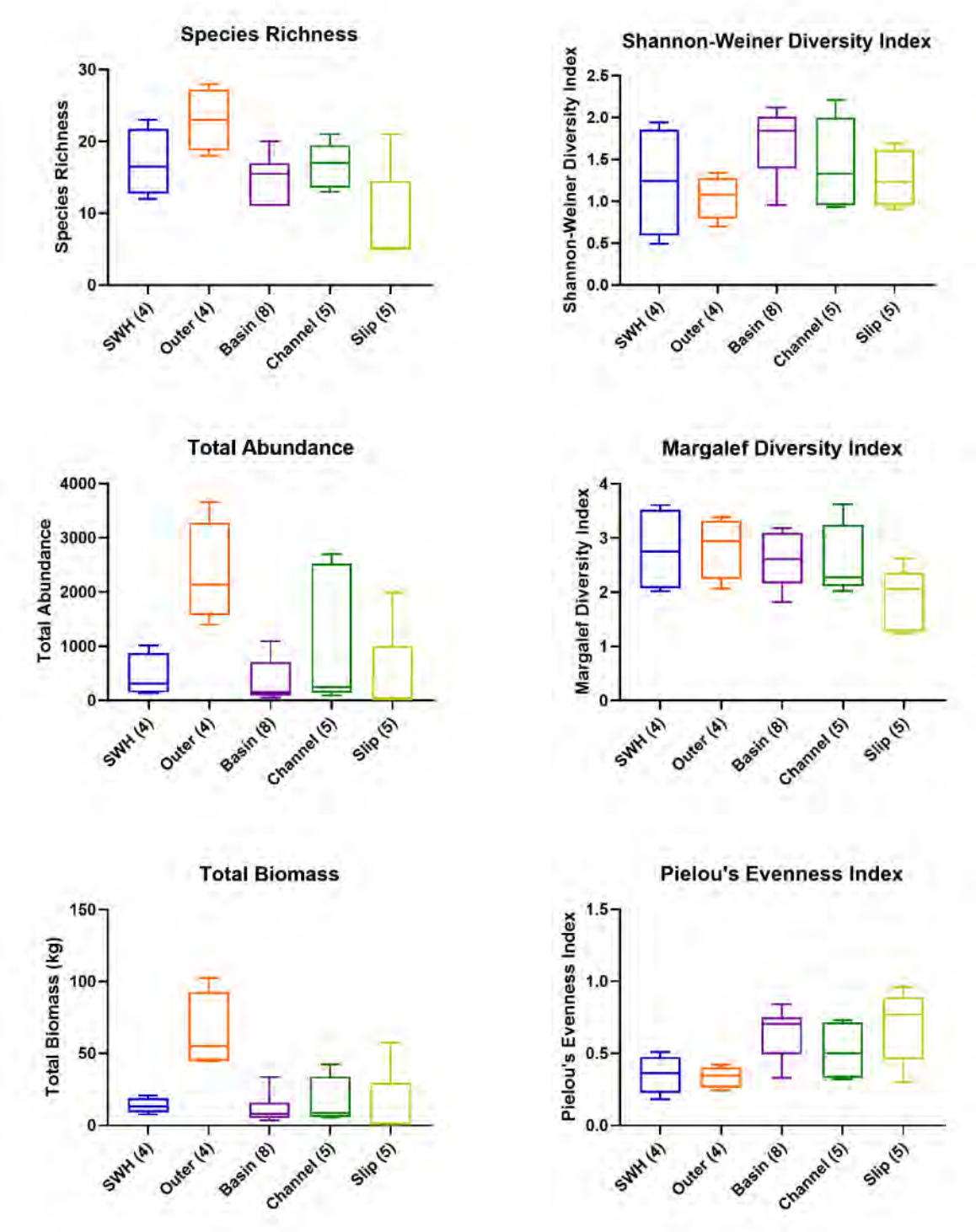
Location and habitat groups shared some patterns, but location groups (Outer Harbor, SWH, channel, basin, and slip) also exhibited unique patterns (Figure 4-39). Species richness was generally highest at the Outer Harbor stations, which included the two stations with highest species richness (LA11 Outer Harbor Channel with 28 species, and LA1 Outer Harbor Pier 400 with 25 species). The station with the third highest species richness was station LB2, in the SWH group, and slip stations LA14 (Consolidated Slip), LA16 (Bannings Landing), and LB4 (Channel 2), each with only five species, had the lowest species richness. Outer Harbor stations had the highest mean abundance and total biomass, with all four stations dominated by large catches of white croaker and queenfish. Basin and SWH locations had the lowest average abundance and total biomass. Outer Harbor stations on average had the lowest Shannon-Weiner Diversity Index and Pielou's Evenness Index values, with the other four groups showing greater site-to-site variability in species present.

With respect to depth (Shallow, Deep, and Very Deep), field observations indicated that many of the largest catches were in the deepest areas, and the comparison of depth strata groups bears this out (Figure 4-40). Species richness was similar across all depth groups, but average total abundance and biomass were markedly higher at the Very Deep stations. Diversity and evenness indices were similar across all depth groups. Deep stations showed a consistent pattern of low total abundance and biomass but had among the highest overall diversity and evenness index scores because they were less often dominated by one or a few species.



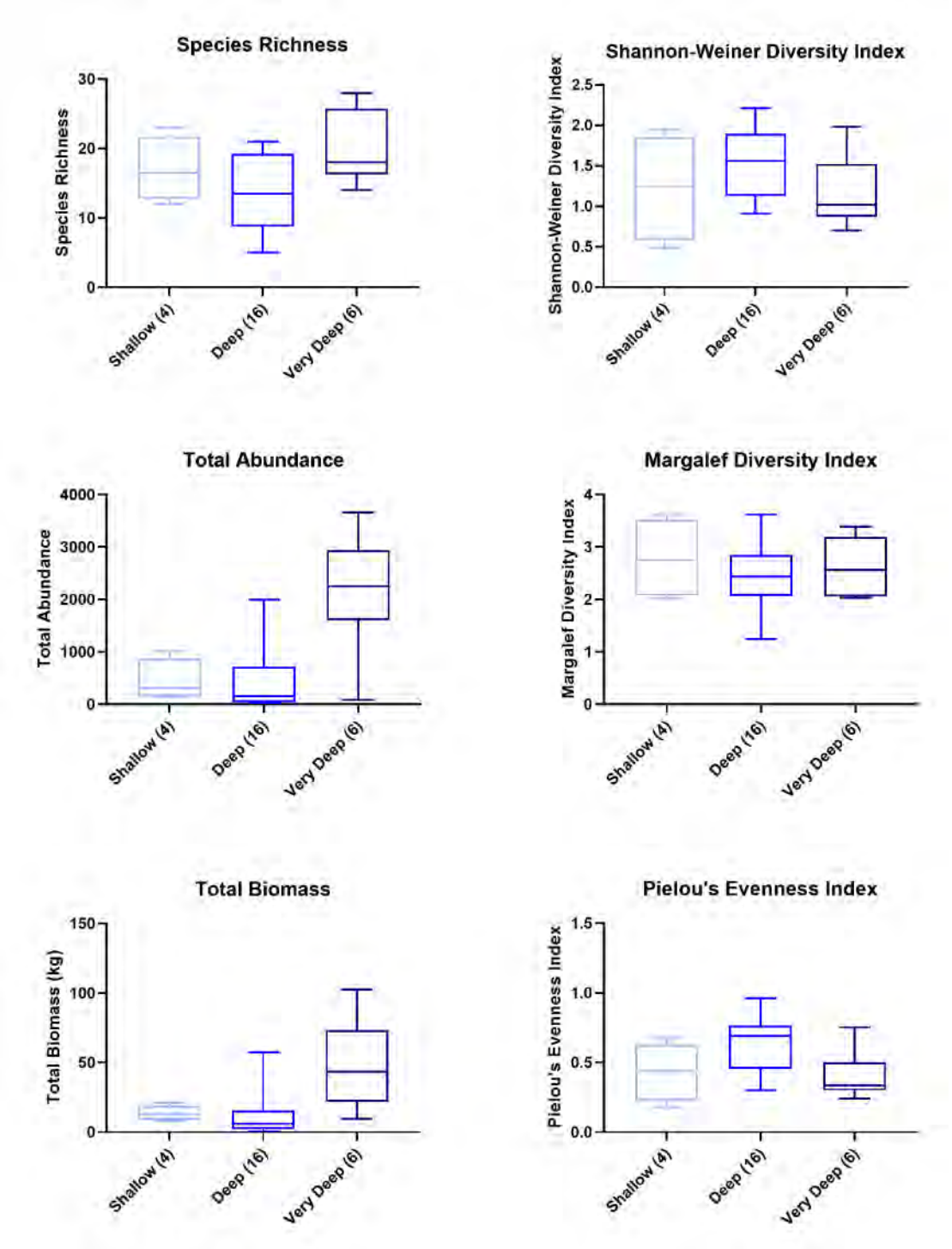
Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 4-38. Station Habitat Group Summaries for Demersal Fish Captured Using Otter Trawls – All Seasons Combined



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 4-39. Station Location Group Summaries for Demersal Fish Captured Using Otter Trawls – All Seasons Combined



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 4-40. Station Depth Strata Group Summaries for Demersal Fish Captured Using Otter Trawls – All Seasons Combined

4.6.3.1 MULTIVARIATE ANALYSES

Multivariate analysis of demersal fish abundance data combined across all sampling events was performed using Primer statistical software (see Appendix A Section A.11). The resultant nMDS plots and shade plots for location, habitat, and depth strata groups not shown in this section are provided in Appendix D. The analysis provided an in-depth evaluation of station groups and patterns of demersal fish communities across stations. Statistically significant differences among each station type (habitat, location, and depth strata) were identified using ANOSIM (see Section 1.7, Appendix D). Pairwise tests showed the pairs within each station type that were the most distinct.

Analysis of the different station habitat types showed that the largest distinction is between Outer Harbor and Inner Harbor stations; Inner Harbor and SWH stations are not substantially distinct from one another (Figure 4-41). The difference between Outer Harbor and Inner Harbor station groups is statistically significant. Location groups except for channel stations are distinct from one another compared with SWH, basin, and slip stations, and with that exception the differences are statistically significant. Depth strata analysis indicated that Shallow and Very Deep stations are the most distinct from one another, but Deep and Very Deep stations are not substantially distinct (Figure 4-42). The difference between the Shallow and Very Deep groups is statistically significant, but the difference between Deep and Very Deep is not.

Cluster analysis with SIMPROF analysis of trawl abundance data identified seven groups of stations (Groups A through G) that are significantly different from one another. The resulting nMDS plot (Figure 4-43) can be overlaid onto the station map (Figure 4-44) for easier interpretation. From the cluster analysis groups, a shade plot was prepared to display the relative abundances of the top 35 species (as determined by their ability to discriminate stations) at each station (Figure 4-45).

Stations in Groups A and B are found predominantly in the Inner Harbor areas within slips and basins, except for station LA4 (Port of Los Angeles Main Channel). These station groups are unique in that no white croaker individuals were caught during either season at any of these stations. SWH stations are spread across three groups (E, F, and G); these results are different from those during the 2018 Biosurvey, in which all SWH stations were in one cluster. Groups E and F are primarily Outer Harbor and SWH stations with diverse fish communities and high abundances of white croaker, queenfish, specklefin midshipman, and shiner perch. Group G includes SWH station LB2 (Port of Long Beach SWH) and stations LA7 (Pier 300) and LA14 (Consolidated Slip) and is unique in the high abundance of shiner perch compared with other species at those stations. Groups C and D are made up of Outer Harbor stations in the Port Complex that are relatively deep, including stations LA9 (Pier 400) and A11 (Port of Los Angeles Main Channel) and stations LB7 and LB12 (Port of Long Beach Main Channel). These two groups are dominated primarily by white croaker and queenfish, but are also characterized by high abundances of species such as vermillion rockfish, chilipepper rockfish, bocaccio, and speckled sanddab relative to other stations.

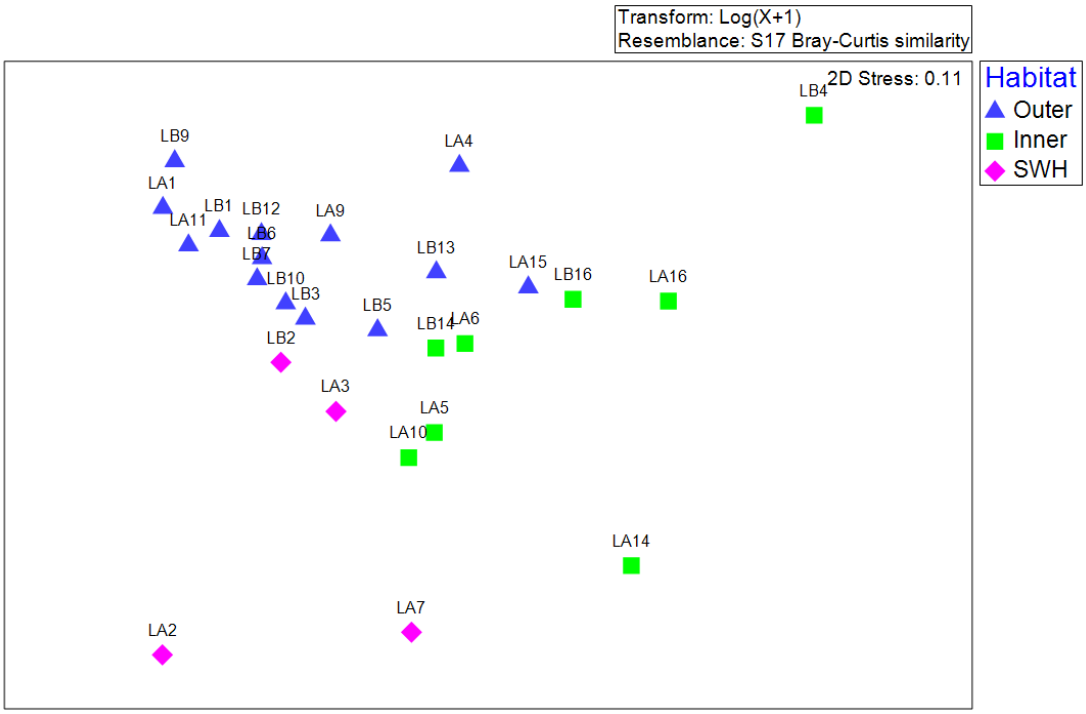


Figure 4-41. Habitat Groups nMDS Plot – All Seasons Combined

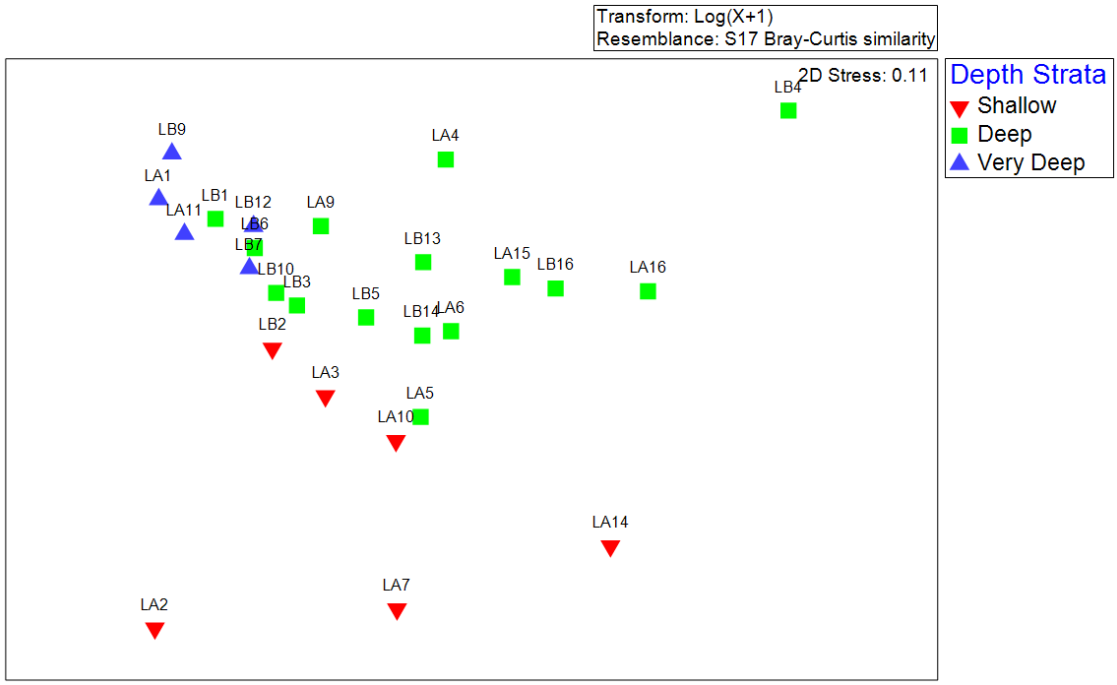


Figure 4-42. Depth Strata Groups nMDS Plot – All Seasons Combined

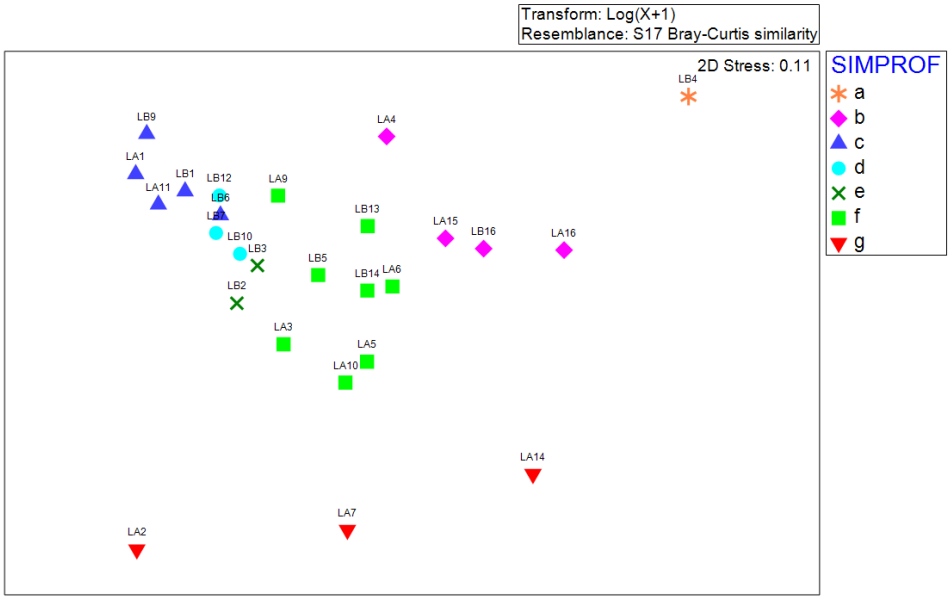
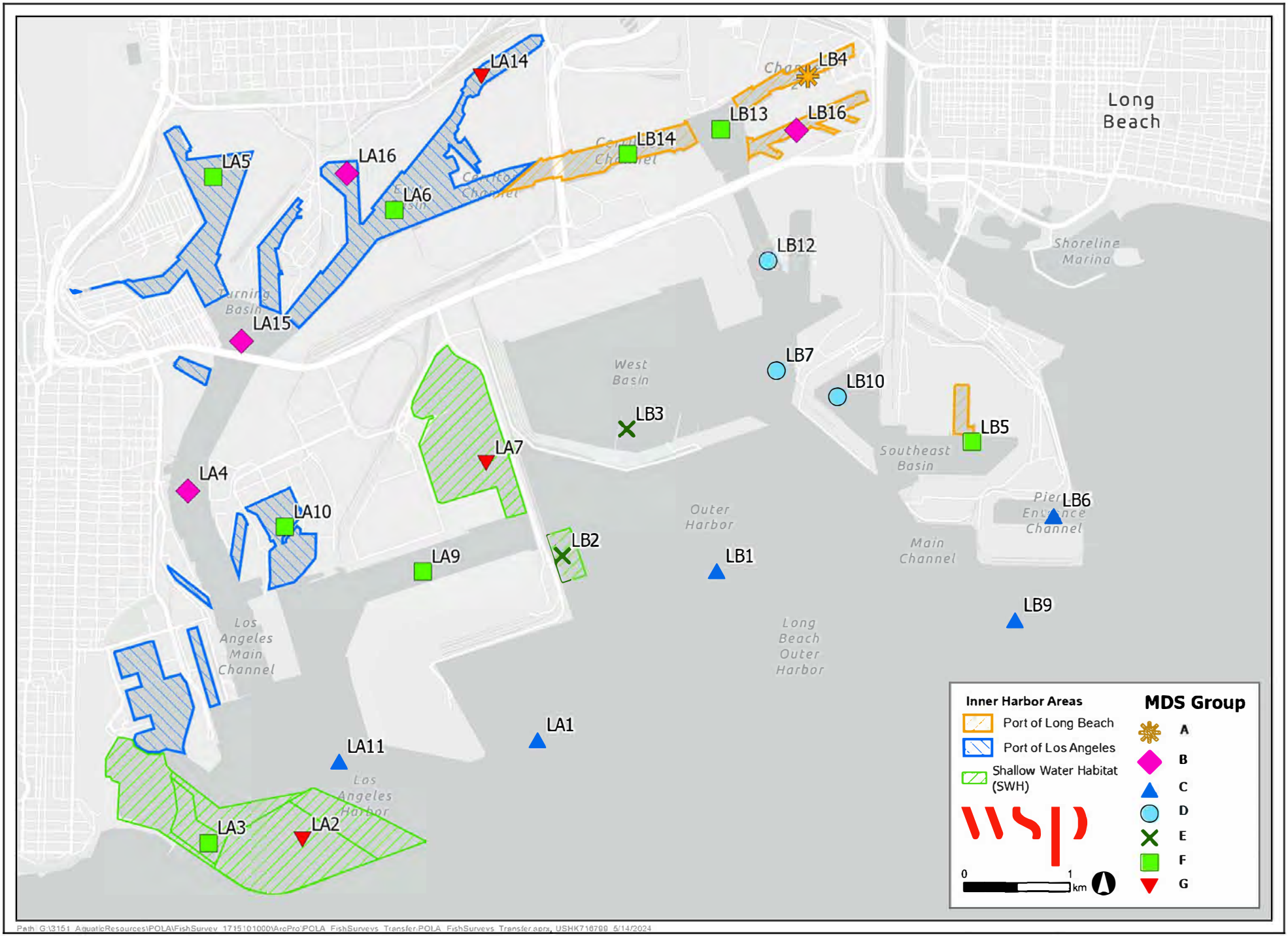
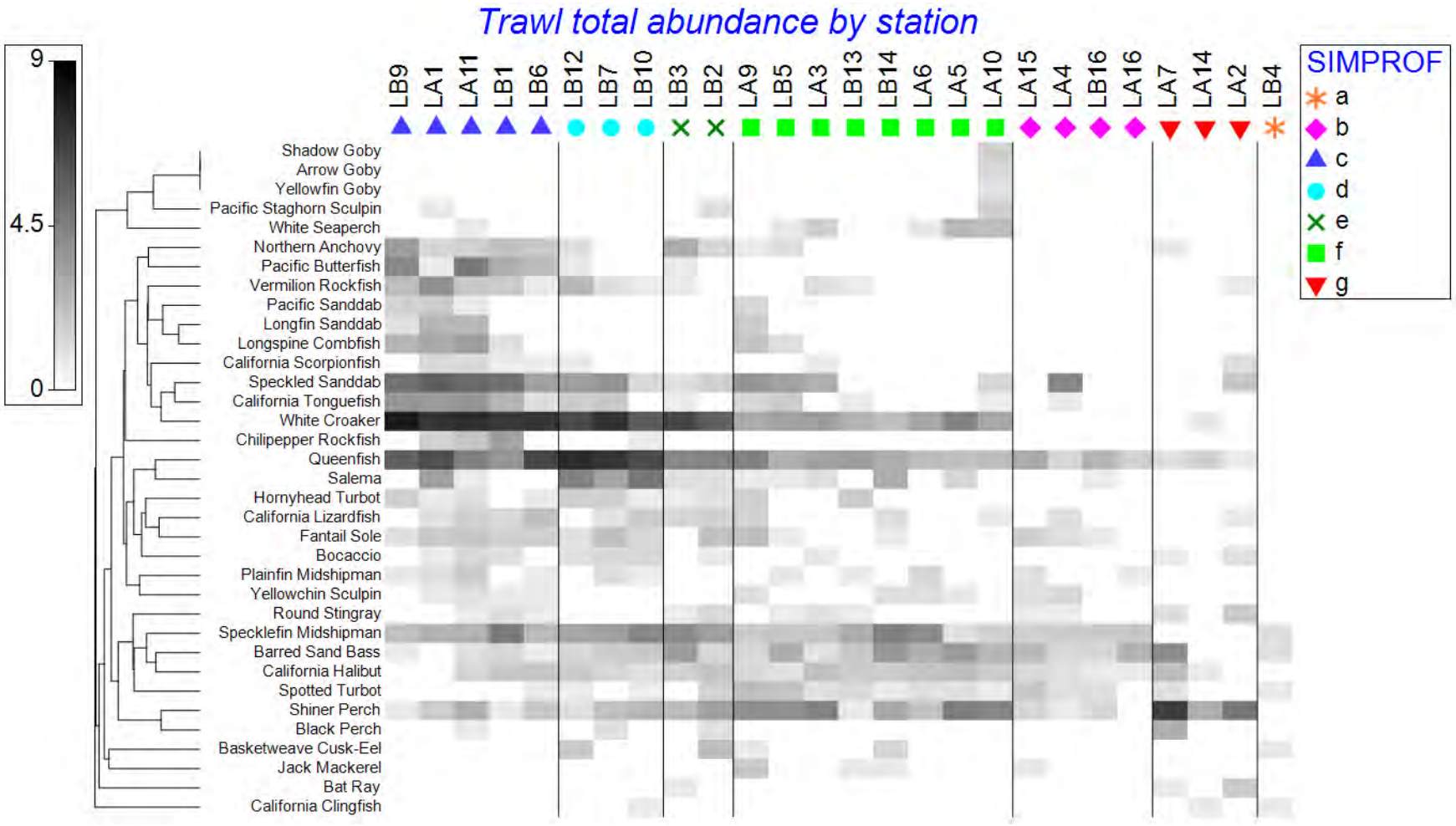


Figure 4-43. Similarity Profile Analysis Groups nMDS Plot – All Seasons Combined



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Figure 4-44. Similarity Profile Analysis Fish Trawl Groups Station Map Overlay –All Seasons Combined



The scale reflects abundance data that have been transformed and normalized

Figure 4-45. Species Heatmap Derived from Similarity Profile Group Analysis for Top 35 Species – All Seasons Combined

4.6.4 FISH HEALTH

Overall, the fish captured appeared healthy, and most specimens had normal color and energy. External anomalies that are associated with stress such as lesions, tumors, fin erosion, and spinal deformities were very rare; only four white croaker were observed to have spinal deformities (Table 4-19, Figure 4-46). This represents an anomaly rate of 0.018% of the 21,523 total fish captured in otter trawls during the 2023 Biosurvey. Fish anomalies were first described in the 2018 Biosurvey. The 2023 Biosurvey anomaly rate was lower than the rate of 0.040% during the 2018 Biosurvey. The anomaly rate in the Port Complex was 2023 is also lower than the rate of 0.025% during Southern California Bight-wide regional monitoring in 2023 (Deihl et al., 2026).

Table 4-19. Fish Anomalies Identified from Benthic Trawls

Station	Location	Sampling Date	Species	Common Name	Size Class (cm)	Anomaly
LA9	Channel	4/17/2023	*Genyonemus lineatus*	White Croaker	8	Spinal Deformity
LB10	Basin	4/18/2023	*Genyonemus lineatus*	White Croaker	9	Spinal Deformity
LB9	Outer	7/19/2023	*Genyonemus lineatus*	White Croaker	13	Spinal Deformity
LB10	Basin	7/19/2023	*Genyonemus lineatus*	White Croaker	13	Spinal Deformity

cm = centimeter(s)



Figure 4-46. Spinal Deformity in White Croaker

4.6.5 HISTORICAL COMPARISONS

Trawl sampling across the 2000, 2008, 2013, 2018, and 2023 Biosurveys captured a total of 104 different fish species (Appendix D), although each year's species richness has remained similar – from 56 to 63 (Figure 4-47). Of the 104 fish species collected, 29 were captured in all five Biosurveys; many of them are abundant and commonly encountered during sampling and thus can be considered as characteristic of the Port Complex (Table 4-20). During each Biosurvey, several unique species were captured that did not appear in any of the other Biosurvey trawls. For example, in 2023, species such as horn shark (*Heterodontus francisci*), pink surfperch (*Zalembius rosaceus*), and pygmy poacher (*Odontopyxis trispinosa*) were captured for the first time. These captures each consisted of one individual and likely represent either occasional visitors to the Port Complex or very uncommon residents that happened to be encountered. They may also represent species that are normally associated with hard substrate or other habitat types not effectively sampled using open-water trawling, such as the horn shark and pygmy poacher. These fish are common in the Port Complex but are not normally present over the soft bottom or within the open pelagic habitats currently targeted by these Biosurveys (see Section 5.4).

Mean abundance of collected using trawls per station in each Biosurvey ranged more widely, from 178 to 402 fish across 2000-2023 (206 in 2023), largely as a result of occasional very large catches of one or two species in some years but not others. For example, during the 2000 Biosurvey, trawl sampling captured more than 20,000 white croakers, far more than in any other Biosurvey. Mean biomass per station during four of the five Biosurveys has been from 5 to 7 kg; the substantially higher mean biomass in 2013 (11.3 kg per station) was likely due in part to unusually large catches of California lizardfish (*Synodus lucioceps*) not captured in other Biosurveys.

The five Biosurveys to date were compared in terms of their demersal fish species composition by identifying the top 10 species (by abundance or biomass) in each Biosurvey, combining all other species into the category "other," and calculating the percent composition of each of the 11 species categories (Figures 4-48 and 4-49). The top three species in terms of relative abundance were the same in the 2018, 2008, and 2000 Biosurveys: northern anchovy, white croaker, and queenfish. In 2023, however, shiner surfperch replaced northern anchovy as one of the three most abundant species. This increase could be attributed in part to substantial increases in eelgrass habitat throughout the Port Complex from 2018 to 2023; eelgrass is known to be favorable habitat for shiner surfperch (Love, 2011). In 2013, California lizardfish replaced northern anchovy as one of the three most abundant trawl-caught species and was even more abundant than queenfish that year. The large increase in lizardfish abundance was a trend across the Southern California Bight during regional monitoring in 2013. The reason for the lizardfish population increase during this time is still uncertain but could be partially due to the cooler waters and strong upwelling that preceded the Biosurveys conducted during summer 2013 (Walther et al., 2017). A few other species, such as specklefin midshipmen, California tonguefish, barred sand bass, and California halibut, were represented in the top 10 species across all five Biosurveys.

Relative biomass across the five Biosurveys consistently showed white croaker to be the largest contributor, ranging from 38% of total biomass in 2000 to 66% in 2023. The relative biomass contributions for other species were more variable, but California halibut and queenfish were in the top four species during four of the five Biosurveys. Biomass is easily influenced by catches of a few large individuals because the top 10 species list has included species such as Pacific electric ray (2018 and 2008), bat ray (2023, 2013, 2008, and 2000), and shovelnose guitarfish (2013 and 2000).

The EI was also chosen as a comparative tool to assess the structure of demersal fish communities over the past 20+ years of biological monitoring in the Port Complex. The top 15 species captured using otter trawls for each Biosurvey year ranked by EI scores are listed in Table 4-21, with the 7 species appearing across all five Biosurveys highlighted. White croaker was by far the highest ranked species across all years, and queenfish was never lower than fourth highest. 2023 was the first Biosurvey year in which northern anchovy and California lizardfish did not appear in the top 15 species by EI.

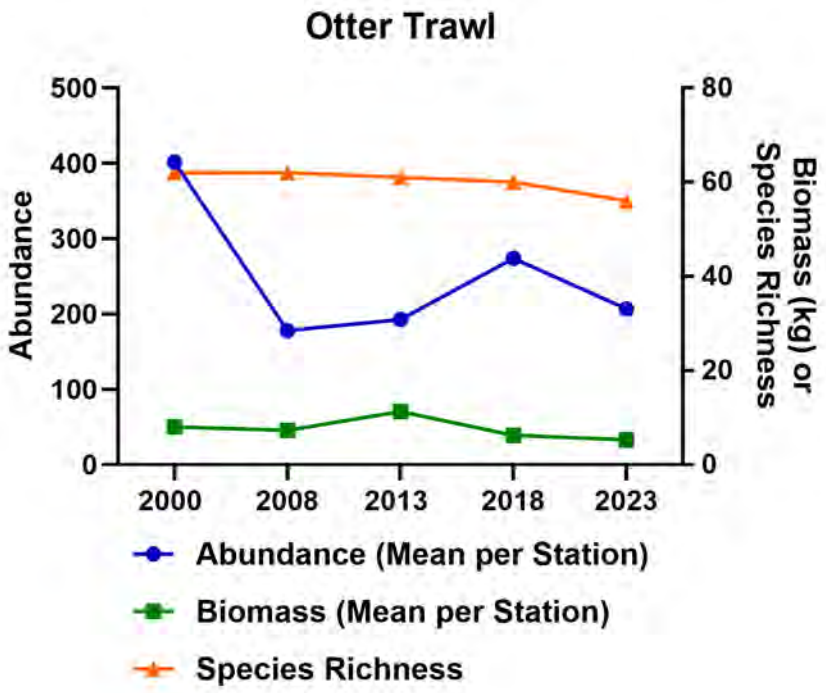
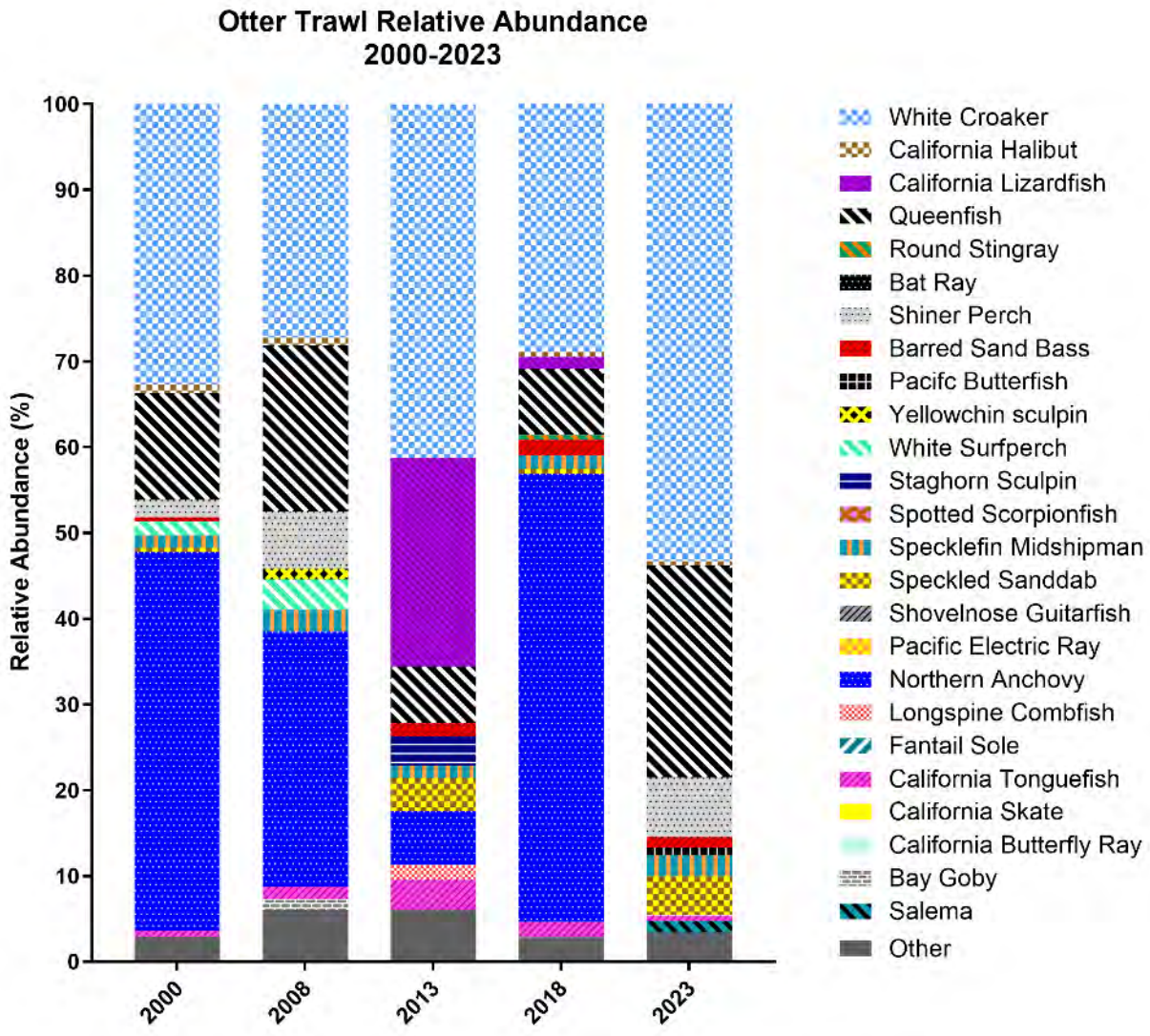
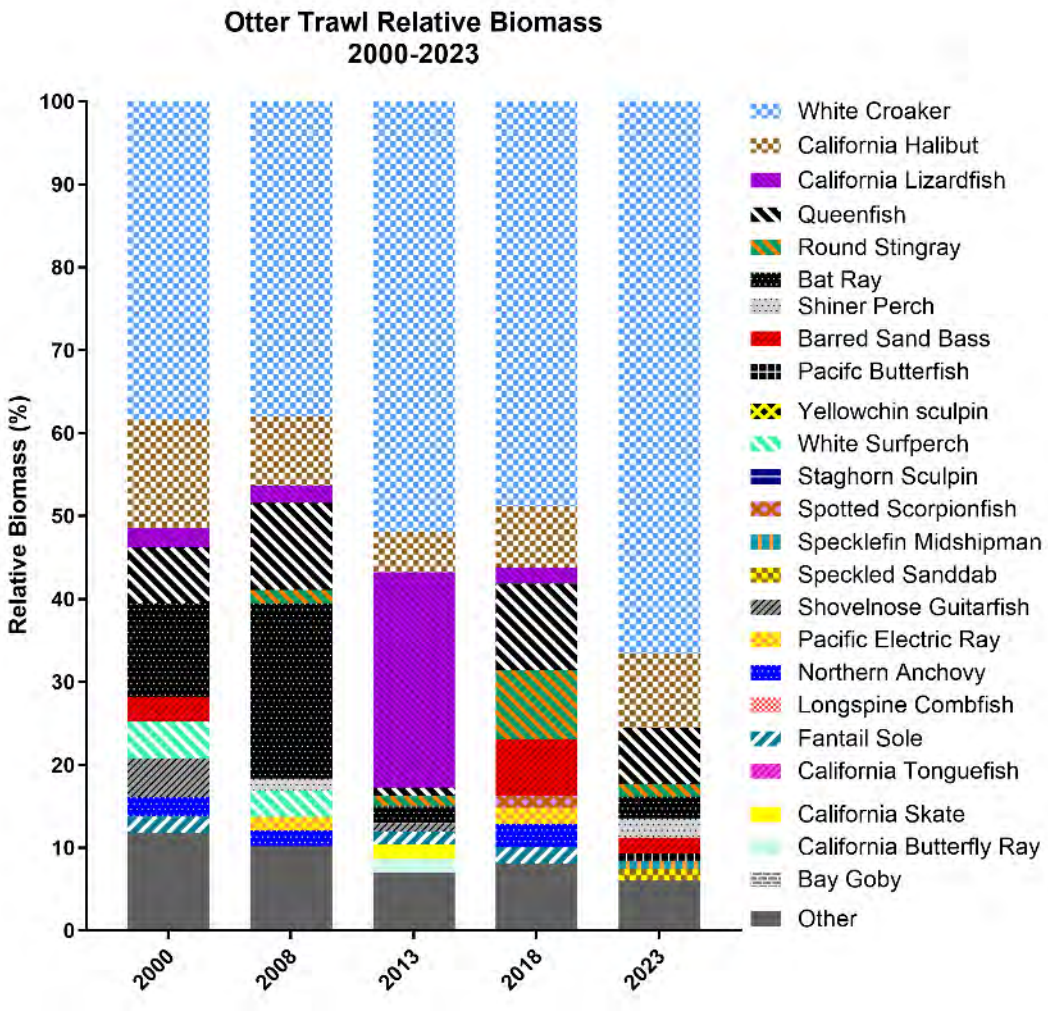


Figure 4-47. Historical Comparison of Species Richness, Mean Abundance, and Mean Biomass Collected Using the Benthic Otter Trawl



Top 10 species are shown for each specific time period.

Figure 4-48. Historical Comparison of Relative Abundance of Fish Captured by Otter Trawls



Top 10 species are shown for each specific time period.

Figure 4-49. Historical Comparison of Relative Biomass of Fish Captured by Otter Trawls

Table 4-20. Historical Trawl Fish Abundance of Species Caught in All Biosurvey Years to Date

Common Name	Scientific Name	2023	2018	2013	2008	2000
Barred Sand Bass	*Paralabrax nebulifer*	261	519	309	130	310
Basketweave Cusk-Eel	*Ophidion scrippsae*	19	10	46	5	50
Bat Ray	*Myliobatis californica*	7	5	8	37	54
Black Surfperch	*Embiotoca jacksoni*	20	5	6	5	24
California Halibut	*Paralichthys californicus*	97	162	153	192	547
California Lizardfish	*Synodus lucioceps*	41	389	4,780	116	121
California Scorpionfish	*Scorpaena guttata*	12	50	29	11	13
California Skate	*Raja inornata*	7	6	62	23	11
California Tonguefish	*Symphurus atricaudus*	144	509	685	291	372
English Sole	*Parophrys vetulus*	6	1	2	24	3
Fantail Sole	*Xystreurys liolepis*	60	103	152	46	94
Giant Kelpfish	*Heterostichus rostratus*	11	29	28	7	52
Hornyhead Turbot	*Pleuronichthys verticalis*	29	30	110	93	130
Northern Anchovy	*Engraulis mordax*	77	14,883	1,241	6,037	22,846
Pacific Butterfish	*Peprilus simillimus*	188	2	29	1	47
Pacific Staghorn Sculpin	*Leptocottus armatus*	7	1	662	7	8
Plainfin Midshipman	*Porichthys notatus*	20	98	90	6	135
Queenfish	*Seriphus politus*	5,322	2,201	1,298	3,922	7,705
Round Stingray	*Urobatis halleri*	21	166	28	26	35
Shiner Surfperch	*Cymatogaster aggregata*	1,497	138	17	1,354	1,321
Speckled Sanddab	*Citharichthys stigmaeus*	985	175	762	121	332
Specklefin Midshipman	*Porichthys myriaster*	538	444	282	517	1,084
Spotted Turbot	*Pleuronichthys ritteri*	47	35	24	34	179
Thornback Ray	*Platyrhinoidis triseriata*	2	11	20	4	13
Vermillion Rockfish	*Sebastes miniatus*	87	11	45	20	4
White Croaker	*Genyonemus lineatus*	11,475	8,231	8,106	5,527	20,762
White Surfperch	*Phanerodon furcatus*	27	34	35	729	993
Yellowchin Sculpin	*Icelinus quadriseriatus*	17	22	43	262	72
Yellowfin Goby	*Acanthogobius flavimanus*	2	2	4	53	2

Table 4-21. Historical Summary of Fish Captured using the Otter Trawl (2000–2023) – Top 15 Species Ranked by EI

2023 Trawl Fish Ecological Index — **56 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
White Croaker	*Genyonemus lineatus*	53.3	66.5	73.1	8,758
Queenfish	*Seriphus politus*	24.7	6.8	96.2	3,032
Shiner Perch	*Cymatogaster aggregata*	7.0	2.3	92.3	857
California Halibut	*Paralichthys californicus*	0.5	8.9	84.6	795
Speckled Sanddab	*Citharichthys stigmaeus*	4.6	1.3	61.5	364
Specklefin Midshipman	*Porichthys myriaster*	2.5	1.0	88.5	307
Barred Sand Bass	*Paralabrax nebulifer*	1.2	1.9	88.5	278
Salema	*Haemulon californiensis*	1.3	0.3	50.0	78.0
Round Stingray	*Urobatis halleri*	0.1	1.5	46.2	73.5
Fantail Sole	*Xystreurys liolepis*	0.3	0.8	57.7	63.0
Pacific Butterfish	*Peprilus simillimus*	0.9	0.9	26.9	47.2
CaliforniaTonguefish	*Symphurus atricaudus*	0.7	0.2	50.0	43.7
Spotted Turbot	*Pleuronichthys ritteri*	0.2	0.3	65.4	36.4
Bat Ray	*Myliobatis californica*	0.0	2.7	11.5	31.0
Vermilion Rockfish	*Sebastes miniatus*	0.4	0.2	46.2	28.4

Species that appear in the top 15 across all Biosurvey years are highlighted.

2018 Trawl Fish Ecological Index — **59 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
White Croaker	*Genyonemus lineatus*	28.9	48.8	96.2	7,474
Northern Anchovy	*Engraulis mordax*	52.2	2.8	88.5	4,866
Queenfish	*Seriphus politus*	7.7	10.5	96.2	1,749
Barred Sand Bass	*Paralabrax nebulifer*	1.8	6.8	92.3	796
California Halibut	*Paralichthys californicus*	0.6	7.3	92.3	729
Round Stingray	*Urolophus halleri*	0.6	8.3	65.4	583
California Lizardfish	*Synodus lucioceps*	1.4	2.0	84.6	284
California Tonguefish	*Symphurus atricauda*	1.8	1.0	92.3	260
Fantail Sole	*Xystreurys liolepis*	0.4	2.0	80.8	194
Specklefin Midshipman	*Porichthys myriaster*	1.6	0.5	80.8	166
California Scorpionfish	*Scorpaena guttata*	0.2	1.4	42.3	67.4
Speckled Sanddab	*Citharichthys stigmaeus*	0.6	0.4	53.8	53.7
Shiner Surfperch	*Cymatogaster aggregata*	0.5	0.4	61.5	52.0
Diamond Turbot	*Hypsopsetta guttulata*	0.1	0.5	46.2	26.8
Spotted Sand Bass	*Paralabrax maculatofasciatus*	0.2	0.4	34.6	20.3

Table 4-21. Historical Summary of Fish Captured using the Otter Trawl (2000–2023) – Top 15 Species Ranked by EI (continued)

2013 Trawl Fish Ecological Index — **61 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
White Croaker	*Genyonemus lineatus*	41.2	51.9	100	9,314
California Lizardfish	*Synodus lucioceps*	24.3	25.9	100	5,026
Queenfish	*Seriphus politus*	6.60	1.06	88	766
Northern Anchovy	*Engraulis mordax*	6.31	0.26	81	658
California Halibut	*Paralichthys californicus*	0.78	4.88	96	566
Speckled Sanddab	*Citharichthys stigmaeus*	3.88	0.71	88	459
California Tonguefish	*Symphurus atricaudus*	3.49	0.43	88	392
Staghorn Sculpin	*Leptocottus armatus*	3.37	0.18	73	355
Longspine Combfish	*Zaniolepis latipinnis*	1.71	0.83	35	255
Barred Sand Bass	*Paralabrax nebulifer*	1.57	0.86	92	243
Fantail Sole	*Xystreurys liolepis*	0.77	1.62	81	239
Specklefin Midshipman	*Porichthys myriaster*	1.43	0.88	96	231
Bat Ray	*Myliobatis californica*	0.04	2.00	23	204
California Skate	*Raja inornata*	0.32	1.62	85	193
California Butterfly Ray	*Gymnura marmorata*	0.02	1.67	4	168

2008 Trawl Fish Ecological Index — **62 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
White Croaker	*Genyonemus lineatus*	27.2	41.1	100	34,506
Queenfish	*Seriphus politus*	19.3	11.5	100	10,782
Bat Ray	*Myliobatis californica*	0.18	22.9	37	6,517
Northern Anchovy	*Engraulis mordax*	29.7	2.10	100	4,590
White Surfperch	*Phanerodon furcatus*	3.59	3.49	100	3,053
California Halibut	*Paralichthys californicus*	0.94	2.89	100	2,326
California Lizardfish	*Synodus lucioceps*	0.57	2.23	100	1,784
Fantail Sole	*Xystreurys liolepis*	0.23	1.31	84	873
Shiner Surfperch	*Cymatogaster aggregata*	6.66	0.56	63	694
California Skate	*Raja inornata*	0.11	1.50	58	676
Specklefin Midshipman	*Porichthys myriaster*	2.54	0.54	89	601
Barred Sand Bass	*Paralabrax nebulifer*	0.64	0.83	84	592
Round Stingray	*Urobatis halleri*	0.13	1.71	37	492
California Tonguefish	*Symphurus atricaudus*	1.43	0.42	100	468
Hornyhead Turbot	*Pleuronichthys verticalis*	0.46	0.44	89	348

2000 Trawl Fish Ecological Index — **62 Species Total**

Species		% of Total Abundance	% of Total Biomass	Frequency of Trawl Capture (%)	Ecological Index
Common Name	Scientific Name				
White Croaker	*Genyonemus lineatus*	35.9	38.4	100	7,424
Northern Anchovy	*Engraulis mordax*	39.5	2.3	100	4,178
Queenfish	*Seriphus politus*	13.3	6.8	100	2,007
California Halibut	*Paralichthys californicus*	0.95	13.0	100	1,395
Bat Ray	*Myliobatis californica*	0.09	11.3	61	694
White Surfperch	*Phanerodon furcatus*	1.72	4.37	100	608
Barred Sand Bass	*Paralabrax nebulifer*	0.54	3.01	100	355
Shiner Surfperch	*Cymatogaster aggregata*	2.28	1.34	83	302
Specklefin Midshipman	*Porichthys myriaster*	1.87	0.70	94	243
Shovelnose Guitarfish	*Rhinobatos productus*	0.05	4.76	50	241
California Lizardfish	*Synodus lucioceps*	0.21	2.39	89	231
Fantail Sole	*Xystreurys liolepis*	0.16	2.00	94	204
Spotted Turbot	*Pleuronichthys ritteri*	0.31	1.19	89	134
CaliforniaTonguefish	*Symphurus atricauda*	0.64	0.59	78	95.8
Hornyhead Turbot	*Pleuronichthys verticalis*	0.22	0.62	83	70.4

Species that appear in the top 15 across all Biosurvey years are highlighted.

4.6.6 DISCUSSION

Fish communities in soft-bottom habitats within the Port Complex are largely dominated by white croaker and queenfish, species that forage for small invertebrates such as worms and shrimp, as well as a few predatory species such as barred sand bass and California halibut. The diverse epibenthic and infaunal invertebrate community provides ample foraging opportunity for numerous other fish species. Eelgrass beds and the protected shallow soft-bottom habitats also provide critical nursery habitat for a number of managed and commercially important fish species common to the Port Complex. The abundant fish populations also make the Port Complex important feeding grounds for large, solitary predatory species, including several observed in several Biosurveys such as leopard sharks, bat rays, and Pacific electric rays.

Fish community populations in shallow subtidal and soft-bottom habitats have remained relatively similar across Biosurvey years. The most notable change in fish populations during the 2023 Biosurvey was a large increase in the population of shiner surfperch, which may be a result of expanded eelgrass habitat throughout the Port Complex.

As observed for the pelagic fish species, a key observation for the most abundant fish species was the high proportion of juvenile fish captured, indicating the role of the Port Complex as a productive nursery habitat.

4.6.6.1 MANAGED SPECIES

Seven of the species managed under the PCG FMP were captured using otter trawls during the 2023 Biosurvey (Table 4-22), and three additional PCG FMP species were observed during dive surveys (see Section 5.4). The most abundant of the managed species were the vermillion rockfish, chilipepper rockfish, and bocaccio; only single individuals of cabezon, black-and-yellow rockfish, and olive/yellowtail rockfish were observed during dive surveys. Past Biosurveys have documented 17 managed species, although their abundance has consistently been low and variable from year to year.

Giant sea bass have been a protected species since 1982, when both commercial and sport fishing of the species was banned. The International Union for Conservation of Nature and Natural Resources (IUCN) classified the species as critically endangered in 2004, and efforts to better monitor their populations are underway in California. Giant sea bass were first recorded in the Port Complex in 2013, with two individuals captured during trawls. One individual was captured during 2018 trawl sampling, but none were captured in the 2023 Biosurvey.



Vermillion rockfish (Sebastes miniatus)

Table 4-22. Pacific Coast Groundfish FMP Species Abundance in the Port Complex

Common Name	Scientific Name	Abundance				
		2023	2018	2013	2008	2000
Big Skate	*Raja binoculata*	0	0	0	0	8
Black Rockfish	*Sebastes melanops*	0	0	0	0	32
Bocaccio	*Sebastes paucispinis*	19	1	1	0	0
Brown Rockfish	*Sebastes auriculatus*	0	1	4	1	0
Cabezon	*Scorpaenichthys marmoratus*	3	0	4	0	1
Calico Rockfish	*Sebastes dallii*	0	0	9	0	0
California Scorpionfish	*Scorpaena guttata*	13	50	31	11	19
English Sole	*Parophrys vetulus*	6	1	2	24	3
Grass Rockfish	*Sebastes rastrelliger*	0	0	0	0	3
Leopard Shark	*Triakis semifasciata*	6	0	2	0	3
Lingcod	*Ophiodon elongatus*	0	0	0	0	1
Pacific Sanddab	*Citharichthys sordidus*	12	1	0	171	52
Spiny Dogfish Shark	*Squalus acanthias*	0	0	0	1	0
Vermillion Rockfish	*Sebastes miniatus*	87	11	45	20	4
Chilipepper Rockfish	*Sebastes goodei*	36	0	0	0	0
Black-and-Yellow Rockfish	*Sebastes chrysomelas*	1	0	0	0	0
Olive/Yellowtail Rockfish	*Sebastes flavidus/serranodides*	1	0	0	0	0
Groundfish Ecosystem Component Species						
California Skate	*Raja inornata*	7	6	63	23	11

In 2018, a bocaccio was caught during lampara sampling. Cabezon, black-and-yellow rockfish, and olive/yellowtail rockfish were observed during dive surveys in 2023. Leopard sharks were caught in 2023 during beach seine sampling.

4.7 NON-NATIVE SPECIES

Species identified in each element of the 2023 Biosurvey and in the previous Biosurveys (2000 through 2018) were cross-referenced to determine their status with web-based databases and scientific literature, including the following:

- Non-native status determined from the NEMESIS database (Fofonoff et al., 2020), which was compiled with information previously contained in the California Aquatic Non-Native Organism Database (CANOD) and used in previous Biosurveys.

When no information for a species was available, the species name was entered into other databases such as the World Register of Marine Species (WoRMS) and/or Integrated Taxonomic Information System (ITIS) to verify taxonomic status and/or synonyms. A synonym is a scientific name that applies to a taxon that may be referred to by a different scientific name. If a synonymized name was present, it was entered into the non-native species databases to determine whether status information was available.

4.7.1 BENTHIC INFAUNA

Of the 372 infaunal species identified in the 2023 Biosurvey, 19 were identified as non-native (Table 4-23). During the five Biosurveys combined, 30 non-native species have been identified. In 2023, the 19 non-native species represented 5.11% of the total species identified. This percentage is greater than those in the 2000, 2008, and 2013 Biosurveys, which ranged from 2.2 to 3.5% of all species identified, but less than the percentage in the 2018 Biosurvey, in which non-native species accounted for 5.15% of the total. Although the percentage of non-native species decreased slightly in 2023, their relative abundance increased dramatically; the 6,295 non-native individuals made up 33.4% of the 18,848 total infaunal organisms collected, higher than the 18% identified over the past three Biosurveys (12.5 to 18% from 2008 through 2018), but is similar to the 30.6% identified in the 2000 Biosurvey.

The bivalve *Theora lubrica* was identified in all station groups in 2023 and is the most widespread non-native species, having been captured at 81% of the stations. This wide distribution nevertheless decreased from the distribution in previous Biosurveys, in which found *Theora lubrica* was identified at 100% of the stations in 2000, 93% in 2008, 97% in 2013, and 91% in 2018. *Pseudopolydora paucibranchiata* and *Philine auriformis* were the only other widely distributed species (identified at 44% and 41% of stations, respectively) in 2023, with no other non-native species detected at more than 25% of stations. Nearly all of the *Monocorophium acherusicum* (91%) individuals were captured at station LB2; 75% of *Caprella simia* were captured at station LA12, and 61% of *Pseudopolydora paucibranchiata* were captured at station LA10. The prevalence of these three species at these stations was a driving factor in the statistical grouping shown in Figure 4-18.

A study examining benthic infauna communities from regional monitoring in the summer of 1998 was conducted in nine southern California embayments, including 46 stations in the Port Complex (Ranasinghe et al., 2005). There were no significant differences in the relative abundance of non-native species among the harbors. The Port Complex had the lowest percent non-native species (7.2%) of the harbors in the study (range of 7.2 to 12.4%) where non-natives were detected (only one station, in Ventura Harbor, had no non-natives), and the third-lowest percent non-native abundance (26.2%; range of 12.5 to 31.9%). There was a significant positive correlation between non-native species abundance and total abundance, the total number of species, and native species abundance. The authors theorize that this finding could indicate that resources are not limiting, and therefore there is little or no direct competition. However, two of the most abundant species in the regional study were a tube-dwelling worm (*Pseudopolydora paucibranchiata*) and the Asian date mussel (*Arcuatula senhousia*, formerly *Musculista senhousia*), both of which modify the habitat with their tubes and byssal mats. This creates structure and habitat heterogeneity that can actually enhance the abundance of native species (Ranasinghe et al., 2005).

Table 4-23. Abundance of Non-Native Benthic Infauna – 2000–2023

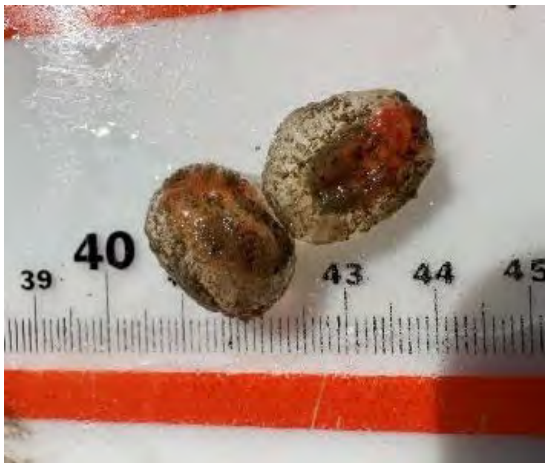
Phylum	Species Name	2023	2018	2013	2008	2000
Annelida	*Hydroides elegans*	0	0	1	0	0
	Megasyllis nipponica	36	2	0	0	0
	Branchiomma bairdi	1	0	0	0	0
	Polydora cornuta	0	0	0	0	2
	Pseudopolydora paucibranchiata	4,930	1,451	80	326	7,667
Arthropoda	*Caprella mutica*	2	0	0	0	0
	Caprella simia	241	15	0	7	0
	Corophium heteroceratum	0	276	377	286	395
	Deltamysis holmquistae	0	1	0	0	0
	Grandidierella japonica	325	332	8	66	149
	Leucothoe nagatai	9	0	0	0	0
	Monocorophium acherusicum	204	4	0	0	157
	Monocorophium insidiosum	0	1	0	5	0
	Monocorophium uenoi	1	0	0	0	0
	Paranthura japonica	5	4	0	0	0
Bryozoa	*Amathia verticillata*	0	P	P	0	0
Chordata	*Ascidiella aspersa*	9	0	0	0	0
	Ciona robusta	5	0	0	0	0
	Ciona savignyi	12	1	0	0	0
	Molgula ficus	1	1	0	0	0
	Styela clava	1	0	0	0	0
Cnidaria	*Laomedea calceolifera*	0	12	0	0	0
	Nematostella vectensis	0	1	0	0	0
Mollusca	*Arcuatula senhousia*	68	97	1	0	0
	Crassostrea gigas	0	0	0	2	0
	Mytilus galloprovincialis	3	2	0	4	1
	Philine auriformis	24	155	14	35	21
	Theora lubrica	418	609	494	1,007	1,490
	Venerupis philippinarum	0	1	0	0	0
Total Infauna Abundance		18,848	16,436	7,770	11,011	32,328
Total Infauna Species Richness		372	369	344	258	361
# Non-Native Species		19	19	8	9	8
% of Infauna Species Non-Native		5.11	5.15	2.33	3.49	2.22
% of Infauna Abundance Non-Native		33.4	18.0	12.5	15.8	30.6

Non-native designation as determined by NEMESIS database (Fofonoff et al., 2020). P = Present when no abundance information is available.

4.7.2 EPIBENTHIC INVERTEBRATES

A total of non-native epibenthic invertebrate species listed in the California Non-native Estuarine and Marine Organisms (Cal-NEMO) database were collected during trawl sampling in 2023, and no non-native species were captured using beach seines.

The most abundant non-native species was the European ascidian (*Ascidiella aspersa*), a solitary sea squirt, which contributed 6.9% of the total biomass collected across all trawls (Table 4-24); none were collected in previous Biosurveys. This species was identified for the first time in the Eastern Pacific in 2019 (Nydam et al., 2022) at Newmarks Yacht Centre in the Port of Los Angeles, the same location where the non-native ascidians *Ascidia zara* and *Ciona savignyi* were first recorded (Nichols et al., 2023). Another new species identified in 2023 was the ascidian *Corella japonic*a, which is native to Japan and was positively identified using deoxyribonucleic acid (DNA) in a separate study in summer 2023 at the Newmarks Yacht Centre (Stefaniak et al., 2025). During the 2023 Biosurvey, one *C. japonica* individual was collected in spring trawls at LB4 (Port of Long Beach Channel 3), and in the summer trawls, 25 individuals were captured five stations across the Inner Harbor, including LB16 (Port of Long Beach Channel 2), LB14 (Cerritos Channel), LA4 (Port of Los Angeles Main Channel), LA5 (West Basin), and LA15 (Turning Basin). The expansion of these species is potentially related to commercial shipping activity (Nichols et al., 2023, Stefaniak et al., 2025), and the presence of these species both on docks and on the seafloor can likely be explained by adults attached to ships releasing larvae into the water, and adults becoming dislodged from the ships during docking operations (by tug wash, abrasion from fenders, etc.) and settling onto the seafloor. Although *C. japonica* is not yet listed as a non-native species in the Cal-NEMO database because of its recent identification, this species is likely to be added in the future, and its distribution is worth monitoring in subsequent surveys.



Non-native ascidian Corella japonica

Six chordates and three molluscs composed the other eight non-native species collected in 2023. Six of the non-native species collected in 2023 were not collected in previous Biosurveys. The abundances of the other three non-native species (*Styela plicata, S. clava,* and *Philine auriformis*) were lower than in previous Biosurveys (Table 4-25). Although the two non-native tunicate species, the Pacific oyster and Mediterranean mussel, were not captured in trawls in the 2000 and 2008 Biosurveys, these species, which are generally associated with hard substrates, were identified during riprap sampling during those surveys. The presence of these species in the epibenthos during the past two Biosurveys may be due to these animals becoming dislodged from hard substrate and scattering over the soft bottom or to the collection of debris and small rocks from the bottom to which these animals attached.

The white bubble snail (*P. auriformis*) has been one of the most abundant non-native species captured in the Port Complex since 2018. In 2023, 18 individuals were collected. The absence of the white bubble snail in 2008 is due to the taxonomic effort that identified only the paper bubble (*Philine alba*) to species, and all other individuals in the genus were left at *Philine sp*. Even if all the individuals of *Philine sp*. in 2008 are assumed to be *P. auriformis*, only 29 individuals were collected; if this information is accurate, 2008 is the only Biosurvey year in which this non-native species was not among the most abundant non-native species.

4.7.3 DEMERSAL FISHES

During trawl sampling in 2023, only one introduced fish species, the yellowfin goby (*Acanthogobius flavimanus*) was captured. This species has been caught in every Biosurvey to date. Two individuals were caught across all sampling events in station LA10 (Fish Harbor), an abundance that is similar to that in previous Biosurveys.

Table 4-24. Abundance, Biomass, and Frequency of Trawl Capture of Non-Native Epibenthic Invertebrates – 2023

Species			Total Abundance	Total Biomass (kg)	% of Total Biomass	Frequency of Trawl Capture (% of stations)
Phylum	Common Name	Scientific Name				
Chordata	European Ascidian	*Ascidiella aspersa*	1,031	15.6	6.93	84.6
	Sea Vase Ascidian	*Ciona robusta*	398	5.11	2.27	61.5
	Warty Tunicate	*Styela clava*	33	0.38	0.17	34.6
	Blunt-Spined Microcosmus	*Microcosmus squamiger*	33	0.16	0.07	19.2
	Common Camellia	*Corella japonica*[1]	26	0.07	0.03	23.1
	Sea Grape	*Molgula ficus*	21	0.14	0.06	26.9
	Pleated Tunicate	*Styela plicata*	19	0.32	0.14	19.2
	Sea Squirt	*Ascidia zara*	6	0.01	0.00	19.2
Mollusca	Asian Date Mussel	*Arcuatula senhousia*	2	0.00	0.00	7.69
	Mediterranean Mussel	*Mytilus galloprovincialis*	148	1.78	0.79	23.1
	White Bubble Snail	*Philine auriformis*	18	0.03	0.01	23.1

1. Not currently in Cal-NEMO database as a non-native species at time of publication.
Cal-NEMO = California Non-native Estuarine and Marine Organisms; kg = kilogram(s)

Table 4-25. Abundance of Non-Native Epibenthic Invertebrates in Trawls – 2000–2023

Species			2000	2008	2013	2018	2023
Phylum	Common Name	Scientific Name					
Arthropoda	Oriental Shrimp	*Palaemon macrodactylus*	0	2	15	23	0
Bryozoa	Spaghetti Bryozoan	*Amathia verticillata*	0	0	NA	NA	0
Chordata	European Ascidian	*Ascidiella aspersa*	0	0	0	0	1,031
	Sea Vase Ascidian	*Ciona robusta*	0	0	0	0	398
	Warty Tunicate	*Styela clava*	0	0	141	380	33
	Blunt-Spined Microcosmus	*Microcosmus squamiger*	0	0	0	0	33
	Common Camellia	*Corella japonica*	0	0	0	0	26
	Pleated Tunicate	*Styela plicata*	0	0	49	77	19
	Sea Squirt	*Ascidia zara*	0	0	0	0	6
Mollusca	Asian Date Mussel	*Arcuatula senhousia*	0	0	0	0	2
	Mediterranean Mussel	*Mytilus galloprovincialis*	0	0	0	0	148
	Pacific Oyster	*Crassostrea gigas*	0	0	22	149	0
	White Bubble Snail	*Philine auriformis*	409	0	200	308	18

Abundance data are not applicable to the bryozoan *A. verticillata.*
NA = not applicable

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5 HARD SUBSTRATE ASSOCIATED COMMUNITIES

Most of the shoreline of the Port Complex consists of rock dikes known as riprap; the remainder is formed by steel walls known as sheet piling, concrete or wooden bulkheads, and a limited amount of sandy beach. In addition, extensive breakwaters and jetties add several miles of riprap to the total. Tens of thousands of concrete, wood, and steel pilings support the wharfs and docks of the marine terminals, maritime service businesses, recreational boating marinas, and other infrastructure throughout the Port Complex. The sheer number of these structures make riprap and pilings a significant habitat type in the Port Complex, supporting a wide variety of marine flora and fauna.

Past Biosurveys have demonstrated that much of the riprap within the Port Complex supports extensive stretches of canopy-forming algae such as giant kelp (*Macrocystis pyrifera*) and feather boa kelp (*Egregia menziesii*). Results of a study by MEC in 1986 and 1987 (MEC, 1988) indicated that *Macrocystis pyrifera* on the San Pedro Breakwater had densities more than 10 times higher than nearby mature coastal kelp beds, with extremely high annual productivity (70 kilograms per square meter per year [kg/m^2/yr]) compared with 22 to 30 kg/m^2/yr for other kelp beds in southern California (Foster and Schiel, 1985). The authors attributed this productivity to two factors; (1) the steep slope of the riprap jetties that results in a narrow band of kelp with a large edge-to-volume ratio that allows for greater light penetration, and (2) the diminished energy within the protected habitats behind the breakwaters that allows kelp to grow at shallower depths and produce more blades per stipe length, similar to kelp beds found at similar depths in protected coves along Catalina Island (MEC, 2002). In addition to the primary canopy-forming species, kelp communities are generally composed of a number of species of shorter stature (understory) and encrusting red, brown, and green algae, and they support a diverse assemblage of invertebrates that live on the kelp and the understory algae and on the riprap itself and a number of fish species that rely on the kelp community for shelter and food. Riprap that does not support kelp nevertheless supports a diverse assemblage of algae and invertebrate animals, the composition of which varies with depth, degree of exposure to air, wave energy, and other factors.

Pilings likewise have been shown by previous Biosurveys to support a diverse assemblage of algae and invertebrates, again varying with depth and water movement, as well as degree of shading and composition of the piling material. Coralline algae and fleshy algae such as *Sargassum*, *Undaria*, and *Ulva*, and a variety of attached and motile invertebrates such as tunicates, bryozoans, sponges, tube worms, barnacles, mussels, and sea stars have been documented forming dense growths on pilings.

For the 2023 Biosurvey, essentially the same methods for the 2000, 2008, and 2013 Biosurveys were used for hard substrate associated communities. However, modifications, including a more comprehensive survey of macroalgae and of riprap and piling associated invertebrates and fishes, were introduced in 2018 and used in 2023. The survey design is described in detail in Appendix A. Briefly, the extent of kelp and other canopy-forming macroalgae was assessed via satellite imagery, and canopy-forming algae, understory algae, encrusting algae, and the invertebrates associated with the riprap were assessed by divers using swath and UPC methods. Piling habitat was assessed using modified (for the vertical nature of the habitat) UPC techniques. The integration of these survey elements allows for a more complete picture of the habitat available on riprap and pilings and the associated communities that use them.

The results of these sampling efforts are presented in this section as follows:

- Kelp canopy area estimated from satellite imagery
- Density of targeted canopy-forming algae, understory algae, and invertebrate species collected by swath surveys on riprap subtidal habitats and piling habitats
- Percent cover of invertebrates and algae on (1) riprap subtidal and intertidal habitats, and (2) pilings as a rapid assessment method to compare against quadrat scrapings
- Detailed taxonomic composition of invertebrates and algae from quadrat scrapings on subtidal and intertidal riprap and piling habitats
- Density and occurrence of fish observed by divers at riprap and piling habitats

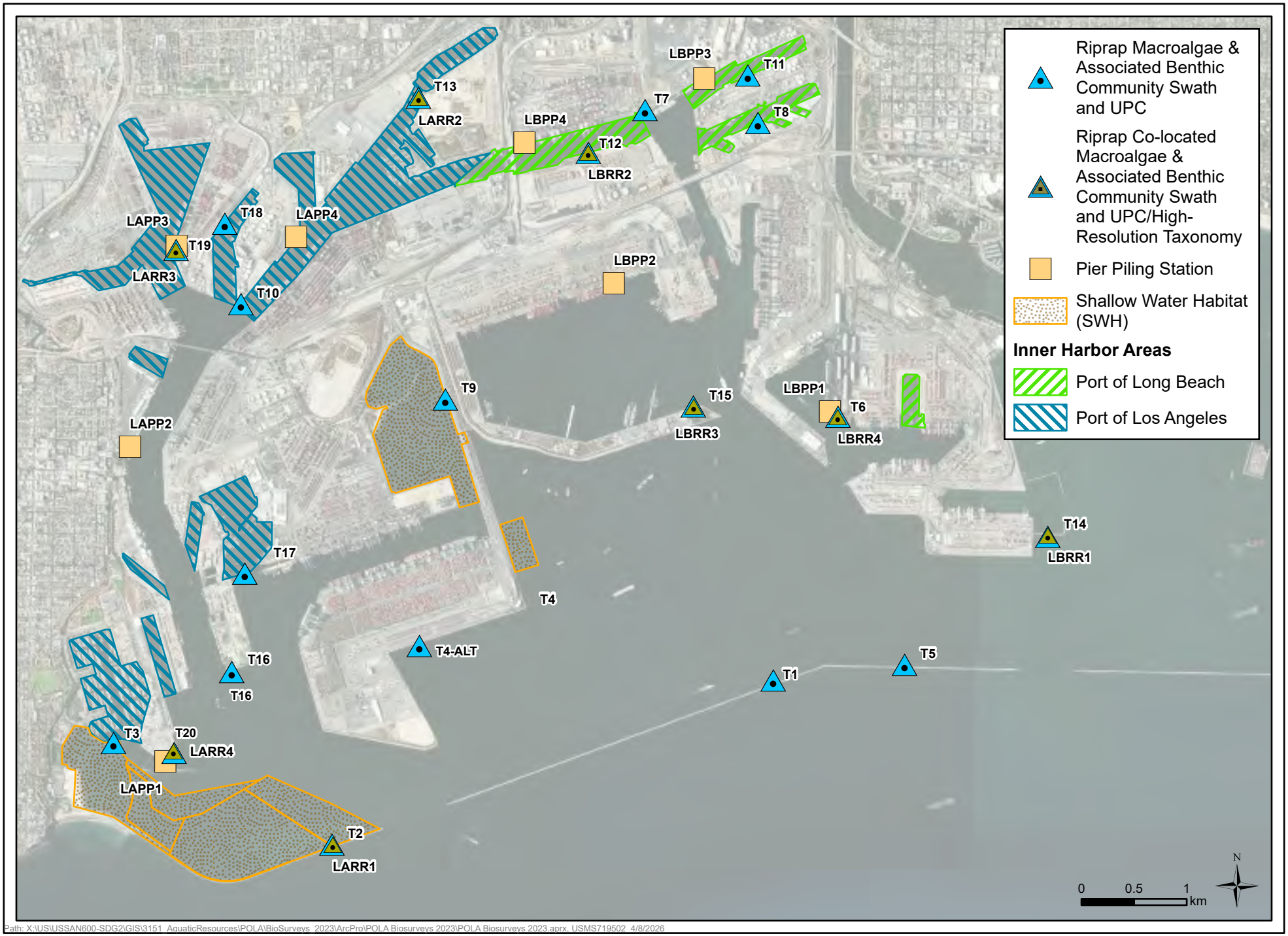
5.1 HABITAT CHARACTERISTICS

Visual surveys of riprap were conducted in spring and summer 2023, and quadrat scrapings and percent cover surveys on pier pilings were conducted only in summer 2023. Riprap and piling habitat data were analyzed by habitat (Inner Harbor and Outer Harbor), location (Breakwater, SWH, outer, channel, basin, and slip) and by depth (upper and lower intertidal, and subtidal). Station designations and more detailed descriptions of survey methods for visual surveys, quadrat scrapings, and kelp canopy imagery are provided in Table 5-1, Figure 5-1, Figure 5-2, and Appendix A. Additional multivariate analysis and data summary tables are provided in Appendix E.

Table 5-1. Riprap and Pier Piling Station Locations and Station Groups

Kelp Station	Riprap Station	Pier Piling Station	Port	Habitat	Location	Station Descriptor	# of Depth Strata
T1	–	–	POLB	Outer	Breakwater	Middle Breakwater	4
T2	LARR1	–	POLA	Outer	SWH	Cabrillo SWH Phase 2 Breakwater	3
T3	–	–	POLA	Outer	SWH	North Cabrillo Beach and Scout Camp	3
T4-ALT[1]	–	–	POLA	Outer	Outer	Outer East Pier 400	3
T5	–	–	POLB	Outer	Breakwater	East Middle Breakwall	4
T6	LBRR4	LBPP1	POLB	Outer	Basin	Southeast Basin	3
T7	–	–	POLB	Outer	Basin	Inner Harbor Turning Basin	3
T8	–	–	POLB	Inner	Slip	Channel 3	3
T9	–	–	POLA	Outer	SWH	Seaplane Lagoon	2
T10	–	–	POLA	Inner	Basin	East Basin Channel Entrance	3
T11	–	–	POLB	Inner	Slip	Channel 2	3
T12	LBRR2	–	POLB	Inner	Channel	Cerritos Channel	3
T13	LARR2	–	POLA	Inner	Slip	South of Consolidated Slip	3
T14	LBRR1	–	POLB	Outer	Breakwater	Pier J Breakwater	4
T15	LBRR3	–	POLB	Outer	Basin	Navy Mole	3
T16	–	–	POLA	Outer	Outer	POLA Main Channel Entrance	3
T17	–	–	POLA	Inner	Basin	Fish Harbor Entrance	3
T18	–	–	POLA	Inner	Slip	Slip 1	3
T19	LARR3	LAPP3	POLA	Inner	Basin	POLA West Basin South	3
T20	LARR4	LAPP1	POLA	Outer	Slip	Berth 48	3
–	–	LAPP2	POLA	Outer	Channel	POLA Main Channel – USS Iowa	–
–	–	LAPP4	POLA	Inner	Channel	East Basin Channel	–
–	–	LBPP2	POLB	Outer	Basin	Pier T	–
–	–	LBPP3	POLB	Inner	Slip	Pier B	–
–	–	LBPP4	POLB	Inner	Channel	Pier A	–

1. T4 was relocated westward, as shown on Figure 5-1, because of poor visibility during spring and summer surveys.
POLA = Port of Los Angeles; POLB = Port of Long Beach



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Figure 5-1. Riprap, Pier Piling, Macroalgae, and Associated Benthic Invertebrate Community Stations

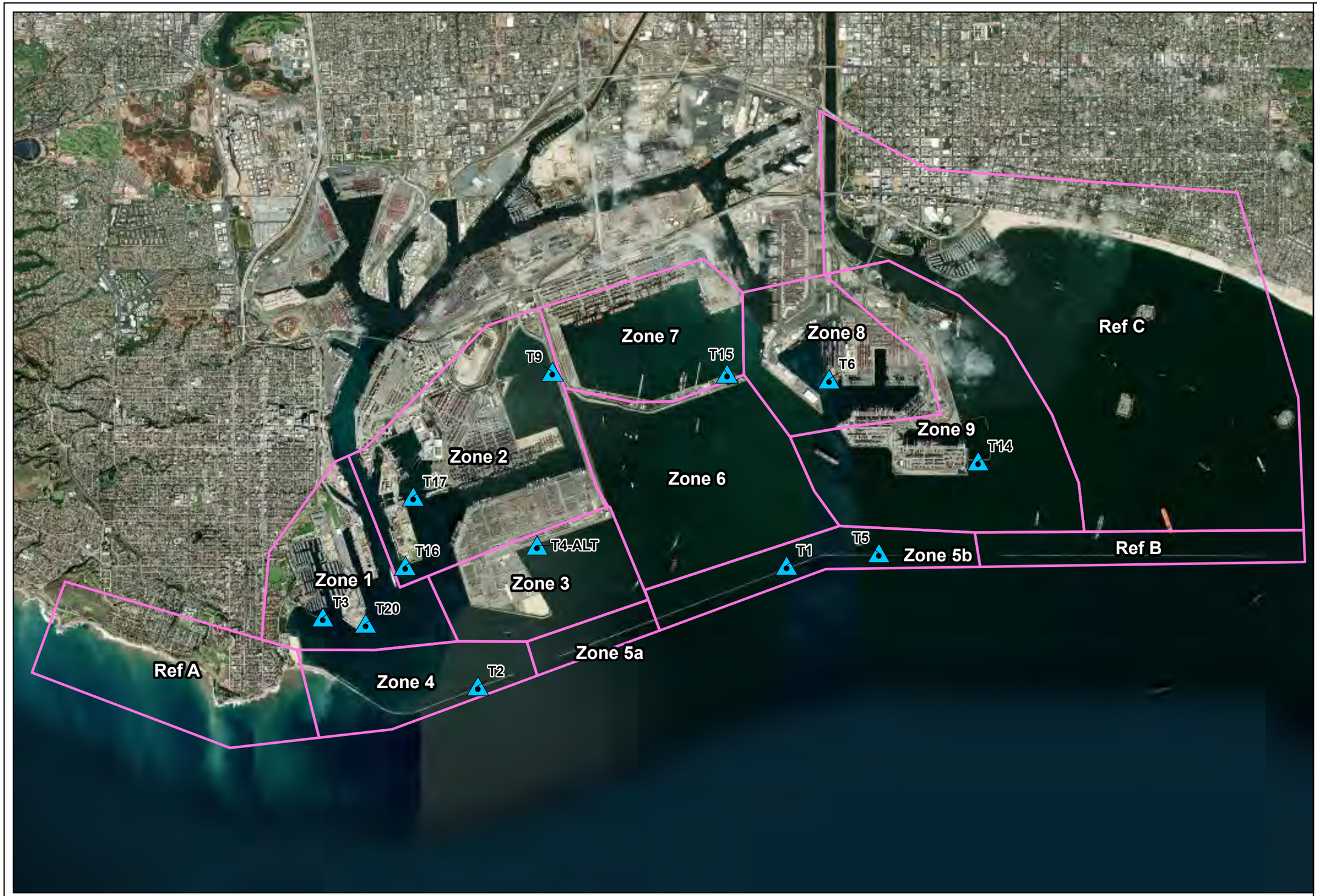


FIGURE 5-2
Kelp Canopy Zones and Kelp Survey Stations

Path: \\corp.pbwan.net\glb-e&i\US\USSAN600-SDG2\GIS\3151_AquaticResources\POLA\POLA_POLB_Kelp_CanopyMapping_2022\ArcPro\POLA Kelp Canopy Monitoring\POLA Kelp Canopy Monitoring.aprx, USMS719502, 11/4/2025

Service Layer Credits: World Imagery: Vantor

5.2 KELP CANOPY FROM SATELLITE IMAGERY

5.2.1 2023 KELP CANOPY

Kelp canopy at the surface and near the surface (<1 meter deep) was monitored via high-resolution satellite imagery in the Port Complex for the first time as part of the Biosurveys in place of the aerial imagery used in previous Biosurveys (see Appendix A for detailed methodology). Based on comparisons with existing visual survey methods, satellite imagery appears to be highly accurate in detecting viable kelp canopy (Wood, 2021; WSP, 2023, 2024, 2025). Reference areas outside the Port Complex boundaries in Eastern San Pedro Bay (the eastern breakwater and energy islands) and natural rocky reef off of Palos Verdes (Point Fermin and White's Point) were mapped to provide context for seasonal and annual variability in kelp canopy within the Port Complex. Satellite imagery in 2023 was timed to align as closely as possible with diver surveys. Spring imagery in 2023 was more challenging to acquire because record-setting occurrences of overcast conditions, resulting in spring images late in the season.

Spring imagery (a composite of images from June 20 and July 8, 2023) identified 39.1 acres of kelp canopy across the Port Complex (Table 5-2, Figure 5-3; see Appendix E for full acreage by survey zone). Kelp canopy slightly increased in the summer (a composite of images from August 6 and 22, 2023) to 43.6 acres (Table 5-2, Figure 5-4). Kelp was detected in all survey zones in both seasons, and kelp acreage increased from spring to summer in the reference areas off Palos Verdes and in eastern San Pedro Bay. The areas of the Port Complex that contained the most kelp canopy (Figure 5-5) included the middle breakwater (more than 9.5 acres, Zones 5a and 5b), Cabrillo Breakwater and SWH (more than 7 acres across both seasons, Zone 4), Port of Long Beach outer anchorages (more than 5 acres, Zone 6), and outer Pier J (more than 3 acres, Zone 9).

Table 5-2. 2023 Kelp Canopy Acreage in the Port Complex and Nearby Reference Areas

Season	Spring	Summer
Dates	**6/20 and 7/8/23[1]**	**8/6 and 8/22/23[1]**
Tide (meters MLLW)	**1.04 and 0.88**	**1.32 and 1.38**
Port Complex Surface Kelp Canopy Total Acreage	34.8	33.1
Port Complex Submerged Kelp Canopy Total Acreage	4.30	10.5
Port Complex Kelp Canopy Total Acreage (Surface + Submerged)	**39.1**	**43.6**
POLA Kelp Total Acreage (Surface + Submerged)	14.5	19.7
POLB Kelp Total Acreage (Surface + Submerged)	24.6	23.9
Reference Kelp Total Acreage (Surface + Submerged)	25.4	41.1

1. Spring and summer images were composites of images from two dates to achieve full coverage of the Port Complex.
MLLW = mean lower low water

Tidal elevation and tidal currents are known to influence the amount of canopy available at the surface for detection by aerial or satellite sensors, with a study in British Columbia finding that a 2-meter increase in tide resulted in a 40% decrease in detectable kelp canopy (Nijland et al., 2019). The spring and summer imagery was captured within a tidal range of 0.88 meter MLLW to 1.38 meters MLLW (Table 5-2), which could result in a slight underestimation of the summer acreage compared with the spring acreage and may be reflected in a higher percentage of submerged (<1 meter depth) kelp canopy observed in the summer compared with the percentage in the spring.



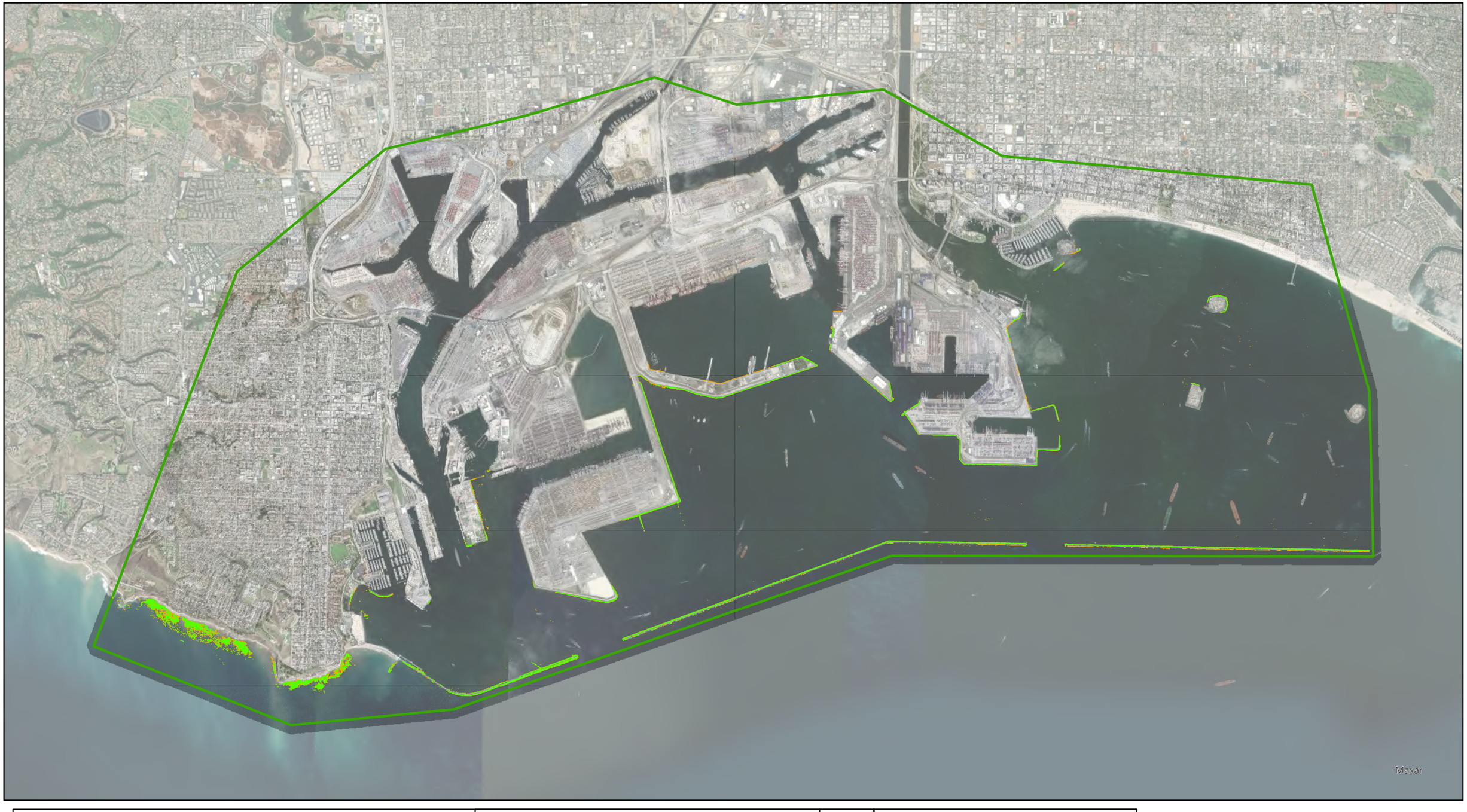
Spring 2023 Kelp Canopy
Biological Surveys of the Ports of Long Beach and Los Angeles, CA

N

Kelp Canopy Classifications

FIGURE **5-3**

(Near) Surface Kelp
Submerged Kelp
Area of Interest



Summer 2023 Kelp Canopy
Biological Surveys of the Ports of Long Beach and Los Angeles, CA

N

Kelp Canopy Classifications

WSP

FIGURE **5-4**

(Near) Surface Kelp

Submerged Kelp

Area of Interest

5.2.2 HISTORICAL COMPARISONS

The history of kelp along the breakwaters is not well documented during the period of their construction from the early to mid-1900s. In 1977, the Los Angeles Harbor Department transplanted nearly 500 adult *Macrocystis pyrifera* to the San Pedro Breakwater with approximately 75 individuals sourced from Baja, Mexico, and the rest from Abalone Cove on the Palos Verdes peninsula (MEC, 1988, 2002). Although no further management efforts have focused on kelp habitat, the expansion of kelp to nearby harbor areas is the product of fortuitous circumstances that have resulted in the creation of suitable hard-bottom substrate in areas that have adequate circulation such as rock breakwaters, shorelines, and containment structures for shallow water habitat mitigation areas that were populated through natural recruitment cycles (MEC, 2002). Although the 2033 Biosurvey breaks with the use of aerial imagery from historical surveys, it does not change the conclusion that Port Complex infrastructure and ongoing expansion have created favorable habitat for canopy forming kelp across the Outer Harbor areas of the Port Complex for several decades.

In addition to the satellite images obtained for spring and summer in 2023, the Port Complex has been compiling a library of quarterly satellite images dating back to 2018 (WSP, 2025; see Appendix E for the full data set). As of late 2025, the library included 19 images from 2018 through 2024, including coverage for the entire 2018 and 2023 Biosurvey periods. High-resolution satellite imagery is a relatively new and evolving technology, and insufficient imagery from the period before 2016 is available for historical comparisons with results for earlier Biosurveys.

The total acreage of kelp canopy measured in 2023 was approximately 60% of the acreage in 2018 across both seasons, with peak summer kelp canopy acreages of 71.4 in 2018 compared with 43.6 in 2023 (Table 5-3). The acreage reported in 2018 was the highest of any of the years imaged from 2018 through 2024, consistent with CDFW monitoring results for kelp canopy in Los Angeles County, which also showed that the kelp canopy was nearly twice as high in 2018 as it was for the rest of 2014 through 2024 (CDFW, 2025). During the 2018 and 2023 Biosurveys there was a modest increase in kelp acreage from spring to summer, which is consistent with the known peak growing season in spring and typical annual kelp canopy maximum in late summer (Cavanaugh et al., 2011; Bell et al., 2020).

Historical frequency of kelp canopy occurrence across all seasons was mapped using data from 2018 through 2024 imagery (Figures 5-5 through 5-8). In these figures, red and orange areas indicate areas where kelp occurs in most years, and blue and green indicate areas where kelp occurs only sporadically. The natural kelp beds in reference area A have relatively little orange and red, and the kelp beds along the inside of the breakwaters and southern-facing riprap jetties of Pier 400 and Pier J show persistent kelp canopy. Although natural rocky reefs are exposed to winter storms that can remove kelp, these areas of the Port Complex have favorable water circulation from exchange through the breakwaters and the nearby gates but offer enough protection that the canopy may be removed only in the largest storms. All zones included show kelp recruitment; however, kelp is not persistent likely because of physical limitations from reduced water circulation and temperature stress in the summer that can result in canopy senescence. Areas closer to the breakwaters may also receive stronger recruitment pulses from nearby coastal kelp beds than those farther inside the Port Complex, increasing the frequency of kelp occurrence year over year.

Table 5-3. 2018 and 2023 Kelp Canopy Acreage in the Port Complex

Season	Spring 2018	Summer 2018	Spring 2023	Summer 2023
Dates	**4/17**	**7/1**	**6/20 and 7/8**	**8/6 and 8/22**
Tide (m MLLW)	**1.25**	**1.09**	**1.04 and 0.88**	**1.32 and 1.38**
Port Complex Surface Kelp Canopy Total Acreage	57.4	34.5	34.8	33.1
Port Complex Submerged Kelp Canopy Total Acreage	7.66	36.8	4.30	10.6
Port Complex Kelp Canopy Total Acreage (Surface + Submerged)	**65.0**	**71.4**	**39.1**	**43.6**
POLA Kelp Total Acreage (Surface + Submerged)	26.4	35.4	14.5	19.7
POLB Kelp Total Acreage (Surface + Submerged)	38.6	36.0	24.6	23.9

MLLW = mean lower low water; **Bold** is combined acreage for Port Complex



		Historical (2018–2024) Kelp Canopy Frequency of Occurrence Port of Long Beach and Port of Los Angeles, CA	N	**Ref A and Zones 1 and 4**	FIGURE **5-5**

Frequency (n=19)
- 0-20%
- 21-40%
- 41-60%
- 61-80%
- > 80%
- Zone



		Historical (2018–2024) Kelp Canopy Frequency of Occurrence Port of Long Beach and Port of Los Angeles, CA	N	All POLA Zones (1-5a)	FIGURE 5-6

Frequency (n=19)

- 0-20%
- 21-40%
- 41-60%
- 61-80%
- > 80%
- Zone



		Historical (2018—2024) Kelp Canopy Frequency of Occurrence Port of Long Beach and Port of Los Angeles, CA	N	All POLB Zones (5b-9)	FIGURE 5-7

Frequency (n=19)

- 0-20%
- 21-40%
- 41-60%
- 61-80%
- > 80%
- Zone



Historical (2018–2024) Kelp Canopy
Frequency of Occurrence
Port of Long Beach and Port of Los Angeles, CA

N

Ref B, Ref C, Zone 9

FIGURE **5-8**

Frequency (n=19)

- 0-20%
- 21-40%
- 41-60%
- 61-80%
- > 80%
- Zone

5.2.3 SEASONAL TRENDS AND KELP STRESSORS

Separate from the kelp mapping described in the previous section using commercial sensors with <2-meter resolution, the relationship between temperature and local kelp canopy was explored in 2013 and 2024 using free images available from NASA's Terra and Aqua satellites and their Moderate Resolution Imaging Spectroradiometer (MODIS; Wood, 2021). The SST and a calculated Kelp Biomass Index of kelp canopy on nearby Point Fermin (within the above-mentioned reference area A) were plotted; the floating 9-day mean of each is displayed in Figure 5-9. This analysis of kelp thermal tolerance was conducted on natural kelp beds off Point Fermin because of the lower resolution (100 meters) of MODIS imagery. The proximity of these kelp beds makes them good comparisons for kelp beds within the Port Complex.

As the SST mean for each year passes the 20°C threshold, the Kelp Biomass Index value stops increasing (a sign that kelp growth has slowed) and then subsequently declines (indicating die-off of kelp canopy near the surface) as SST mean temperatures reach their peak. The growth-maximum of kelp is represented by a peak of the Kelp Biomass Index value usually in April and May, with the highest rates of senescence occurring in July and August, and minimum index values occurring in the fall and winter. It is evident from the MODIS data that the measured kelp canopy during the 2014 through 2016 heat wave was the exception to this annual growth trend; the high SST for most of the year led to minimum Kelp Biomass Index values during the peak of the summer when SST was the highest.

The typical pattern of kelp senescence was observed for kelp within the Port Complex in the 2018 satellite images; more than half of the kelp canopy measured by satellite in July was submerged because the canopy had already begun to senesce and float throughout the Port Complex (Wood, 2021). This pattern of more submerged kelp in July was not as evident in 2023, despite similar Port Complex-wide sea surface temperatures in July 2023 (21.2°C) and 2018 (21.9°C), indicating that other factors such as peak summer SST and the persistence of SST above a certain threshold may influence how quickly and at what time in the year the kelp canopy begins to die back. There was an increase in floating kelp observed in August 2023 compared with June 2023, as shown on Figures 5-3 and 5-4.

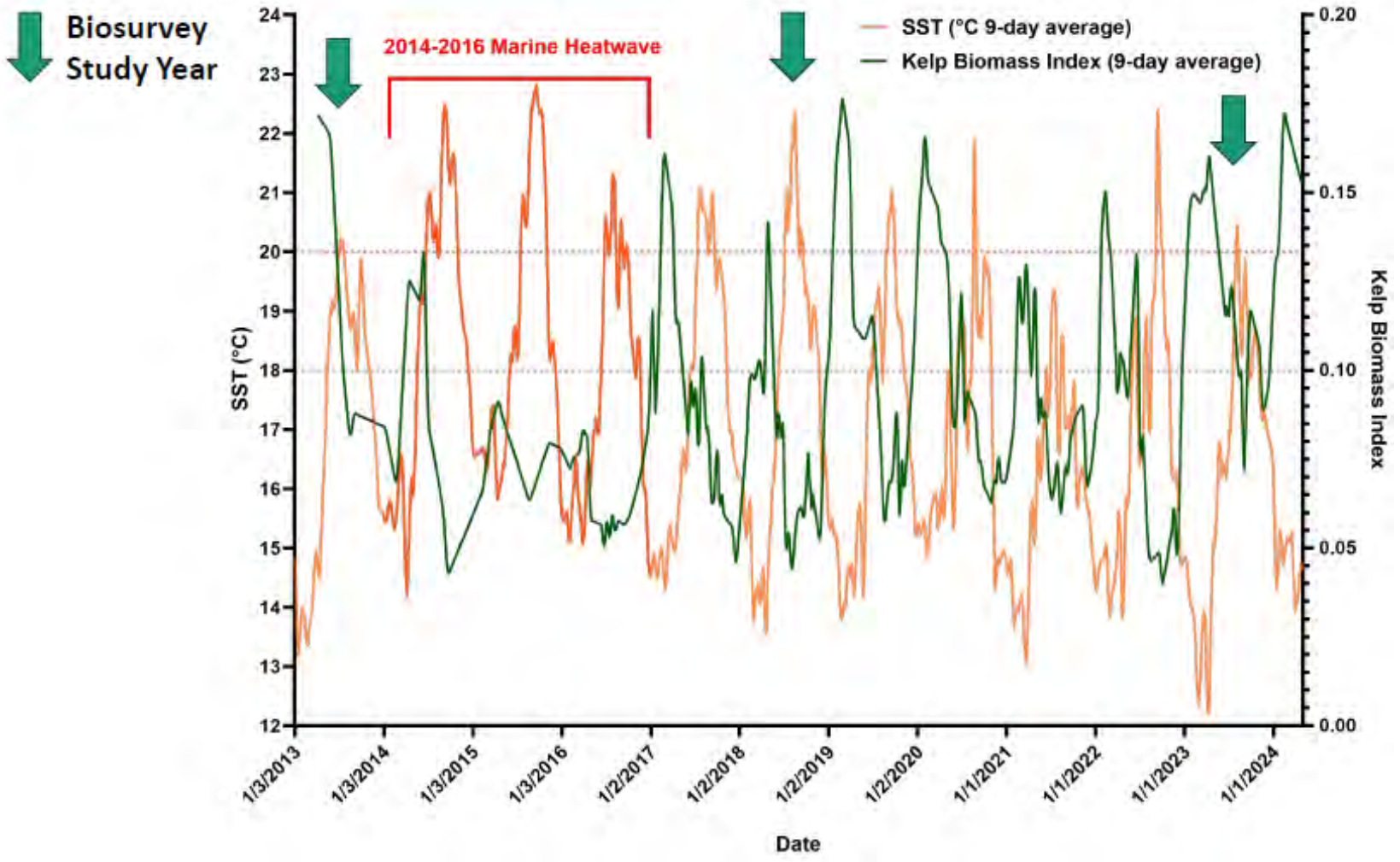
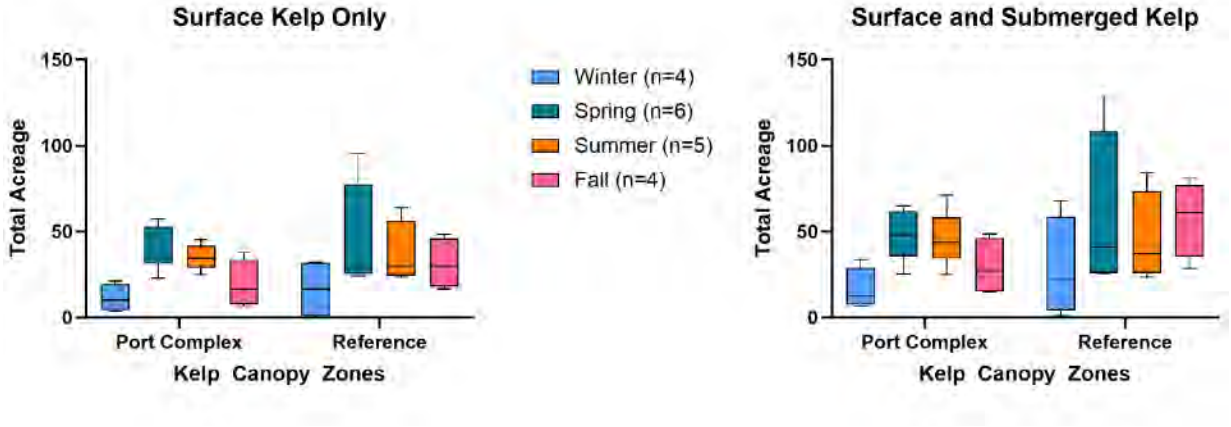


Figure 5-9. Sea Surface Temperature and Kelp Biomass Index from 2013–2024 on Kelp Beds Near Point Fermin, California

Using the historical library of images within the Port Complex (n=19), surface kelp canopy was, on average, highest in the spring and summer and lowest in the winter (Figure 5-10). This same trend was also observed in the reference areas for surface kelp, although when submerged kelp was added, the highest kelp canopy acreage occurred in spring and fall. The variability of kelp canopy acreage across seasons was much higher in the reference areas, which is likely due to exposure of the kelp beds off Palos Verdes to more variable wave conditions that can rip out kelp during large swells. For both surface kelp only and surface plus submerged kelp within the Port Complex, an ANOVA using natural log-transformed acreages indicated that kelp canopy area in the winter was significantly less than kelp canopy acreage in the spring and summer (p-value 0.0107 and p-value 0.0162 respectively), but acreages were not different for the other seasons (p-value 0.0075). There were no statistically significant differences between seasons for the reference areas.



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 5-10. Kelp Acreage by Season for Surface Kelp Only and Surface Plus Submerged Kelp in the Port Complex and Reference Areas – 2018–2024

5.3 MACROALGAE AND MACROINVERTEBRATES

In addition to the canopy-forming species (primarily *Macrocystis pyrifera*), kelp communities on riprap generally include other algal species that can be categorized into layers distinguished by morphological adaptations (Dayton et al., 1984; Dayton, 1985). These include (1) a tall understory canopy in which fronds are supported well above the substratum by erect stipes (characteristic species include *Pterygophora californica* and *Eisenia arborea*); (2) a low understory canopy in which fronds lie on or immediately above the substratum (e.g., *Laminaria farlowii* and *Stephanocystis osmundacea*); (3) densely packed algal turf made up of articulated coralline algae (*Corallina pinnatifolia* and *C. vancouveriensis*, *Lithothrix aspergillum*) and many species of foliose and siphonous red, brown, and green algae; and (4) encrusting coralline algae (e.g., *Lithophyllum* sp. and *Lithothamnion* sp.). These complex communities provide habitat for numerous sessile and mobile invertebrates that can be large and easily identified during visual diver surveys, although most of the invertebrates are small and cryptic within the algal turfs and attached to the rocks.

Previous Biosurveys used only quadrat scrapings to sample smaller cryptic invertebrates, and divers qualitatively assessed the percent cover of macroalgae species. One of the most impactful changes to the 2018 Biosurvey design was modification of the riprap and piling surveys to incorporate methods used in regional monitoring programs of coastal rocky reefs, primarily from the PISCO. The result was a much more rigorous quantitative assessment of algal, invertebrate, and fish communities that still included quadrat scrapings for high resolution taxonomy of the epifaunal community on riprap and pilings. In 2023, the methodology was updated again to include a quantative survey of fish density on riprap and pilings The methods are briefly described in Section 1.6.5., with more complete descriptions and details in Appendix A.

5.3.1 DENSITY OF TARGETED MACROALGAE AND MACROINVERTEBRATES

Swath surveys on riprap habitats were used to gather abundance information on target species of canopy-forming algae, understory algae, and macroinvertebrates. The abundance of target species at a given station was divided by the area surveyed to obtain density. Note that box and whisker plots show density as # individuals/m^2, while maps show density as # individuals per 100 m^3 for ease of display and comparison.

5.3.1.1 CANOPY FORMING ALGAE

Giant kelp (*Macrocystis pyrifera*) and feather boa kelp (*Egregia menziesii*) are the only canopy-forming algae species that were targeted by the swath surveys. In addition to counting the giant kelp and feather boa individuals encountered within the swath, divers counted the number of stipes greater than 1 meter in height as a way to assess recruitment and biomass of kelp, a technique that has been shown to be complementary to aerial and satellite canopy imaging methods (Cavanaugh et al., 2011).



Giant kelp (Macrocystis pyrifera) in the Outer Harbor

Riprap

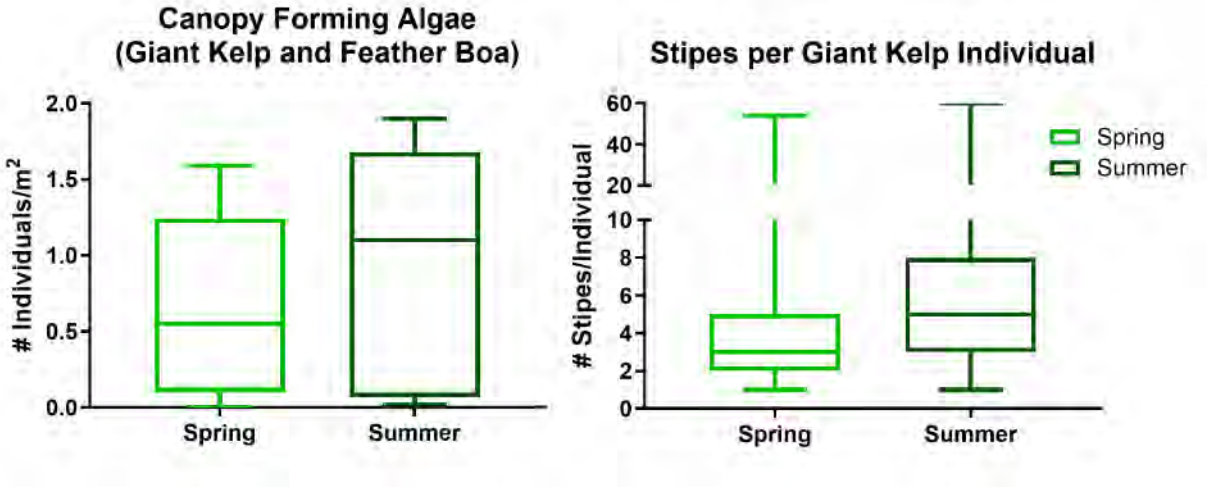
Canopy-forming algae were observed at 12 sites on the breakwaters and in the Outer Harbor (Figures 5-11 through 5-13). Although the mean density of canopy-forming kelp was higher in the summer (0.97 individuals/m^2) compared with the spring (0.67 individuals/m^2), the difference analyzed with a Welch's t-test on square-root transformed data was not statistically significant (p=0.43) . Station T14 (Pier J Breakwater) had the highest density of canopy-forming algae in the spring (1.59/m^2), closely followed by station T2 (CSWH Phase 2 Breakwater, 1.52/m^2). In the summer, the density was highest at station T16 (Port of Los Angeles Main Channel Entrance, 1.90/m^2), and three other stations (T2, T14, T15) had densities above 1.60/m^2.

The mean number of stipes per giant kelp individual, an indication of kelp age and structural value, better predicts the standing biomass compared with density (Reed et al., 2009). In 2023, the mean number of stipes per plant was greater

in summer (5.3) than in spring (3.6), a statistically significant difference (Figure 5-11). The largest (most stipes >1 meter) giant kelp individuals encountered in spring and summer had 54 and 60 stipes, respectively, both times at station T5 on the Middle Breakwater, indicating that it could be the same individual measured in both seasons. Giant kelp is known to recruit in the spring (Schiel and Foster, 2015), indicating that the sampling captured increased recruitment from spring to summer, thus accounting for the higher density and more stipes per individual.

Feather boa kelp was primarily distributed in the Breakwater and Outer Harbor areas that experience more wave energy, which is a key habitat requirement for this species (Figures 5-12 and 5-13). Feather boa in the spring averaged 0.04 individuals/m^2 compared with 0.17 individuals/m^2 in the summer, although the difference was not significantly different using a Welch's t-test on square-root transformed data ($p = 0.24$), nor was the number of stipes per individual using log-transformed data ($p=0.33$).

Some areas within the Port Complex are likely to sustain large, foundational kelp habitat, whereas others may opportunistically recruit kelp but are unlikely to sustain it long term. A useful metric to examine this phenomenon is the California Coastal Commission's definition of a medium- to high-density giant kelp forest, which includes a threshold of more than 4 adult kelp individuals (i.e., with 8 or more stipes >1 meter in height) per 100 m^2 of substratum (Reed et al., 2023). The density of all kelp, adult kelp, and feather boa kelp per 100 m^2 in spring (Figure 5-12) and summer are shown in Figure 5-13. Of the 12 sites with kelp present, stations T6 (Southeast Basin), T7 (Port of Long Beach Inner Harbor Turning Basin), and T9 (Seaplane Lagoon) were the only ones with no adult kelp individuals present in either season. All other stations achieved medium to high densities of adult kelp individuals, ranging from 5.0 to 57.5 adult individuals/100 m^2 (station T17 – Fish Harbor Entrance and T2 – CSWH Phase 2 Breakwater, respectively) in the spring and 10.0 to 82.5 adult individuals/100 m^2 (stations T17 and T15 – Fish Harbor Entrance and Navy Mole, respectively) in the summer (Figures 5-12 and 5-13). The stations with the highest densities of adult kelp individuals included those on the breakwaters (stations T1, T2, and T5), Outer Harbor riprap embankments (stations T15 – Navy Mole and T16 – Port of Los Angeles Main Channel Entrance) and the riprap border on the inside of station T17 (Fish Harbor Entrance).



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median.

Figure 5-11. Canopy-Forming Algae Density and Giant Kelp Stipes per Individual by Season

5.3.2 UNDERSTORY ALGAE

In addition to assessing canopy-forming algae species, swath surveys also characterized understory kelp species, some of which are considered non-native. Common understory species in southern California kelp forests include *Pterygophora californica, Eisenia arborea*, *Laminaria farlowii*, *Sargassum horneri, Sargassum muticum, Undaria pinnatifida*, and *Stephanocystis osmundacea*. Although the first three species were not observed on any transect during the spring or summer swath surveys, they have been recorded in surveys at nearby coastal reefs in Palos Verdes and Orange County (Reef Check: http://data.reefcheck.us/), so their absence inside the Port Complex could be the result limiting physical conditions such as temperature and wave action. The relative density of each understory algae species observed in the Port Complex for each season is shown in Figure 5-14.

S. osmundacea was the only targeted native understory alga observed in the Port Complex in 2023. It occurred in both seasons (Figure 5-15); it was observed at three stations in the spring (station T3 – North Cabrillo Beach and Scout Camp, T14 – Pier J Breakwater, and T16 – Port of Los Angeles Main Channel Entrance) and two stations in the summer (T14 and T16). Spring density ranged from 0.08/m^2 at station T3 to 0.44/m^2 at station T14, and summer density ranged from 0.01/m^2 at station T14 to 0.88/m^2 at station T16.

The other three understory algae species observed in 2023 Biosurvey are considered non-native: *Sargassum horneri, S.muticum*, and *U. pinnatifida*. *S. muticum* and *S. horneri* can at times become the dominant algal species, with high densities and heights of over 4 meters, occasionally forming a "canopy" that reaches the surface in shallow locations, as was observed in the spring at station T15 (Navy Mole) and station T9 (Seaplane Lagoon).

At least one of those species was identified at every station except station T4-Alt (Outer East Pier 400), which was devoid of any macroalgae, and all three species were observed during both seasons (Figures 5-16 and 5-17). The density of *S. horneri* was greatest at station T11 (Channel 2) in spring (2.91/m^2) and station T19 (Port of Los Angeles West Basin South) in summer (4.07/m^2). Density of *S. muticum* in the spring was greatest at station T15 (Navy Mole, 5.20 /m^2), although station T9 (Seaplane Lagoon, 4.21/m^2) also had high densities. In summer, station T18 (Slip 1) had the highest density of *S. muticum* (3.20/m^2). The density of *U. pinnatifida* was greatest in spring at station T20 (Berth 48, 1.53/m^2, Fish Harbor Entrance) and station T12 (Cerritos Channel, 1.43/m^2), and in summer at station T20 (0.27/m^2).

As in 2018, the density of all three non-native species was higher on average at Inner Harbor stations than at Outer Harbor stations. Mean density of *U. pinnatifida* declined by 90% from spring to summer across all habitats, and *S. muticum* experienced a 413% increase in mean density at Inner Harbor stations and a 69% decrease at Outer Harbor stations. Both species are annuals that in their native ranges experience senescense and die off in summer months when water is warmer (Epstein and Smale, 2017; Engelen et al., 2015), so the Outer Harbor reduction is not unexpected. The increase of *S. muticum* at Inner Harbor stations, however, is contrary to the seasonal pattern observed in 2018. Note that the densities of non-native algae in 2023 are 2 to six 6 lower than densities d in 2018, so the different seasonal patterns could be attributed to site-specific variability rather than a clear pattern between the seasons. Conversely, despite also having an annual life cycle in its native range (Marks et al., 2015), *S. horneri* mean density increased by 265% from spring to summer in 2023 at Inner Harbor stations and 205% at Outer Harbor stations. It is possible that because 2023 was a colder year than 2018, the seasonal die-back of these species occurred later in the year, after the summer surveys were completed.

The *S. muticum* individuals observed in the spring were generally larger, mature plants that created a sub-canopy, and most individuals in the summer were small juveniles (usually no larger than 10 cm tall or wide). Although *S. horneri* is known to create dense stands of larger adults of similar size, most of the *S. horneri* individuals encountered in both seasons were relatively small. The 2023 Biosurvey did not differentiate between the life stages, which could be useful in the future to better understand the dynamics of these populations. The year-round presence of these species is likely attributable to cooler environmental conditions than in their native range in the Western Pacific. These cooler conditions partially inhibit dormancy of the reproductive adults, resulting in overlapping generations that are continuous through time even though individuals die within 12 months of recruitment (Marks et al., 2015; Epstein and Smale, 2017; Engelen et al., 2015).

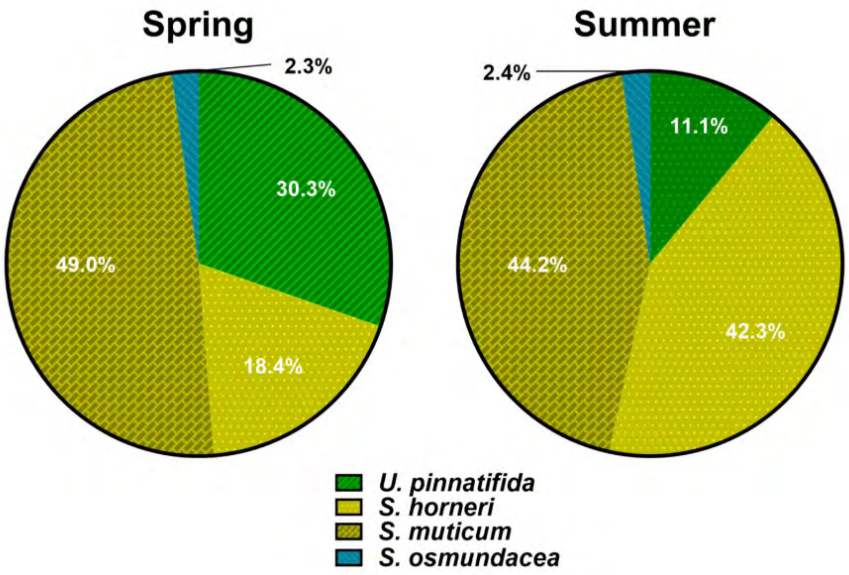
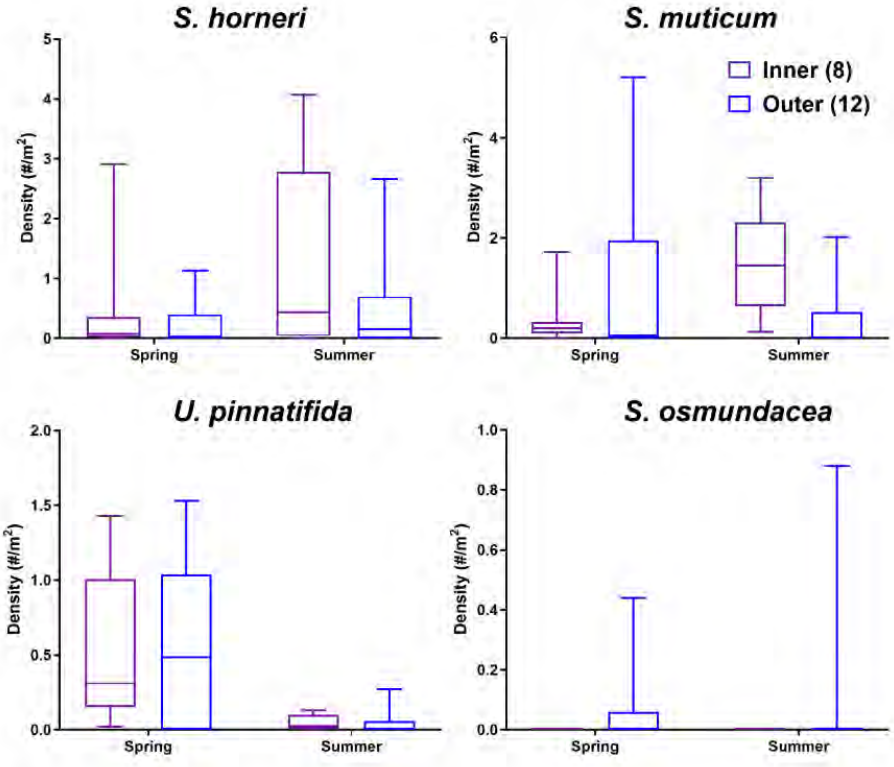


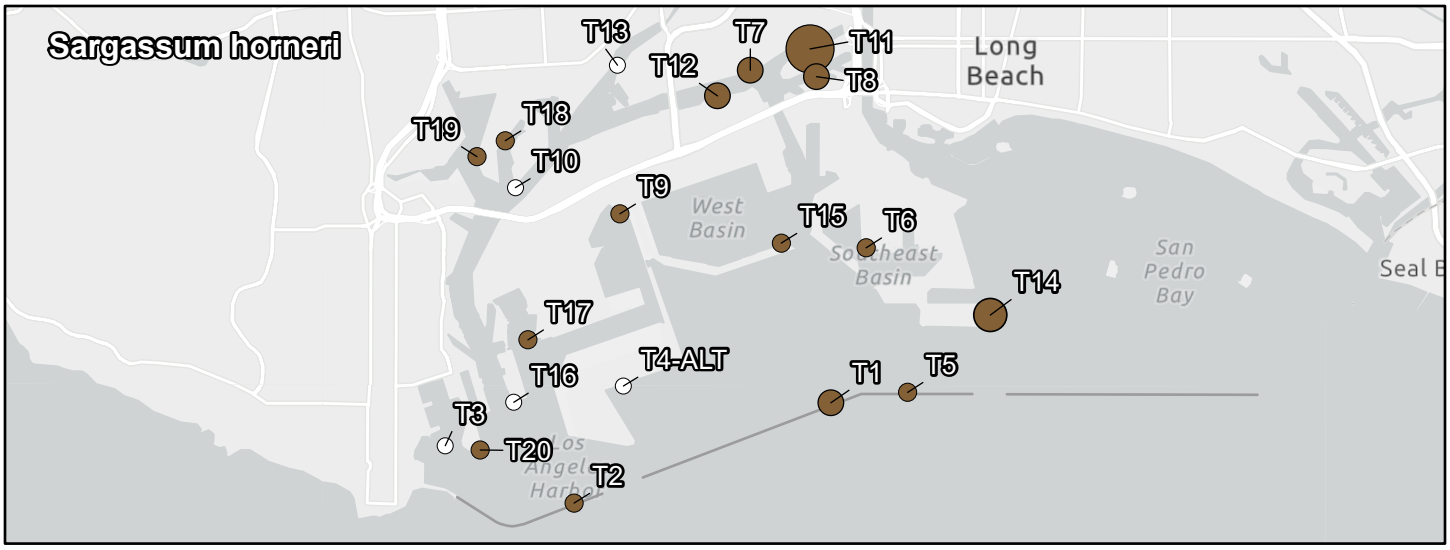
Figure 5-14. Percent Composition of Understory Algae Species Measured by Swath Surveys on Riprap – Spring and Summer 2023

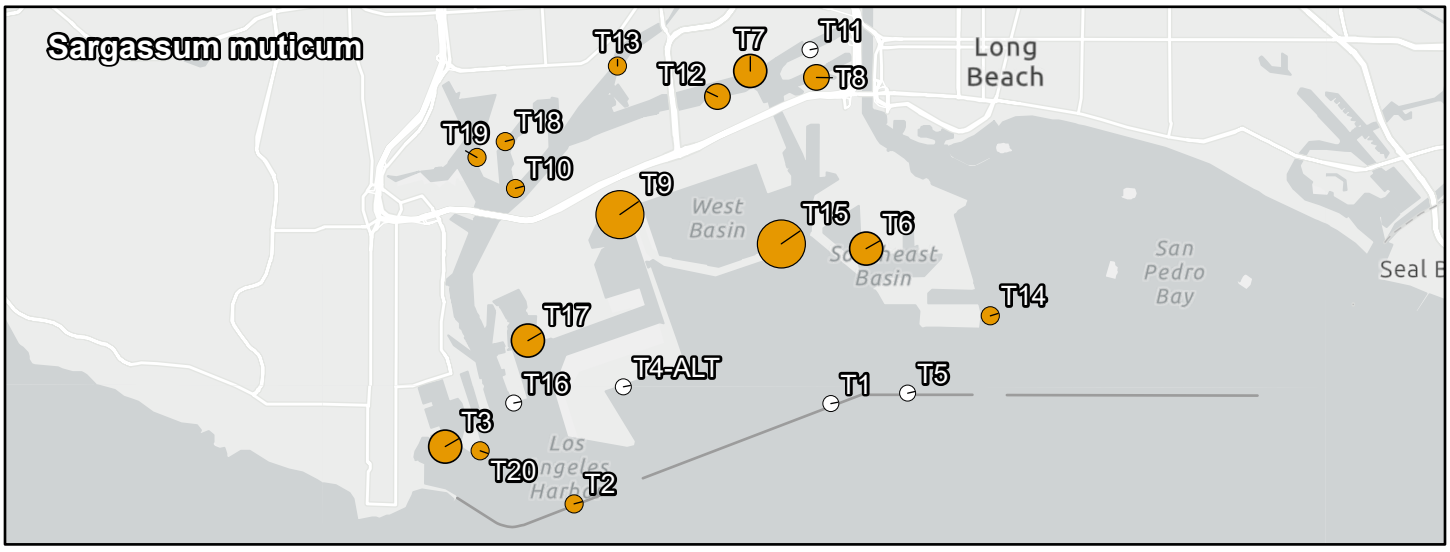


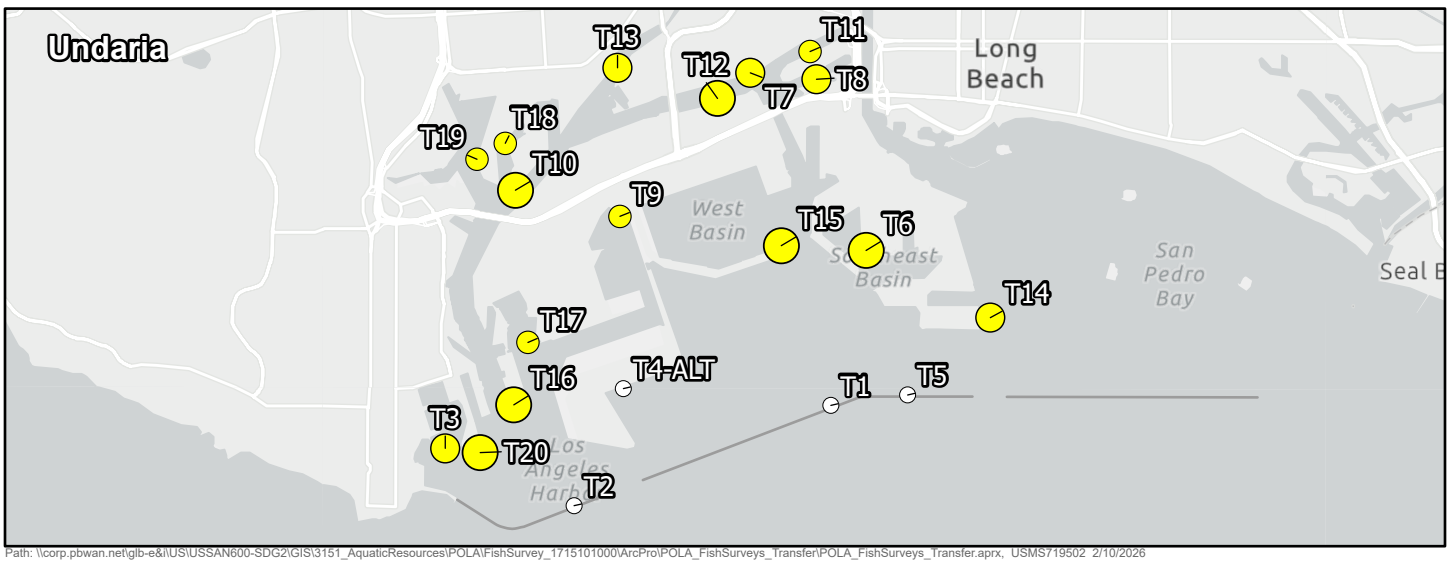
Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 5-15. Density of Understory Algae Species Measured by Swath Surveys on Riprap in Inner Harbor and Outer Harbor Habitats – Spring and Summer 2023

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Light Gray Base: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community







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Density (#/100m^2)

- 0
- 1 - 25
- 26 - 75
- 76 - 250
- 251 - 550

Species

- Sargassum horneri
- Sargassum muticum
- Undaria

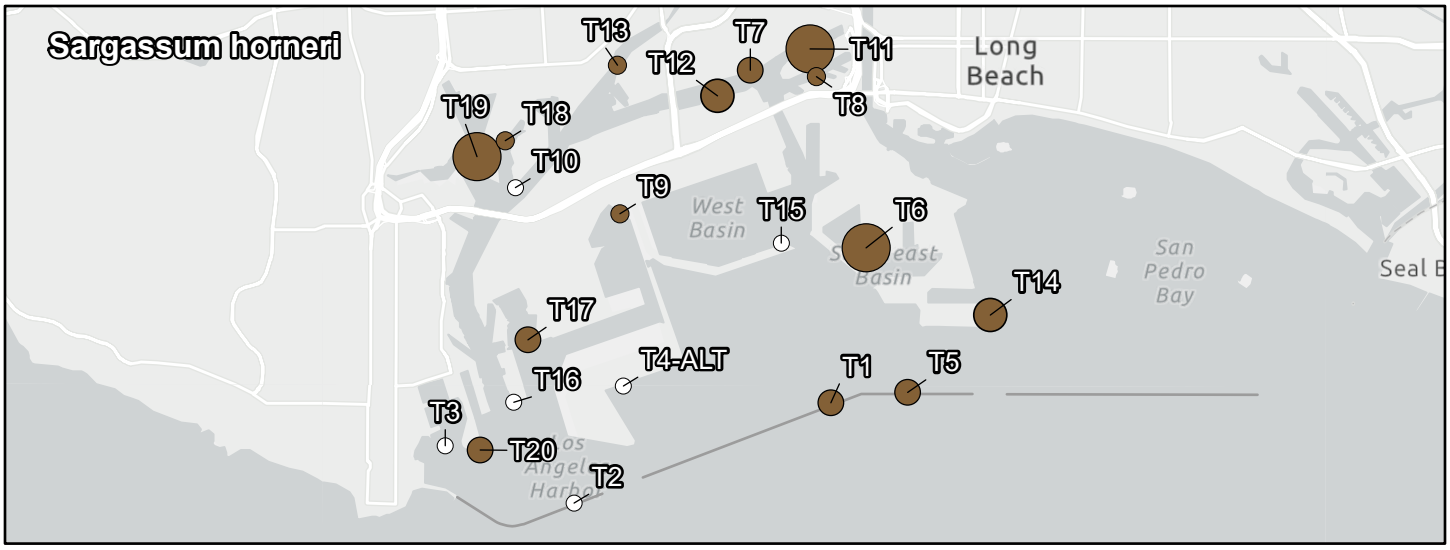
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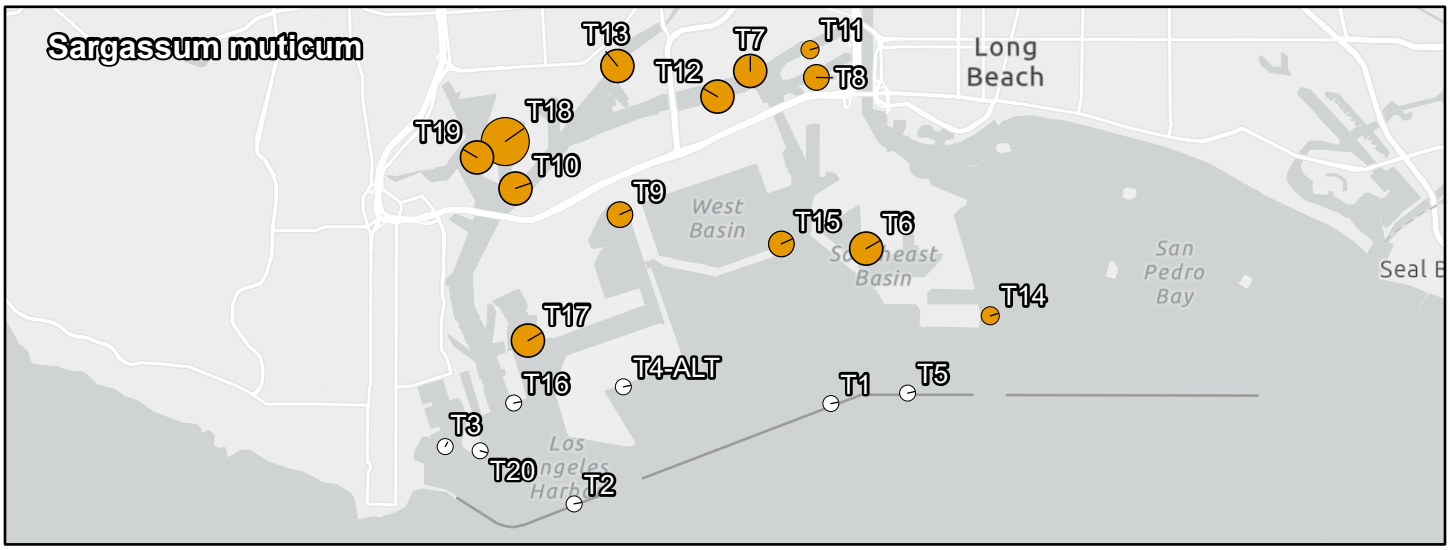
0 1 2 Miles

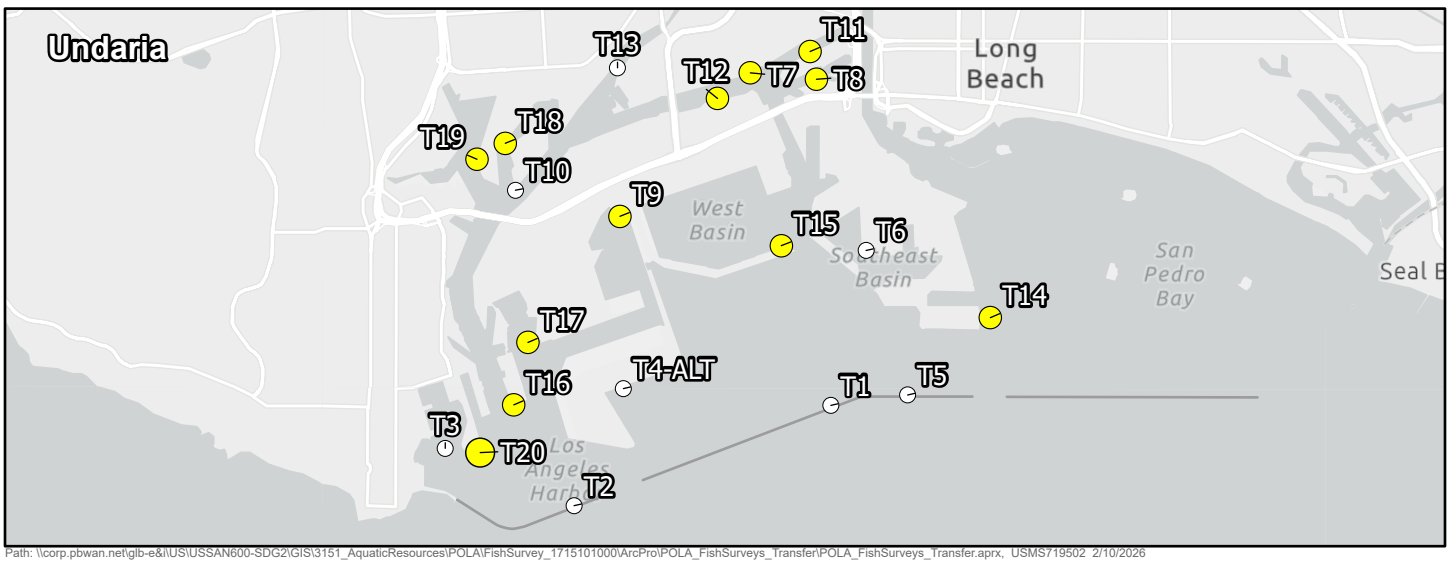
FIGURE 5-16

2023 Spring Non-Native Algae Density

Service Layer Credits: Light Gray Reference: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
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Density (#/100m^2)

- 0
- 1 - 25
- 26 - 75
- 76 - 250
- 251 - 550

Species

- Sargassum horneri
- Sargassum muticum
- Undaria

1:122,771

0 1 2 Miles

FIGURE 5-17

2023 Summer Non-Native Algae Density

Pilings

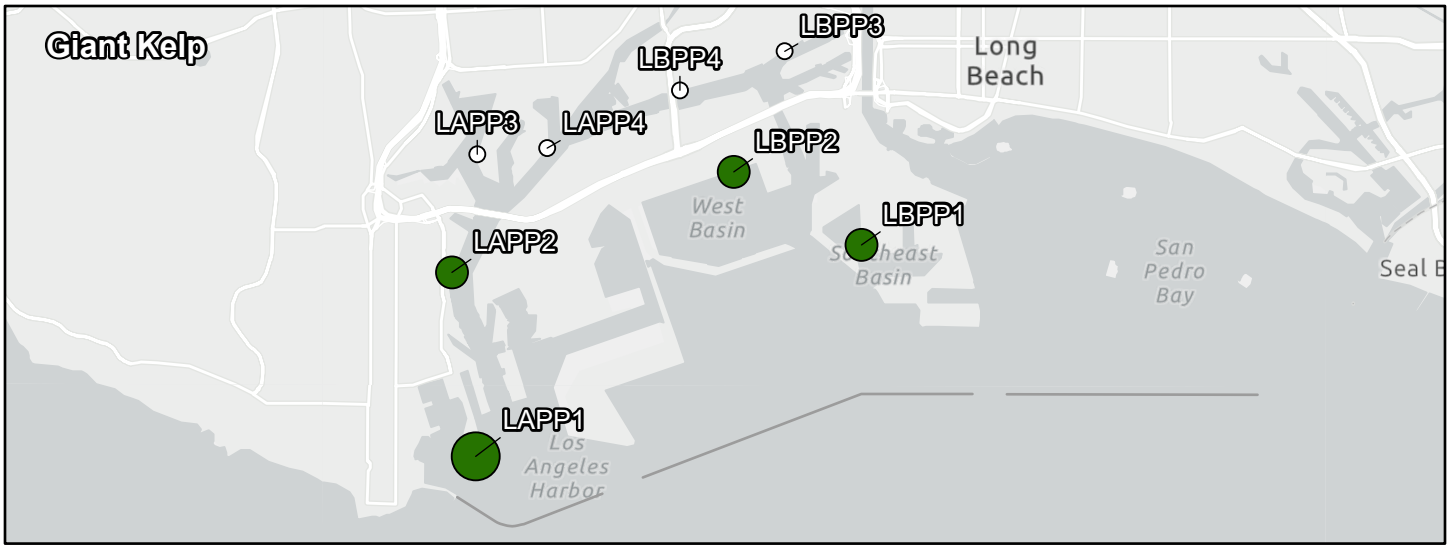
Swath surveys of target macroalgae species were performed on pilings during the summer surveys on the outer faces of the pilings. Giant kelp was observed on all outer pilings (Figure 5-18), with densities ranging from 0.18 individual/m^2 (station LAPP2 – Port of Los Angeles Main Channel) to 1.20 18 individuals/m^2 (station LAPP1 – Berth 48), with the largest individuals observed at stations LBPP1 (Southeast Basin) and LBPP2 (Pier T), each with 9 stipes. No feather boa kelp was observed growing on pilings. The kelp present on pilings is notably absent in past aerial imagery and current satellite imagery, likely because the canopy is very localized around pilings and does not extend far enough from the edge of the wharfs to be detected by remote sensing because of limited resolution. This indicates that the total kelp canopy acreage across the Port Complex is slightly underestimated, and the distribution of kelp may be more extensive than results for past surveys have indicated.

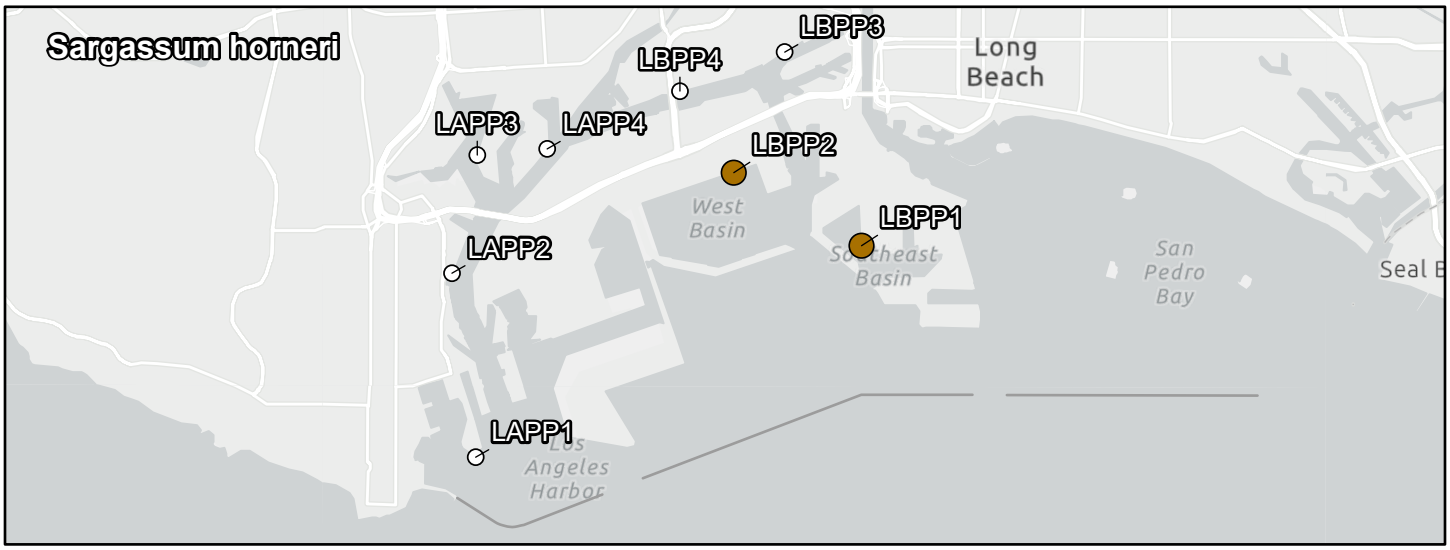
No *Sargassum muticum* was observed on pilings, and *S. horneri* was counted only on Outer Harbor pilings (Figure 5-18), although at low densities (0.06 to 0.12 individual/m^2). *Undaria* was counted on piles in both the Inner Harbor and Outer Harbor (Figure 5-18), with relatively similar densities across habitats ranging from 0.58 to 1.43 individuals/m^2. Note that these two species were observed on nearby pilings that were not quantitatively surveyed, so the occurrence of this species is likely underrepresented in the 2023 Biosurvey. Nevertheless, density of macroalgae on piling habitats was observed to be low across the Port Complex.

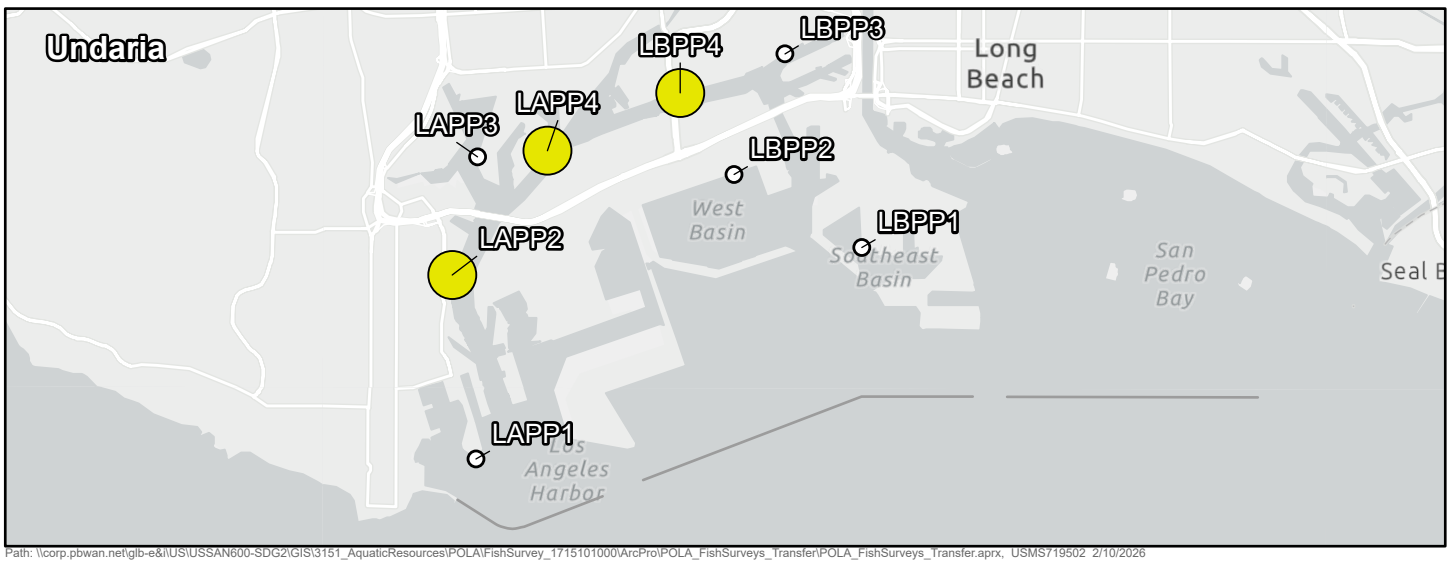


Kelp canopy from attached giant kelp at piling station LAPP1 in the Outer Harbor

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Density (#/100m^2)

- 0
- 1 - 15
- 16 - 50
- 51 - 145

Species

- Giant Kelp
- Sargassum Horneri
- Undaria

1:122,771

0 1 2 Miles

FIGURE 5-18

Density of Algae on Pilings – Summer 2023

5.3.3 INVERTEBRATES

A target list of invertebrates that encompass different feeding guilds (predators, herbivores, detritivores, and filter feeders) was the focus of the diver swath surveys. Predators included California spiny lobster (*Panulirus interruptus*), bat stars (*Patiria miniata*), and ochre sea star (*Pisaster ochraceus*). Filter feeders included anemones larger than 10 cm tall or wide (*Anthropleura* spp. and tube-dwelling species such as *Pachycerianthus fimbriatus*), brown and golden gorgonians (*Muricea fruticosa* and *Muricea californica*), red gorgonian (*Leptogorgia chilensis*), and rock scallop (*Crassadoma gigantea*). Herbivores primarily consisted of wavy turban snails (*Megastrea undosa*) and four species of urchins: red (*Mesocentrotus franciscanus*), purple (*Strongylocentrotus purpuratus*), white (*Lytechinus anamesus*, only in spring), and crowned (*Centrostephanus coronatus*). The herbivores also included two species of abalone: green (*Haliotis fulgens*) and pink (*H. corrugata*). Detritivores and scavengers included warty sea cucumbers (*Apostichopus parvimensis*) and Kellet's whelk snail (*Kelletia kelletii*).

Riprap

The relative contribution of each feeding guild to the total abundance did not vary noticeably from the spring to the summer surveys (Figure 5-19), and filter feeders were the only guild with statistically significant difference (one-way ANOVA, p=0.004) in abundance with Outer Harbor habitats having higher densities of filter feeders in the summer (Figure 5-20). The density of invertebrate feeding guilds at each station averaged across both seasons is shown in Figures 5-21 and 5-22.

Herbivores made up the largest proportion of animals surveyed (Figure 5-19), and across all seasons were on average more abundant at Outer Harbor stations (5.23 individuals/m^2) compared with Inner Harbor stations (0.46 individual/m^2; Figure 5-20). Purple urchins and wavy turban snails were the most abundant herbivores observed on riprap throughout the Port Complex, and red and crowned urchins were more common in the Outer Harbor and at Breakwater stations in relatively low densities below 0.5 individual/m^2. Purple urchin abundance in both seasons was highest at station T4-ALT (Outer East Pier 400), with spring densities of 14.0 individuals/m^2 and summer densities of 58.5 individuals/m^2. The next highest densities were at station, T1 (Middle Breakwater), with 7.1 individuals/m^2 in the spring. Excluding results for station T4-ALT, purple urchin densities were similar across all other stations, with an average of 0.92 individuals/m^2 in the spring and 0.71 individual/m^2 in the summer (Figure 5-21).

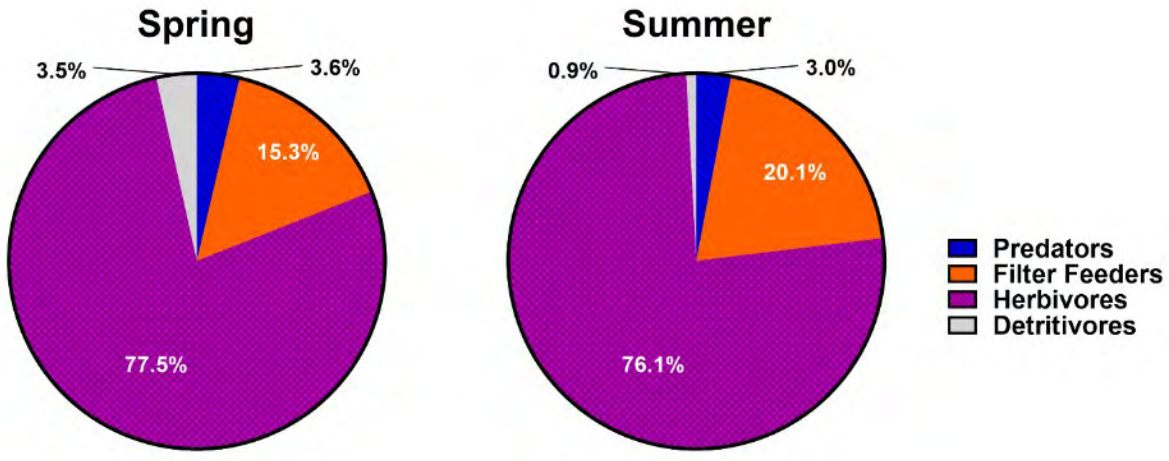
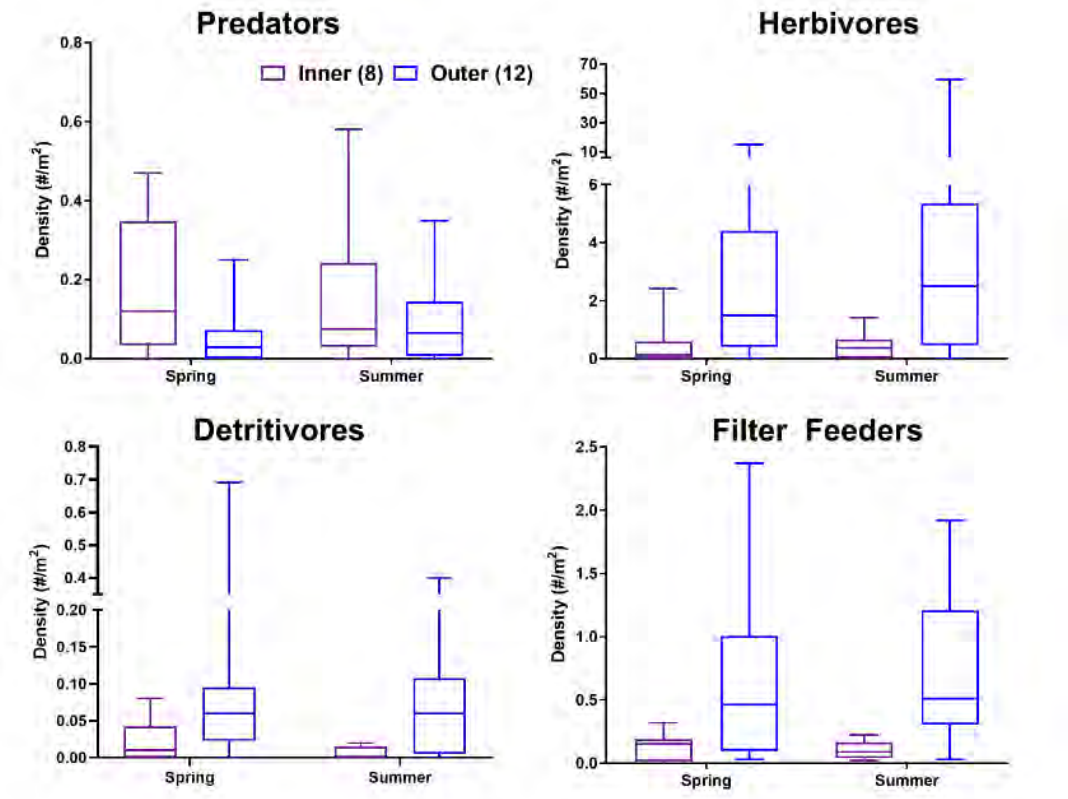


Figure 5-19. Proportion of Invertebrate Feeding Guilds Measured by Swath Surveys on Riprap – Spring and Summer 2023



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 5-20. Density of Invertebrate Feeding Guilds Measured by Swath Surveys on Riprap in Inner Harbor and Outer Harbor Habitats – Spring and Summer 2023

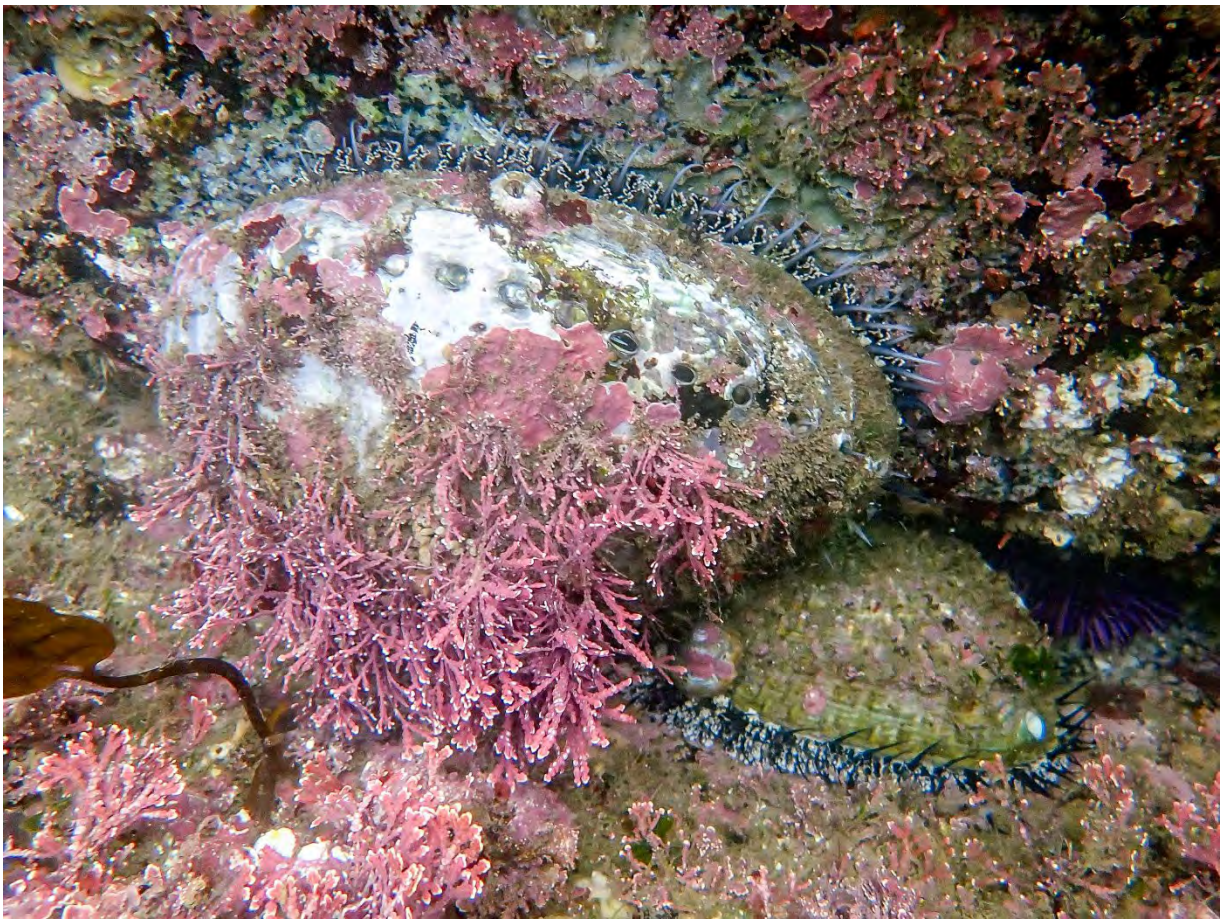
The filter feeders were the next most abundant group (Figure 5-19), with an average across both seasons of 0.11 individual/m^2 at Inner Harbor stations and 0.69 individual/m^2 at Outer Harbor stations, which was a statistically significant difference. Brown/golden gorgonians and rock scallops were the most abundant filter feeders, and red gorgonians and large anemones were common but were not observed in densities above 0.5 individual/m^2. The types of anemones varied by habitat, with large *Anthopleura* sp. common in the lower intertidal zone at Outer Harbor stations; Inner Harbor stations more commonly had large tube anemones (such as the Pacific tube anemone, *Pachycerianthus fimbriatus*) in the subtidal zone. Rock scallops were more abundant at Outer Harbor stations (0.30 individual/m^2) compared with Inner Harbor stations (0.08 individual/m^2) across both seasons, and large gorgonians (>10 cm) were rare at Inner Harbor stations (<0.01 individuals/m^2) compared with the Outer Harbor (0.36 individual/m^2). The highest density of filter feeders in both seasons was observed at station T4-ALT, with 2.37 individuals/m^2 in the spring, largely composed of brown/golden gorgonians and rock scallops (Figure 5-22).

The average density of predators was approximately twice as high at Inner Harbor stations (0.16 individual/m^2) than at Outer Harbor stations (0.07 individual/m^2), although there were no significant differences between habitats and seasons (Figure 5-20). This trend may in part reflect the more complex habitats of the Outer Harbor and breakwater, which include large boulders with deep crevices and overhangs that provide abundant refuge for these animals that make them harder to detect. Bat stars were on average the most abundant predator across all seasons and stations (0.8 individual/m^2), followed by California spiny lobster (0.03 individual/m^2). Ochre stars and giant spine stars were infrequently observed (<0.01 individual/m^2) in the lower intertidal zone at Outer Harbor stations (Figure 5-22).

Detritivores and scavengers were more abundant at Outer Harbor stations across all seasons (0.12 individual/m^2) than at Inner Harbor stations (0.01 individual/m^2), although there were no significant differences between habitats and seasons (Figure 5-20). Warty sea cucumbers were slightly more abundant across all seasons (0.04 individual/m^2) compared with Kellet's whelks (0.02 individual/m^2). Across all stations, Kellet's whelks were on average slightly

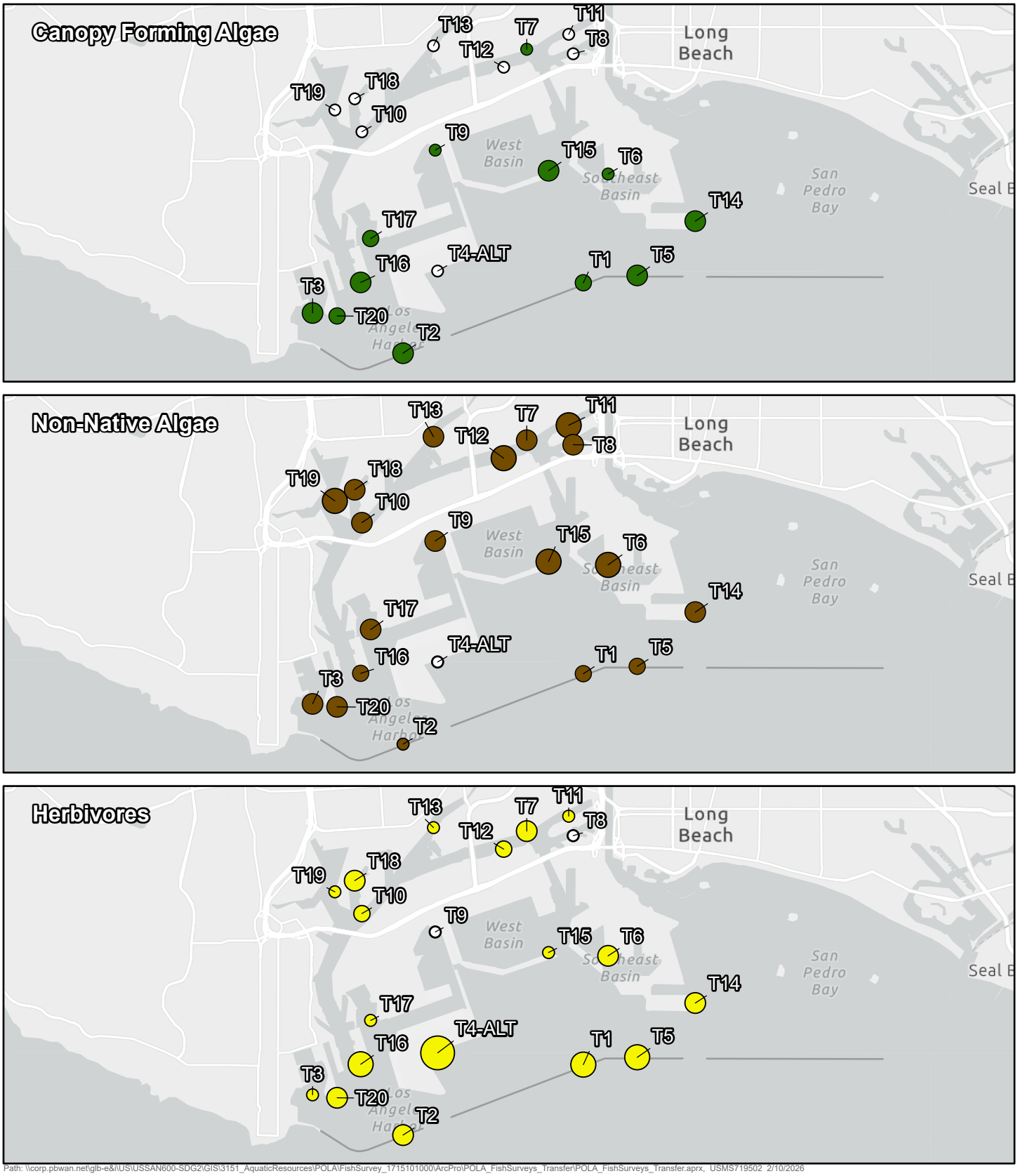
more abundant in the spring (0.53 individual/m^2) than the summer (0.39 individual/m^2), with the highest density in both seasons at station T1 (Middle Breakwall), with 1.67 individuals/m^2 in the spring and 1.86 individuals/m^2 in the summer (Figure 5-22).

Green and pink abalone were found in Outer Harbor habitats on breakwaters and riprap; 34 individuals were counted and sized across both seasons at the three breakwater stations (T1, T2, and T5), station T14 (Pier J Breakwater) and station T16 (Port of Los Angeles Main Channel Entrance). Densitites at these five stations for both species combined ranged from 0.01 to 0.07 individual/m^2 in the spring to 0.03 to 0.28 individual/m^2 in the summer. The 21 green abalone captured ranged from 14 to 26 cm in total length and occurred at densities of 0.02 to 0.28 individual/m^2; the 13 pink abalone ranged from 6 to 23 cm in total length and occurred at densities of 0.02 to 0.13 individual/m^2. Numerous small and large empty abalone shells were identified at these sites as well, indicating that recruitment and predation are occuring for these species at these stations. The density of pink abalone was similar to the average density (0.04 individual/100 m^2) of pink abalone identified in Point Loma during a 2009 survey (Coates et al., 2014). Rossetto et al. (2013) modeled the size at which 50% of individuals are sexually mature at Isla Natividad, Mexico, and found the threshold to be 136 ± 7.8 mm for green abalone and 126.5 ± 2.3 mm for pink abalone. If the same size threshold holds for the population in the Port Complex, all of the green abalone and 77% of the pink abalone captured were mature adults. Abalone can live for more than 30 years, so although the 2018 Biosurvey was the first to document abalone using the new methodology, these species have likely existed in the Port Complex for decades.



Green (top) and pink (bottom) abalone in the Outer Harbor at station T16

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Density (#/100m^2)

- 0
- 1 - 25
- 26 - 75
- 76 - 300
- 301 - 900
- 901 - 4000

Parameter

- Canopy Forming Algae
- Non Native Algae
- Herbivores

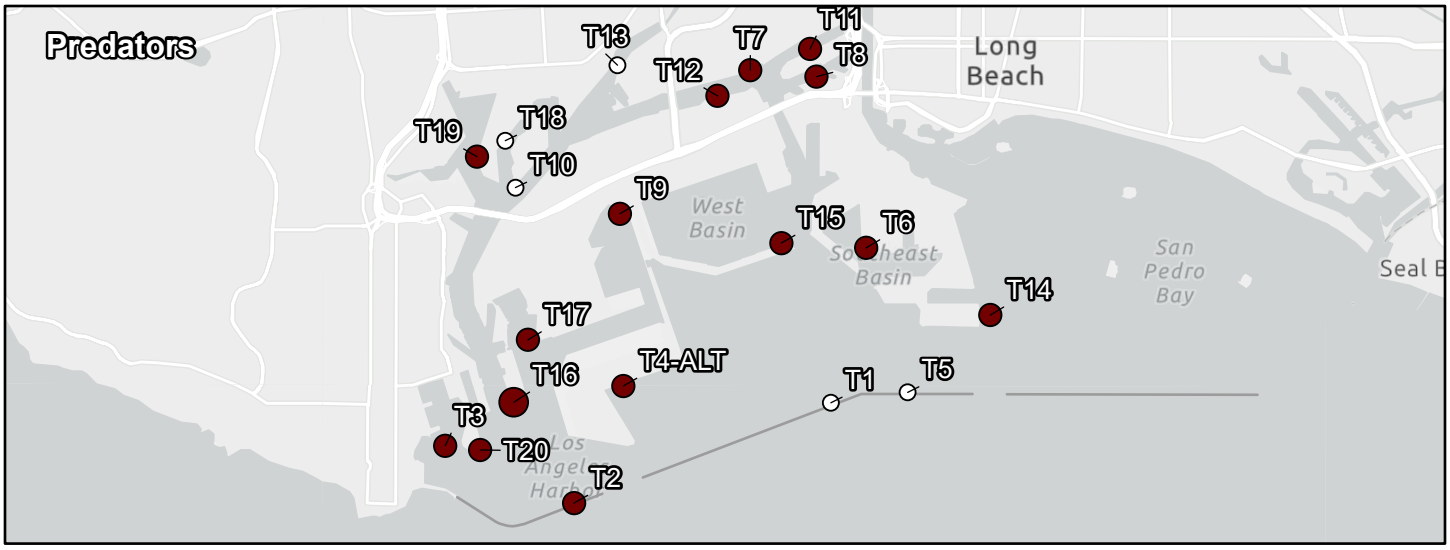
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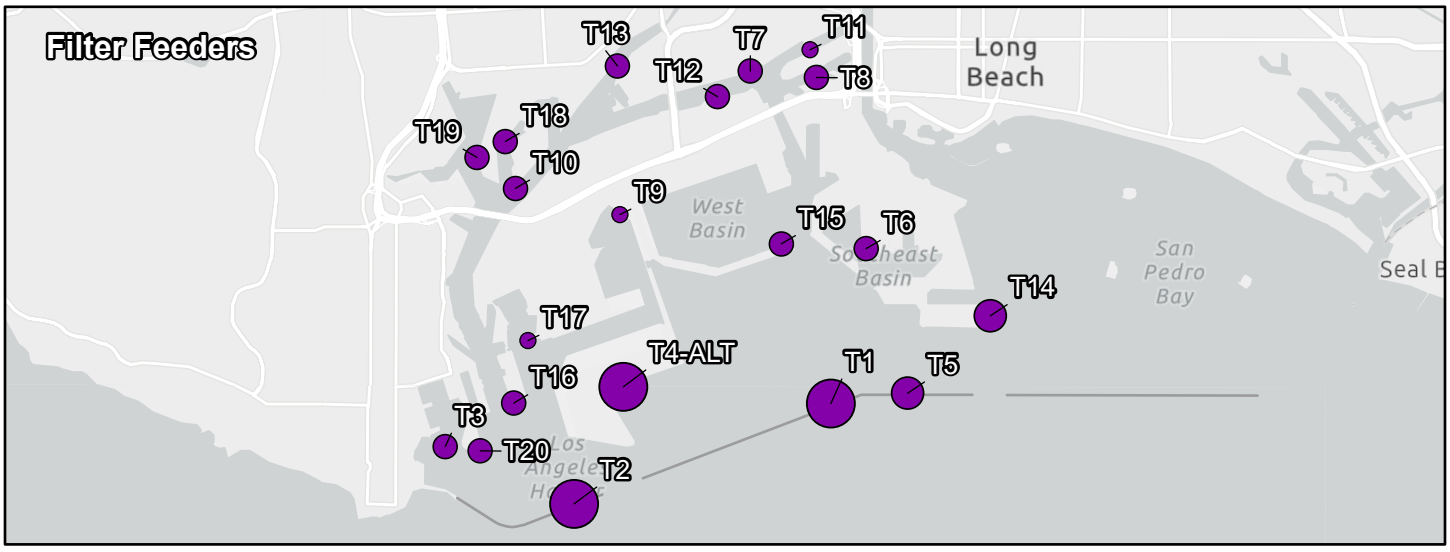
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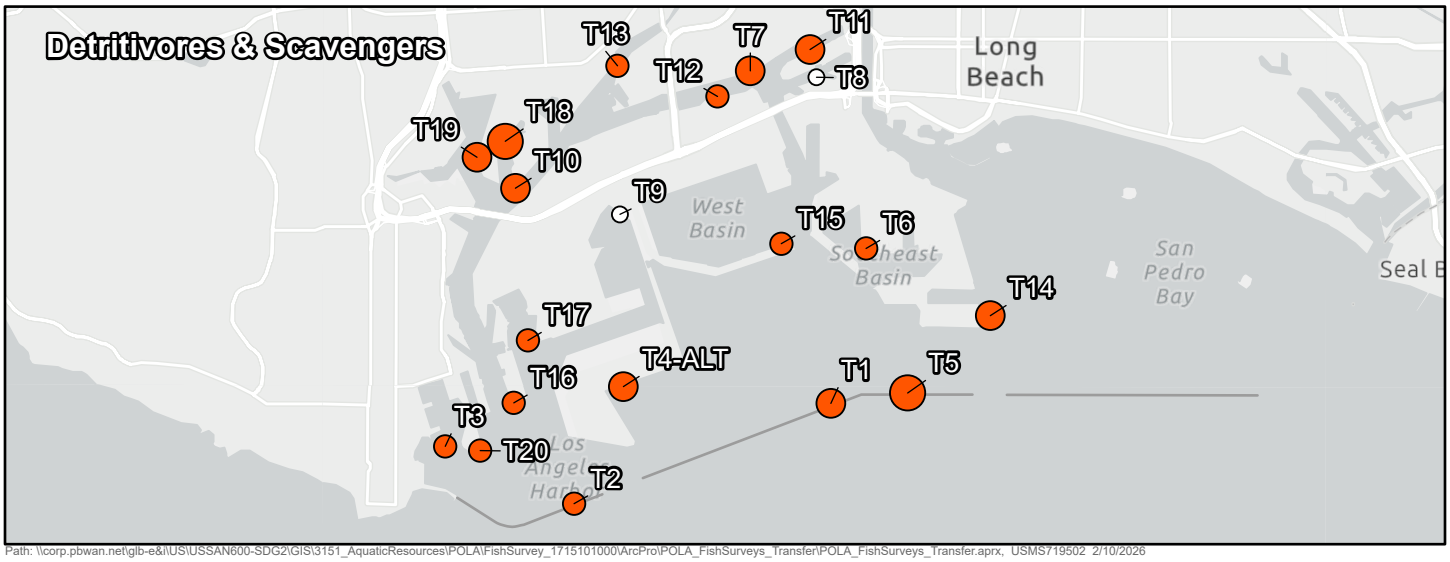
FIGURE 5-21

Density of Canopy-Forming Algae, Non-Native Algae, and Herbivores Averaged Across Spring and Summer Surveys

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Density (#/100m²)

- 0
- 1 - 10
- 11 - 50
- 51 - 100
- 101 - 215

Parameter

- Predator
- Filter Feeder
- Detritivores & Scavengers

1:122,771

0 1 2 Miles

FIGURE 5-22

Density of Predator, Filter Feeder, and Detritivore Invertebrates Averaged Across Spring and Summer Surveys

Pilings

Piling invertebrate communities were surveyed using swath methodology for the first time in 2023 and were primarily composed of filter feeders, followed by predators and herbivores (Figure 5-23). No detritivore target species were observed on pilings during these surveys. Densities of filter feeders averaged 1.41 individuals/m^2 at Inner Harbor stations and 2.15 individuals/m^2 at Outer Harbor stations. Outer Harbor stations were dominated by rock scallops (1.15 individuals/m^2), followed by brown/golden gorgonians (0.73 individual/m^2) and red gorgonians (0.27 individual/m^2; Figure 5-24). Inner Harbor stations had higher densities of brown/golden gorgonians (0.62 individual/m^2) than of rock scallops (0.54 individual/m^2) and red gorgonians (0.24 individual/m^2). Bat stars were observed on Inner Harbor piles (1.03 individuals/m^2 at Berth 147), and ochre stars (0.06 individual/m^2 at Berth T134) and giant spine stars (0.12 individual/m^2 at Berth G215) were observed on Outer Harbor piles. Only red urchins were counted on Inner Harbor piles during this survey (0.15 individual/m^2 at Berth 147), although red and purple urchins were observed on nearby piles throughout the Port Complex in low abundances.

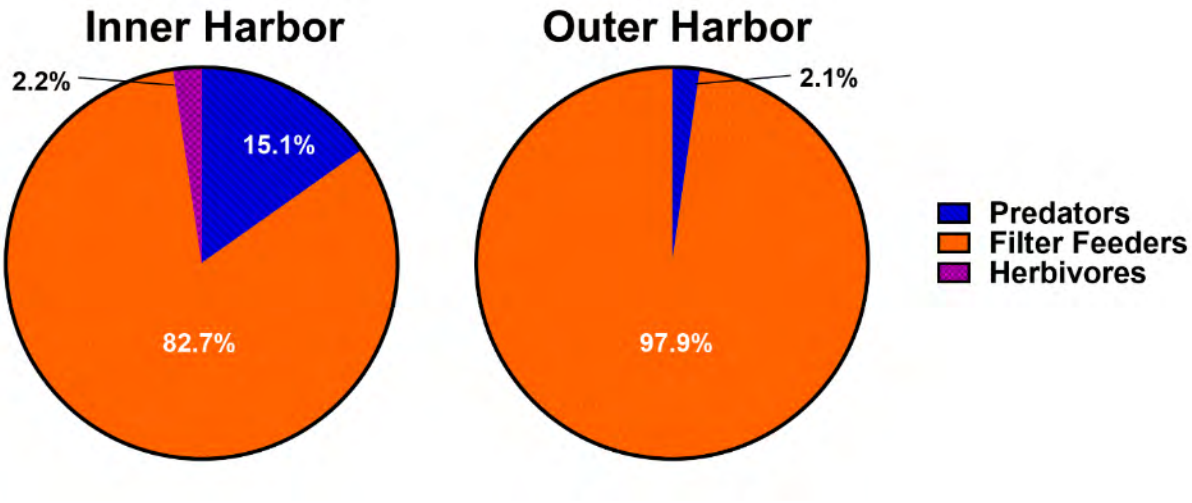
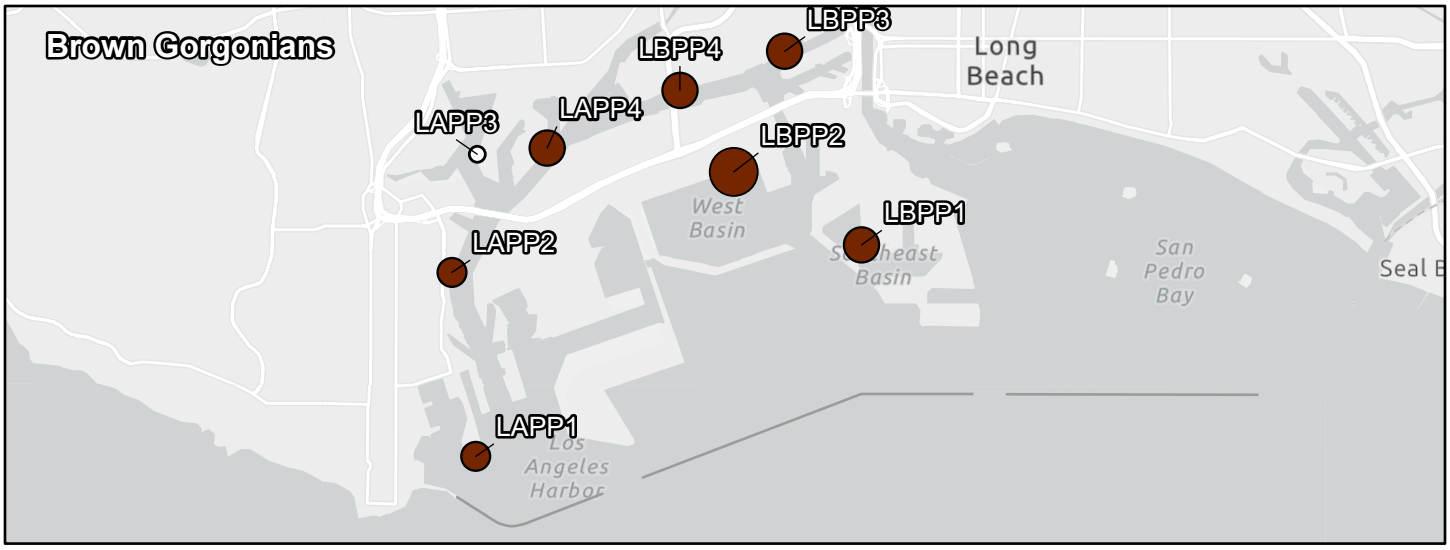
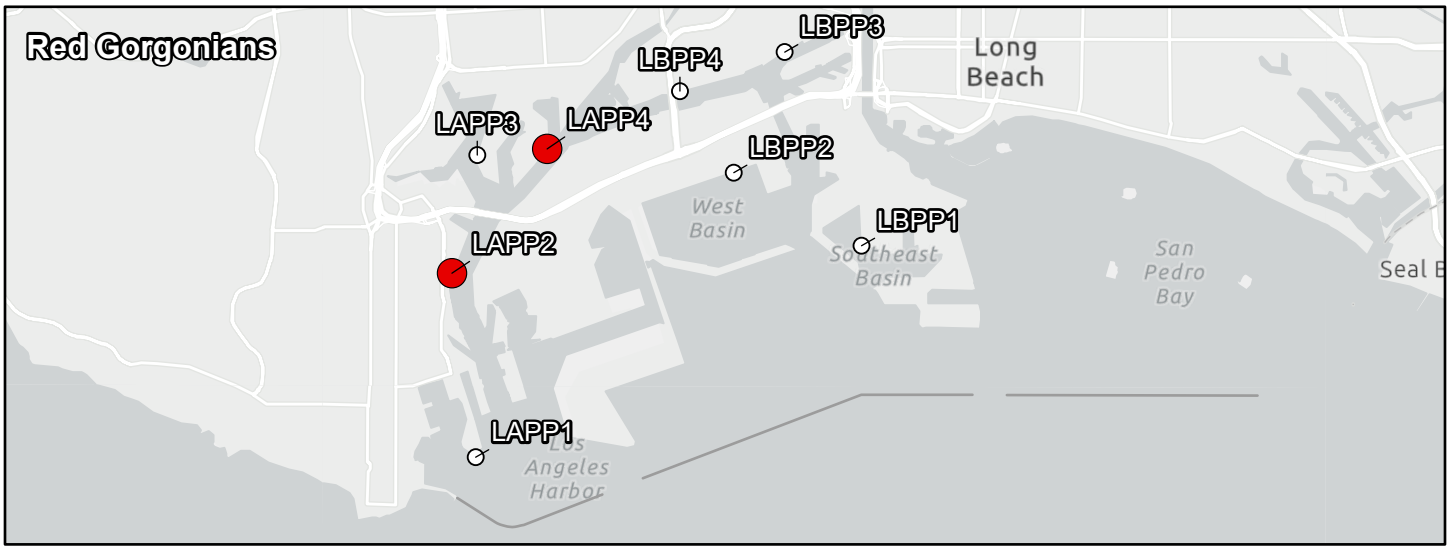
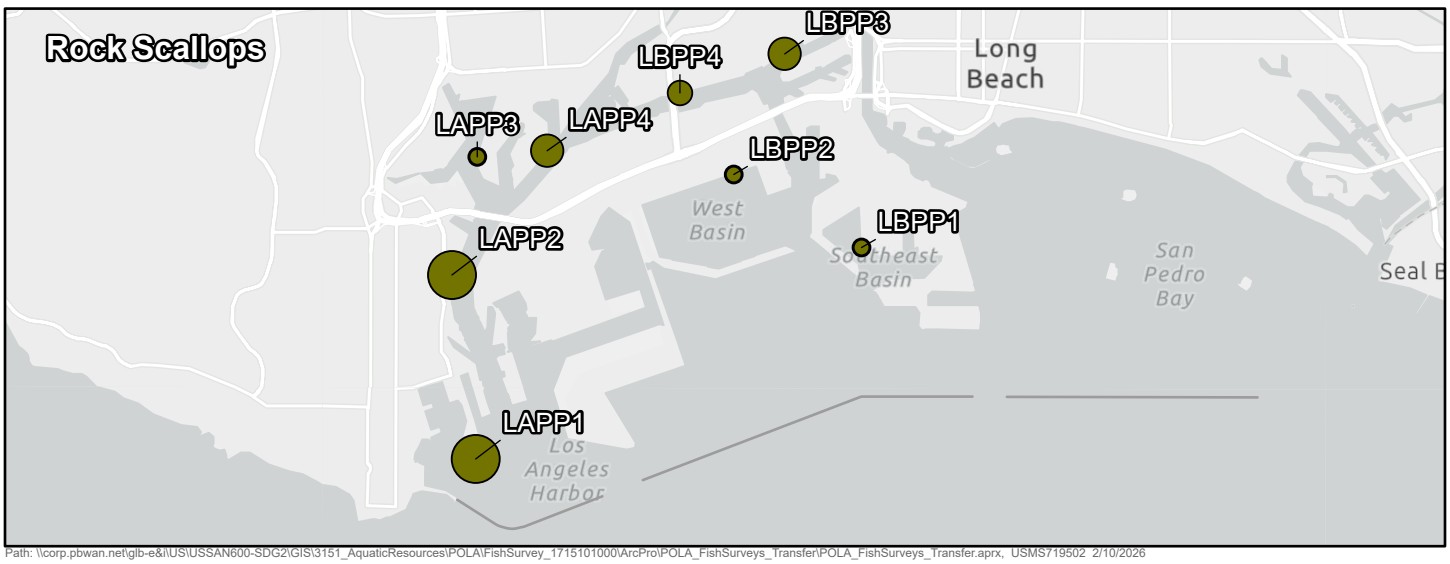


Figure 5-23. Proportion of Invertebrate Feeding Guilds Measured by Swath Surveys on Pilings in Summer 2023 Across Inner Harbor (n=4) and Outer Harbor (n=4) Stations

Service Layer Credits: Light Gray Reference: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Light Gray Base: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community







Path: \\corp.pbwan.net\glb-e&i\US\USSAN600-SDG2\GIS\3151_AquaticResources\POLA\FishSurvey_1715101000\ArcPro\POLA_FishSurveys_Transfer\POLA_FishSurveys_Transfer.aprx, USMS719502 2/10/2026

Density (#/100m^2)

- 0
- 1 - 25
- 26 - 50
- 51 - 125
- 126 - 230

Species

- Brown Gorgonians
- Red Gorgonians
- Scallops

1:122,771

0 1 2 Miles

FIGURE 5-24

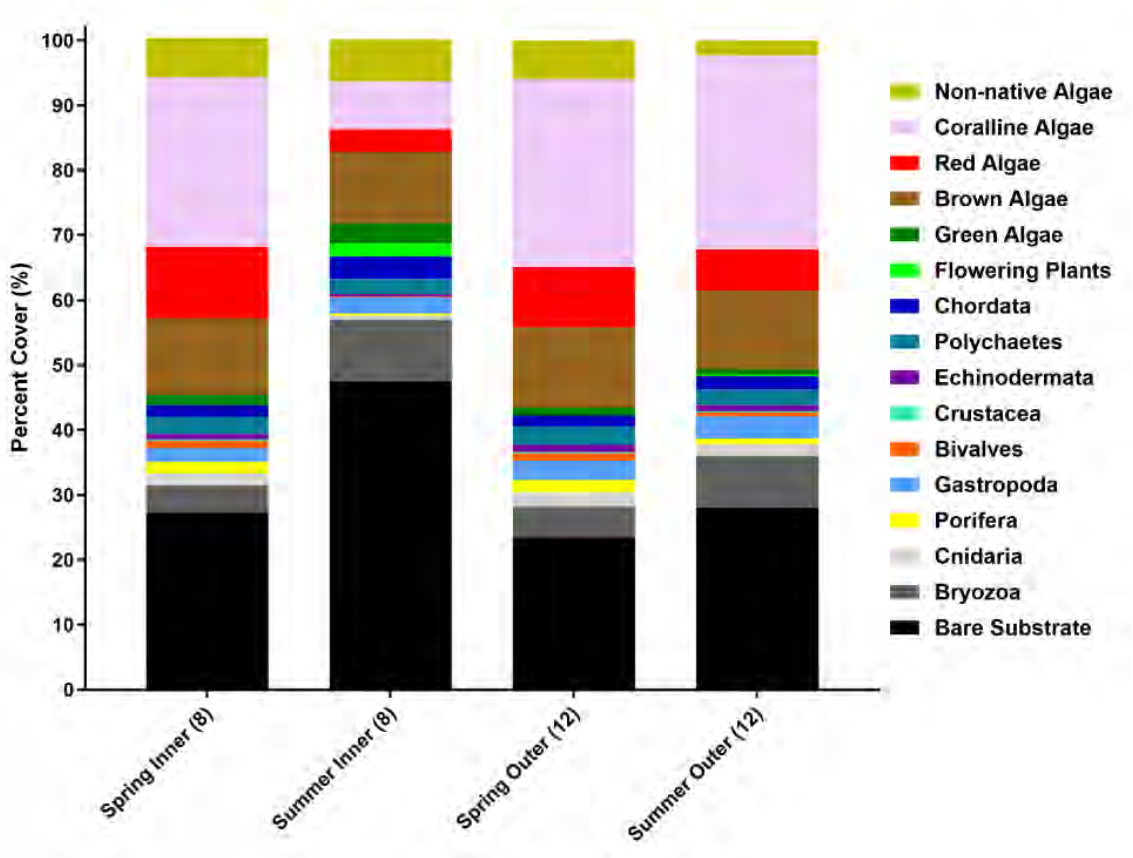
Density of Brown/Golden Gorgonians, Red Gorgonians, and Rock Scallops on Pilings Surveyed by Swath in Summer 2023

5.3.4 PERCENT COVER OF MACROALGAE AND MACROINVERTEBRATES

The UPC survey characterized the percent cover of invertebrate and algae species that grow close to the substrate surface. These surveys were performed at riprap stations to complement the swath surveys and at pier piling stations as a rapid-assessment method to compare with results of quadrat scrapings. At all 20 riprap stations, UPC surveys were conducted on the same subtidal transects on which swath data were taken. At the eight riprap stations where quadrat scrapings were taken at the intertidal and subtidal zones, UPC data were obtained for matching intertidal and subtidal depths. At the eight pier piling stations, UPC data were collected vertically along the face of the piling and encompassed intertidal and subtidal zones where quadrats were scraped. Unlike swath surveys in which only targeted organisms were recorded, all invertebrates and algae encountered during the UPC surveys were assigned a taxonomic category and recorded.

5.3.4.1 RIPRAP

Riprap was sampled in the subtidal zone at all 20 stations in the spring and summer. UPC data were compiled into major taxonomic groups and compared across seasons and between Inner Harbor and Outer Harbor habitats, averaged across stations (Figure 5-25). Inner Harbor stations on average had more bare substrate (bare rock, sand, and mud) than Outer Harbor stations. This difference was mostly because Inner Harbor stations had more evident sedimentation near the riprap/soft-bottom interface, presumably the result of nearby sources of suspended particles such as the Dominguez Channel and storm drains, and resuspension from disturbance events such as vessel activity. Inner Harbor stations also had higher coverage by tunicates (Chordata) and bryozoans compared with Outer Harbor stations. Outer Harbor stations had a larger proportion of small snail species (Gastropod), red algae, and coralline algae, including several articulated species (*Lithophyllum aspergillum, Corallina chilensis,* and *Corallina vancouveriensis*).



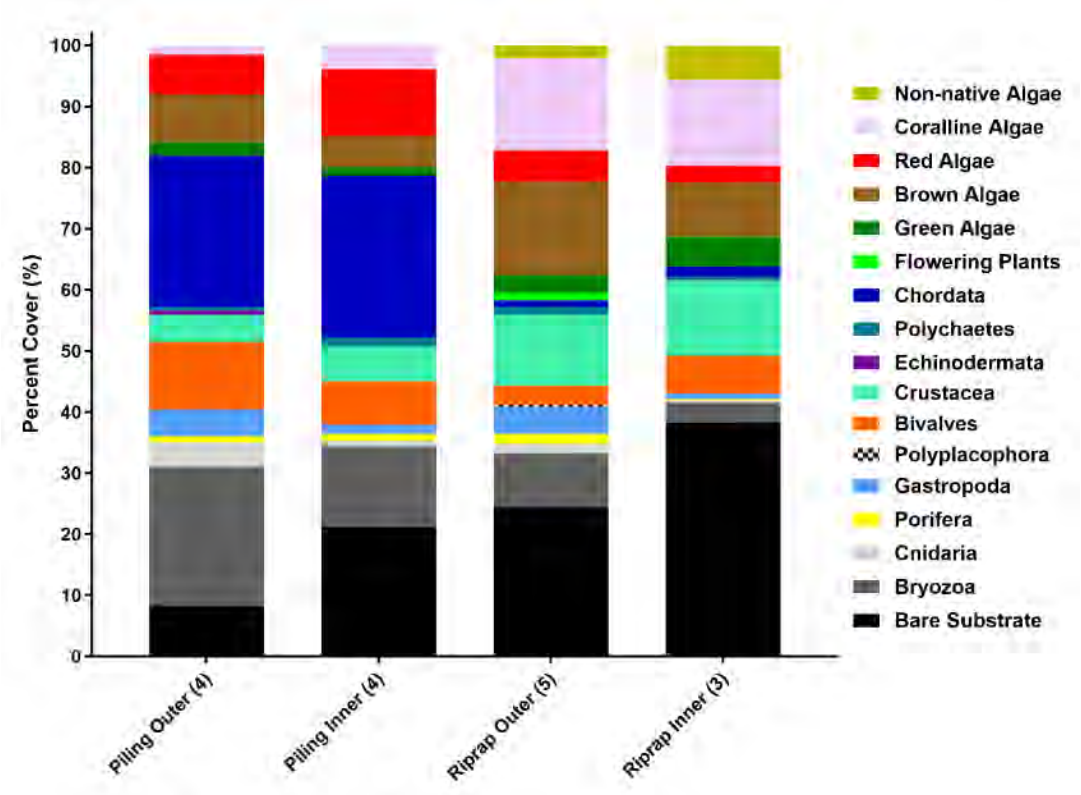
Averaging across stations results in totals not adding up to exactly 100%. Non-native algae encompasses *Sargassum muticum*, *Sargassum horneri*, and *Undaria*.

Figure 5-25. Average Percent Cover of Inner Harbor and Outer Harbor Riprap Stations By Season

5.3.4.2 PILINGS

The greatest percent cover measured during the UPC survey across all pilings was by chordates (primarily solitary tunicates), bryozoans, red algae, bivalves, and bare substrate. Differences between Inner Harbor and Outer Harbor piling stations were subtle, with higher coverage by chordates and red algae at Inner Harbor piling stations compared with higher coverage by bryozoans, cnidarians, and bivalves at Outer Harbor piling stations.

Pilings in both Inner Harbor and Outer Harbor areas had higher percentages of cover by chordates, bivalves, red algae, and bryozoans than at riprap stations, and riprap had higher cover from coralline algae, brown algae, crustacea, and bare substrate (Figure 5-26). Pilings showed more pronounced differences between habitat areas compared with riprap, with patterns similar to those outlined above such as higher coverage of bivalves and gastropods at Outer Harbor stations and more than twice as much bare substrate at Inner Harbor stations.



Averaging across stations results in totals not adding up to exactly 100%. Non-native algae encompasses *Sargassum muticum*, *Sargassum horneri*, and *Undaria*.

Figure 5-26. Average Percent Cover of Inner Harbor and Outer Harbor Riprap and Piling Stations By Substrate

5.3.5 MACROALGAE AND MACROINVERTEBRATE HISTORICAL COMPARISONS

In the 2018 Biosurvey, the survey methodology from previous Biosurveys was changed, and the revised methodology was used in 2023. This difference limits direct comparisons of results between Biosurvey years prior to 2018 with respect to macroalgae and macroinvertebrates, but establishes a baseline for more rigorous comparisons in the future. The 2018 and 2023 Biosurveys obtained more rigorous quantitative data for targeted invertebrates and macroalgae (see Appendix A Section A.5), and prior Biosurveys obtained more qualitative presence/absence data and estimated percent cover only for macroalgae. Frequency of occurrence (as a percentage of stations with species present across

all seasons) of canopy algae (*Macrocystis* and *Egregia*) and understory algae (*Stephanocystis osmundacea*, *Undaria*, and *Sargassum* spp.) is one of the few meaningful comparisons available across Biosurvey years (Table 5-4).

Table 5-4. Frequency of Occurrence (Percentage of Sampling Stations) of Macroalgae Across Biosurvey Years

Species	2000	2008	2013	2018	2023
Giant Kelp	50	55	60	45	60
Feather Boa Kelp	35	40	35	10	30
Stephanocystis osmundacea	0	10	25	20	10
Sargassum muticum	80*	85*	90	90	80
Sargassum horneri	NA	NA	50	75	80
Undaria pinnatifida	10	75	70	65	80

* Indicates that the 2000 and 2008 Biosurveys did not differentiate between *S. muticum* and *S. horneri* and thus *S. muticum* is assumed.
NA = not applicable

Occurrence of giant kelp has been consistent across Biosurvey years, with feather boa observed at more stations in the 2023 Biosurvey than in the 2018 Biosurvey because of the addition of a lower intertidal swath transect in 2023, as recommended in the 2018 Biosurvey Report (Wood, 2021a). Feather boa occurs primarily at the shallowest margins of the kelp beds where there is high wave energy, which the revised 2023 Biosurvey methodology captured effectively compared with the 2018 methodology, and the presence of feather boa kelp was more consistent with the results for the 2000 through 2013 Biosurveys. *S. osmundacea* occurrence has remained relatively steady since 2000, when there none were observed, with occurrence of 10 to 25% in the most recent surveys. *Undaria* was not commonly identified in the 2000 Biosurvey, but has been observed at 65 to 80% of stations in the past four Biosurveys. In the 2000 and 2008 Biosurveys, there was no differentiation between the two non-native *Sargassum* species in part because of the absence of *S. horneri* in the Port Complex until 2003 (Amec Foster Wheeler Environment & Infrastructure, Inc., 2015). Although *S. horneri* had become common by 2005, the 2008 Biosurvey did not differentiate between the species. Accordingly, the frequency of occurrence in 2008 is assumed to reflect primarily *S. muticum*, which has been commonly identified across all years at 80 to 90% of the stations. *S. horneri* has steadily increased in occurrence since 2013 and now among the most common algae encountered.

Although the 2018 and 2023 Biosurveys both used the same swath methodology, the addition of the lower intertidal transect at all riprap stations in 2023 introduces a depth stratum that was not previously included in the density calculations for algae and invertebrates and so makes comparisons of density difficult for some species. It was found that the lower intertidal zone was populated by species such as giant kelp, feather boa kelp, abalone, and sea stars in higher abundances than had previously been measured. For example, during the 2023 Biosurvey, at Outer Harbor stations with kelp, 54 to 57% of the total kelp individuals counted were encountered along the lower intertidal transect. Abalone were more commonly encountered on the lower intertidal transect, and densities of these species when they were present were 2 to 5 times higher than those reported in 2018. Other species such as urchins, gorgonians, and scallops that prefer subtidal habitats are less likely to be confounded by the methodology change and may be compared with greater confidence.

A notable observation at station T4-ALT was that the community resembled deforested reefs described in coastal rocky reefs (Schiel and Foster, 2015), which have high urchin densities and a lack of macroalgae that can result from disease, herbivory, physiological stress (high temperatures and physical removal from storms) or interactions among these processes (Steneck et al., 2002). Deforestation is often buffered by predators that feed on urchins such as sheephead and lobsters (which were commonly observed on riprap habitats within the Port Complex), although urchins from deforested areas have lower gonad production and therefore are lower quality prey, which lobsters have been shown to preferentially avoid and if given the choice prefer kelp-bed urchin instead (Eurich et al., 2014). One of the most notable effects of deforestation is the loss of species that rely on kelp as the main source of primary production, which reduces food web complexity and shifts the community to rely on primary production from plankton, macroalgae, and microalgae (Graham, 2004). The persistent kelp canopy at station T4 compared with the nearby (1 km apart) deforested station T4-ALT indicates that physical conditions, such as higher average water temperatures or

less water circulation due to the semi-protected location on Pier 400, can vary on small spatial scales within the Port Complex, affecting kelp distribution and community structure.

A station in this apparent deforested state was first documented in the 2018 Biosurvey at station T20 (Berth 48). Giant kelp was present at station T20 in the 2000 through 2013 Biosurveys, in addition to 14 different algal species in 2013, but the station was almost entirely devoid of algae other than crustose corallines in 2018. Herbivore species at station T20 such as a pink abalone and urchins were likely relying on outside sources for food, such as drift algae from nearby kelp beds. However, in 2023, the kelp was back at station T20 (0.83 individual/m^2) with many large adult kelp plants observed by divers, and kelp canopy was detected in both seasons by remote sensing. The urchin density dropped from 13.8 to 17.7 individuals/m^2 in 2018 to less than 1 individual/m^2 in 2023 at station T20. It is not possible based on past Biosurvey data to determine whether urchin densities had been increasing at station T20 prior to 2018. Because deforestation events in Southern California are patchy and can be short in duration (Steneck et al., 2002), the current 5-year cycle of the Biosurveys is unlikely to capture year-to-year variation that could determine the processes that likely caused the community shifts at station T20 or to predict when or if conditions at station T4-ALT would change without more frequent data for giant kelp and feather boa kelp.

5.3.6 HIGH-RESOLUTION TAXONOMY OF RIPRAP AND PILING INVERTEBRATES AND ALGAE

Scrapings from duplicate 0.1-m^2 quadrats were collected at three depths (upper intertidal, lower intertidal, and subtidal zones) at the eight riprap and eight piling stations throughout the Port Complex in summer 2023 to obtain detailed taxonomic information on algae and invertebrates (including those too small to be observed by the UPC survey). The resulting data were averaged between replicates and analyzed between stations by substrate type and across tidal heights to examine spatial variability between habitats.

Spatial Comparisons

The data were summarized and broken out by substrate (riprap and piling) and habitat (Inner Harbor and Outer Harbor) (Table 5-5, Figure 5-27) to examine patterns of species richness, abundance, and diversity. There were four piling stations in each habitat; riprap had three Inner Harbor stations and five Outer Harbor stations.

In total, 578 species (545 invertebrate species and 33 algae species) were observed across all stations and substrate types, with an average of 175 species per station. A total of 87,628 invertebrates were collected in the scrapings (average of 2,739 per station). Algal biomass totaled 182 grams across all stations, with an average of 11.4 grams per station. Total invertebrate biomass was 29,913 grams, with an average of 182 grams per station. When all tidal heights were averaged for each station, piling stations had greater mean species richness, abundance, biomass, and Shannon-Weiner Diversity Index values than riprap stations (Table 5-5).

Table 5-5. Species Richness, Abundance, and Diversity In Quadrat Scrapings for Riprap and Piling Stations

Metric	Substrate	Maximum	Mean	Median	Minimum
Species Richness	Riprap	217	147	168	56.0
	Pilings	209	165	161	125
Abundance	Riprap	4,673	2,250	1,954	251
	Pilings	4,859	3,227	2,943	2,223
Biomass (g)	Riprap	126	92.1	95.1	37.1
	Pilings	609	283	212	117
Shannon-Weiner Diversity Index	Riprap	3.67	2.37	2.43	0.53
	Pilings	3.76	2.55	2.82	0.72

Mean species richness, abundance, biomass, and diversity were higher at Outer Harbor stations than at Inner Harbor stations (Table 5-6). The only significant differences using unpaired Welch's t-tests on log-transformed data showed that species richness was higher at Outer Harbor riprap (p=0.004) and piling (p=0.003) stations, with higher total abundance at Outer Harbor riprap stations (p=0001).

Table 5-6. Algae and Invertebrate Species Richness, Abundance, and Diversity Index Values Derived from Quadrat Scrapings for Riprap and Piling Stations Between Inner Harbor and Outer Harbor Habitats

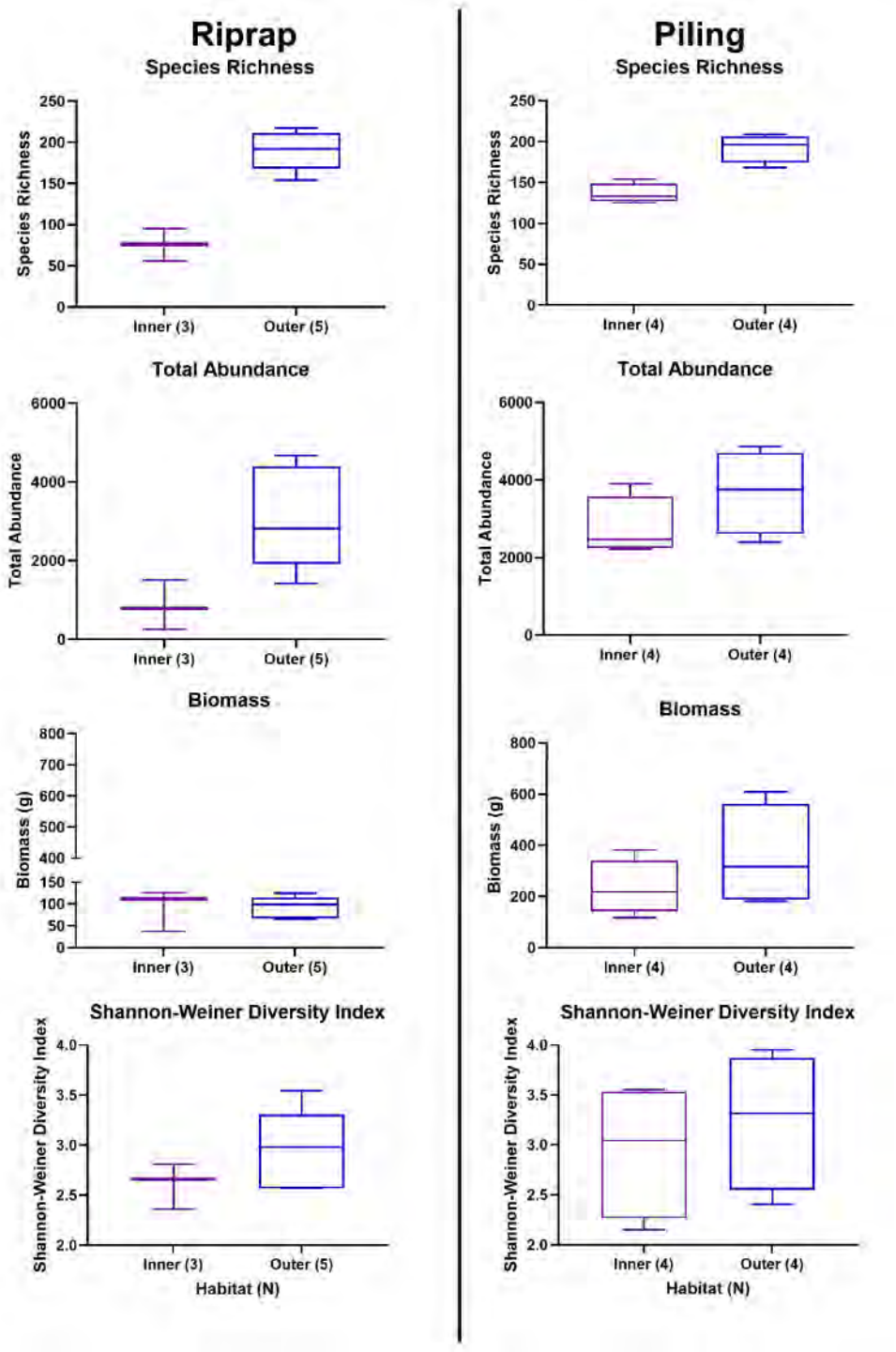
Metric	Substrate	Habitat	Max	Mean	Median	Min
Species Richness	Riprap	Inner	95	75.7	76.0	56
		Outer	217	190	192	154
	Piling	Inner	154	137	134	125
		Outer	209	193	197	168
Abundance	Riprap	Inner	1,508	848	784	251
		Outer	4,135	3,091	2,825	1,425
	Piling	Inner	3,906	2,765	2,465	2,222
		Outer	4,859	3,689	3,751	2,396
Biomass (g)	Riprap	Inner	126	91.5	112	15.5
		Outer	125	92.5	99.0	65.0
	Piling	Inner	382	234	218	117
		Outer	609	356	316	182
Shannon-Weiner Diversity Index	Riprap	Inner	2.82	2.10	2.15	0.88
		Outer	3.67	2.53	2.50	0.53
	Piling	Inner	3.61	2.54	2.78	0.72
		Outer	3.76	2.56	2.82	1.00

Relative invertebrate abundance by phylum at each riprap and piling station is summarized in Figure 5-28. Arthropods were the most abundant phylum across both substrates, with mollusks as the second most abundant phylum at piling stations compared with riprap, where mollusks and annelids were the next most abundant phyla. Both substrates had relatively low contributions to total abundance by echinoderms and tunicates (Chordata).

With respect to habitat, the differences in relative abundance between Inner Harbor and Outer Harbor riprap stations were large, with Inner Harbor stations overwhelmingly dominated by arthropods and Outer Harbor stations with higher contributions from annelids, echinoderms, and mollusks. Results for pilings were less distinct between habitats, with relatively similar communities dominated equally by arthropods and mollusks, with minor contributions from annelids, tunicates, and echinoderms. The two Outer Harbor pilings stations in the Port of Los Angeles were similar to each other, with fewer mollusks and more arthropods, echinoderms, and tunicates compared with all other piling stations.

Relative invertebrate biomass by phylum at each riprap and piling station is summarized in Figure 5-29. Inner Harbor riprap stations LARR2 and LBRR2 were dominated by mollusks, and station LARR3 had the lowest total biomass of all Inner Harbor riprap stations, with species consisting primarily of arthropods and mollusks. Station LARR1 was on the Cabrillo Breakwater and had a lower biomass of mollusks and more arthropods, tunicates, and "other" species (such as sponges and bryozoans) compared with other Outer Harbor stations. Piling biomass generally was made up of a high proportion of mollusks, with arthropods (mostly barnacles) and chordates (tunicates) as large contributors to total biomass.

Algal biomass was on average more than 8 times as high on riprap stations (19.7 grams) compared with piling stations (3.11 grams), with more algal species found on average at riprap stations (9.6) compared with pilings (3.6). Relative algal biomass (Figure 5-30) differed dramatically between the two substrate types. Coralline algae were overwhelmingly dominant on riprap, and red and green algae were more evenly distributed across pilings .



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 5-27. Algae and Invertebrate Species Richness, Abundance, and Diversity Index Values for Riprap and Piling Quadrats Between Inner Harbor and Outer Harbor Habitats

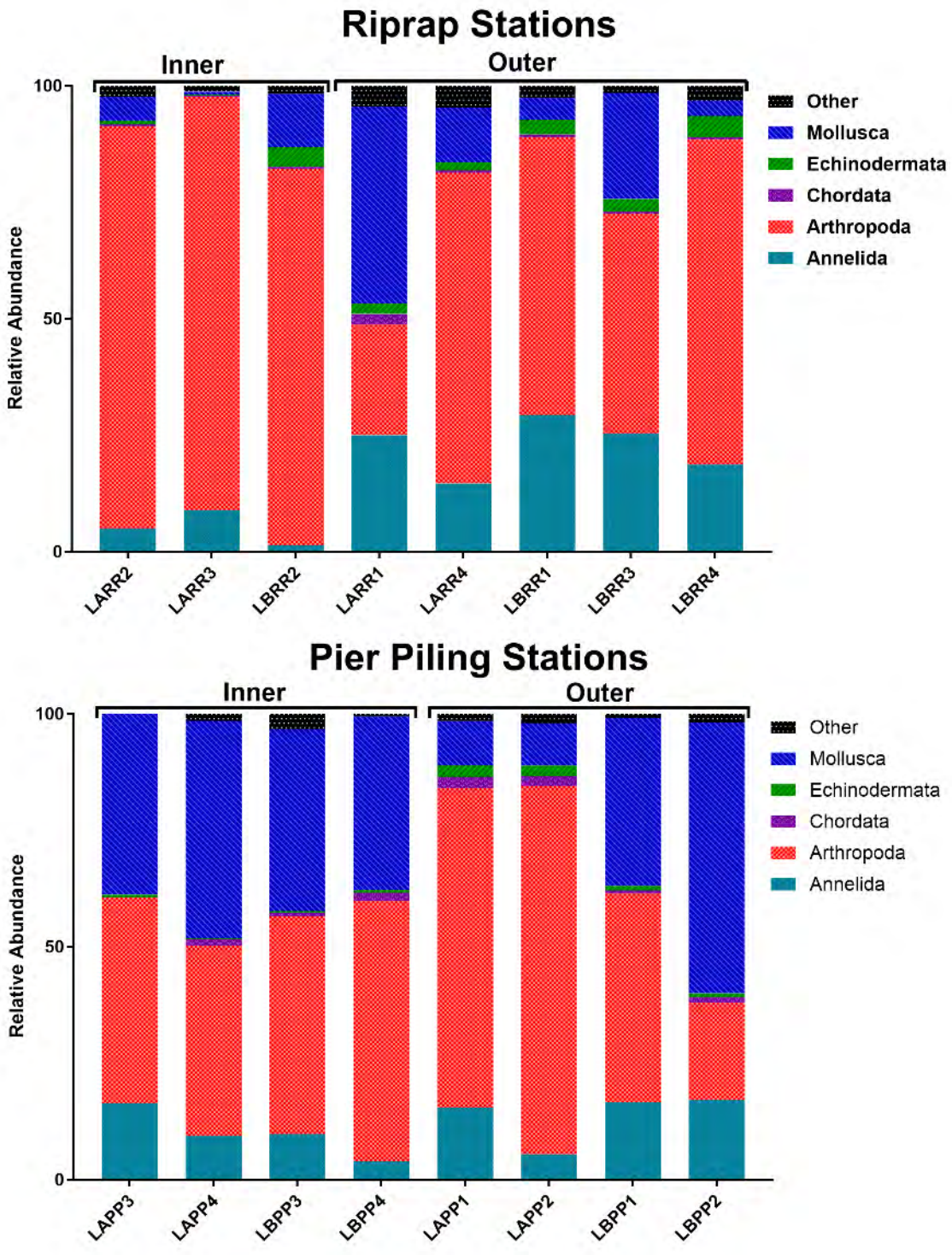


Figure 5-28. Relative Abundance of Invertebrate Phyla at Riprap and Piling Stations from Quadrat Scrapings

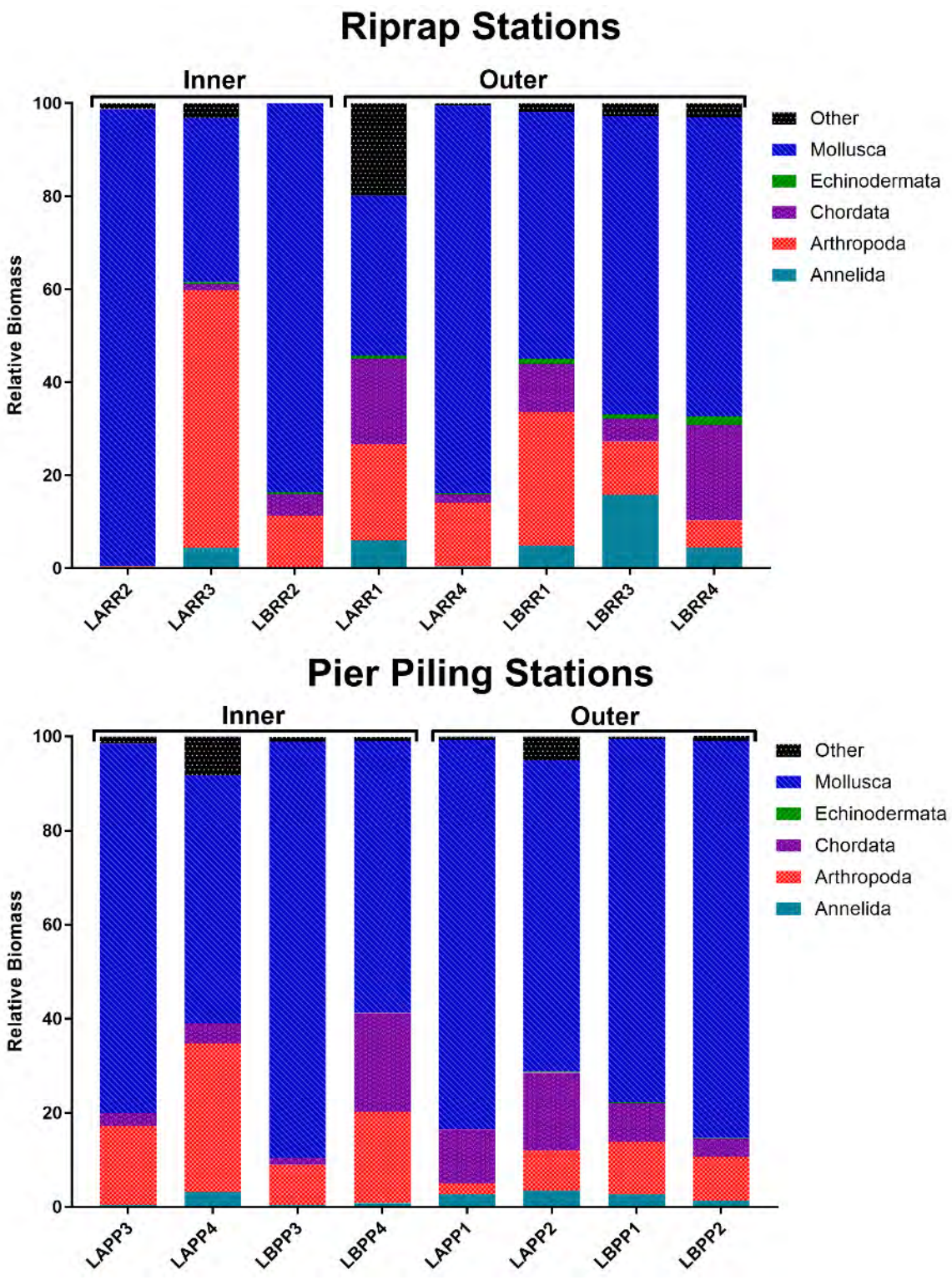


Figure 5-29. Relative Biomass of Invertebrate Phyla at Riprap and Piling Stations from Quadrat Scrapings

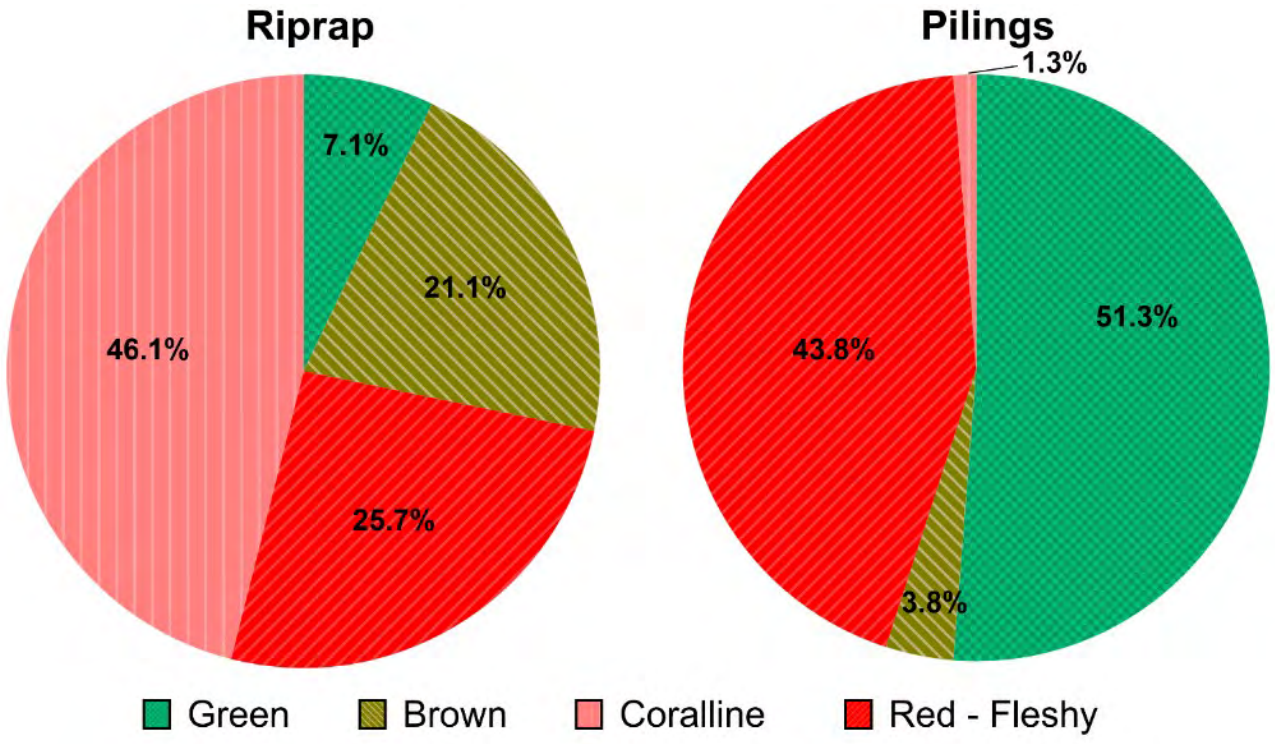


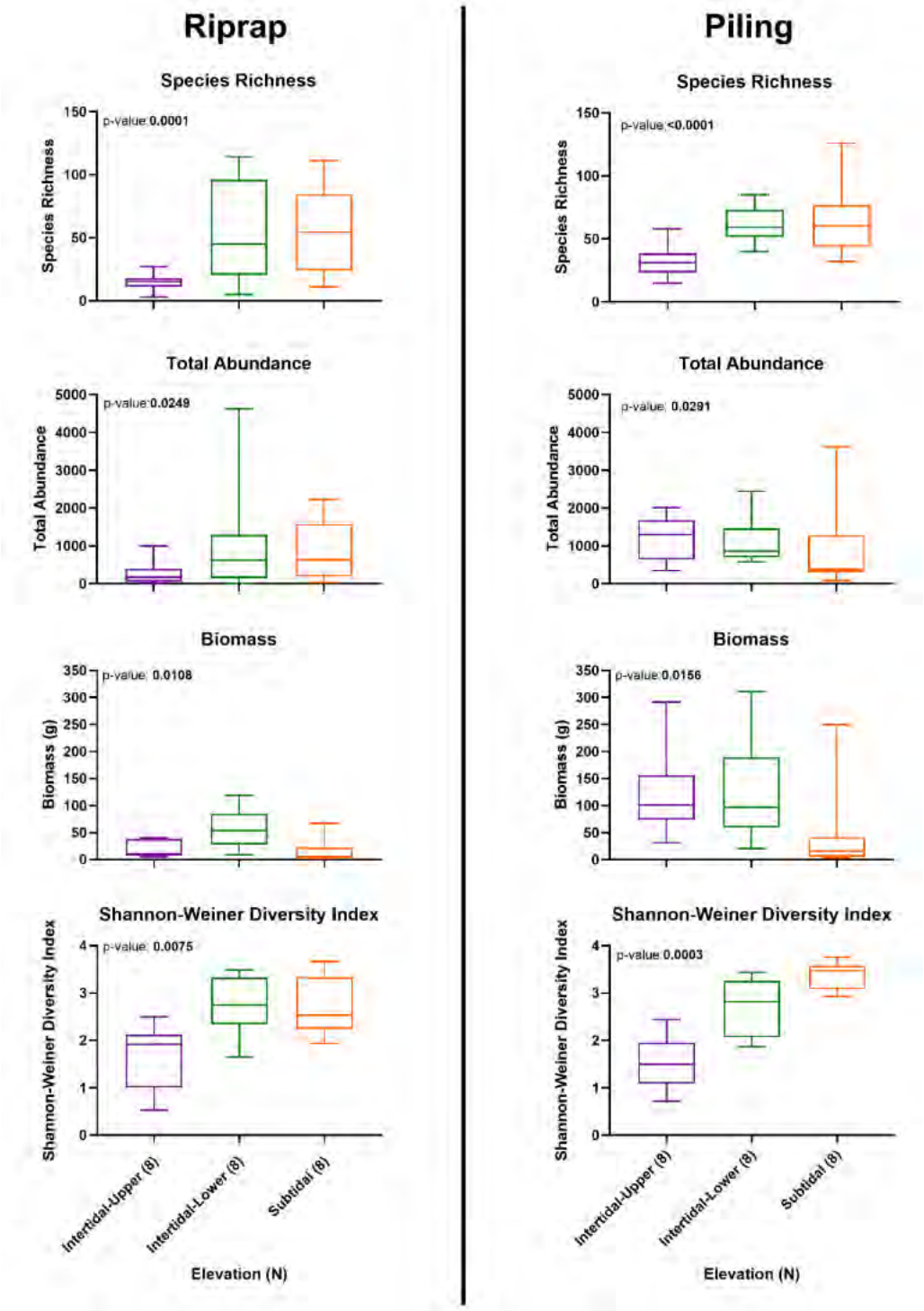
Figure 5-30. Relative Algae Biomass at Riprap and Piling Stations from Quadrat Scrapings

5.3.6.1 INFLUENCE OF TIDAL HEIGHT ON SPECIES COMPOSITION

The scraped quadrat data were also analyzed by substrate and tidal height (Table 5-7, Figure 5-31) to examine species richness, abundance, and diversity as they varied with depth. The Kruskall-Wallis ANOVA with multiple comparisons on square-root transformed data indicated that on riprap the species richness ($p = 0.0001$), abundance ($p = 0.025$), and diversity ($p = 0.008$) were significantly greater in the lower intertidal and subtidal zone than in the upper intertidal zone, and biomass ($p = 0.01$) was significantly higher in the lower intertidal zone than in the upper intertidal and subtidal zones. At piling stations, species richness ($p < 0.0001$) and diversity ($p = 0.0003$) were significantly lower in the upper intertidal zone compared with the lower intertidal and subtidal zones, and subtidal zones were significantly lower in total abundance ($p = 0.029$) and biomass ($p = 0.016$) compared with intertidal zones.

Table 5-7. Algae and Invertebrate Species Richness, Abundance, and Diversity Index Values for Riprap and Piling Quadrats at Different Tidal Heights

Metric	Substrate	Tidal	Maximum	Mean	Median	Minimum
Species Richness	Riprap	Intertidal-Upper	27	15	15	3
		Intertidal-Lower	114	55	45	5
		Subtidal	111	57	55	11
	Piling	Intertidal-Upper	58	32	31	15
		Intertidal-Lower	85	61	59	40
		Subtidal	126	64	61	32
Abundance	Riprap	Intertidal-Upper	997	264	169	10
		Intertidal-Lower	4622	1143	621	8
		Subtidal	2222	844	631	32
	Piling	Intertidal-Upper	2017	1218	1306	344
		Intertidal-Lower	2454	1132	859	584
		Subtidal	3632	877	376	89
Biomass (grams)	Riprap	Intertidal-Upper	40.3	19.4	10.7	4.70
		Intertidal-Lower	119	57.1	53.4	8.76
		Subtidal	67.3	15.6	5.15	0.96
	Piling	Intertidal-Upper	291	124	102	31.5
		Intertidal-Lower	311	125	97.3	20.9
		Subtidal	249	45.8	15.9	3.45
Shannon-Weiner Diversity Index	Riprap	Intertidal-Upper	2.50	1.66	1.92	0.53
		Intertidal-Lower	3.49	2.75	2.75	1.65
		Subtidal	3.67	2.70	2.53	1.93
	Piling	Intertidal-Upper	2.44	1.55	1.50	0.72
		Intertidal-Lower	3.44	2.73	2.82	1.87
		Subtidal	3.76	3.37	3.47	2.93



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 5-31. Algae and Invertebrate Species Richness, Abundance, and Diversity Index Values for Riprap and Piling Stations Between Inner Harbor and Outer Harbor Habitats from Quadrat Scrapings

5.3.7 MULTIVARIATE ANALYSIS OF STATION GROUPINGS AND TIDAL HEIGHT

Multivariate analysis of invertebrate abundance and algae biomass in quadrat scrapings was used for stations and tidal height to examine patterns across habitats and depths. Additional shade plots, nMDS plots, and SIMPER analysis figures, as well as data tables for location, habitat, and depth strata groups, are provided in Appendix E.

Station Analysis

One-way ANOSIM results confirmed significant differences between substrates (pilings and riprap) and between habitats (Inner Harbor and Outer Harbor). SIMPROF analysis results indicated six different groups, as shown in the nMDS plot (Figure 5-32) and overlaid on the station map (Figure 5-33). The shade plot (Figure 5-34) depicts patterns in species composition across the similarity profile groups.

Station Group D was the largest group, consisting of all four Inner Harbor piling stations and Outer Harbor stations LAPP2 (Port of Los Angeles Main Channel – USS Iowa), LBPP1 (Southeast Basin), and LBPP2 (Pier T). These stations were characterized by high abundances of the Mediterranean mussel (*Mytilus galloprovincialis), a* barnacle (*Chthamalus fissus* and *Balanus glandula*), a small crevice-dwelling intertidal bivalve (*Lasea adansoni)*, skeleton shrimp (*Caprella californica cmplx, Caprella* sp.*,* and the non-native *Caprella simia*), and the tanaid *Zeuxo normani complx*. The remaining piling station, LAPP1 (Berth 48), was in Group F with station LBRR1 (Pier J Breakwater) with high abundances of skeleton shrimp, Mediterranean mussels, and barnacles similar to those in Group D as well as the polychaete *Exogone lourei*. Group E had two Port of Long Beach riprap stations that were close to each other, stations LBRR3 (Mole Pier) and LBRR4 (Southeast Basin), and were similar to Group F although they had higher abundances of several amphipods (*Paramicrodeutopus schmitti*, Corophioidea), copepods, and tanaids such as *Zeuxo normani* complx. Group A was composed of three Inner Harbor stations: LARR2 (South of Consolidated Slip), LARR3 (Port of Los Angeles West Basin South), and LBRR2 (Cerritos Channel). These stations generally had lower species richness and abundance and were dominated by skeleton shrimp (including *Caprella* sp. and the non-native *Caprella simia*), copepods, isopods, and polychaetes. Station LARR1 (CSWH Phase 2 Breakwater) was the only station in Group B, likely because its substantially more exposed location constitutes a very different environment than the other stations, which are in more protected locations. The station was marked by high abundances of Mediterranean mussels, the bivalve *Lasea adansoni*, and species that were not observed in high abundance elsewhere such as the scaled worm snail (*Thylacodes squamigerus*) and the shell-boring polychaete *Dipolydora bidentata*. Station LARR4 (Berth 48) was alone in Group C, and was distinctive in its high abundance of barnacles, amphipods, and copepods compared with other stations.

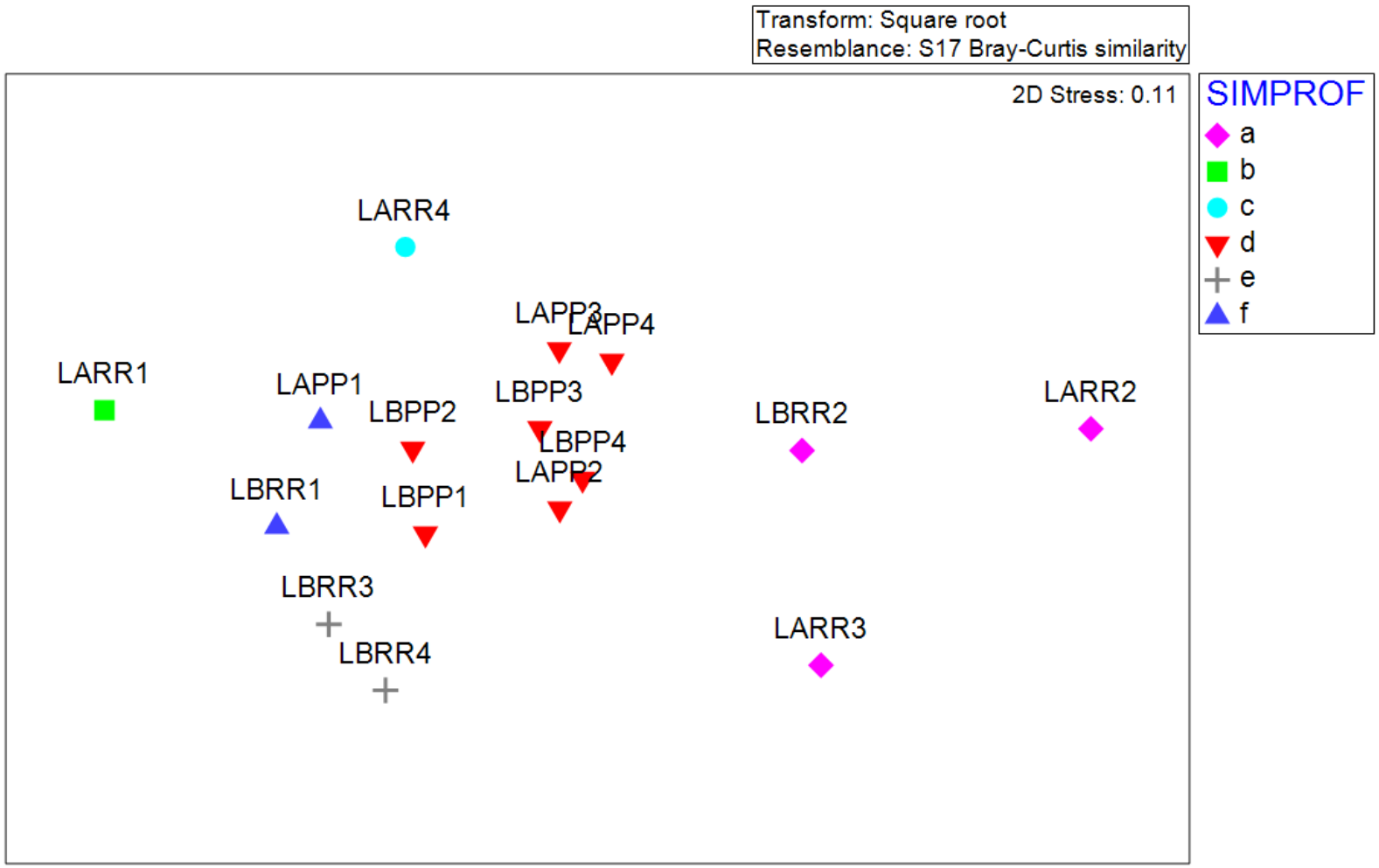
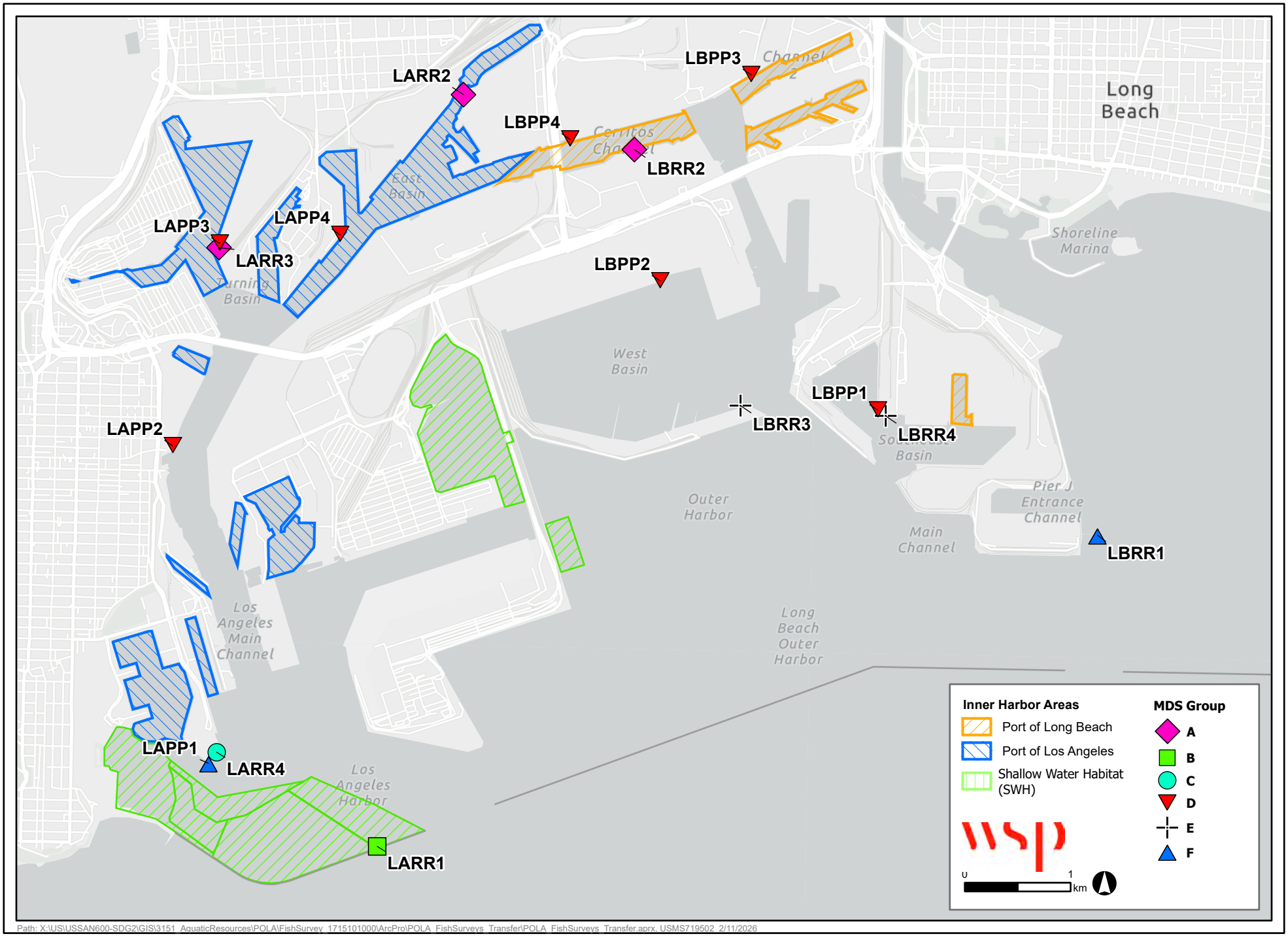
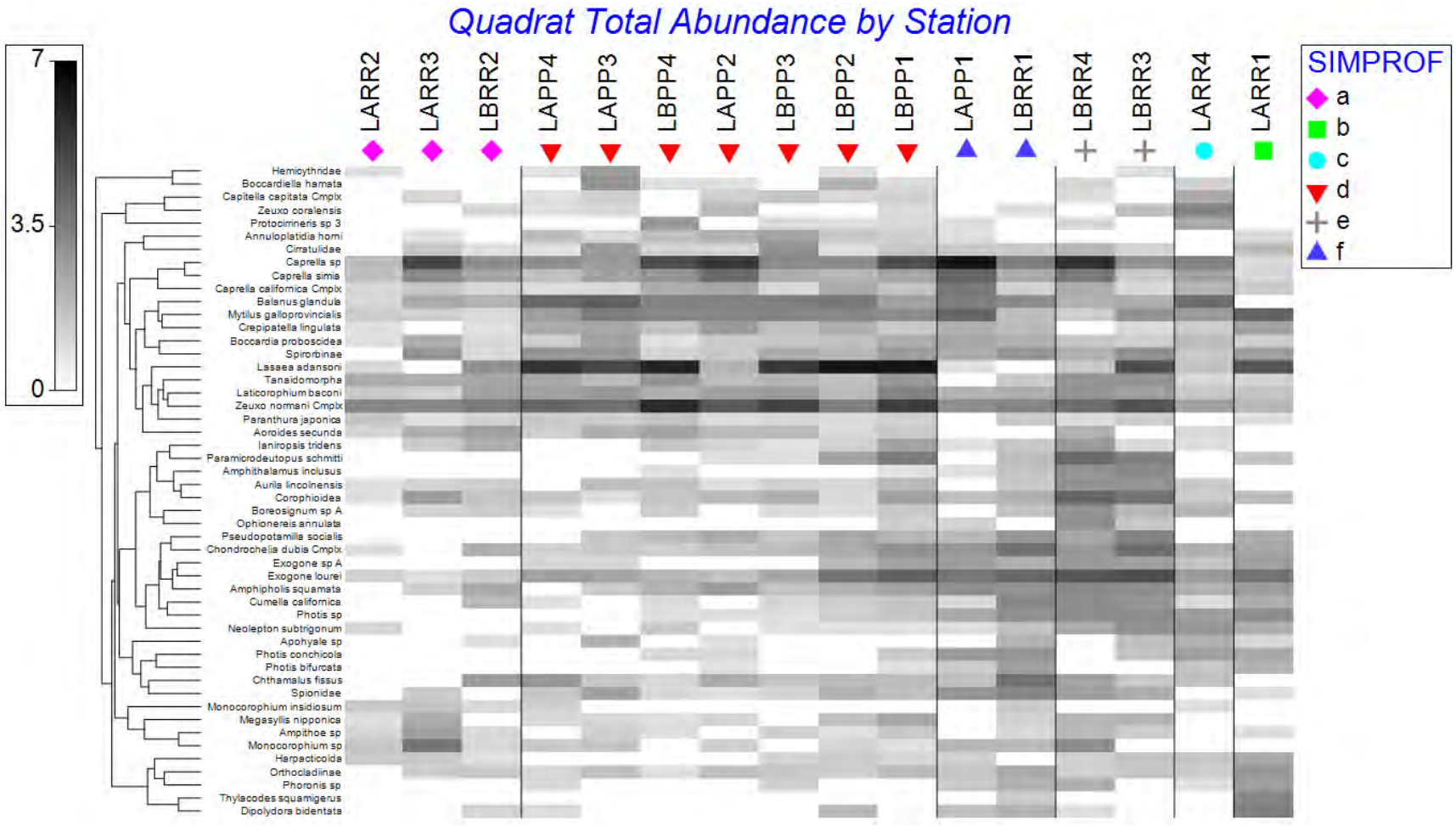


Figure 5-32. nMDS Plot of Riprap and Piling Stations by SIMPROF Group from Quadrat Scrapings



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The scale reflects abundance data that have been transformed and normalized

Figure 5-34. Riprap and Piling Community Composition (Top 30) Shade Plot Using SIMPROF Groups from Quadrat Scrapings

Tidal Elevation Analysis

The results of the nMDS and one-way ANOSIM of quadrat scrapings by tidal depth (Figure 5-35) confirmed that communities at the various depths are significantly different from one another (α=0.001). Substrate and habitat were both significantly different using ANOSIM, and when these factors were combined (Figure 5-36), all groups were significantly different from one another except for Riprap Outer versus Piling Outer, for which the difference was very close to significant (α=0.058). The shade plot by tidal height (Figure 5-37) offers a visualization of the transition of the community through each tidal depth. Upper intertidal samples were characterized by a few species that are tolerant of the harsh physical conditions present, such as Mediterranean mussels *(Mytilus galloprovincialis)*, barnacles (*Balanus crenatus* and *Chthamalus fissus*), and bivalves (*Lasaea adansoni*) that thrive in crevices in rocks and between mussels. The lower intertidal and subtidal communities are less distinct from one another than they are from the upper intertidal communities. The lower intertidal samples had a diverse assemblage of species, including barnacles and mussels, but also many crustaceans (e.g., *Caprella* sp. and, non-native *Caprella simia, Zeuxo normani,* and *Laticorophium baconi*) and annelids (e.g., *Exogone lourei* and *Spirorbinae*) that cannot tolerate the long exposure to air and the resultant high temperatures and desiccation characteristic of the upper intertidal zone. The subtidal zone showed far fewer of the species that are found in the upper intertidal such as barnacles, although Mediterranean mussels were still present at many stations. Subtidal samples included many of the crustaceans that were found in the lower intertidal zone, but also included numerous species that were almost exclusively observed in the subtidal zone such as the brachiopod (lamp shells) *Annuloplatidia horni* and the small burrowing bivalve *Neolepton subtrigonum*.

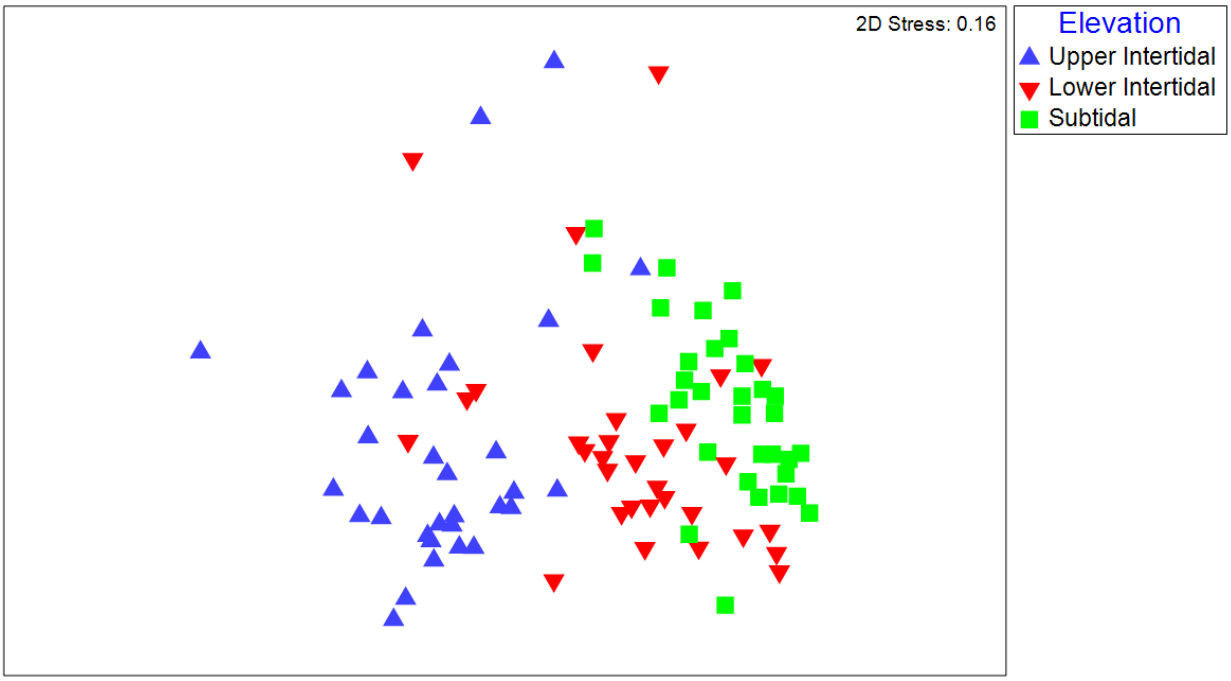


Figure 5-35. nMDS Plot of Riprap and Piling Community by Tidal Depth from Quadrat Scrapings

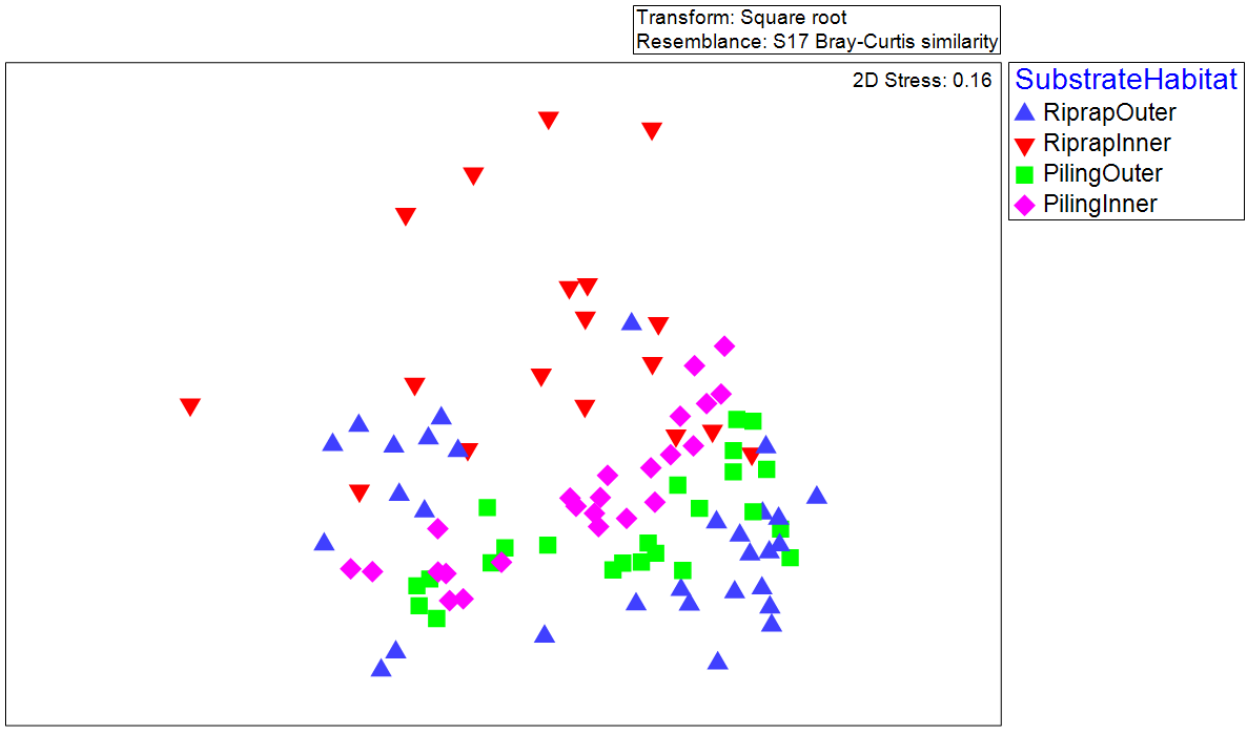
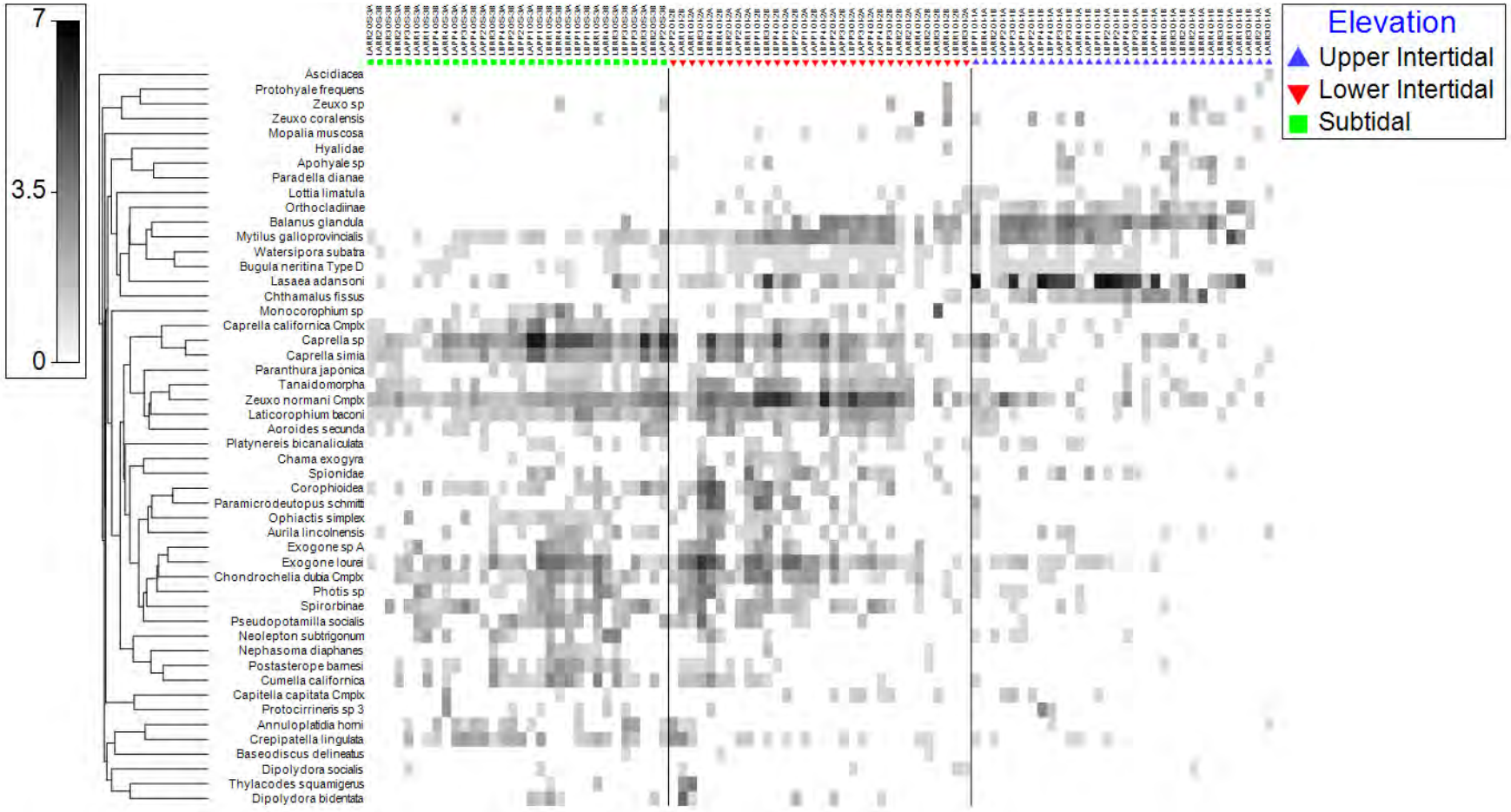


Figure 5-36. nMDS Plot of Riprap and Piling Community by Substrate and Habitat from Quadrat Scrapings



The scale reflects abundance data that have been transformed and normalized

Figure 5-37. Riprap and Piling Community Composition Shade Plot (Top 30) by Tidal Depth from Quadrat Scrapings

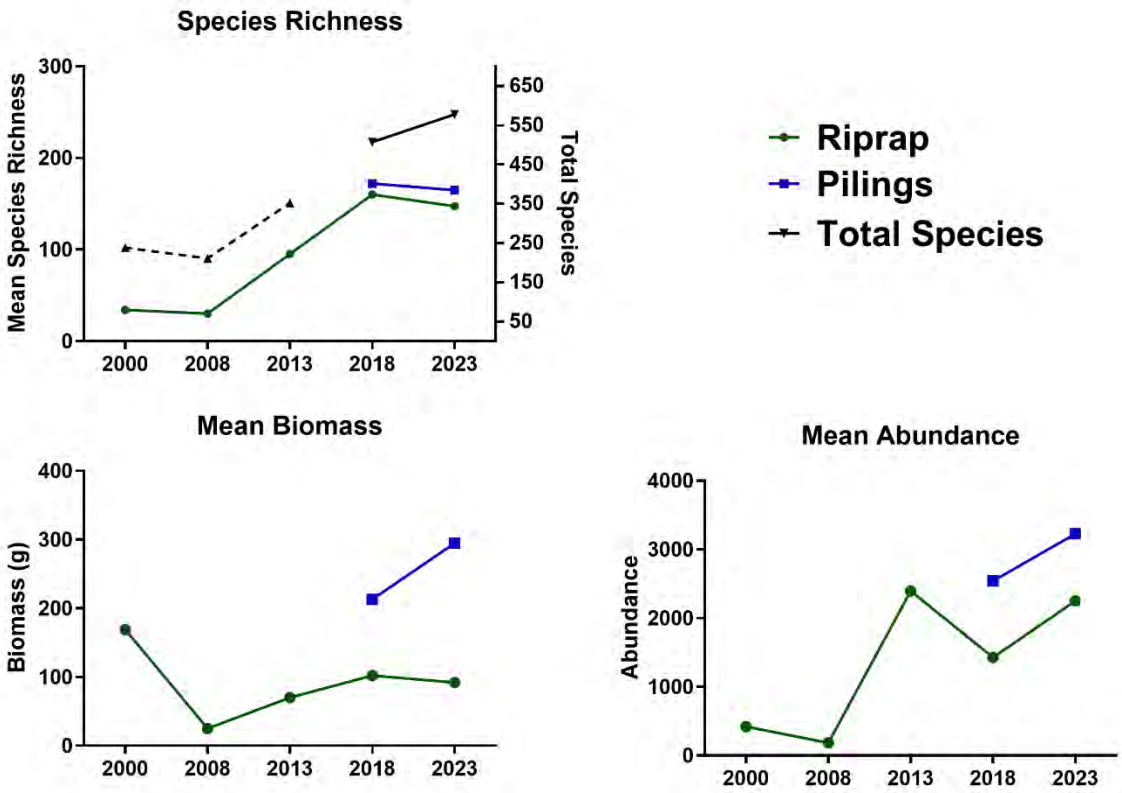
5.3.8 QUADRAT SCRAPINGS HISTORICAL COMPARISONS

Quadrat scraping data from previous Biosurveys can be compared with the caveat that the 2000, 2008, and 2013 Biosurveys included only seven riprap stations and one piling station and samples were collected across two seasons (spring and summer). For the 2018 and 2023 Biosurveys, stations were added (8 riprap and 8 piling), but sampling was conducted in only one season (summer), which has generally showed higher species richness, abundance, and biomass (MBC, 2016). In Figure 5-38, data for the 2000, 2008, and 2013 Biosurveys are shown for all seasons and all stations combined (riprap and only 1 piling station); for the 2018 and 2023 Biosurveys, the piling stations have been separated from the riprap stations because the increase in piling stations allowed calculations of mean values.

Total species richness in 2023 (578 species) was higher than in all previous Biosurveys, and ranged from 238 to 507 species (Figure 5-38). The mean number of species per station in 2023 was similar to the number per station in 2018 for riprap (147 species in 2023 versus 160 in 2018) and pilings (165 in 2023 versus 172 in 2018); in both years the mean species per station for riprap was markedly higher than results for earlier Biosurveys (Figure 5-38). In 2018, the addition of piling stations also increased the spatial coverage of quadrat scrapings throughout the Port Complex and added more samples in a different substrate that is conducive to species that may not be present on riprap. In 2023, 145 species were observed only on pilings, 194 species that were observed only on riprap, and 326 species observed on both pilings and riprap.

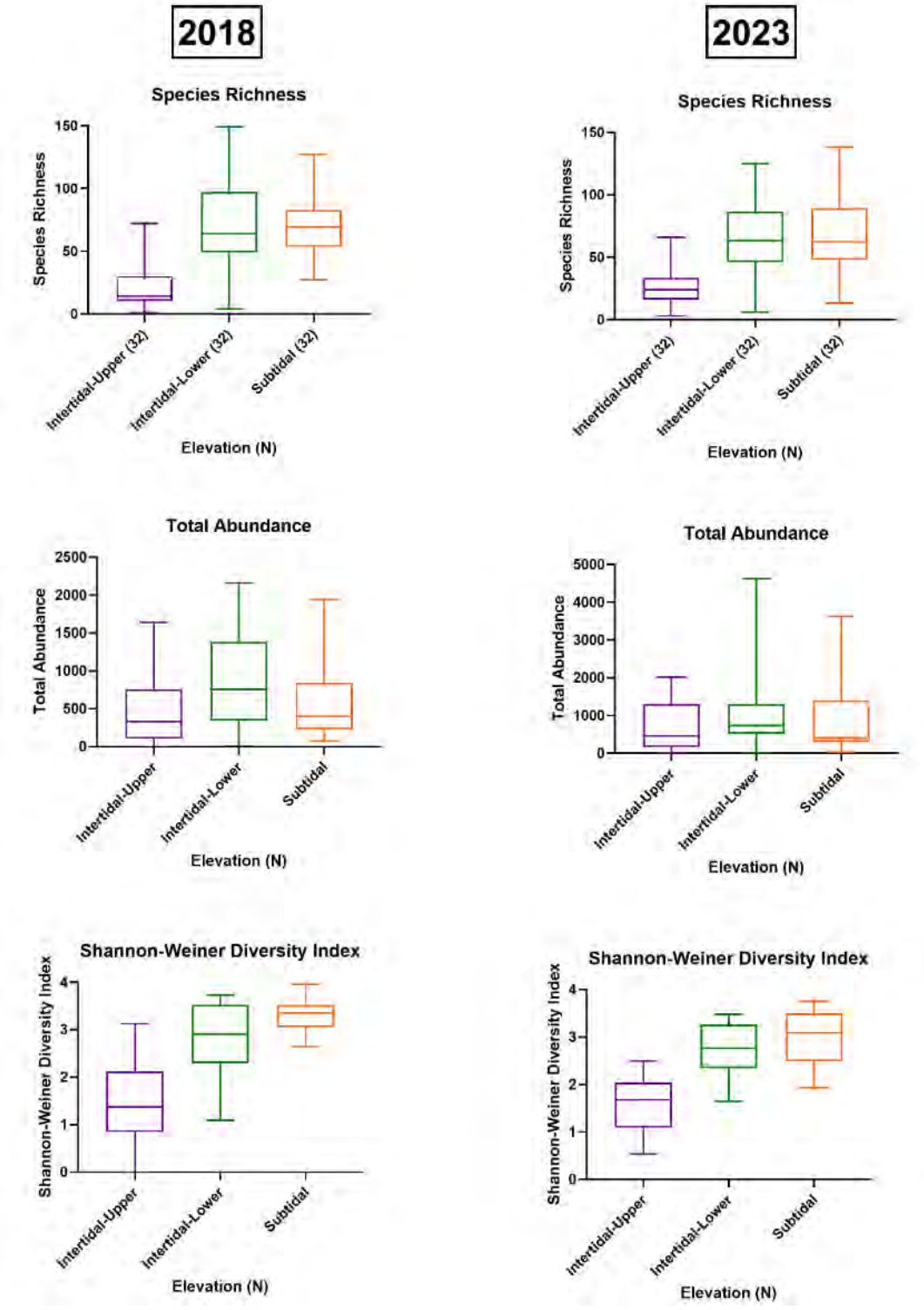
Mean abundance on riprap was higher in 2023 (2,249) than in 2018 (1,427) and markedly higher than in 2000 and 2008 (Figure 5-38); the mean abundance on pilings (3,230) in 2023 was also higher than in 2018 (2,541). Mean biomass at riprap stations (Figure 5-38) has shown considerable variability and no clear pattern over the years, likely due in part to the variable seasonality and station types across Biosurvey years. The mean biomass on pilings in 2023 (295 grams) was higher than in 2018 (213 grams); however, the mean biomass on riprap in 2023 (92 grams) was slightly lower than in 2018 (102 grams).

The patterns of species richness, total abundance, and diversity at all riprap and piling stations with respect to tidal height were similar across all samples in 2018 and 2023 (Figure 5-39). Both species richness and diversity were higher in subtidal and lower intertidal zones compared with the upper intertidal zones, and total abundance was similar across all elevations (Figure 5-39). During the 2023 Biosurvey, median abundances were similar to those during the 2018 Biosurvey (Figure 5-39), although the maximum abundances were higher in 2023.



Note: Dashed line indicates species totals when only 1 piling station was included in historical surveys before 2018.

Figure 5-38. (Clockwise) Total Species Richness from Quadrat Scrapings Per Biosurvey, Mean Abundance Per Station, and Mean Biomass Per Station by Biosurvey



Vertical lines depict the range of values, the horizontal line depicts the median of all values, and the boxes depict the first quartile above and below the median. (N)= number of stations.

Figure 5-39. Species Richness, Abundance, and Diversity Index Values for 2018 and 2023 Tidal Height Scrapings at Pilings and Riprap Stations

5.4 FISH SURVEYS OF RIPRAP AND PILING HABITATS

A limitation of trawl and lampara sampling in characterizing the fish community of an area is that the equipment can target only pelagic or soft-bottom habitat, meaning that reef-associated species that may not inhabit these habitats are underrepresented, or not present at all, in the resulting data. To fill this data gap, the 2023 Biosurvey included diver-conducted fish counts and sizing to the nearest centimeter as part of the swath survey. In addition the presence of fish species observed anywhere onsite was recorded for the 20 riprap and 8 piling stations (Table 5-1). The swath surveys were conducted in two seasons (spring and summer) for riprap and one season (summer) for pilings.

5.4.1 FISH OCCURRENCE

The divers observed 37 species at riprap stations and 14 species at piling stations (Table 5-8). In total, 17 the species observed during the riprap and piling surveys were not captured in trawl or lampara net sampling because they are typically associated with rocky-reef or high-relief habitats; examples include garibaldi (*Hypsypops rubicundus*), opaleye (*Girella nigricans*), sheephead (*Pimelometopon pulchrum*; both males and females), horn shark (*Heterodontus francisci*), and moray eel (*Gymnothorax mordax*). Additionally, 5 species were observed for the first time as part of the Biosurvey program: cabezon (*Scorpaenichthys marmoratus*), blue banded goby (*Lythrypnus dalli*), large mouth blenny (*Labrisomus xanti*), black and yellow rockfish (*Sebastes chrysomelas*), and olive/yellowtail rockfish (*Sebastes serranoides/flavidus*).

Across all stations, barred sand bass, black perch, and kelp bass were the most commonly observed at more than 50% of the stations. Riprap stations had a more diverse fish community, with 15 species observed at more than 25% of stations; pilings had 8 species observed at more than 25% of the stations. Piling stations had higher occurrences of pelagic species such as blacksmith, jacksmelt, and juvenile smelt. Riprap communities included common species such as opaleye and garibaldi that were absent from piling stations, and only white surfperch were observed at piling stations and not also observed at riprap stations.



Kelp bass in kelp canopy along the breakwater

Table 5-8. Frequency of Occurrence of Fish Species at Riprap and Pier Piling Habitat

Species		Frequency of Occurrence (%)		
Common Name	Scientific Name	Riprap Habitat	Pier Piling Habitat	Riprap and Pier Habitats
Barred Sand Bass	*Paralabrax nebulifer*	95	75	89
Black Perch	*Embiotoca jacksoni*	90	38	75
Kelp Bass	*Paralabrax clathratus*	70	63	68
Opaleye	*Girella nigricans*	70	0	50
Blacksmith	*Chromis punctipinnis*	35	50	39
Garibaldi (adult)	*Hypsypops rubicundus*	55	0	39
Round Ray	*Urolophus halleri*	45	12.5	36
Topsmelt	*Atherinops affinis*	45	12.5	36
Smelt sp[1]	*Osmeridae*	30	37.5	34
Horn Shark	*Heterodontus francisci*	45	0	32
Giant Kelpfish	*Heterostichus rostratus*	35	13	29
Halfmoon	*Medialuna californiensis*	35	13	29
Pile Surfperch	*Damalichthys*	30	25	29
Rock Wrasse (female)	*Halichoeres semicinctus*	35	13	29
Sargo	*Anisotremus davidsonii*	25	25	25
Shiner Surfperch	*Cymatogaster aggregata*	35	0	25
Blenny sp	*Blenniidae*	25	0	18
Kelp Perch	*Brachyistius frenatus*	20	13	18
Painted Greenling	*Oxylebius pictus*	25	0	18
Zebraperch	*Kyphosus vaigiensis*	25	0	18
Chameleon Goby	*Tridentiger trigonocephalus*	20	0	14
Senorita	*Oxyjulis californica*	20	0	14
Sheephead (male)	*Pimelometopon pulchrum*	20	0	14
Cabezon	*Scorpaenichthys marmoratus*	15	0	11
Jacksmelt	*Atherinopsis californiensis*	5	25	11
Rock Wrasse (juvenile)	*Halichoeres semicinctus*	15	0	11
Spotted Kelpfish	*Gibbonsia elegans*	15	0	11
Bat Ray	*Myliobatis californica*	10	0	7
Blue Banded Goby	*Lythrypnus dalli*	10	0	7
Garibaldi (juvenile)	*Hypsypops rubicundus*	10	0	7
Large Mouth Blenny	*Labrisomus xanti*	10	0	7
Rock Wrasse (male)	*Halichoeres semicinctus*	5	12.5	7
Sheephead (female)	*Pimelometopon pulchrum*	10	0	7
Black & Yellow Rockfish	*Sebastes chrysomelas*	5	0	4
Black Croaker	*Cheilotrema saturnum*	5	0	4
California Halibut	*Paralichthys californicus*	5	0	4
Goby sp	*Gobiidae*	5	0	4
Moray Eel	*Gymnothorax mordax*	5	0	4
Olive/Yellowtail Rockfish	*Sebastes serranoides/flavidus*	5	0	4
Sargo (juvenile)	*Anisotremus davidsonii*	5	0	4
Scorpionfish sp	*Scorpaenidae*	5	0	4
Sculpin sp	*Cottidae*	5	0	4
Spotted Sand Bass	*Paralabrax maculatofasciatus*	5	0	4
White Surfperch	*Phanerodon furcatus*	0	12.5	4
Total Species		**37**	**14**	**38**

1. Species excluded from species richness total at bottom of table because could not be identified to species. Green shading indicates species that have not been recorded in past Biosurveys (2000-2018). Yellow shading indicates species was not observed in trawl, lampara, or beach seine in 2023.

5.4.2 FISH DENSITY

5.4.2.1 SPECIES COMPARISONS

A total of 29 species of fish were counted during swath transect surveys at piling and riprap stations, with 27 species at riprap stations and 12 species at piling stations. Black perch and blacksmith were the most abundant species at riprap stations, and smelt was the most abundant at piling stations (Table 5-9). Only barred sand bass, black perch, and kelp bass were counted on transects across both substrates (riprap and pilings) and habitat types (Inner Harbor and Outer Harbor) in both seasons. Horn sharks were the only other species observed across all riprap habitats in both seasons, while pilings also had blacksmith and smelt observed across all habitat types. Riprap stations had higher species richness at Outer Harbor than at Inner Harbor stations, and higher species richness in the summer compared to the spring (Table 5-9). Piling stations were surveyed only in the summer and species richness was higher at the Outer Harbor stations than at Inner Harbor stations.

The average density of fish across all riprap stations (Table 5-9, Figure 5-40) was nearly twice as high in the summer (74.0 fish/100 m^2) than in the spring (42.8 fish/100 m^2). Inner Harbor riprap stations across both seasons were dominated by black perch (10.9 fish/100 m^2 in spring and 22.8 fish/100 m^2 in summer); topsmelt (9.38 fish/100 m^2) and shiner perch (6.88 fish/100 m^2) were among the top three most abundant species in the spring compared with barred sand bass (9.06 fish/100 m^2) and opaleye (4.38 fish/100 m^2), which were among the top three in summer. At Outer Harbor riprap stations, blacksmith (17.6 fish/100 m^2 in spring and 11.9 fish/100 m^2 in summer) and black perch (6.39 fish/100 m^2 in spring and 33.5 fish/100 m^2 in summer) were among the top three most abundant across both seasons, with garibaldi (6.67 fish/100 m^2) in the top three in the spring and kelp bass (10.0 fish/100 m^2) in the top three in the summer.

Piling stations in both Inner Harbor and Outer Harbor habitats were dominated by juvenile smelt (3.13 fish/100 m^2 at Inner Harbor stations and 125 fish/100 m^2 at Outer Harbor stations; Table 5-9, Figure 5-41). Barred sand bass was the second most abundant (1.88 fish/100 m^2) species at Inner Harbor stations followed by a tie between the remaining black perch, blacksmith, and kelp bass (0.63 fish/100 m^2). Outer Harbor stations had higher diversity, with schooling pelagic species jacksmelt (25.6 fish/100 m^2) and blacksmith (25.0 fish/100 m^2) making up the top three most abundant species.

Compared with the riprap stations surveyed in the summer, pilings had more species in common with Outer Harbor stations compared with Inner Harbor stations. (Table 5-9, Figure 5-41). Pilings tended to aggregate pelagic species (e.g., jacksmelt, blacksmith, and smelt) at higher densities compared with riprap, although the habitat complexity of riprap affords more microhabitats (e.g., crevices, overhands, kelp canopy, etc.) that promote increased species diversity and higher densities of benthic species such as perch, bass, garibaldi, and horn sharks.

Table 5-9. Average Density of Fish Species at Riprap and Pier Piling Habitat

Substrate	Riprap						Piling		
Habitat	All		Inner		Outer		All	Inner	Outer
Season	Spring	Summer	Spring	Summer	Spring	Summer	Summer		
Average Species Density	#/100 m^2		#/100 m^2		#/100 m^2		#/100 m^2	#/100 m^2	#/100 m^2
Barred Sand Bass	3.00	7.50	3.13	9.06	2.92	6.46	4.06	1.88	6.25
Bat Ray	0	0.13	0	0	0	0.21	0	0	0
Black Croaker	0	0.08	0	0	0	0.14	0	0	0
Black Perch	8.21	**29.2**	**10.9**	**22.8**	6.39	**33.5**	1.56	0.63	2.50
Blacksmith	**10.5**	7.13	0	0	**17.6**	11.9	12.8	0.63	25.0
Blenny sp.	0	0.25	0	0.63	0	0	0	0	0
Cabezon	0	0.08	0	0	0	0.14	0	0	0
Chameleon Goby	0	0.50	0	1.25	0	0	0	0	0
Garibaldi	4.00	5.92	0	0	6.67	9.86	0	0	0
Halfmoon	1.21	0.42	0	0	2.01	0.69	1.56	0	3.13
Horn Shark	1.08	0.63	1.3	0.63	0.97	0.63	0	0	0
Jacksmelt	0	0	0	0	0	0	12.8	0	25.6
Kelp Bass	3.58	6.38	1.3	0.94	5.14	10.0	4.69	0.63	8.75
Kelp Perch	0.25	0.38	0	0	0.42	0.63	0.63	0	1.25
Kelpfish sp.	0.50	0	0	0	0.83	0	0	0	0
Moray Eel	0.13	0	0	0	0.21	0	0	0	0
Olive/Yellowtail Rockfish	0.13	0	0	0	0.21	0	0	0	0
Opaleye	0.17	5.25	0	4.38	0.28	5.83	0	0	0
Painted Greenling	0.38	0.25	0	0	0.63	0.42	0	0	0
Pile Perch	0	2.88	0	0.94	0	4.17	0.32	0	0.63
Rock Wrasse	0.92	1.42	0	0	1.53	2.36	0	0	0
Round Ray	1.50	1.46	3.75	1.25	0	1.60	0.63	0	1.25
Sargo	0.21	0.75	0	0	0.35	1.25	2.19	0	4.38
Senorita	0	0.33	0	0	0	0.56	0	0	0
Sheephead	0.29	0.46	0	0	0.49	0.76	0.31	0	0.63
Shiner Perch	2.75	1.25	6.88	1.25	0	1.25	0	0	0
Smelt sp.	0	0	0	0	0	0	**64.1**	**3.13**	**125**
Spotted Kelpfish	0.13	0.13	0	0.31	0.21	0	0	0	0
Topsmelt	3.75	0	9.38	0	0	0	0	0	0
White Perch	0	0	0	0	0	0	0.63	0	1.25
Zebra Perch	0.13	1.29	0.31	0	0	2.15	0	0	0
Species Richness	20	24	8	11	16	21	12	5	12

Bold = Highest density in each column; underline = top 3 density in each column

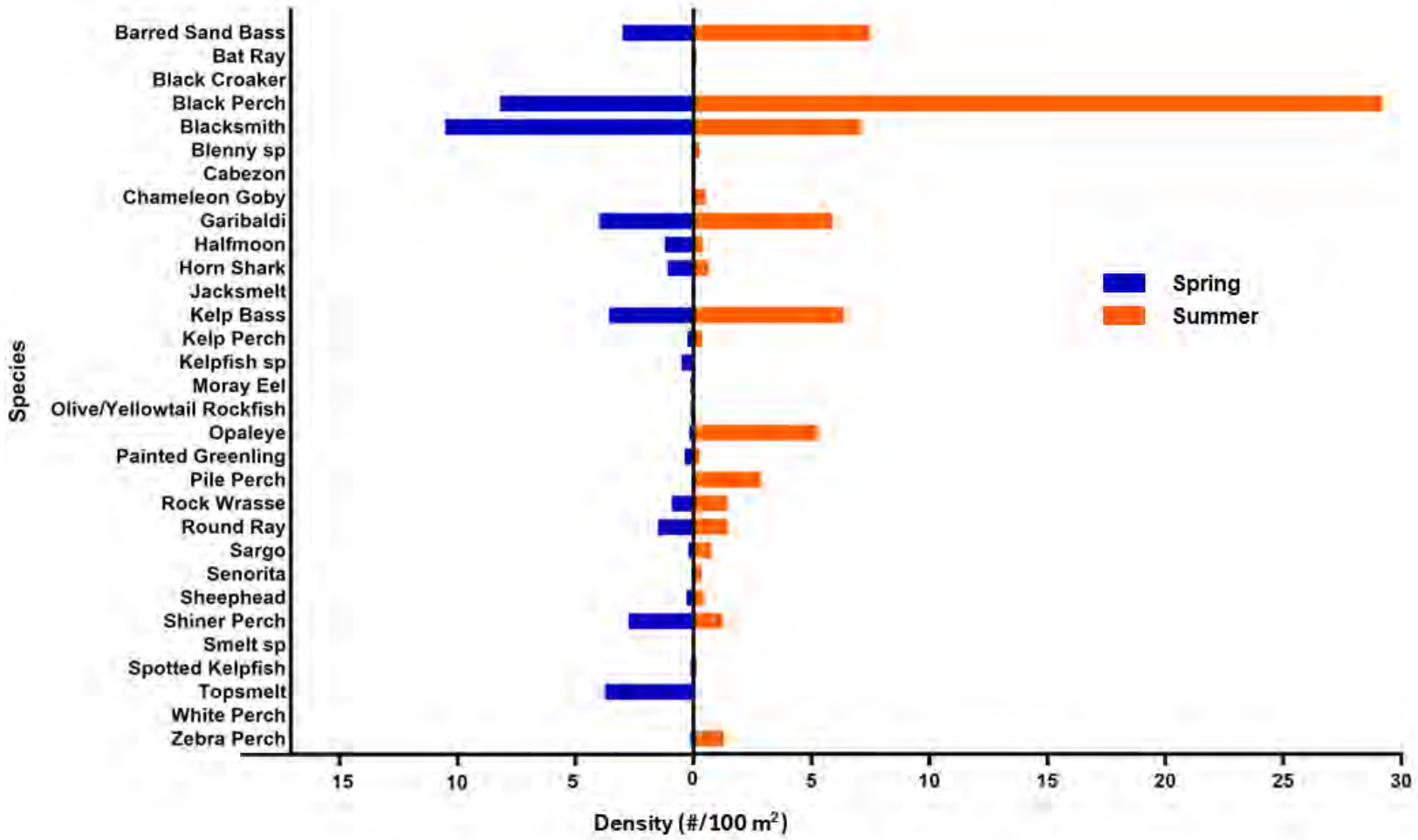


Figure 5-40. Fish Species Average Density at Riprap Stations During Spring and Summer Surveys

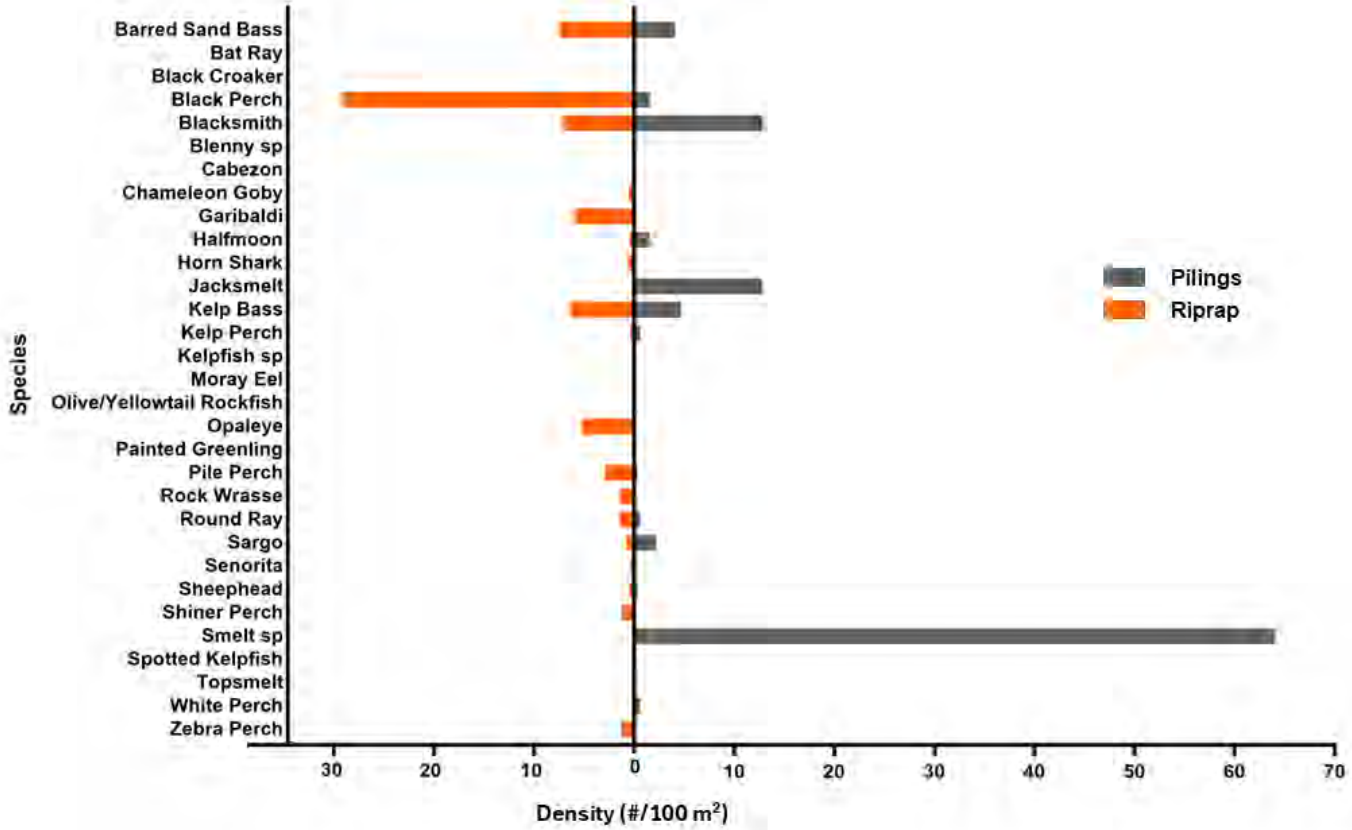


Figure 5-41. Fish Species Average Density at Riprap and Piling Stations During Summer Surveys

5.4.2.2 STATION COMPARISONS

Species richness in the spring across all riprap stations ranged from 1 to 9 total fish species with densities ranging from 2.50 fish/100 m^2 to 150 fish/100 m^2; in summer, the number of species per station ranged from 1 to 14 with densities ranging from 5.00 fish/100 m^2 to 190 fish/100 m^2 (Table 5-10). Species richness at piling stations ranged from 1 to 9 species, with densities ranging from 2.50 fish/100 m^2 to 535 fish/100 m^2. Pilings had lower mean species richness but higher mean fish density than riprap across both seasons, although these differences were not statistically significant (Figure 5-42). Pilings had a statistically significant lower mean diversity score (1.48) compared with riprap in both spring (1.73) and summer (1.98),likely due in part to the high degree of dominance of smelt at piling stations.

The riprap stations with the highest species richness and density of fishes tended to be on the breakwaters (stations T1, T2, and T5) and at Outer Harbor stations (stations T4-ALT, T14, and T20). These stations had high densities of barred sand bass, black perch, blacksmith, garibaldi, kelp bass, opaleye, rock wrasse, and zebra perch. Inner Harbor station T13 (Consolidated Slip) had similarly high densities of fish, but the community was composed primarily of shiner perch, topsmelt, black perch, and round rays. The most abundant species at each riprap station during the spring and summer surveys are shown in Figure 5-43. Black perch was generally the most abundant species in both seasons, and barred sand bass in the Inner Harbor and garibaldi on the breakwaters had similar abundances in both seasons.

The most abundant species at each piling station is shown in Figure 5-44. Piling stations with the highest diversity and density of fishes were in the Outer Harbor. All the piling stations had kelp growing on the pilings that likely affords additional refuge and foraging habitat compared with Inner Harbor piling stations. These Outer Harbor piling stations were the only locations where species such as kelp bass, sargo, sheephead, kelp perch, and halfmoon were observed (Table 5-10). Inner Harbor piling stations had only one to three species per station, most commonly barred sand bass.

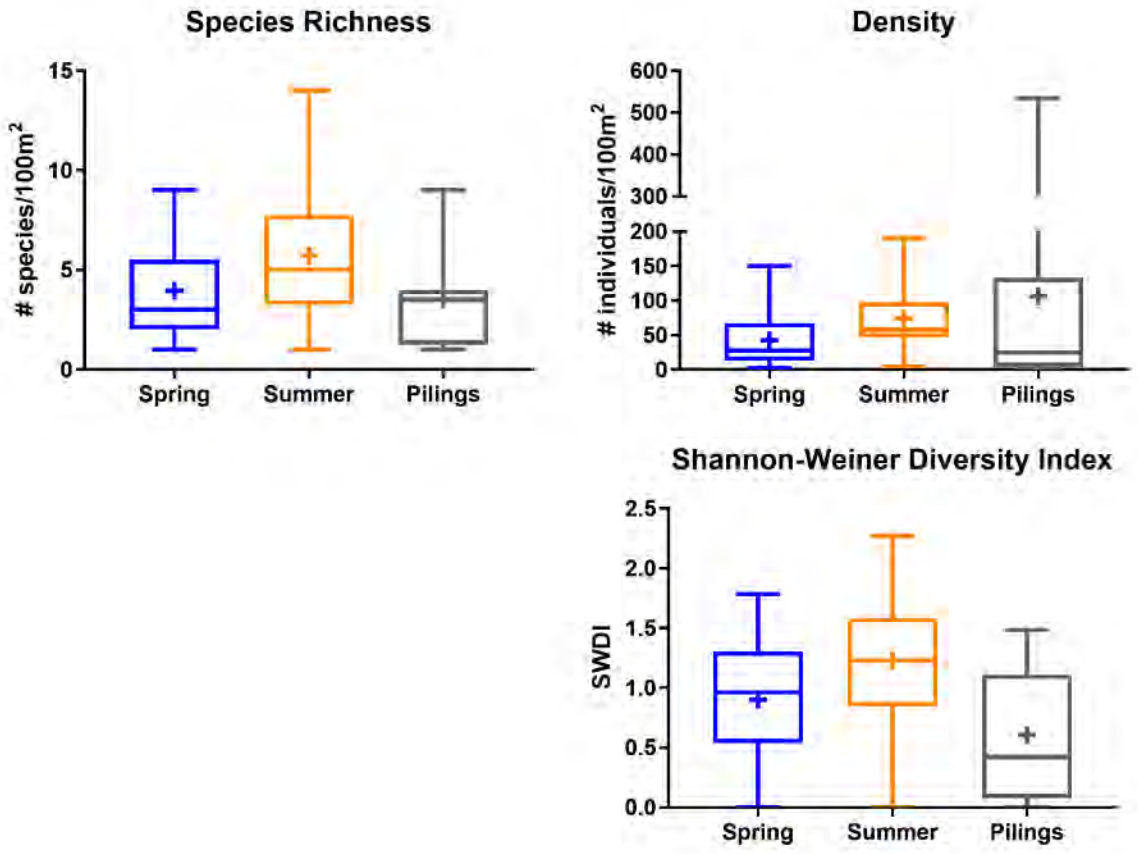


Barred sand bass schooling near piling-sediment interface in POLA Main Channel

Table 5-10. Average Density of Fish Species at Riprap and Pier Piling Habitat

Station	Port	Habitat	Spring		Summer		Spring and Summer Average
			Species Richness	Abundance (#/100 m^2)	Species Richness	Abundance (#/100 m^2)	Abundance (#/100 m^2)
T1	POLB	Outer	8	140	8	98.3	119
T2	POLA	Outer	9	90.0	8	145	118
T3	POLA	Outer	3	30.0	5	55.0	42.5
T4-ALT	POLA	Outer	4	20.0	6	140	80.0
T5	POLB	Outer	9	102	10	83.3	92.5
T6	POLB	Outer	4	17.5	7	103	60.0
T7	POLB	Outer	1	2.50	4	42.5	22.5
T8	POLB	Inner	2	7.50	3	57.5	32.5
T9	POLA	Outer	3	15.0	6	57.5	36.3
T10	POLA	Inner	1	5.00	1	12.5	8.75
T11	POLB	Inner	1	2.50	2	5.00	3.75
T12	POLB	Inner	2	15.0	4	45.0	30.0
T13	POLA	Inner	3	150	3	55.0	103
T14	POLB	Outer	7	75.0	14	96.7	85.8
T15	POLB	Outer	4	25.0	6	57.5	41.3
T16	POLA	Outer	4	12.5	5	65.0	38.8
T17	POLA	Inner	3	30.0	5	82.5	56.3
T18	POLA	Inner	3	40.0	4	50.0	45.0
T19	POLA	Inner	2	45.0	3	40.0	42.5
T20	POLA	Outer	6	32.5	10	190	111
LAPP1	POLA	Outer	–	–	9	140	–
LAPP2	POLA	Outer	–	–	4	113	–
LAPP3	POLA	Inner	–	–	2	15.0	–
LAPP4	POLA	Inner	–	–	1	2.50	–
LBPP1	POLB	Outer	–	–	4	535	–
LBPP2	POLB	Outer	–	–	4	35.0	–
LBPP3	POLB	Inner	–	–	1	2.50	–
LBPP4	POLB	Inner	–	–	3	7.50	–

m^2 = square meter(s); POLA = Port of Los Angeles; POLB = Port of Long Beach

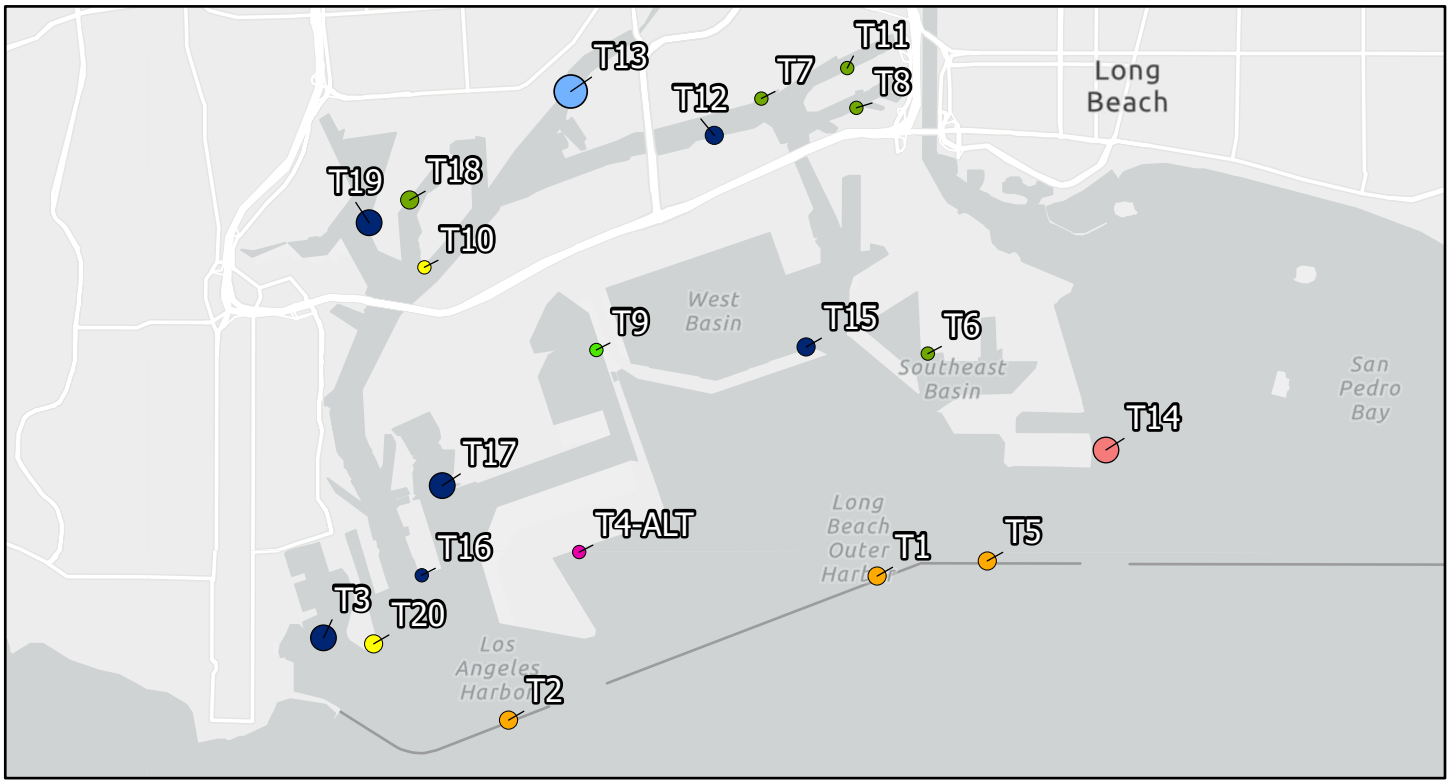


Vertical lines depict the range of values, the horizontal line depicts the median of all values, the '+' symbol represents the mean, and the boxes depict the first quartile above and below the median.

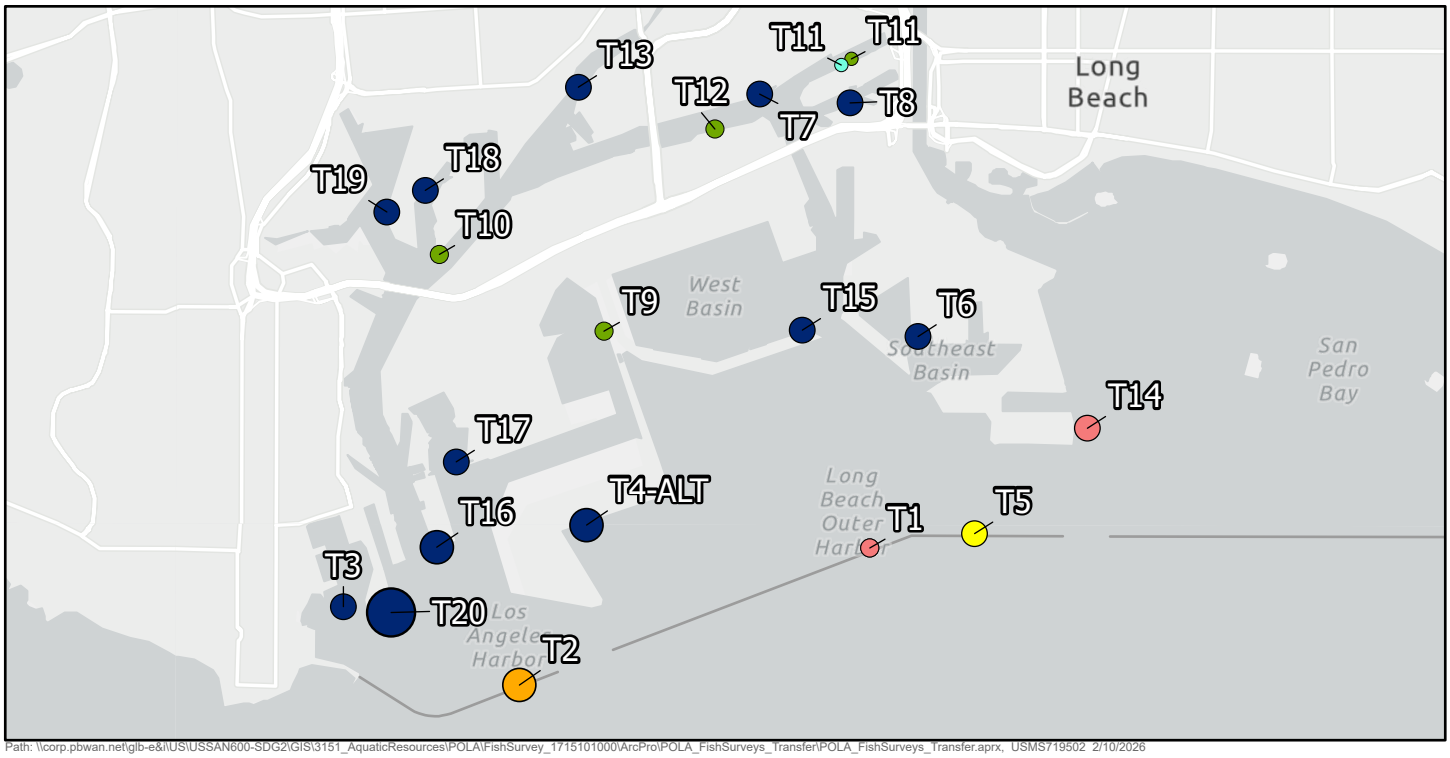
Figure 5-42. Species Richness, Density, and Diversity at Riprap (Spring and Summer) and Piling Stations (Summer)

Service Layer Credits: Light Gray Reference: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Light Gray Base: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Spring 2023



Summer 2023



Path: \\corp.pbwan.net\glb-e&i\US\USSAN600-SDG2\GIS\3151_AquaticResources\POLA\FishSurvey_1715101000\ArcPro\POLA_FishSurveys_Transfer\POLA_FishSurveys_Transfer.aprx, USMS719502 2/10/2026

Density (#/100m^2)

- 3 - 10
- 11 - 20
- 21 - 50
- 51 - 75
- 76 - 100

Species

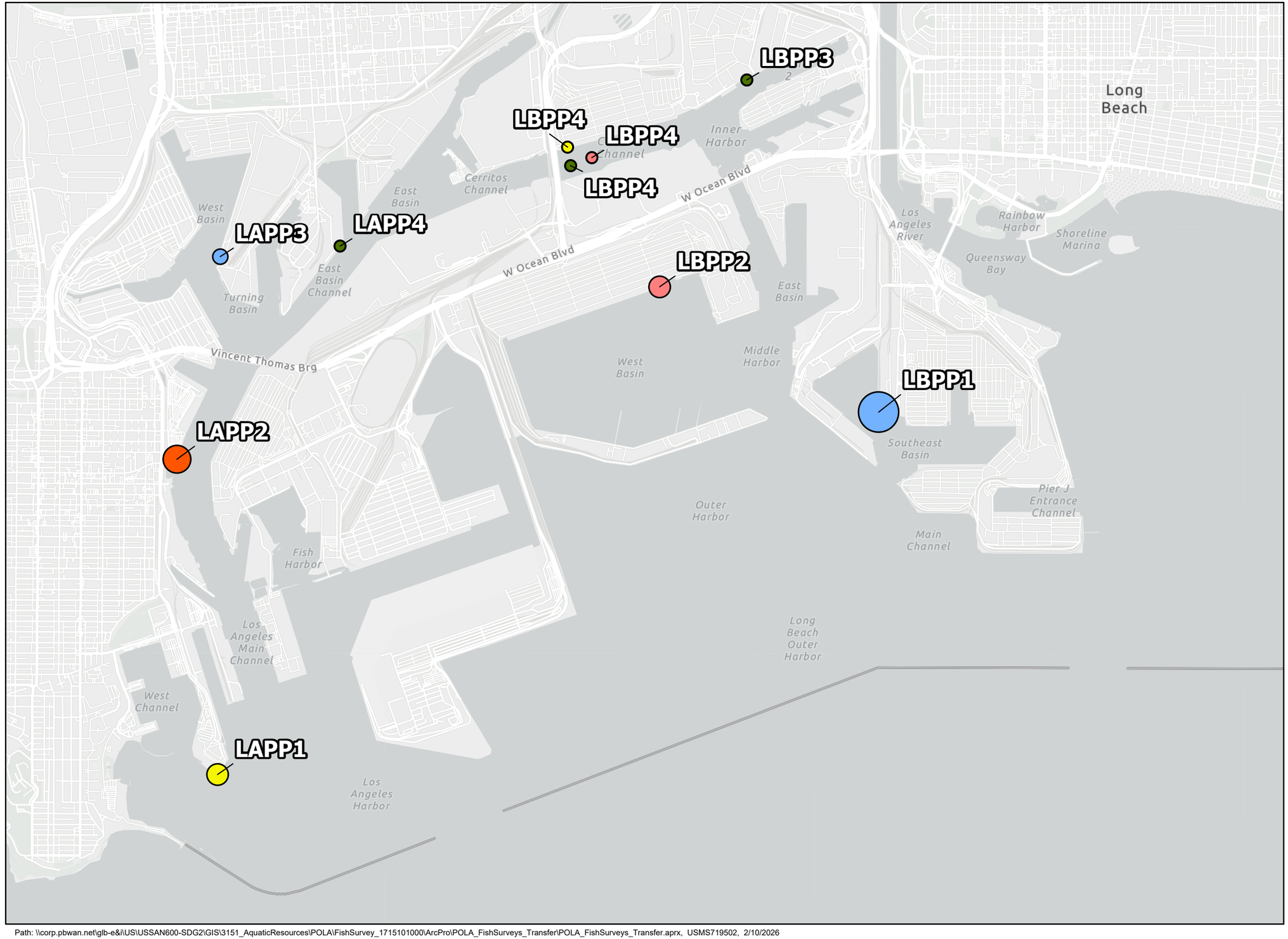
- Barred Sand Bass
- Black Perch
- Blacksmith
- Garibaldi
- Kelp Bass
- Kelpfish sp.
- Rock Wrasse
- Spotted Kelpfish
- Topsmelt

1:85,522

0 1 2 Miles

FIGURE 5-43

Most Abundant Fish Species at Riprap Stations – Spring and Summer 2023



Density (#/100m^2)

- 3 -5
- 6 - 13
- 14 - 20
- 21 - 105
- 106 - 500

Species

- Barred Sand Bass
- Blacksmith
- Jacksmelt
- Kelp Bass
- Smelt sp.

1 inch =2,989 feet
0 1,000 Feet

FIGURE 5-44

Most Abundant Fish Species at Piling Stations – Summer 2023

Service Layer Credits: Light Gray Reference: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Light Gray Base: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS,

Path: \\corp.pbwan.net\glb-e&i\US\USSAN600-SDG2\GIS\3151_AquaticResources\POLA\FishSurvey_1715101000\ArcPro\POLA_FishSurveys_Transfer\POLA_FishSurveys_Transfer.aprx, USMS719502, 2/10/2026

5.4.3 SIZE CLASS

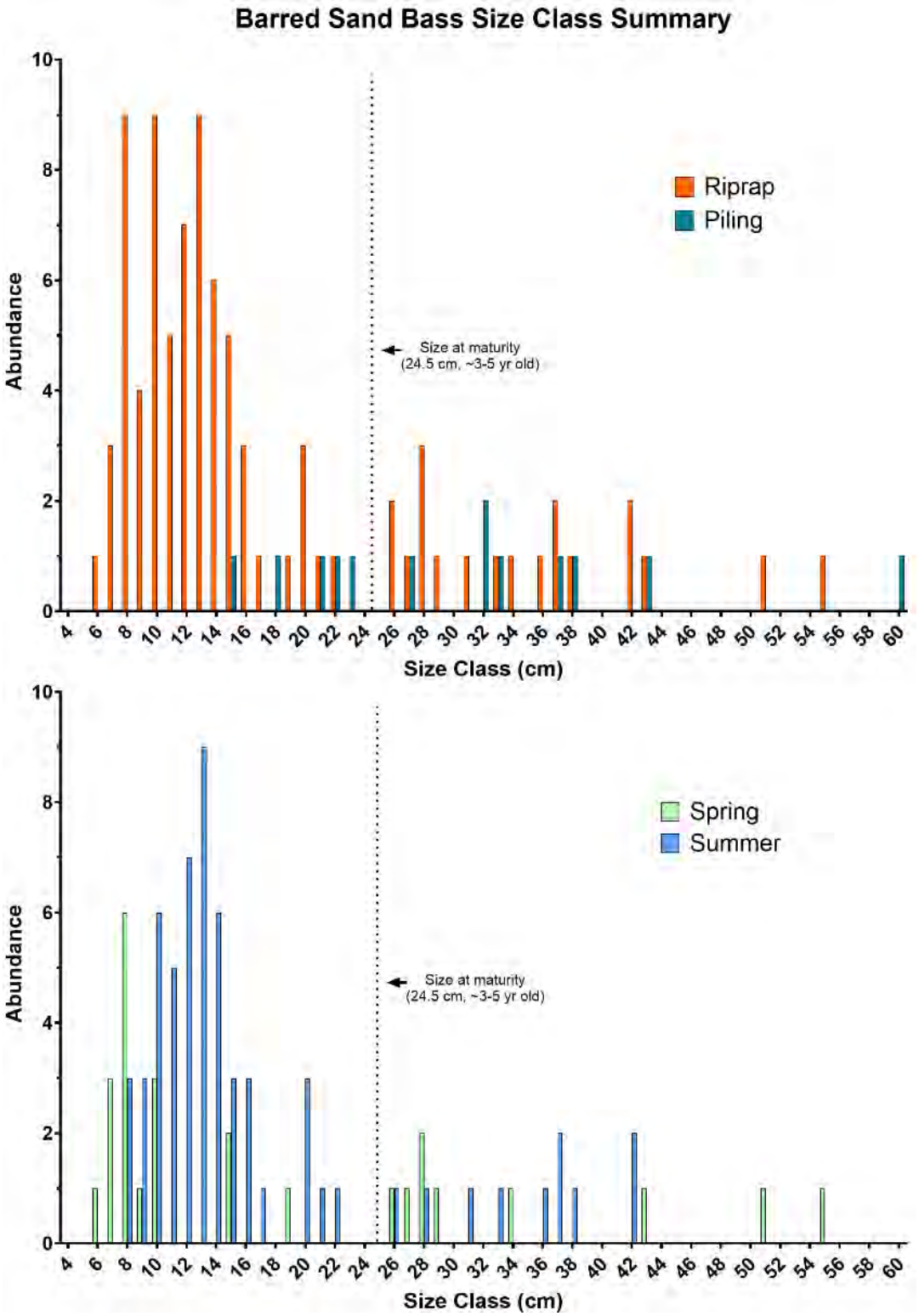
Size class was analyzed for the top three fish species surveyed at riprap and piling stations (barred sand bass, kelp bass, and black perch), with the highest frequency of occurrence during dive surveys, and garibaldi, which is a protected species in California. Length at maturity information is provided for species when this information is available. Size class figures in this section compare species abundance on riprap during the spring and summer and on riprap (all seasons combined) compared with on pilings.

Barred sand bass ranged in size from 6 to 55 cm at riprap stations and 15 to 60 cm at piling stations. The most common size class for barred sand bass at riprap stations was 8 to 16 cm in the spring and 7 to 16 cm in the summer (Figure 5-45). Maturity of 50% of the male and female barred sand bass population occurs when fish reach approximately 3 years of age (22 cm and 24 cm TL, respectively), and 100% of fish are mature at 4 to 5 years of age, with a length of approximately 26 to 27 cm (Love, 2011). Based on the average of this range (24.5 cm), approximately 22% of the population at riprap stations and 61% of the population observed at piling stations may be considered mature. Seasonal size class analysis showed approximately 34% of the population in the spring and 16% of the population in the summer were mature adults. Juvenile barred sand bass were observed in greater abundance during the summer surveys at the riprap stations compared with abundance at the piling stations. Riprap habitats create microhabitats such as overhangs and crevices that protect juvenile fish from predation, whereas piling stations lack the same complexity. Approximately 0.3% of the 312 barred sand bass captured during trawls were considered mature (Figure 4-45); at piling stations, approximately 61% of the population were considered to be mature. It is possible that larger adult bass prefer areas around pilings and riprap for the shelter they provide (Lowe et al., 2003) and the abundance of foraging opportunities on animals such as fish, crabs, and octopus. Juvenile bass may prefer shallow, soft-bottom areas where higher temperatures help them grow, and they can find prey that is more appropriate to their size such as small fish, shrimp, and worms (Love, 2011).

Kelp bass ranged in size from 7 to 53 cm at the riprap stations and 20 to 34 cm at the piling stations. Fish on the riprap stations showed a bimodal size distribution across both seasons (Figure 5-46). The spring population had a smaller size class centered around 7 to 10 cm and a larger size class from 21 to 34 cm. The summer population had a smaller size class around 9 to 15 cm and a larger size class from 18 to 36 cm. Maturity of 50% of the male and female kelp bass population occurs when fish reach approximately 3 years of age (22 cm and 22.6 cm TL, respectively), and 100% of fish are mature at 3 to 5 years of age, with a length of approximately 26 to 27 cm (Love, 2011). Based on the average of this range (23.5 cm), approximately 58% of the population at the riprap stations and 60% of the population at the piling stations may be considered mature. Seasonal size class analysis indicated a similar pattern, with approximately 62% of the population in the spring and 56% of the population in the summer considered mature.

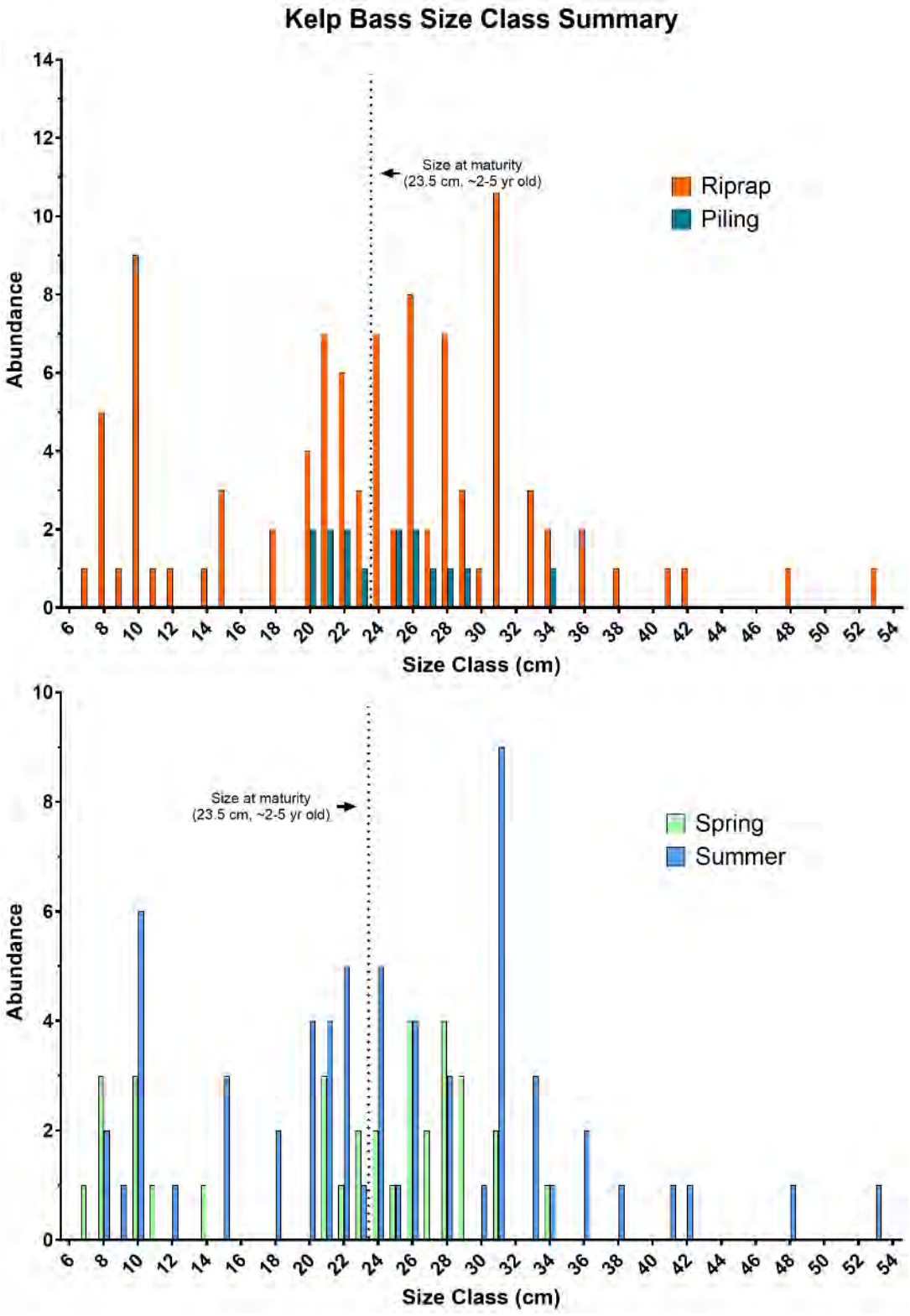
Black perch ranged in size from 6 to 31 cm and had a normal distribution in the summer surveys centered around 8 to 15 cm (Figure 5-47). Maturity of 50% of the male and female black perch population occurs when fish reach approximately 1 to 2 years of age with a length of approximately 15 cm (CDFW, 2025). All but 5 of the 309 individual black perch captured were found on riprap stations, and approximately 30% of those may be considered mature. Four of the five individual black perch collected at piling stations were large enough to be considered mature. Approximately 54% of the population on riprap during the spring may be considered mature compared with approximately 23% of the population during the summer.

Garibaldi observed during dive surveys ranged in size from 13 to 33 cm and had a normal seasonal distribution in both spring and summer centered around 19 to 29 cm (Figure 5-47). Maturity of 50% of the male and female garibaldi population occurs when fish reach approximately 5 to 6 years of age with a length of approximately 20.3 to 22.8 cm (CDFW, 2025). Garibaldi were collected only at riprap stations, and approximately 95% of the population may be considered mature. Seasonal size class analysis results indicated similar trends for both spring and summer, with more than 93% of the population considered mature across both seasons.



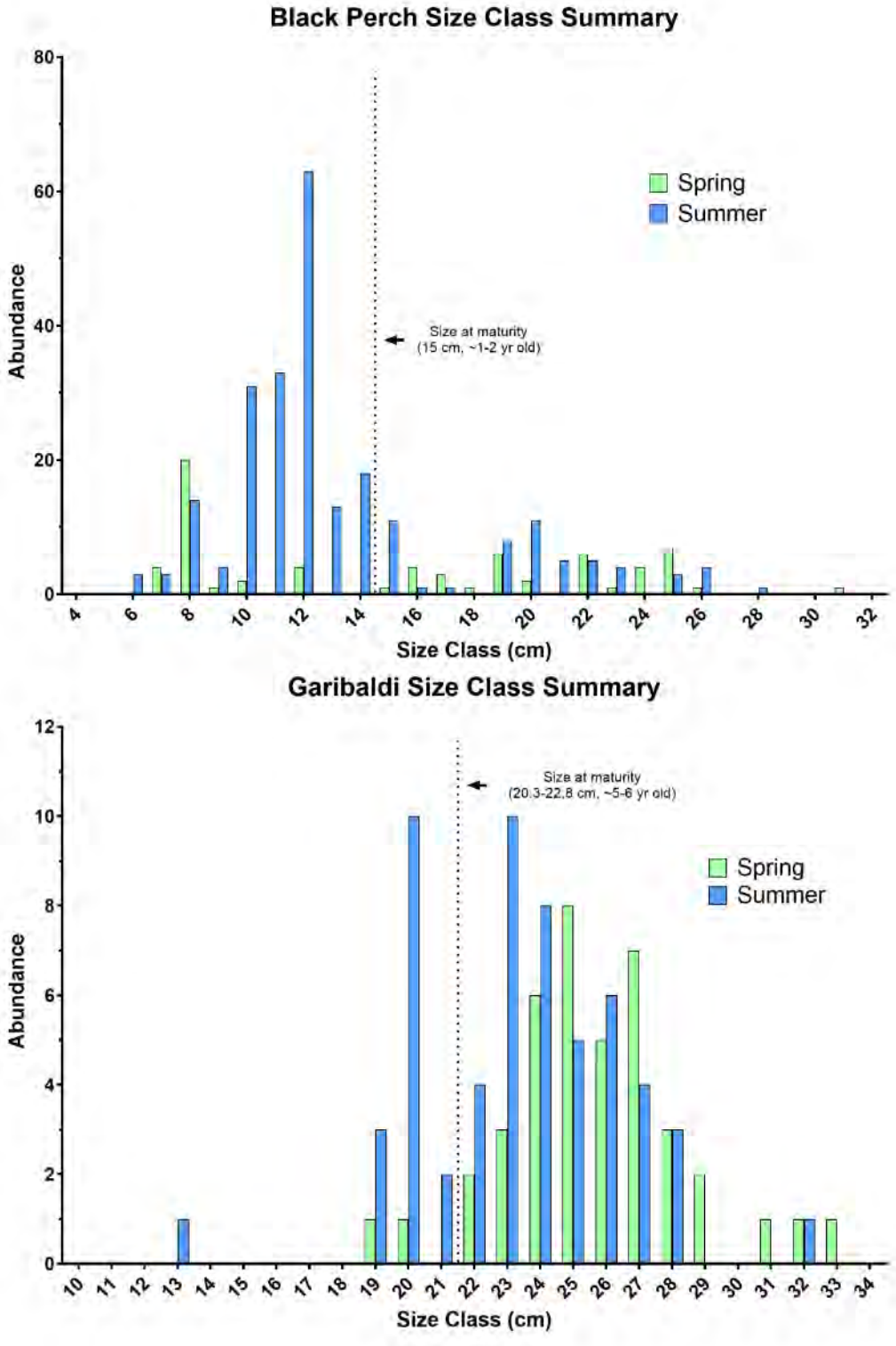
Size class between substrates (top) and between seasons at riprap stations only (bottom).

Figure 5-45. Barred Sand Bass Size Class Summary



Size classes between substrate (top) and between seasons at riprap stations only (bottom).

Figure 5-46. Kelp Bass Size Class Summary



Size classes between seasons at riprap stations only.

Figure 5-47. Black Perch and Garibaldi Size Class Summary

5.4.4 MULTIVARIATE ANALYSIS

Results of multivariate analysis of the fish density data for riprap and piling stations indicated the following patterns:

- The ANOSIM analysis indicated a significant difference between the fish communities on riprap between for spring and summer and a significant difference between piling and riprap stations in the summer (Appendix E).
- When stations were grouped by substrate and season (Figure 5-48), riprap stations were significantly different from each other in both seasons, and in summer riprap was significantly different from pilings. There was no significant difference between piling stations and riprap stations in spring.
- When stations were grouped by habitat and substrate (Figure 5-49), there were significant differences between Outer Harbor riprap stations and both Inner Harbor riprap and Inner Harbor piling stations, as well as between Inner Harbor riprap stations and Outer Harbor piling stations.
- The SIMPER analysis of species contribution identified black perch, barred sand bass, kelp bass, and garibaldi as most representative of Outer Harbor riprap stations, compared with just black perch and barred sand bass for Inner Harbor riprap stations. Outer Harbor piling stations were characterized by kelp bass, barred sand bass, and blacksmiths compared with only barred sand bass for Inner Harbor piling stations. The patterns of fish densities across different substrates and habitat types averaged across both seasons is shown in Figure 5-50.
- When results for riprap stations were averaged across both seasons, a SIMPROF analysis of the fish communities resulted in five groups (Figure 5-51). The largest cluster was Group D, which included 12 Inner Harbor and Outer Harbor riprap stations and 1 piling station (LAPP2 – Port of Los Angeles Main Channel). These stations were characterized by SIMPER for the abundance of black perch, barred sand bass, and kelp bass. The second largest cluster was Group E, which included five piling stations and riprap stations in (T11 – Channel 2) and T10 – Port of Los Angeles East Basin), characterized by high abundance of barred sand bass and low abundance of secondary species. Group C included the four riprap stations (T1, T2, T5, and T14) in the federal breakwaters and Pier J breakwaters and piling station LAPP1 at Berth 48, all of which had high kelp densities that led to their fish communities being composed of blacksmith, kelp bass, halfmoon, black perch, and garibaldi. Group B included only two riprap stations (T19 – Port of Los Angeles West Basin South) and T13 – South of Consolidated Slip), which both had eelgrass beds and fish communities that were characterized by black perch and round rays, with station T13 also having high densities of shiner perch. Pier piling station LAPP3 (Port of Los Angeles West Basin South) was the only station in Group A and was separated out because of its lack of barred sand bass and low abundances of only black perch and juvenile smelt.

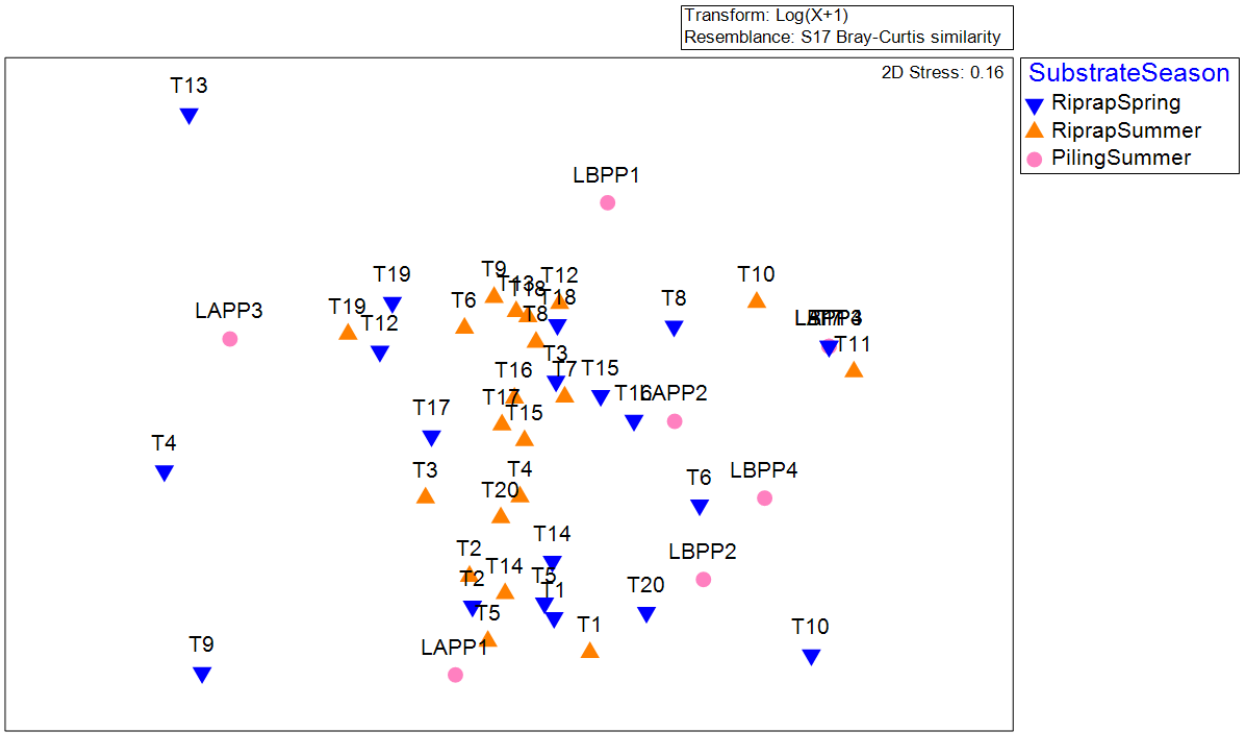


Figure 5-48. nMDS Plot of Fish Density by Substrate and Season

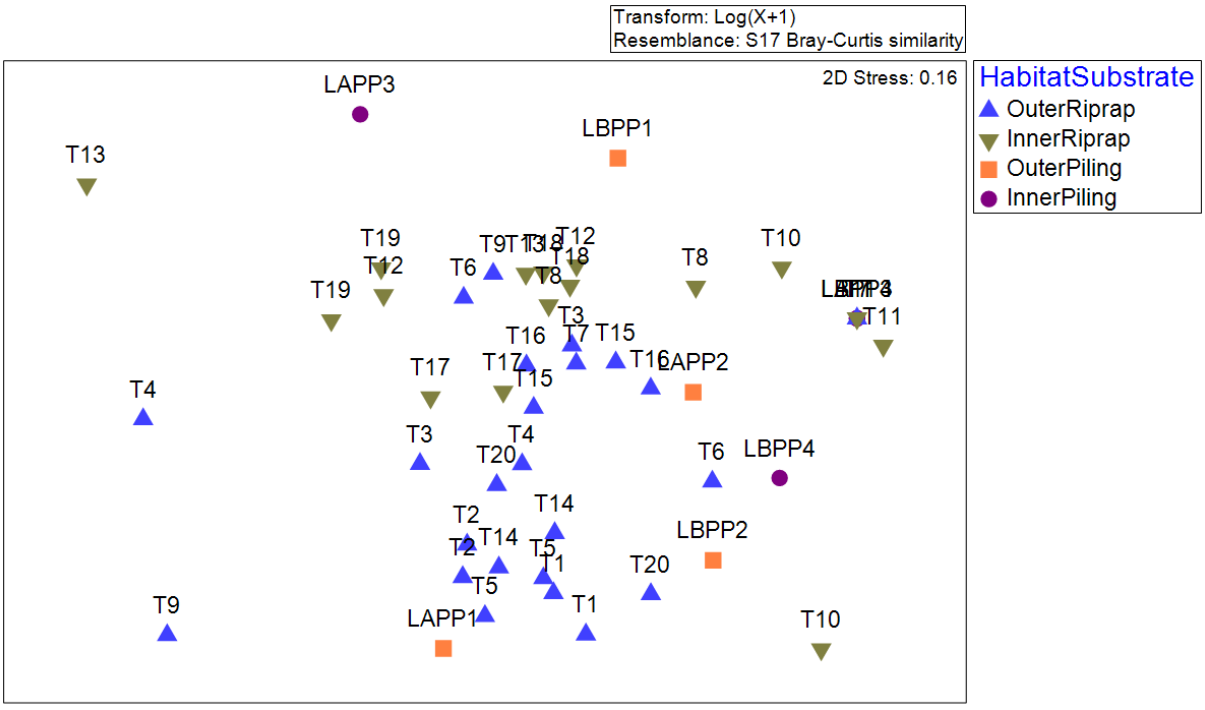
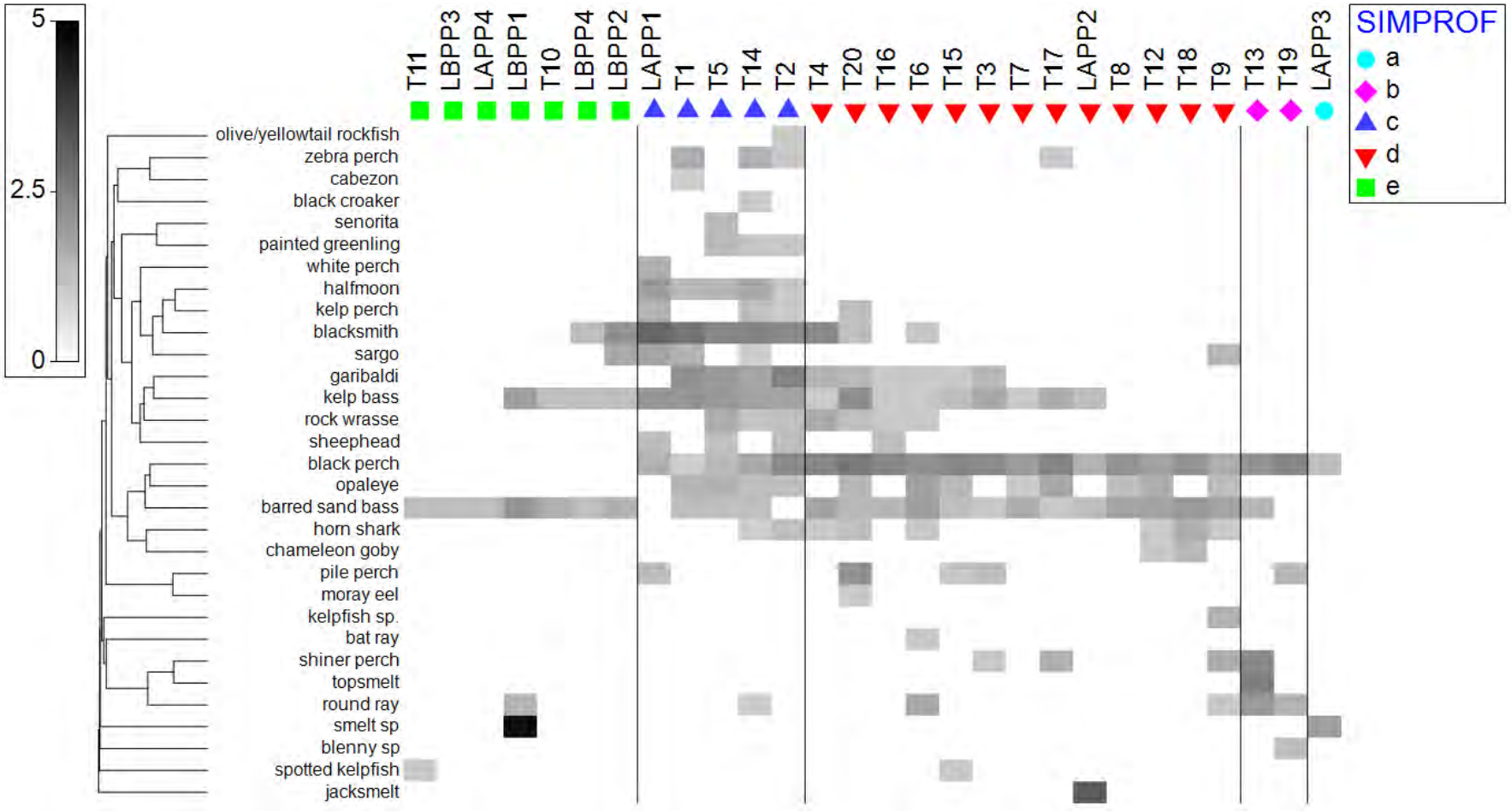
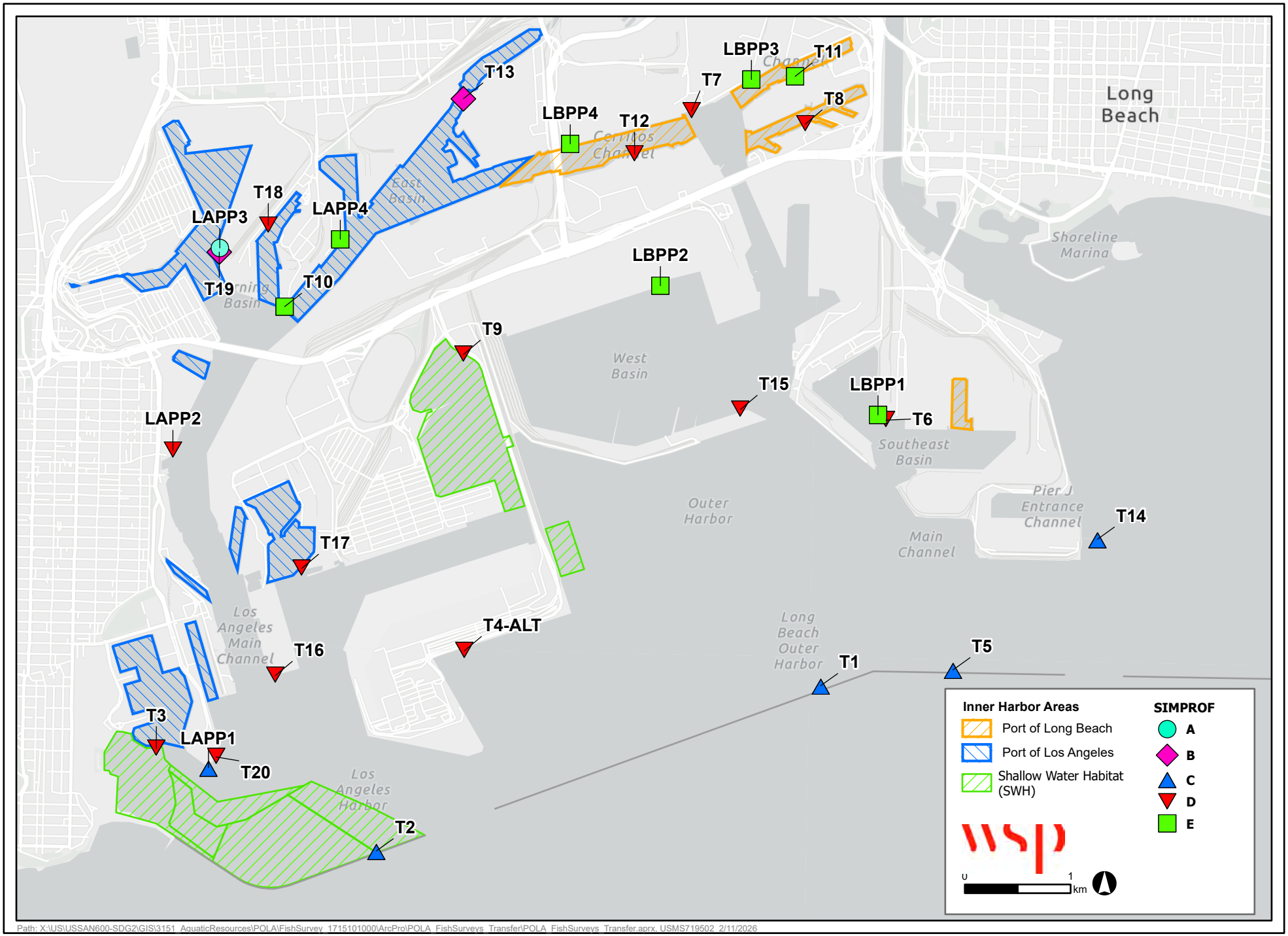


Figure 5-49. nMDS Plot of Fish Density by Substrate and Habitat



The scale reflects abundance data that have been transformed and normalized

Figure 5-50. Shade Plot of Fish Density by Station for Habitat and Substrate Combined Across Spring and Summer



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5.5 DISCUSSION

The 2023 Biosurvey used survey methodologies that were newly introduced in 2018 to quantify the algal, invertebrate, and fish communities on riprap and pilings within the Port Complex. The piling stations added in 2018 allowed for a more robust comparison between the riprap and piling substrates. Fish in these habitats have been inconsistently documented in past Biosurveys, but the results of the 2018 and 2023 Biosurveys indicate that fish rely on these habitats for shelter and foraging opportunities. The 2023 Biosurvey featured enhanced qualitative monitoring that integrated the whole community, including, for the first time, estimates of fish density on riprap and pilings. Although comparability with historical surveys is important and is maintained as much as possible, the 2018 and 2023 Biosurvey methodology provides a strong baseline moving forward for better assessing hard-substrate-associated communities and for detecting how they may change over time.

5.5.1 KELP CANOPY AND KELP HABITAT

Based on recommendations from the 2018 Biosurvey Report regarding the mismatch of kelp canopy derived from aerial imagery and diver surveys, the Port Complex has made considerable effort to incorporate remote sensing into kelp canopy monitoring within the Port Complex (Wood, 2021; WSP, 2023, 2024, 2025). Kelp canopy observations by dive teams aligned well with the presence of kelp canopy identified in the satellite imagery, providing confidence in this methodology for future Biosurveys. These efforts have also provided historical comparisons dating back to 2018 and have established nearby kelp canopy reference areas outside the Port Complex to provide additional regional context for observed trends in kelp canopy.

Summer and spring are the peak seasons for kelp recruitment and growth, as indicated by the comparisons of seasonal acreage totals and the temperature versus kelp biomass index trends for nearby natural reefs off Palos Verdes. Coupling kelp canopy and water quality parameters (i.e., temperature, turbidity, water clarity, and chlorophyll-a) in the remote sensing approach allowed for further exploration of the physical environmental factors that can affect kelp canopy distribution in the Port Complex (see Sections 2.3 and 2.4).

The historical kelp canopy frequency shows that kelp canopy is most common along the breakwaters and on Outer Harbor riprap along the piers, channels, and basins that receive enough tidal exchange and wave energy (from offshore swell, wind swell, and boat wakes) to promote kelp growth. Occasional recruitment farther inshore has been observed, such as at station T7 (Port of Long Beach Inner Harbor Turning Basin) in 2023, where one individual was observed in the summer; however, results for the frequency analysis indicate that kelp does not persist in these areas.

Diver surveys provide additional insight into how kelp grows on structures around the Port Complex. In the areas where kelp canopy is most persistent, the diver surveys indicate high densities of kelp recruits and high densities of adult kelp individuals that provide complex habitats for fish, invertebrates, birds, and marine mammals. The breakwater and Outer Harbor areas with the most wave action also had high densities of feather boa kelp that contributes to the canopy that grows in proximity to the riprap. The revised methods for swath surveys in 2023 were more successful in quantifying this species compared with the 2018 surveys, in which feather boa kelp was noted across these habitats, but the target depths of the swath surveys were too deep to include the intertidal zone where feather boa kelp is present.

A notable finding from adding a modified swath survey for piling habitats in 2023 was that giant kelp was present at all four Outer Harbor piling stations, including station T16 (Port of Los Angeles Main Channel) and station LBPP2 (Port of Long Beach Pier T). Although kelp has been observed on piles in past surveys, the 2023 Biosurvey was the first to quantify it as part of the survey protocol. Kelp that grows on pilings has not been captured in past aerial imagery or satellite imagery because the canopy often does not extend far enough from the edge of the shoreline or pier to be visible to the sensors, and often the shoreline is masked during analysis of the satellite imagery to eliminate edge interference.

Edge interference is also relevant in areas where piers extend away from the riprap where kelp might be present, such as kelp observed in 2023 near Cabrillo Marina at Berth 46 that did not appear in the satellite imagery. This observation reinforces that satellite imagery and dive surveys are complementary and are best used in tandem to understand kelp dynamics in the Port Complex. It also indicates that some areas with more complex infrastructure may have kelp

frequency underestimated using remote sensing methods; in such areas, divers may be necessary to evaluate kelp frequency and dynamics.

5.5.2 HARD SUBSTRATE INVERTEBRATE AND MACROALGAL COMMUNITIES

One of the most readily apparent breaks in community structure is at riprap stations that have giant kelp present compared with those that do not. This difference is likely driven primarily by physical factors such as available substrate, water movement from tidal and wave action, and temperature variability from Outer Harbor to Inner Harbor areas (see Section 2). The breakwaters and Outer Harbor riprap walls can be grouped together as those that support giant kelp, and channels, basins, slips, and Inner Harbor areas can be grouped together as areas that do not support giant kelp.

The breakwaters and Outer Harbor riprap walls are a unique structural feature in the Port Complex because they are constructed with large boulders (boulders >1 meter were defined as "reef" in the Biosurvey) that provide both substantial surface area for algal and invertebrate recruitment and substantial interstitial space that helps capture drift algae, provides refuge from predators, and is habitat for invertebrates such as brittle stars, urchins, juvenile abalone, and fishes (Schiel and Foster, 2015). The presence of giant kelp that reaches from the bottom to form a canopy at or near the surface also creates a vertical structure in the water column, allowing for protection and thus positively affecting the abundance of fish and marine mammals (Arkema et al., 2009). The diversity of habitats resulting from variations in rock type, topography, and the structural complexity of large benthic organisms (e.g., kelp holdfasts, gorgonians, etc.) within a kelp forest has been shown to be arguably the most important contributor to local species diversity and abundance (Alexander et al., 2009). The interstitial space in the breakwaters is also key in helping promote wave-driven water movement, which provides high-energy environments that are favorable to algal recruitment, especially for canopy-forming species such as the feather boa kelp found almost exclusively on the breakwaters.

The high-relief boulder habitat in the Port Complex is more similar to the reefs around the Channel Islands than to the shelf-like, low-relief rocky reefs found along the mainland coast (Pondella et al., 2015). The boulders are covered by high densities of fleshy red algae, crustose coralline algae, barnacles, mussels, bryozoans, and tubeworms. These habitats support diverse invertebrate communities that include filter-feeding gorgonians, large predators such as lobsters, and grazers such as urchins and abalone, which rely primarily on detritus in the form of detached or dying algae that floats to the bottom as the base of the food chain.

Results of studies of kelp forests in central California indicate that as much as 70% of kelp primary production becomes detritus that is consumed by numerous species that range from small crustaceans to larger herbivores within the kelp forest. However, some can drift into nearby soft-bottom habitats and provide particulate organic matter for epibenthic and infaunal invertebrates and nearby filter feeders (Schiel and Foster, 2015), thereby increasing secondary production in those habitats (Krumhansl and Scheibling, 2012). Drifting giant kelp was observed being consumed by various species at Inner Harbor stations throughout the Port Complex, indicating connectivity between Outer Harbor kelp forests and Inner Harbor benthic communities. Drift kelp may also be supporting organisms at stations such as T4-ALT (Outer East Pier 400) where high densities of urchins were observed despite the absence of all macroalgae. The expansion of eelgrass habitat at the Port Complex since 2018, including to some riprap stations surveyed by divers in 2023, also means increased foraging habitat and shelter for animals that are common in the Inner Harbor, and eelgrass detritus also likely plays an important role in fueling nearby benthic communities.

Channel, basin, and slip habitats were generally grouped together in swath and UPC analyses because these stations had no canopy-forming algae present; instead, the algal community was dominated by non-native *Sargassum*, which seasonally grows in very high densities and forms a pseudo-canopy at shallow stations. *Sargassum*, especially *S. muticum*, was observed at lower densities in 2023 compared with 2018. Accordingly, the patterns of abundance and distribution across the Port Complex could be better understood through future monitoring to understand interannual and seasonal dynamics and their impact on local species The riprap substrate in these habitats generally consists of smaller boulders and cobbles with higher percentages of gravel and sand compared with substrate at Outer Harbor stations. These habitats experience less wave energy, and some areas show sedimentation that blankets the rocky substrate, resulting in loss of available habitat for colonization by algae and sessile invertebrates. This higher level of sedimentation is likely the result of inputs of suspended sediments from storm drains and the Dominguez Channel that settle because of the lower wave energy (depositional) environment of the Inner Harbor. Sediments that are resuspended from the seafloor from vessel activity, such as the propellers of tugboats, can also be redistributed onto

riprap habitats. However, the sedimentation on the riprap also provides available habitat for eelgrass recruitment and the eelgrass habitat expansion that was observed at Inner Harbor riprap stations in 2023 compared with 2018, especially at station T13 (South of Consolidated Slip) and station T19 (Port of Los Angeles West Basin South). The presence of eelgrass in those areas changed the complexion of the nearby fish and invertebrate communities that were observed by divers and collected using trawls in 2023, with more perch (shiner perch and black perch) especially abundant.

Across the Port Complex, low intertidal and subtidal zones with exposed rocky substrate are generally covered with articulated coralline algae, snails such as wavy top (*Megastrea undosa*) and Kellet's whelks (*Kelletia kelletii*), warty sea cucumbers (*Apostichopus parvimensis*), and bat stars (*Patiria miniata*). At stations with more microhabitats due to larger boulders, interstitial spaces supported predators such as spiny lobsters (*Panulirus interruptus*) and horn sharks (*Heterodontus francisci*). Both swath and UPC surveys, which target the larger invertebrate and algal species that are readily visible without a microscope, generally indicated little variation among the communities at channel, basin, and slip stations. Results of swath surveys on pilings generally indicated that large gorgonians and rock scallops were dominant across all stations, but sea stars, urchins, and other large mobile invertebrates were less common. The high densities of these filter feeding species, along with the high densities of mussels, barnacles, and other filter feeding invertebrates, may be in part responsible for the improving water clarity in the Port Complex (Firth et al., 2024) that has likely contributed to the increased distribution of eelgrass.

Quadrat scrapings, which assess the smaller invertebrates and algae species, indicated that the community varies by substrate (pilings versus riprap), habitat (Inner Harbor and Outer Harbor), and tidal elevations with the greatest differences observed on riprap. Communities attached to the pilings looked similar across the Port Complex, with Outer Harbor pilings different in that they grew giant kelp that attracted more fish. The patterns observed in the 2023 surveys were consistent with those in 2018 with respect to species richness, abundance, and diversity across habitats and tidal elevations. Notably, at the four locations where riprap stations were in proximity to piling stations with quadrats taken at the same tidal elevations, none of the piling and riprap stations clustered together in the statistical analyses, highlighting the unique biological communities found on each substrate type regardless of location within the harbor.

5.5.3 FISH COMMUNITIES

The presence and density of fish on riprap and piling stations were comprehensively assessed for the first time in 2023, and the results of those surveys build on the initial observations of fish occurrences from the 2018 Biosurvey. As with fish in soft-bottom and pelagic habitats, some species, such as bass and perch, showed seasonal variability in abundance and size class, and others, such as horn sharks, garibaldi, round rays and rock wrasse, were consistent across seasons. There were significant differences in the fish communities at riprap versus piling stations, likely due to the differences in foraging opportunities and available shelter between riprap and pilings. Piling stations supported higher abundances of pelagic species, such as blacksmith, jacksmelt, halfmoons, and juvenile smelt than riprap stations did. Riprap stations differed in their fish community composition at Inner Harbor versus Outer Harbor habitats, likely in part due to increased complexity and availability of microhabitats in the Outer Harbor compared with riprap in the Inner Harbor that may be partially or entirely buried under sediment and have smaller boulders and cobble as the base. Although these features eliminate habitat complexity, they do provide the opportunity for eelgrass to grow. Eelgrass in turn supports a unique fish community, as observed in the Biosurvey, with increased presence of perch and round rays at these stations that feed on small invertebrates in the eelgrass beds.

The Outer Harbor and breakwater areas support the highest diversity of fishes on riprap, with species such as zebra perch, garibaldi, sheephead, señorita, and blacksmith commonly observed in nearby coastal kelp forests. These results are consistent with those of a study of a narrow kelp bed along the San Pedro Breakwater nearly 40 years ago (MEC, 1988), which found the most abundant species to be blacksmith, three species of surfperches, señorita, and kelp bass, and documented abundant populations of sheephead, garibaldi, and zebra perch. The MEC study also indicated that, on the basis of size distributions of fish on forested and unforested breakwater, the kelp bed served as nursery habitat for a number of the abundant fish species by providing refuge and small-sized prey. Fish surveys on shallow (<17-meter depth) oil platforms on the San Pedro shelf from 2006 to 2008 identified 28 species, with 19 species in common with those observed during the 2023 Biosurvey associated with pilings and riprap (Martin and Lowe, 2010), indicating that many of these species may use shallow, structured habitats regardless of the substrate. The same study

found that the top 25 meters of the structure contained 95% of total fish density and 77% of total fish biomass across shallow and deep oil platforms, affirming the value of shallow, structured habitats on the San Pedro shelf.

The fish assemblage associated with pilings was not as diverse as that on riprap, but this result may be at least partly due to the sampling effort on each habitat; there were more than twice as many riprap stations as piling stations, and divers surveyed pilings only in the summer. Size class analysis results indicated that large adult barred sand bass were more common on pilings than on riprap, although both pilings and riprap had larger percentages of mature adult fish than soft-bottom habitats did. Adult kelp bass were commonly observed at riprap and piling stations, although the adult kelp bass were more common at riprap stations with high densities of kelp compared with unforested stations. The prevalence of kelp bass using mid-water areas and barred sand bass and surf perches primarily using benthic habitats was also observed in shallow (<21 meters) oil platforms on the San Pedro shelf (Martin and Lowe, 2010). Results of studies of kelp bass tagged and tracked within a marine reserve at Catalina Island indicated that the largest kelp bass used under-pier habitats almost exclusively during the day and foraged along riprap covered slopes at night (Lowe et al., 2003). These fish also had smaller home ranges compared with smaller kelp bass that used sparse kelp canopy for cover around sand/mud habitat. This pattern is thought to be due in part to the refuge from predators and presence of schooling baitfish near the pier, which provided a high-quality habitat that the larger fish defended from other kelp bass. This finding indicates that the high occurrence of kelp bass, barred sand bass, and surfperches (among others) within the Port Complex associated with pilings and riprap may represent positive habitat selection due to refuge from predators and increased foraging opportunities.

5.5.4 NON-NATIVE SPECIES

During the 2023 Biosurvey, 41 non-native invertebrate and algae species collected in quadrat scrapings quantified the density of and percent cover of three non-native algae (*Sargassum horneri, S. muticum,* and *Undaria*). The non-native chameleon goby (*Tridentiger trigonocephalus*) was documented by dive surveys for the first time in 2023.

Across all Biosurveys, 55 non-native species have been cataloged on hard substrates using quadrat scrapings (Table 5-11). During the 2023 Biosurvey, 41 species were collected on riprap and pilings combined (7.09% of all species in quadrat scrapings), which was very similar to the relative abundance of non-natives in the 2018 Biosurvey (6.31%) and higher than that in the previous Biosurveys (Table 5-11). The next highest percentage of non-native species was 3.41% in 2013, although previous Biosurveys had only one piling station. Of the 41 non-native species on both substrates, 15 were collected for the first time in 2023, driven primarily by 5 new chordate (tunicate) species. It is unlikely that these results reflect an actual dramatic increase in non-native species in the Port Complex that did not previously exist. Instead, the results are most likely due to the increased effort that began in 2018 to sample more concrete pilings, which represent a very different habitat than riprap, and favor different communities. Three of the species observed for the first time in 2023 on hard substrates were identified only on riprap, all of them annelids (*Amblyosyllis nigrolineata, Proceraea okadai,* and *Parasabella fullo*). Only one of the new species was identified only on pier pilings, the amphipod *Jassa marmorata*. The other 11 new species were identified on both riprap and pier pilings.

During the 2023 Biosurvey, two non-native algae species and 37 non-native invertebrate species were identified at riprap stations, and 35 non-native invertebrate species were identified on pilings (Table 5-12). Non-native species were more abundant at riprap stations (2,115) than at piling stations (1,396). The difference in abundance was driven primarily by *Caprella simia* (810 on riprap and 435 on pilings) and *Mytilus galloprovincialis* (930 on riprap and 599 on pilings). The tunicate *Ciona robusta*, the amphipods *Aoroides secunda* and *Grandidierella japonica,* and the annelid *Pseudopolydora paucibranchiata* were among the few non-native species that were more abundant at piling stations than at riprap stations. The addition of piling stations for the 2018 and 2023 Biosurveys highlights the importance of sampling different substrates, given that physical conditions, predation, and grazing pressure may influence the presence of different non-native species

The non-native chameleon goby (*Tridentiger trigonocephalus*) was identified at five Inner Harbor riprap stations (T10 – East Basin Channel Entrance, T12 – Cerritos Channel, T13 – South of Consolidated Slip, T18 – Slip 1, and T19 – Port of Long Beach West Basin South) and was counted on transect at two of them (stations T12 and T18) during the summer surveys. These species were observed in relatively low abundance (2.5 to 7.5 individuals/100 m^2) in the upper subtidal zones at those stations. Although this is the first confirmed sighting of this species since 2013 when individuals were captured in trawls, the larvae of these species were likely detected in 2018 but were identified only to genus (*Tridentiger* sp.).

Table 5-11. Non-Native Species Collected in Quadrat Scrapings Across Biosurvey Years

Phyla	Species Name	2000	2008	2013	2018	2023
Annelida	*Amblyosyllis nigrolineata*					X
Annelida	*Branchiomma bairdi*				X	X
Annelida	*Hydroides elegans*			X	X	
Annelida	*Megasyllis nipponica*				X	X
Annelida	*Parasabella fullo*					X
Annelida	*Polydora cornuta*	X				
Annelida	*Proceraea okadai*					X
Annelida	*Pseudopolydora paucibranchiata*	X		X	X	X
Arthropoda	*Amphibalanus amphitrite*		X		X	X
Arthropoda	*Ampithoe longimana*					X
Arthropoda	*Amphibalanus improvisus*		X			
Arthropoda	*Aoroides secunda*					X
Arthropoda	*Caprella drepanochir*				X	
Arthropoda	*Caprella mutica*				X	X
Arthropoda	*Caprella scaura*			X		
Arthropoda	*Caprella simia*		X		X	X
Arthropoda	*Grandidierella japonica*		X	X	X	X
Arthropoda	*Jassa marmorata*					X
Arthropoda	*Leucothoe nagatai*			X	X	X
Arthropoda	*Monocorophium acherusicum*		X	X		X
Arthropoda	*Monocorophium insidiosum*	X			X	X
Arthropoda	*Monocorophium uenoi*					X
Arthropoda	*Paranthura japonica*				X	X
Bryozoa	*Anguinella palmata*				X	X
Bryozoa	*Cryptosula pallasiana*				X	X
Bryozoa	*Watersipora arcuata*			X		
Chordata	*Ascidia zara*				X	X
Chordata	*Ascidiella aspersa*					X
Chordata	*Botrylloides diegensis*					X
Chordata	*Botrylloides violaceus*				X	X
Chordata	*Botryllus schlosseri*				X	X
Chordata	*Ciona robusta*				X	X
Chordata	*Ciona savignyi*				X	X
Chordata	*Didemnum vexillum*				X	
Chordata	*Diplosoma listerianum*					X
Chordata	*Microcosmus squamiger*				X	X
Chordata	*Molgula ficus*				X	X
Chordata	*Molgula manhattensis*					X
Chordata	*Polyandrocarpa zorritensis*				X	X
Chordata	*Styela canopus*					X

Table 5-11. Non-Native Species Collected in Quadrat Scrapings Across Biosurvey Years (continued)

Phyla	Species Name	2000	2008	2013	2018	2023
Chordata	*Styela clava*			X	X	X
Chordata	*Styela plicata*				X	X
Chordata	*Symplegma reptans*				X	
Mollusca	*Arcuatula senhousia*					X
Mollusca	*Crassostrea gigas*	X		X		
Mollusca	*Crassostrea virginica*		X			
Mollusca	*Crepidula convexa*				X	
Mollusca	*Magallana gigas*					X
Mollusca	*Mytilus galloprovincialis*	X	X	X	X	X
Mollusca	*Philine auriformis*				X	
Mollusca	*Theora lubrica*			X	X	
Mollusca	*Venerupis philippinarum*			X		
Ochrophyta	*Caulacanthus okamurae*					X
Ochrophyta	*Sargassum horneri*				X	X
Ochrophyta	*Sargassum muticum*				X	X
Total Number of Non-Native Species		**5**	**7**	**12**	**32**	**41**
Total Number of Species		**238**	**211**	**352**	**507**	**578**
% Non-Native Species		**2.10**	**3.32**	**3.41**	**6.31**	**7.09**

The 2023 and 2018 Biosurveys include riprap and piling stations.

Table 5-12. Non-native Species Average Abundance from Quadrat Sampling at 2023 Riprap and Piling Stations

Phylum	Species	Piling	Riprap
Annelida	*Amblyosyllis nigrolineata*	0	1
Annelida	*Megasyllis nipponica*	37	66.5
Annelida	*Proceraea okadai*	0	0.5
Annelida	*Branchiomma bairdi*	0.5	3.5
Annelida	*Parasabella fullo*	0	1.5
Annelida	*Pseudopolydora paucibranchiata*	16	1.5
Arthropoda	*Amphibalanus amphitrite*	0.5	0
Arthropoda	*Ampithoe longimana*	1	3
Arthropoda	*Aoroides secunda*	97	81.5
Arthropoda	*Grandidierella japonica*	13.5	2.5
Arthropoda	*Caprella mutica*	6.5	7
Arthropoda	*Caprella simia*	435	810
Arthropoda	*Monocorophium acherusicum*	2	0.5
Arthropoda	*Monocorophium insidiosum*	7.5	12.5
Arthropoda	*Monocorophium uenoi*	15	0.5
Arthropoda	*Jassa marmorata*	2	0
Arthropoda	*Leucothoe nagatai*	14.5	6.5
Arthropoda	*Paranthura japonica*	26.5	15
Bryozoa	*Cryptosula pallasiana*	2.5	3
Bryozoa	*Anguinella palmata*	0.5	2
Chordata	*Diplosoma listerianum*	2.5	4
Chordata	*Ascidia zara*	2	2.5
Chordata	*Ascidiella aspersa*	32	37.5
Chordata	*Ciona robusta*	27.5	21.5
Chordata	*Ciona savignyi*	18.5	45
Chordata	*Molgula ficus*	1.5	2.5
Chordata	*Molgula manhattensis*	0.5	1
Chordata	*Microcosmus squamiger*	7	18.5
Chordata	*Botrylloides diegensis*	1.5	0.5
Chordata	*Botrylloides violaceus*	0.5	0.5
Chordata	*Botryllus schlosseri*	1.5	3
Chordata	*Polyandrocarpa zorritensis*	0	1
Chordata	*Styela canopus*	2	2.5
Chordata	*Styela clava*	8	2.5
Chordata	*Styela plicata*	7	6
Heterokontophyta	*Sargassum horneri*	0	5.95
Heterokontophyta	*Sargassum muticum*	0	0.9
Mollusca	*Arcuatula senhousia*	0.5	0.5
Mollusca	*Mytilus galloprovincialis*	599	930
Mollusca	*Magallana gigas*	6.5	7
Rhodophyta	*Caulacanthus okamurae*	0.1	4.25
Total Abundance		**1,396**	**2,115**

Although the number of non-native species has increased in the past 23 years, it appears that the increase is likely related to an overall increase in species richness related to additional sampling effort. As shown in the species saturation curve using all quadrat scrapings across piling and riprap stations (Figure 5-52), even with the 96 samples collected, the number of total species does not reach a saturation point. In the 2000 Biosurvey of riprap epifaunal communities, 5 non-native invertebrate species of 238 total (2.10%) were collected, and that number has increased in subsequent surveys. In the 2023 Biosurvey, 41 non-native species of 578 total species (7.09%) were identified , a substantial increase from 2000, but a similar percentage compared with the 2018 Biosurvey, during which 32 non-native species were identified, for a total species richness of 507 (6.31%).

A 2011 study by CDFW (2014) targeting non-native species was designed to use quadrat scrapings to sample artificial structures and paired Van Veen grabs to sample benthic infauna at 18 harbors throughout California, including 8 stations in the Port Complex, using methods similar to those used to sample the same communities in the 2023 Biosurvey. The results indicated 665 taxa within the Port Complex, 57 of which were non-native species (8.4% of all species), the highest number of non-natives in any harbor surveyed. Mission Bay and San Diego Bay were tied for second most non-native species with 53 each, representing 11.1% and 12.0% of all species, respectively. The Port Complex ranked 9th of the 13 Southern California harbors studied in terms of the proportion of non-native species, with the highest proportion of non-native species in San Diego Bay; Avalon Harbor had the lowest proportion of non-native species (4.5%).

A major concern regarding the introduction of non-native species is that they will displace native species, eventually becoming dominant and altering the function of these habitats. Considering the relative abundance of non-native species on riprap, results for abundance during the 2023 Biosurvey (7.5%) were very similar to those in 2018 (8.1%), 2000 (7.5%) and 2008 (6.1%), and were lower than those in 2013 (15%), which had a high abundance (1,543) of the tube-building amphipod *Monocorophium acherusicum*. Although no historical data are available for harbor-wide pilings before 2018, the results for the 2018 and 2023 Biosurveys indicated similar relative abundance of non-native species on pilings (8.9% and 7.5%, respectively). Therefore, it does not appear that non-native species are displacing native species because overall diversity has been increasing without a subsequent increase in non-native species relative abundance.

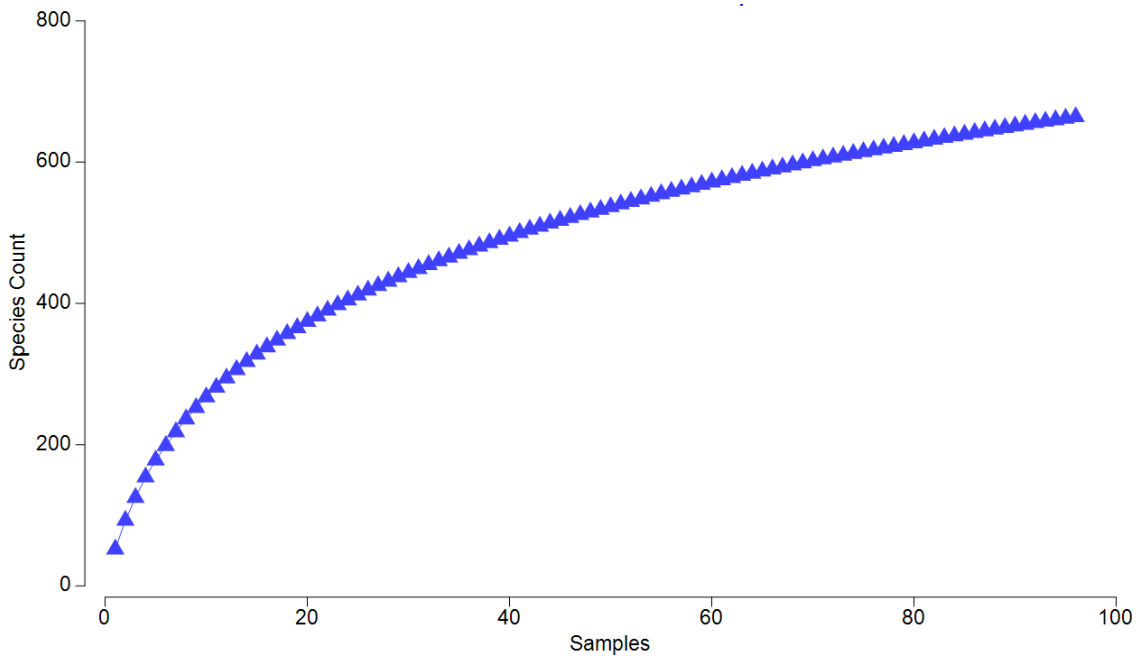


Figure 5-52. Species Saturation Curve from All Quadrat Samples Across Riprap and Piling Stations – Summer 2023

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6 BIRDS

The Port Complex features an assortment of habitats that provide shelter, foraging, and nesting opportunities for a wide variety of avian species, including waterfowl, shorebirds, gulls, aerial fish foragers, upland birds, and raptors. This section presents the results of general avian surveys conducted from 2023 to 2024 within the Port Complex, which used methodologies and survey intervals similar to those used in previous Biosurveys to assess abundance, composition, and habitat usage of avifauna (MEC, 2002; SAIC, 2010; MBC, 2016; Wood, 2021).

Surveys of birds in the Port Complex were conducted once per month from April 2023 through April 2024[1] (Appendix A lists survey dates and conditions). Each survey was conducted on two consecutive days, commencing in the morning and continuing until the survey was completed, typically in the afternoon.

Consistent with previous Biosurveys, the 2023 Biosurvey evaluated birds through a concept called "guilds." Birds that exploit the same set of resources in a similar manner are grouped in the same guild, regardless of their taxonomic relationship with each other. Grouping birds by guilds helps illustrate patterns of habitat usage within the Port Complex, simplifies data management, and allows for direct comparisons across different physical features of the Port Complex. Accordingly, all plunge-diving birds, such as terns and pelicans, were grouped in the Aerial Fish Forager guild; ducks and similar swimming birds, such as grebes, cormorants, loons, and coots, were grouped in the Waterfowl guild; and birds that forage along the shoreline were grouped into the Shorebird guilds (large and small). The Upland guild contained all passerine birds and other species, such as hummingbirds and woodpeckers; Raptors included all birds of prey, including osprey (*Pandion haliaetus*) and vultures. Appendix F lists the species in each guild.

6.1 SURVEY ZONES AND PHYSICAL FEATURES

The Biosurvey area was divided into 31 broad survey zones (Figure 6-1). The major zones and their boundaries were identical to those used during the Biosurveys from 2000 to the present with some minor exceptions discussed in this section (MEC, 2002; SAIC, 2010; MBC, 2016; Wood, 2021). Survey zones were numbered from 1 through 15 and from 19 through 34; the gap in the numbering sequence (16 through 18) reflects changes in Port Complex development, including the Pier 400 landfill and Pier J expansion (MEC, 2002). To better quantify bird usage, for the 2013 Biosurvey, some of the larger survey zones (Zones 1, 2, 3, 4, 8, 10, 22, 24, 25, 26, 27, 31, and 34) were further divided into smaller subzones. For example, Zones 1 and 3 were subdivided (Zones 1a–1b and 3a–3d, respectively) to obtain more detail in large, shallow-water habitats; several marinas and small slips were added as subzones; and several other zones were subdivided to allow for the separation of Inner Harbor and Outer Harbor areas. After the 2013 Biosurvey period, Zones 24c and 24d were filled as part of the Port of Long Beach Middle Harbor Redevelopment Project. These changes resulted in 54 total zones and subzones (Table 6-1). During the 2018 Biosurvey, active filling and construction in Zone 24a resulted in the conversion of the eastern portion of the zone from open-water habitat to hard structures, including pier pilings, containers, and occasionally docked ships. Zone 24a was not removed entirely; it was changed to cover an area with approximately 4 acres less open water but a similar shoreline length.

As with the previous Biosurveys, avian habitat usage in each zone was examined by recording the physical features of observed birds and the corresponding bird activities while using that feature. Birds use the features within each zone to fulfill a variety of needs, from resting and nesting on Port Complex structures, such as buildings, boats, and docks/pilings, to foraging in open-water and shoreline (sandy beach and shallow water) areas. Although the man-made structures within the Port Complex are not traditional nesting habitat for most species, many birds have adapted to use similar features as a substitute. For example, in natural areas, great blue heron (*Ardea herodias*) and osprey construct large stick nests in sturdy trees (Vennesland and Butler, 2020; Bierregaard et al., 2020), but in the Port Complex, both species use lamp posts to fulfill a similar habitat niche. Similarly, double-crested cormorants (*Nannopterum auritum)* usually nest on cliffs, islands, and/or trees (Dorr et. al., 2021), but within the Port Complex, they have adapted to nest in electrical transmission towers. Perches and roosting sites on open water, such as channel markers, buoys, kelp, or

[1] The March 2024 survey was conducted in April 2024 because of unsafe weather conditions during planned survey periods.

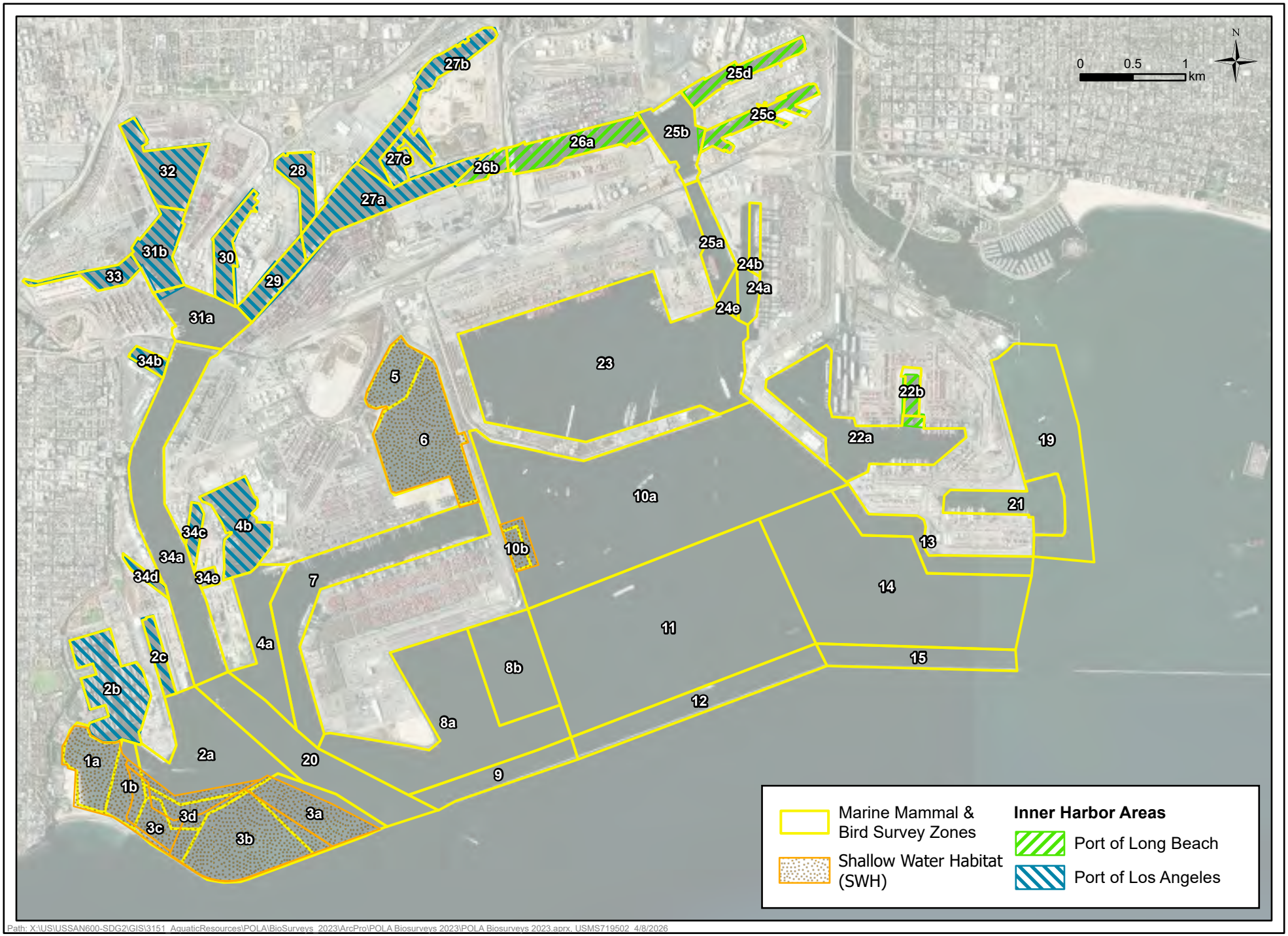
dredge pipes, offer advantages for birds by providing protection from land-based predators and a cooler environment during hot days.

Within the context of the Biosurvey, the physical feature designations involved both natural and man-made elements, including the following 17 types: aerial, anchor line, barge/boat, bridge, building/structure, buoy, dock/piling, dredge pipe, kelp, lamp post, mudflat, open water (>1 foot deep), riprap, sandy beach/intertidal (<1 foot deep), shallow water (<1 foot deep), spill boom, and upland habitat (Appendix A).

Table 6-1. Bird and Marine Mammal Survey Station Groups

Station	Port	Habitat	Location	Station Descriptor	Station	Port	Habitat	Location	Station Descriptor
1a	POLA	SWH	SWH	Cabrillo Beach North and Scout Camp	22a	POLB	Outer	Basin	Southeast Basin
1b	POLA	SWH	SWH	Cabrillo Beach South	22b	POLB	Inner	Slip	Pier G Slip
2a	POLA	Outer	Outer	Bait Barge Area	23	POLB	Outer	Basin	West Basin
2b	POLA	Inner	Basin	Cabrillo Marina	24a	POLB	Outer	Basin	East Basin Pier E-F
2c	POLA	Inner	Slip	East Channel	24b	POLB	Outer	Slip	East Basin Pier E-D
3a	POLA	SWH	SWH	Cabrillo SWH – Phase 2	24e	POLB	Outer	Channel	East Basin Pier D-T
3b	POLA	SWH	SWH	Cabrillo SWH – Phase 1	25a	POLB	Outer	Channel	POLB Back Channel
3c	POLA	SWH	SWH	Cabrillo SWH – Phase 3	25b	POLB	Outer	Basin	Inner Harbor Turning Basin
3d	POLA	SWH	SWH	Cabrillo SWH – Phase 4	25c	POLB	Inner	Slip	Channel 3
4a	POLA	Outer	Outer	Reservation Point East	25d	POLB	Inner	Slip	Channel 2
4b	POLA	Inner	Basin	Fish Harbor	26a	POLB	Inner	Channel	Cerritos Channel
5	POLA	SWH	SWH	Seaplane Lagoon SWH	26b	POLB	Inner	Channel	Cerritos Channel West
6	POLA	SWH	SWH	Pier 300 SWH	27a	POLA	Inner	Basin	East Basin
7	POLA	Outer	Channel	Pier 400 West and Pier 300 Channel	27b	POLA	Inner	Slip	Consolidated Slip
8a	POLA	Outer	Outer	Outer Pier 400 West	27c	POLA	Inner	Slip	East Basin Marinas
8b	POLA	Outer	Outer	Outer Pier 400 East Shallow Water	28	POLA	Inner	Slip	Slip 5
9	POLA	Outer	Breakwater	POLA Middle Breakwater	29	POLA	Inner	Channel	East Basin Channel
10a	POLB	Outer	Outer	Outer Navy Mole	30	POLA	Inner	Slip	Slip 1
10b	POLB	SWH	SWH	POLB SWH	31a	POLA	Outer	Basin	Turning Basin
11	POLB	Outer	Outer	Outer Harbor Anchorages	31b	POLA	Inner	Basin	West Basin South
12	POLB	Outer	Breakwater	POLB West Middle Breakwater	32	POLA	Inner	Basin	West Basin
13	POLB	Outer	Outer	Outer Pier J South	33	POLA	Inner	Slip	Berths 118-120
14	POLB	Outer	Channel	POLB Outer Harbor Main Channel	34a	POLA	Outer	Channel	POLA Main Channel
15	POLB	Outer	Breakwater	POLB East Middle Breakwater	34b	POLA	Inner	Slip	Cruise Center
19	POLB	Outer	Outer	Queensway Bay	34c	POLA	Inner	Slip	Berth 240
20	POLA	Outer	Channel	POLA Outer Main Channel	34d	POLA	Inner	Slip	S.P. Slip
21	POLB	Outer	Slip	Pier J Slip	34e	POLA	Inner	Slip	Slip E

POLA = Port of Los Angeles; POLB = Port of Long Beach; SWH = shallow water habitat



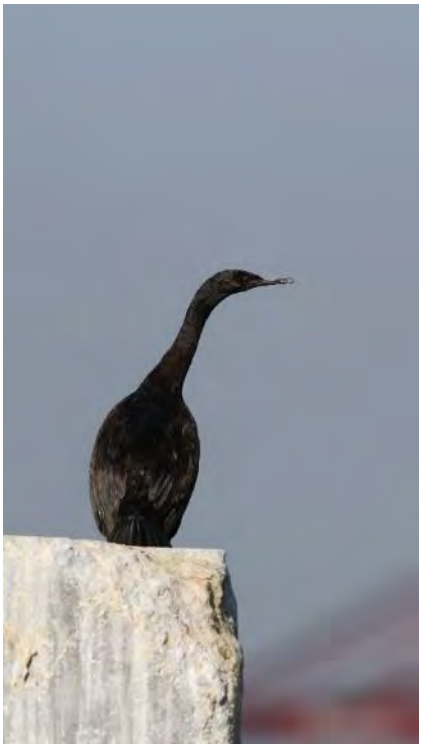
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Figure 6-1. Bird and Marine Mammal Survey Zones

6.2 TOTAL AVIAN AND GUILD ABUNDANCE

A total of 66,447 sightings of individual birds, belonging to 98 species (excluding 4 hybrids) in 33 families, were observed in the Port Complex during the 2023 Biosurvey (Appendix F). Monthly survey totals ranged from a low of 30 species in July 2023 to highs of 61 and 63 species in February and April 2024, respectively (Figure 6-2). Total numbers of individual birds ranged from 3,637 in July 2023 to 8,169 in December 2023, with an overall mean of 5,537 individuals per survey. The abundance of each bird species in the eight ecological guilds and species counts by survey period are provided in Appendix F.

Avian abundance within the Port Complex was highly seasonal, with bird numbers at their peak during migration and winter months and at their lows during the summer (Figure 6-2). Seasonal patterns in the species observed were primarily driven by changing abundances of species in the Waterfowl (grebes, ducks, and cormorants) and Gull guilds, and, to a lesser extent, the Aerial Fish Forager (terns and pelicans) guild (Figure 6-3). Of the 98 bird species observed during the 2023 Biosurvey, 26 species were observed during 10 or more survey months, potentially indicating year-round occupancy or nesting within the Port Complex (Table 6-2). Four additional species were observed during 9 of the 12 of the survey months, also indicating year-round presence. These species include known Port Complex residents such as Eurasian collared dove (*Streptopelia decaocto*), house sparrow (*Passer domesticus*), and peregrine falcon (*Falco peregrinus*). A total of 20 species were observed during only one survey month, indicating rare species that are not typically observed within the area, such as long-tailed duck (*Clangula hyemalis*) and white-winged scoter (*Melanitta deglandi*); an infrequent migratory visitor to the Port Complex, such as redhead shoveler (*Aythya americana*) and northern shoveler (*Spatula clypeata*); or common upland resident species that are infrequently detected using the current survey method, such as finches, warblers, and hummingbirds.



Pelagic cormorant resting on a dock in the Port of Long Beach West Basin (Zone 23)

The patterns of diversity and abundance of avian species in the survey were generally consistent with those during prior surveys within the Port Complex and with the results of regional avifauna studies. A total of 9 of the 10 most abundant avian species belonged to three guilds highly associated with water (Gulls, Aerial Fish Foragers, and Waterfowl); the remaining species, rock pigeon (*Columba livia*), is a species known to be strongly associated with humans and their structures. In the 2023 Biosurvey and the previous Biosurveys, the species was commonly observed throughout the Port Complex on buildings and pilings.

Table 6-2. Monthly Abundance of Birds Observed in at Least 10 Monthly Survey Events April 2023 through April 2024* in All Zones

Common Name	April 2023	May 2024	June 2024	July 2024	August 2024	September 2024	October 2024	November 2024	December 2024	January 2024	February 2024	April 2024	Months in Port
Western Gull	741	840	772	964	1514	1453	2129	2084	2043	1506	999	1083	12
Brandt's Cormorant	1077	2147	926	285	787	556	608	166	749	1257	1519	2736	12
Brown Pelican	130	214	324	1170	535	2100	544	473	272	199	190	213	12
Rock Pigeon	302	218	270	298	584	726	769	705	729	499	531	379	12
Western Grebe	188	64	56	32	45	50	68	480	254	288	575	270	12
California Gull	40	21	2	1	7	25	104	200	466	630	186	108	12
Double-crested Cormorant	95	120	161	151	165	143	191	111	127	166	160	115	12
Heermann's Gull	9	31	18	323	285	269	163	125	131	68	40	74	12
European Starling	11	17	32	42	104	50	67	409	351	38	28	25	12
Great Blue Heron	35	38	47	35	52	73	60	54	39	36	41	45	12
Black Oystercatcher	37	21	30	126	46	38	57	1	2	16	38	32	12
American Crow	22	30	34	13	20	44	34	25	20	20	49	38	12
Common Raven	38	24	21	8	27	11	23	38	18	31	52	57	12
House Finch	34	37	18	13	17	68	15	22	8	20	27	18	12
Snowy Egret	25	8	24	9	11	19	20	12	10	14	12	14	12
Black-crowned Night Heron	3	1	17	3	2	11	4	2	4	3	1	4	12
Osprey	6	2	8	3	2	5	4	3	2	7	7	2	12
Black Phoebe	2	1	5	1	1	1	5	5	5	3	6	1	12
Surf Scoter	163	22	1		2	2	290	1592	2154	1283	1379	653	11
Royal Tern	6		33	10	5	17	67	71	104	49	38	4	11
Eared Grebe	24	4	3		1	5	9	10	12	20	25	7	11
Pelagic Cormorant	3	4	1		5	2	6	12	19	12	12	13	11
Clark's Grebe	3		10	3	2	3	2	9	9	4	7	7	11
Northern Mockingbird	5	4	8	6	4	4	7	1		1	7	5	11
Spotted Sandpiper	14	8			14	21	24	21	26	10	12	6	10
Red-tailed Hawk	3	1	1		1	4	3	5	3	3		2	10

* The March 2024 survey was conducted in April 2024 because of unsafe weather conditions during planned survey period.

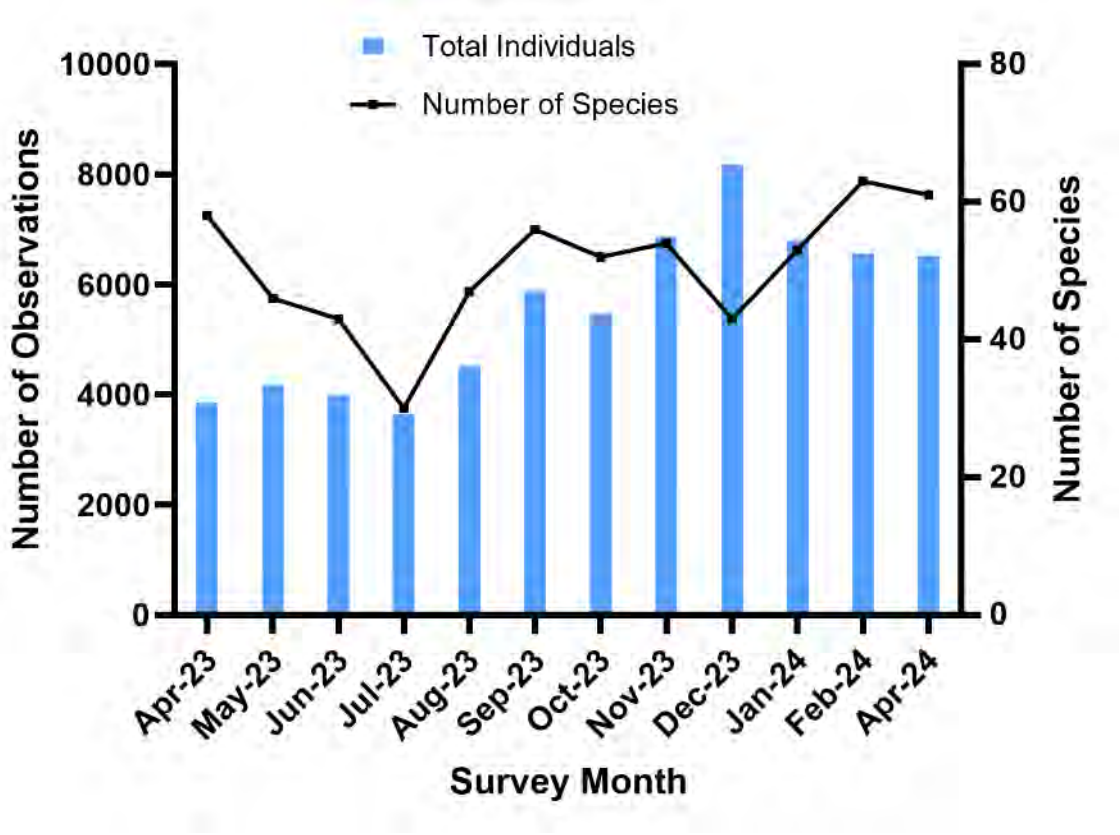


Figure 6-2. Total Avian Abundance and Species Counts by Survey

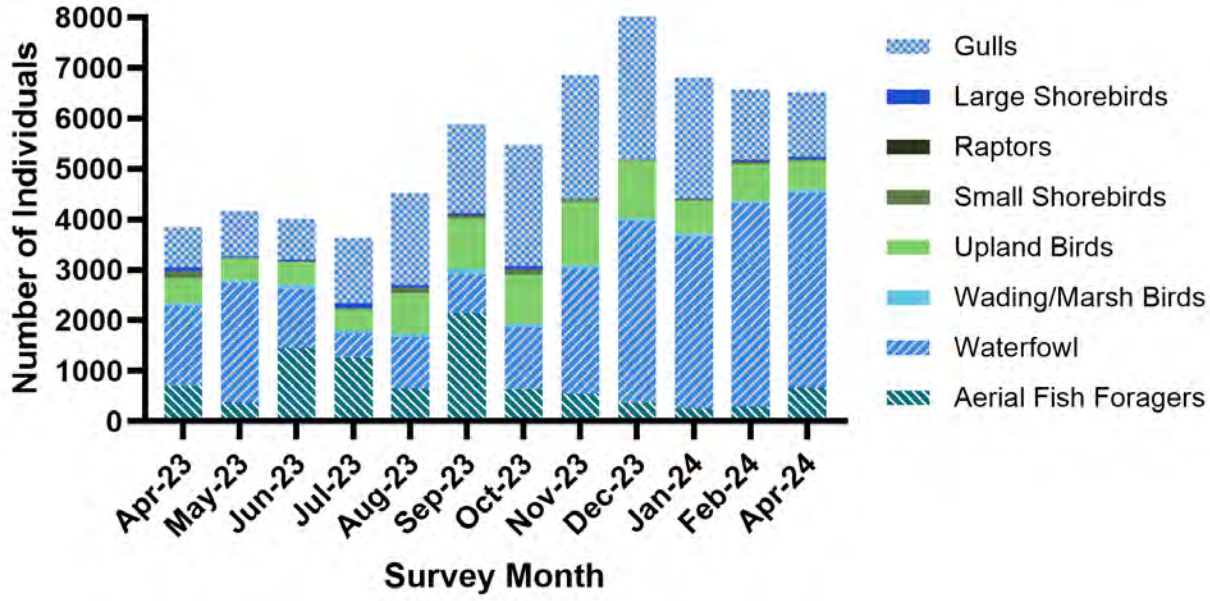


Figure 6-3. Avian Abundance by Guild and Survey Month

Waterfowl was the most abundant guild, making up 39.0% of all birds observed during the survey. Among the 25 Waterfowl species recorded, Brandt's cormorant (*Urile penicillatus*) was dominant, representing 49.5% of all waterfowl sightings, followed by surf scoter (*Melanitta perspicillata*) at 29.1%, western grebe (*Aechmophorus occidentalis*) at 9.1%, and double-crested cormorant (*Nannopterum auritum*) at 6.6%. Together, these four species accounted for 94.3% of all Waterfowl observations. Many Waterfowl species are seasonal; as a result, the guild was most abundant from November 2023 through April 2024 when many migrant species, especially western grebe and surf scoter, joined with the resident Waterfowl of the Port Complex. Small increases in migratory/transient and post-breeding bird species such as bufflehead (*Bucephala albeola*), American coot (*Fulica americana*), lesser scaup (*Aythya affinis*), and eared grebe (*Podiceps nigricollis*) also influenced the seasonal abundance of Waterfowl to some extent. Although some migrant Waterfowl species remained in small numbers year-round, many species (mainly ducks) were completely absent for several months at a time.

A total of 10 species – and two hybrid taxa (glaucous-winged-gull x western gull and glaucous-winged-gull x herring gull) – of gull were observed, accounting for 30.4% of total avian abundance over the 2023 Biosurvey period. Of the 10 Gull species observed, the western gull (*Larus occidentalis*) was by far the most abundant Gull species, accounting for 79.8% of all Gull observations. Western gull, California gull (*Larus californicus*), and Heermann's gull (*Larus heermanni*) together accounted for 96.3% of all Gull observations. Although populations of gulls are high throughout the year in the Port Complex, seasonal patterns were evident (Figure 6-3). Overall, Gull abundance peaked in October 2023 and remained high into January 2024. The western gull was a dominant species during each survey event, but abundances increased notably from August 2023 through January 2024. Heermann's gull was also present year-round but was less abundant from April through June 2023 and January through April 2024. The seasonality of gull populations was driven by the convergence of migratory species (e.g., Heermann's gull, ring-billed gull, and California gull) with the resident populations of adult and recently fledged western gull.

The seven species of Aerial Fish Foragers represented 14.2% of the total abundance. Brown pelican (*Pelecanus occidentalis*) and elegant tern (*Thalasseus elegans*) were the two most common species, accounting for 90.6% of the total observations of all Aerial Fish Foragers (67.3% and 23.3%, respectively). Patterns in the seasonal abundance of Aerial Fish Foragers showed an inverse relationship to those of Waterfowl. Populations peaked during the breeding period (June through September 2023) when the large migrant populations of elegant terns arrived for nesting in the Port Complex, and brown pelicans returned from their offshore nesting colonies on the Channel Islands.

The five remaining avian guilds (Large Shorebirds, Small Shorebirds, Wading/Marsh Birds, Raptors, and Upland birds) accounted for 16.4% of the total abundance during the Biosurvey period. Over 65% of these were two cosmopolitan species in the Upland guild – rock pigeon and European starling (*Sturnus vulgaris*) – both of which were consistently present throughout the Biosurvey period. Other Upland species were mainly incidental sightings of birds flying over the Port Complex, such as American crow (*Corvus brachyrhynchos*) and common raven (*Corvus corax).* The abundance of Wading/Marsh Birds remained relatively constant throughout the Biosurvey period, with only a slight increase during late summer and early fall 2023 because of the nesting success of the great blue heron (*Ardea herodias*). Likewise, Raptors and Large Shorebirds did not exhibit strong seasonal patterns in abundance, primarily because of the year-round presence of osprey and black oystercatcher (*Haematopus bachmani*), which both breed within the Port Complex (MEC, 2002; SAIC, 2010; MBC, 2016; Wood, 2021). Small Shorebirds exhibited slight peaks in abundance during migration and winter months, when species such as spotted sandpiper (*Actitis macularius)*, black turnstone (*Arenaria melanocephala*), surfbird (*Calidris virgate*), and black-bellied plover (*Pluvialis squatarola*) used the Port Complex either on the way to and from their breeding grounds or as a wintering location.

6.3 SPECIES COMPOSITION

6.3.1 ABUNDANT AVIAN SPECIES

The 10 most abundant species accounted for 88.0% of all observations, and the top three species (western gull, Brandt's cormorant, and surf scoter) accounted for over half of total bird abundance (Table 6-3). As a result, the overall abundance of each avian guild was largely driven by large numbers of only a few species.

Table 6-3. Ten Most Abundant Bird Species in the Port Complex, 2023–2024

Species	Total Abundance	Percentage of Total	Guild
Western Gull	16,128	24.3%	Gulls
Brandt's Cormorant	12,813	19.3%	Waterfowl
Surf Scoter	7,541	11.3%	Waterfowl
Brown Pelican	6,364	9.6%	Aeriel Fish Foragers
Rock Pigeon	6,010	9.0%	Upland birds
Western Grebe	2,370	3.6%	Waterfowl
Elegant Tern	2,199	3.3%	Aeriel Fish Foragers
California Gull	1,790	2.7%	Gulls
Double-crested Cormorant	1,705	2.6%	Waterfowl
Heermann's Gull	1,536	2.3%	Gulls
Total	58,456	88.0%	

Although western gulls were present in large numbers year-round, they were most abundant from late summer to early winter. They were observed breeding within the Port Complex, where nests and chicks were identified on Port Complex structures. Later, fledged young were observed foraging and mixing with both migrant and resident gulls. Both Brandt's cormorant and surf scoter were present year-round (surf scoters were not detected in July 2023 but were likely present because individuals were observed during every other Biosurvey month), but neither species nests in the Port Complex. Brandt's cormorant has historically nested in Zone 23 (Port of Long Beach West Basin), most recently observed during the 2008 Biosurvey (SAIC, 2010); however, no nesting attempts have been documented since.

Rock pigeons and brown pelicans were observed in large numbers during every survey event, but only rock pigeons have nested in the Port Complex. Elegant terns are migratory in the Port Complex and were observed only from April through October 2023, remaining completely absent in the other months. Historically, as many as 4,500 elegant terns nested within the Port Complex (Langdon Biological Consulting, LLC [LBC], 2019). Western grebes, although also migratory, were observed during every survey event, with as many as 68 non-breeding individuals oversummering in the Port Complex. The eighth through tenth most abundant species consisted of the California gull, double-crested cormorant, and Heermann's gull. All three of these species were present in the Port Complex year-round, but of these, only the double-crested cormorant is known to breed within the Port Complex.

6.3.2 RARE AND UNCOMMON AVIAN SPECIES

Rare and uncommon sightings during the 2023 Biosurvey included species not typically observed in southern California and species that occur regularly but in low numbers and in specific locations. These species increased overall diversity but contributed little in terms of abundance and had no impact on population densities.



American oystercatcher on the middle breakwater (Zone 12)

Two species classified as rare in the Los Angeles area (CRBC, 2024a; Sullivan et al., 2009; Garrett et al., 2006) were observed during the 2023 Biosurvey: the American oystercatcher (*Haematopus palliatus)* and the yellow-crowned night heron (*Nyctanassa violacea*).

One American oystercatcher was observed foraging and resting on riprap in 5 of the 12 survey months in Zone 15 (Port of Long Beach East Middle Breakwater) and Zone 12 (Port of Long Beach West Middle Breakwater), and once in Zone 19 (Queensway Bay). Although this species occurs with some regularity in coastal northern Baja California, it is still a rare visitor to Southern California. At the northern tip of its range, the American oystercatcher is known to hybridize frequently with the black oystercatcher (Working Group [American Ornithologist] et al., 2020). The bird observed during the 2023 Biosurvey showed little evidence of hybridization (for a southern California bird; validated with photo documentation) and was confirmed as a valid record of an American oystercatcher in California. Photo evidence indicates that this bird may also be the same bird observed during the 2018 Biosurvey (Wood, 2021; B. Stidum, pers. obs.). Also rare, one American x black oystercatcher (hybrid) was observed on August 27, 2023, in Zone 15and on September 27, 2023, in Zone 12.

Four yellow-crowned night herons were documented in September and October 2023 resting on riprap in Zones 12 (Port of Long Beach West Breakwater), 15 (Port of Long Beach East Breakwater), and 4b (Fish Harbor). Historically, yellow-crowned night herons were rare in California, but following successful nesting events in San Diego beginning in 2006, a northward expansion occurred, with birds now regularly documented in Alamitos Bay and the Ballona Wetlands area and as far north as Santa Barbara County (Watts, 2020; CRBC, 2024b).



White-winged scoter observed in the Port of Long Beach West Basin (Zone 23)

Several other uncommon and infrequently encountered species (as defined by the American Birding Association; found in small numbers and typically requiring some effort to locate in appropriate habitat at the right time of year) were documented in the Port Complex, including four observations of short-billed gulls (*Larus brachyrhynchus*) in January and February 2024, a flock of three white-winged scoters on February 24, 2024, in Zone 23 (Port of Long Beach West Basin), two long-tailed ducks in Zone 1a (Cabrillo Beach North and Scout Camp) on January 27, 2024, and two Iceland gulls (*Larus glaucoides*) in Zones 22a (Southeast Basin) and 3a (Cabrillo SWH – Phase 2) on December 10, 2023, and January 27, 2024, respectively. All these species are fairly uncommon but are regular winter migrants to the coastal region of Los Angeles, where they occur seasonally, though usually only in small numbers (Garrett et al., 2006; Sullivan et al., 2009).

Some species observed in 2023 that are considered common in the Los Angeles region but are rarely observed in Port Complex survey efforts because lack of their preferred habitat include ash-throated flycatcher (*Myiarchus cinerascens*), black-necked stilt (*Himantopus mexicanus*), common yellowthroat (*Geothlypis trichas*), western tanager (*Piranga ludoviciana*), snowy plover (*Anarhynchus nivosus*), and rock wren (*Salpinctes obsoletus*).

6.4 SPATIAL VARIATION

As in previous Biosurveys (MEC, 2002; SAIC, 2010; MBC, 2016; Wood, 2021), the avian surveys conducted for the 2023 Biosurvey in 2023–2024 identified spatial variation among survey zones and habitat types.

6.4.1 ABUNDANCE AND SPECIES RICHNESS BY SURVEY ZONE

Certain survey zones supported consistently greater numbers of individual birds or bird species over the 12 monthly surveys. The 10 zones that supported the greatest total numbers of individuals accounted for 53.5% of the 66,447 total observations; seven of those zones include large areas in the Outer Harbor (basins, channels, and breakwaters), two are in SWH Zones 3b and 6, and one is in Inner Harbor Zone 27b (Consolidated Slip) (Figure 6-4). These 10 zones alone comprise slightly less than half (45.1%) of the total Port Complex water area. Zone 14 (Port of Long Beach Outer Harbor Main Channel) supported the highest abundance of birds, with 4,844 individual observations, whereas Zone 34e (Port of Los Angeles Slip E), the smallest survey zone (7.7 acres), had only two birds for the entire Biosurvey period.

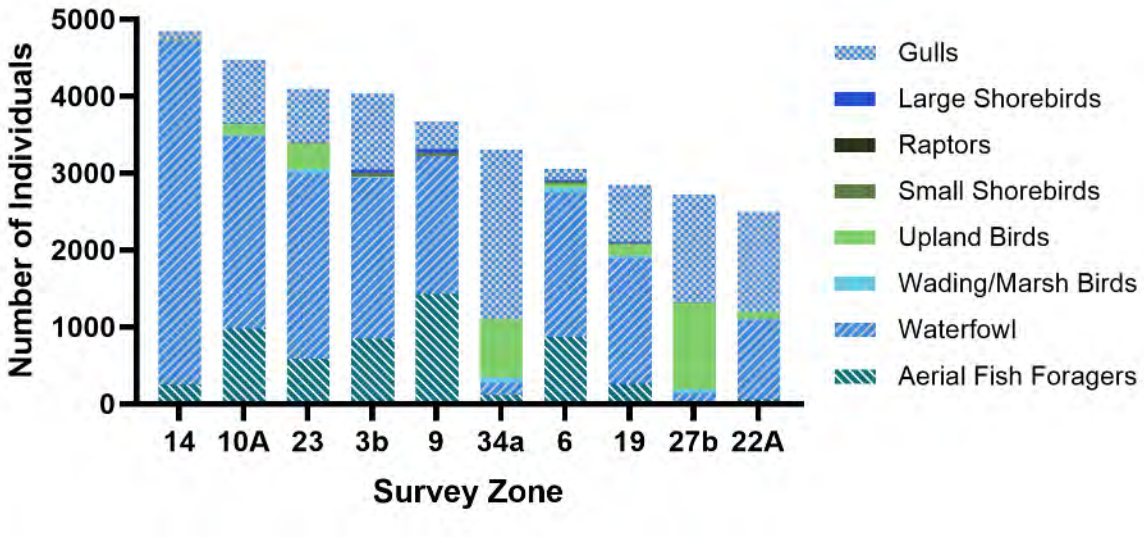


Figure 6-4. Total Abundance of Avian Guilds in the 10 Most Populous Zones During the 2023 Biosurvey

6.4.2 DENSITY BY SURVEY ZONE

Mean avian densities (birds in zone/acre/monthly survey event) for each survey zone are presented in Figure 6-5. Given the high variability in the sizes of the zones (the largest zone [Zone 10a] is 859.2 acres, and the smallest zone [Zone 34e] is 7.7 acres), mean density data provide a better illustration of avian usage over mean abundance alone. Presenting the data as mean densities and total counts for the three most abundant guilds (Waterfowl, Gulls, and Aerial Fish Foragers) within each survey zone (Figures 6-6 through 6-8) offers a more comprehensive view of areas with high avian activity in the Port Complex. This approach provides greater insight than relying on mean abundance alone by effectively highlighting key zones of bird concentrations and activity patterns.

The highest mean bird densities were recorded in Zones 34d (S.P. Slip), 34c (Berth 240), and 2c (East Channel), (7.7, 4.6, and 4.5 birds per acre, respectively (Figure 6-5). These small inner slips of the Los Angeles Main Channel – ranging from 9.7 to 22.0 acres – feature narrow navigation channels bordered by fully developed shorelines (riprap, docks, and pilings) and anthropogenic hard structures (buildings, boats, and buoys). Although small numbers of individuals were observed (an average of 74 to 99 birds per survey), the high densities in these zones were attributed to their smaller sizes (9.7, 16.2, and 22.0 acres for Zones 34d, 34c, and 2c, respectively) relative to the abundance of structures that were heavily used by resting rock pigeons, western gulls, European starlings, and to a lesser extent, double-crested cormorants. The sheltered locations of these zones within the Port Complex, coupled with the presence of commercial fishing vessels (associated with the municipal fish market and a bait barge) and buildings in the area, also likely enhanced their appeal for these birds.

Similar patterns were observed in other slips and basin areas throughout the Port Complex. Additional species such as barn swallows (*Hirundo rustica*) used the open water areas for aerial insect foraging. In Zone 4b (Fish Harbor), large numbers of western gulls scavenged near fishing vessels, and Zone 27b (Consolidated Slip), approximately 1,000 feet from the Potential Industries Recycling Center, attracted significant aggregations of rock pigeons, western gulls, and California gulls.

A total of 18 of the 54 zones had mean densities of greater than one bird per acre; 20 had fewer than 0.5 bird per acre. Zones 8b (Outer Pier 400 East Shallow Water), 20 (Port of Los Angeles Outer Main Channel), and 34e (Slip E) were the least-dense survey areas, with mean densities of fewer than 0.09 bird per acre. Zones 8b and 20 consist primarily of open water, and Zone 34e, a small area with only a narrow strip of riprap habitat, had just two bird observations across the 12-month sampling period.

Of the 10 most populous zones (Figure 6-4), only two (Zones 9 [Port of Los Angeles Middle Breakwater] and 3b [Cabrillo SWH – Phase 1]) also ranked among the 10 zones with the greatest mean density (Figure 6-5). Mean densities in Zones 9 and 3b were driven by large aggregations of gulls, Brandt's cormorants, and brown pelicans. However, Zone 3b, which included the San Pedro Company Bait Barge (Bait Barge) (previously moored in Zone 2a), also had notable rafts of wintering surf scoters, which were absent in Zone 9. In contrast, Zones 34d (S.P. Slip) and 34c (Berth 240) had relatively low total individual bird counts (892 and 888, respectively) but ranked first and second in density (Figure 6-5), indicating that mean avian densities were influenced primarily by the size of the survey zones rather than total avian abundance.

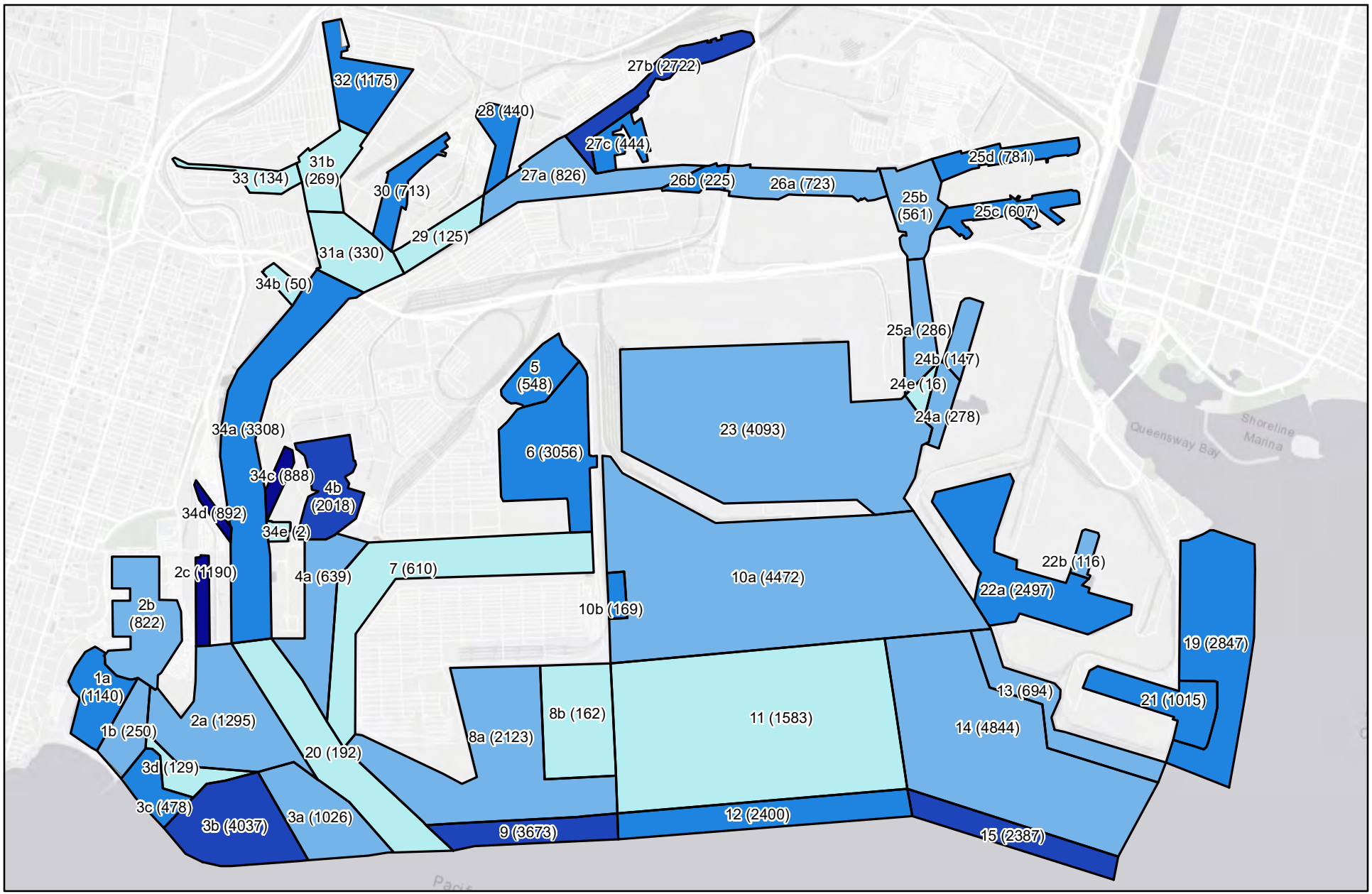


Figure 6-5. Total Mean Avian Density (Per Acre, Color Scale) and Abundance (In Parentheses) by Survey Zone

Total Bird Density - Label = Zone # (Total Count)

N
W
E
S

7.65
0.00

0 0.5 1 2
Kilometers

2023 Biological Survey
Long Beach and Los Angeles Harbors
Port of Long Beach and Port of Los Angeles

6.4.3 PATTERNS OF GUILDS

Waterfowl: Overall, the greatest mean densities of Waterfowl were concentrated around the outer habitats of the Port Complex (Figure 6-6), with the greatest mean densities occurring in Zone 9 (Port of Los Angeles Middle Breakwater) and Zone 3b (Cabrillo Shallow Water Habitat – Phase 1). The riprap in these zones provided communal roosting opportunities for groups of Brandt's cormorants, and the open waters, particularly near the Bait Barge in Zone 3b (previously in Zone 2a prior to the 2023 Biosurvey), held large groups of surf scoters. Zones 15 (Port of Long Beach East Breakwater) and 3c (Cabrillo SWH – Phase 3) also contained stretches of breakwater and were among the top 10 densest survey zones.

Mean densities of Waterfowl were high in Zones 6 (Pier 300 SWH) and 14 (Port of Long Beach Outer Harbor Main Channel) and were driven by large congregations of surf scoters and Brandt's cormorants, along with fewer numbers of lesser scaups, double-crested cormorants, and buffleheads. The highest Waterfowl counts were recorded north and south of the Navy Mole Pier in Zones 14 (Port of Long Beach Outer Harbor Main Channel) and 10a (Outer Navy Mole), with 4,472 and 2,488 total observations, respectively. Although both zones provide large expanses of open water, their usage differed. In Zone 10a, the large moored barges and scows (up to 140 feet long) provided communal roosting locations for large groups of Brandt's cormorants. Zone 14, in contrast, was primarily a transit pathway for these same birds as they moved between their preferred roost in Zone 10a and the nearshore waters outside the Port Complex. This zone alone accounted for 33.4% of the total Brandt's cormorant observations, with up to 2,572 birds (April 7, 2024) recorded flying from Zone 10a through Zone 14.



Herring gull on the riprap along the Port of Long Beach middle breakwater (Zone 12)

Gulls: Zone 34a (Port of Los Angeles Main Channel) had the highest abundance of Gull observations (10.2% of all Gull observations), and Zone 34d (S.P. Slip) had the highest density (Figure 6-7). Other areas of high density and abundance of Gulls were near anthropogenic/opportunistic foraging locations such as the Potential Industries Recycling Center near Zone 27b (Consolidated Slip), Zone 4b (Fish Harbor commercial fishing fleet), and the Bait Barge now in Zone 3b (Cabrillo SWH – Phase 1). Additionally, high Gull activity was observed along the Breakwater (Zones 12 and 15) and among some inner slips and basins (Zones 32 [West Basin] and 2c [East Channel]). Zone 22a (Southeast Basin) now hosts a large western gull nesting colony on the warehouse buildings at the tip of Pier F. Gulls were also observed, in lower numbers, on the sandy beach areas adjacent to Cabrillo Beach (Zone 1a).

Aerial Fish Foragers: Observations were concentrated around Piers 300 and 400, at the outer breakwater, and in the SWH zones (Figure 6-8). Overall, Aerial Fish Foragers were scarce in the Inner Harbor survey zones and in the deep, open-water zones of the Port of Long Beach. Mean densities and abundances of Aerial Fish Foragers were both greatest in Zone 9 (Port of Los Angeles Middle Breakwater), where large aggregations of brown pelicans roosted. Waters seaward of Zone 10a (Outer Navy Mole Pier and Zone 8a (Outer Pier 400 West) also had high abundances (983 and 885 total observations, respectively); however, their large size (549 and 363 acres, respectively) resulted in low densities of Aerial Fish Forager usage. Zone 10a was especially favored by elegant terns and Caspian terns (*Hydroprogne caspia*), which attempted to nest on the moored barges and scows in the area (discussed further in Section 6.7). The outer breakwater habitats (Zones 3a–3c, 9, 12, and 15) also had high densities of birds because these zones provided extensive stretches of riprap used by roosting brown pelicans. Zones 1a (Cabrillo Beach North) and 6 (Pier 300 SWH) had similarly high densities of birds because these zones provided a variety of physical features that were used by Aerial Fish Foragers. The sheltered waters of Zone 6 (Pier 300 SWH) also provided a variety of physical features that were used by this guild. For example, a variety of tern species roosted on the small stretch of the sandy beach, and the riprap served as a roosting site for brown pelicans. Zone 1a provided sandy beach habitat and buoys that were used by roosting black skimmers and tern species. Both areas contain SWH (with eelgrass [*Zostera marina*]) that supported foraging opportunities for Aerial Fish Foragers.

Other Guilds: The densities of the less abundant avian guilds (Raptors, Large and Small Shorebirds, and Upland Birds) were not mapped because the low numbers of birds spread over the entire Port Complex resulted in low densities in all survey zones (fewer than 0.2 bird per acre). However, patterns of usage were observed for these less-abundant avian guilds and are discussed in this section.

Survey Zones 12 (Port of Long Beach West Breakwater), 15 (Port of Long Beach East Breakwater), 1a (Cabrillo Beach North and Scout Camp), 5 Seaplane Lagoon SWH), and 3b (Cabrillo SWH Phase 1) together accounted for over half (58.4%) of all Small Shorebird observations. Notably, Zones 12 and 15 alone contributed 30.2% of these observations, primarily due to black turnstones, spotted sandpipers, and, to a lesser extent, surfbirds resting and foraging on riprap during their non-breeding periods. Similarly, five survey zones (Zones 15, 12, 9, 3b, and 3c) accounted for 85.1% of the Large Shorebird observations. These zones encompass the outer breakwater, where black oystercatcher was the most abundant Large Shorebird species for all survey zones.

Unlike Small and Large Shorebirds, Wading/Marsh Birds were ubiquitous (although in small numbers) throughout the Port Complex, with observations occurring in 48 of the 54 survey zones. This guild was most abundant in Zones 34a (Port of Los Angeles Main Channel), 6 (Pier 300 SWH), 23 (West Basin), 27b (Consolidated Slip), and 4b (Fish Harbor), which together accounted for 35.3% of the total observations. Densities and abundances of great blue heron, the most abundant member of the guild, were highest in Zone 34a. In addition to the known nesting sites in the abandoned cranes and buildings near SoCal Ship Services at Berth 240, new nesting locations were identified in the light-emitting diode (LED) light structures at Everport Terminal Services, which were not in use by nesting birds during the 2018 Biosurvey. Wading/Marsh Bird numbers were also high near other known nesting sites in Zones 6 and 23 near the Navy Mole Pier. Zone 27b featured long stretches of developed shoreline where great blue herons and snowy egrets (*Egretta thula*) roosted, and Zone 4b offered opportunistic foraging opportunities on commercial fishing vessels.

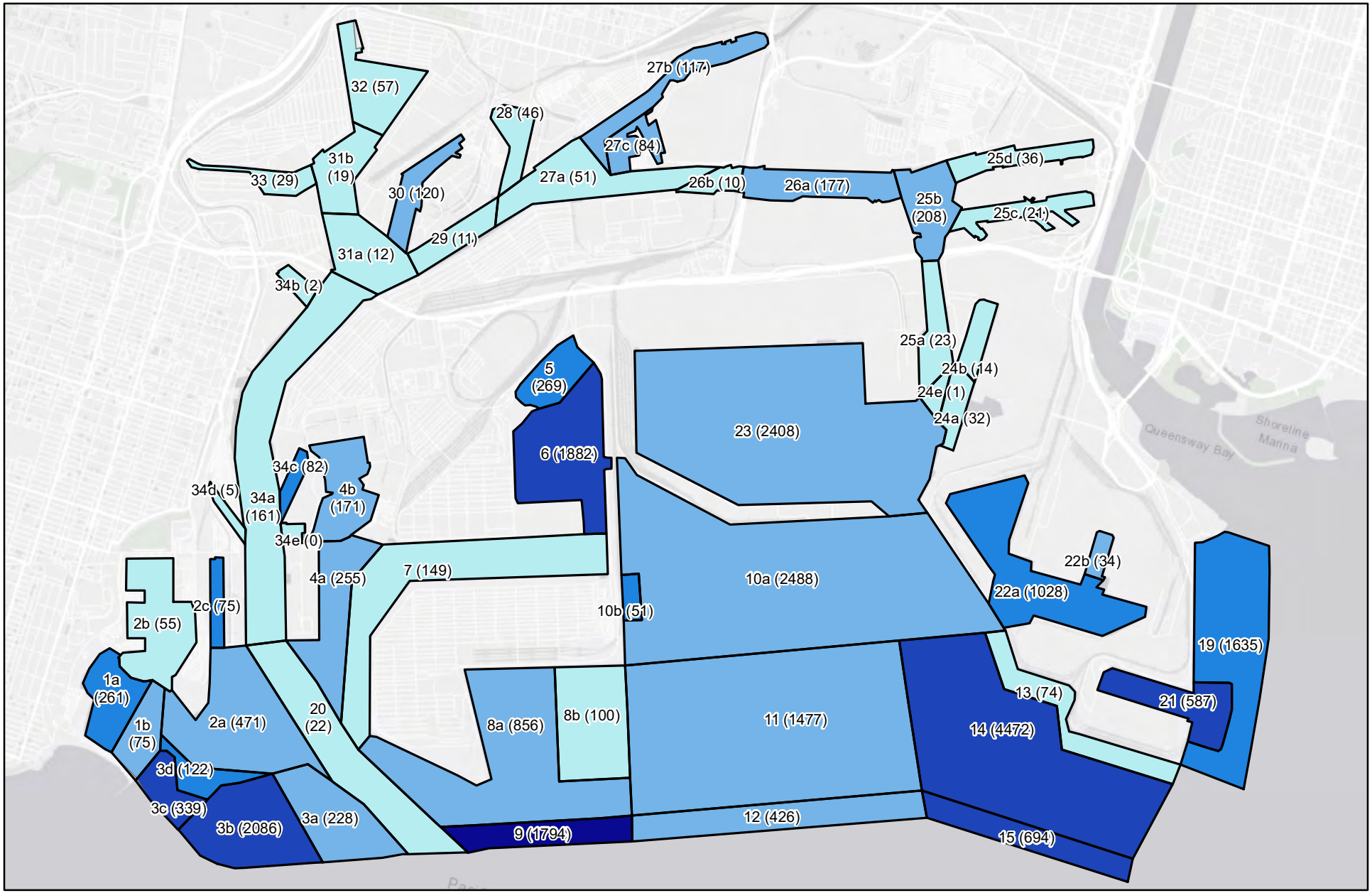


Figure 6-6. Mean Densities (Color Scale) and Abundance (In Parentheses) of Waterfowl by Survey Zone

Waterfowl - Label = Zone # (Total Count)Mean Density (Individuals per Acre)

N
W
E
S

1.87
0.00

0 0.5 1 2
Kilometers

2023 Biological Survey
Long Beach and Los Angeles Harbors
Port of Long Beach and Port of Los Angeles

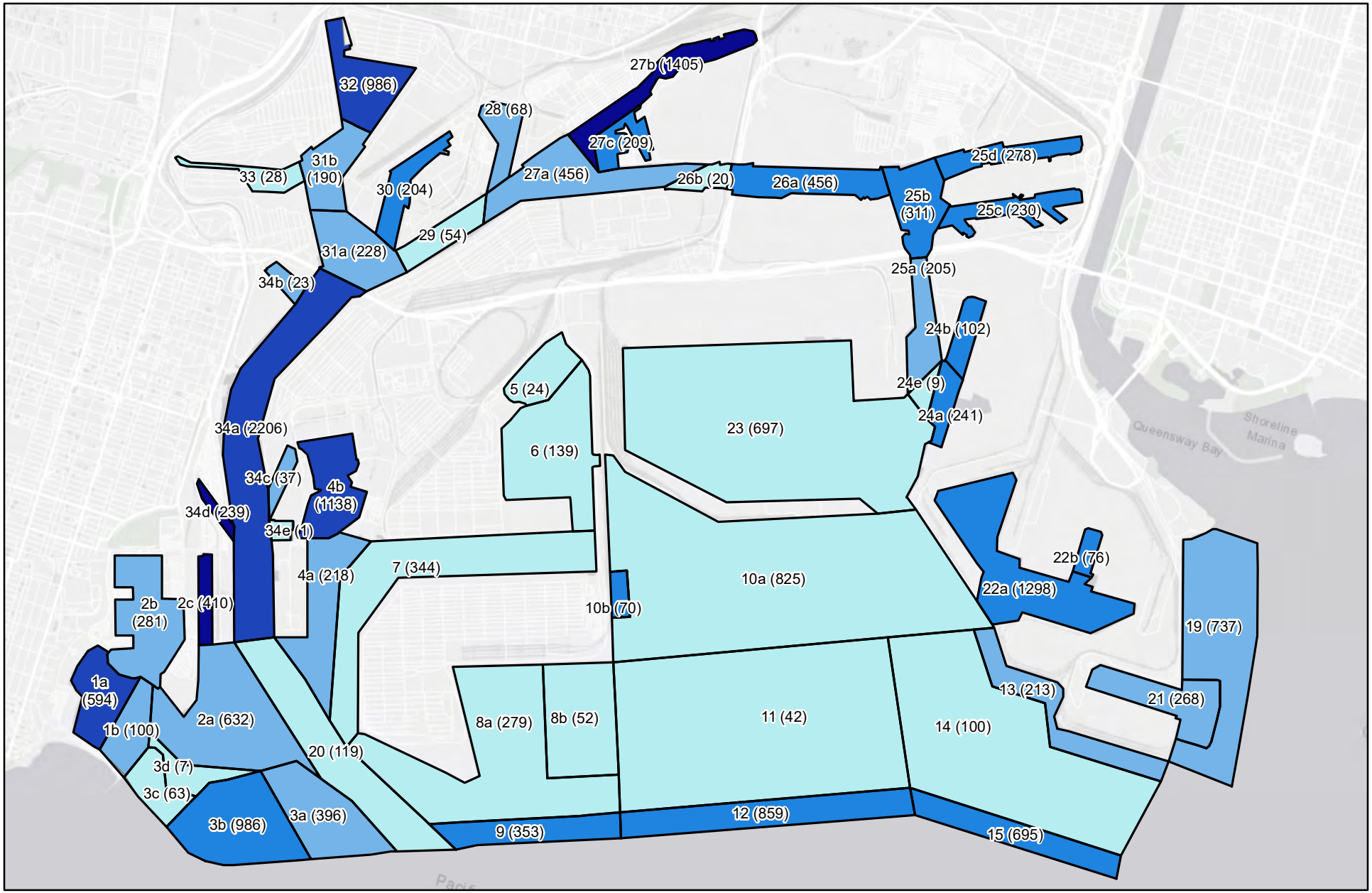


Figure 6-7. Mean Densities (Color Scale) and Abundance (In Parentheses) of Gulls by Survey Zone

Gulls - Label = Zone # (Total Count) Mean Density (Individuals per Acre)

N
W E
S

2.05
0.00

0 0.5 1 2
Kilometers

2023 Biological Survey
Long Beach and Los Angeles Harbors
Port of Long Beach and Port of Los Angeles

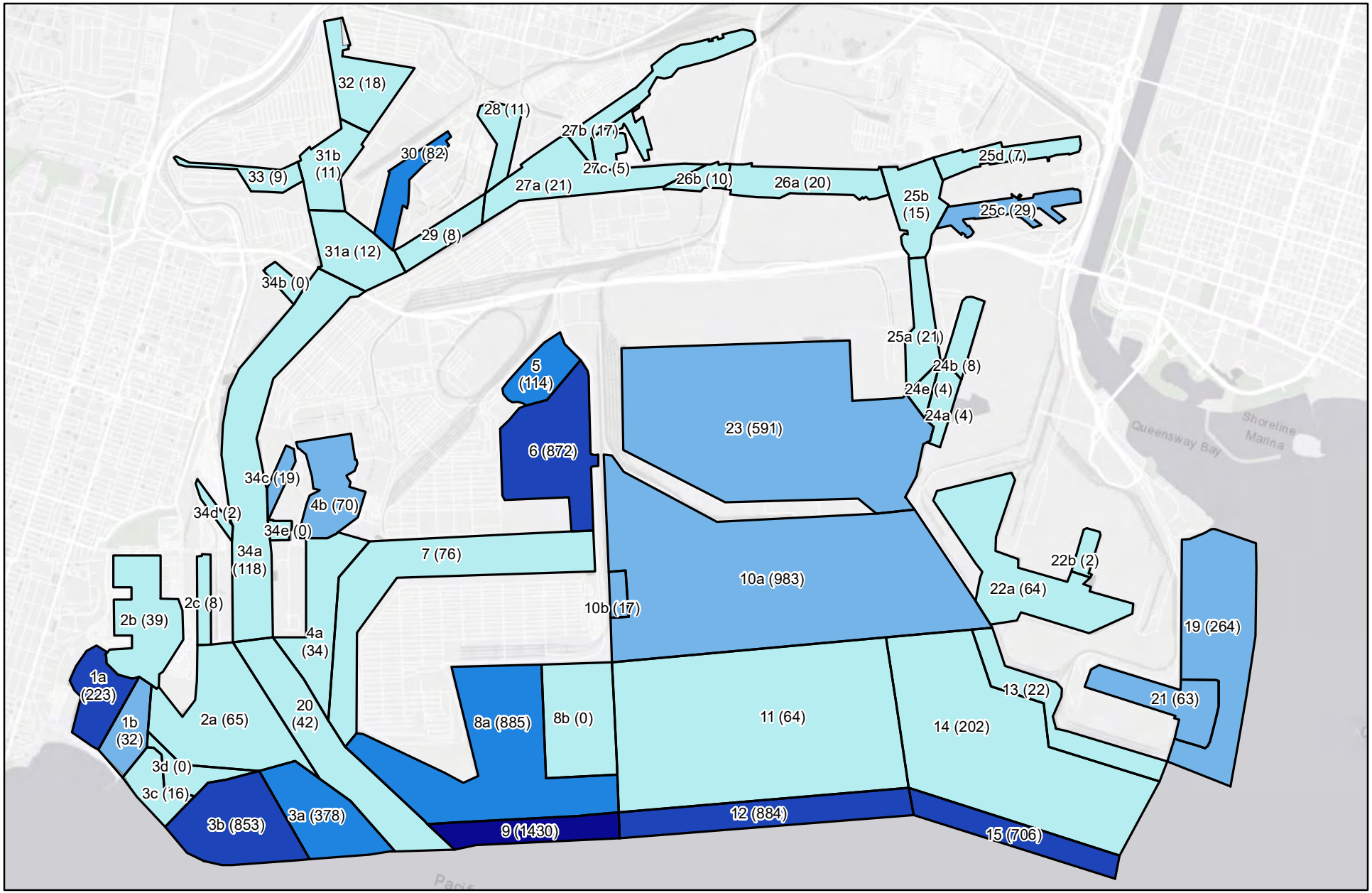


Figure 6-8. Mean Densities (Color Scale) and Abundance (In Parentheses) of Aerial Fish Foragers by Survey Zone

Aerial Fish Foragers - Label = Zone # (Total Count) Mean Density (Individuals per Acre)

2023 Biological Survey
Long Beach and Los Angeles Harbors
Port of Long Beach and Port of Los Angeles

The current survey method, which focuses primarily on aquatic areas, is not designed for comprehensive observations of Upland and Raptor species. Despite this limitation, some trends were observed. Other than osprey, Raptor sightings were generally infrequent and inconsistent, with only 67 Raptors recorded across 38 of the 54 survey zones during the 2023 Biosurvey. Osprey was the most abundant Raptor species, with the highest frequency of observations in Zone 24b (East Basin Pier E-D), where the birds nested on a lamp fixture near the tip of Pier D.



Rock wren forging along the riprap at the Pier J Slip (Zone 21)

The occurrences and distributions of Upland species were overwhelmingly dominated by rock pigeon and European starling (68.0% and 13.3% of all Upland bird observations, respectively). Excluding these species, Upland birds accounted for only 2.5% of all avian species observed across all survey events. Given this and the incidental nature in which Upland birds were detected, no figures depicting the densities of Upland species are presented in this report. Still, patterns of usage by Upland birds within the Port Complex were noted. After the rock pigeon and European starling, the most numerous Upland species were American crow, common raven, and house finch (*Haemorhous mexicanus*). Overall, Upland species were most abundant in Zones 27b (Consolidated Slip), 34a (Port of Los Angeles Main Channel), 34c (Berth 240), 2c (East Channel), and 34d (S.P. Slip). These zones are either slips or channels that contain large sections of completely developed shorelines with urban structures (e.g., large docks, buildings, piers, etc.), which these Upland species often use for roosting, nesting, and foraging.

6.5 AVIAN USAGE OF PHYSICAL FEATURES AND AVIAN ACTIVITY

As discussed in Section 6.1, many bird species use the physical features in their environment for a variety of activities. These features can support activities ranging from merely resting to actively foraging. As in previous Biosurveys, the data on avian abundance and distribution collected in the 2023 Biosurvey were evaluated in terms of how birds interact with the various physical features within in the Port Complex.

Figure 6-9 illustrates the use of habitat types in the Port Complex by the 10 most abundant species of birds observed during the 2023 Biosurvey. As previously discussed, these 10 species account for 88.0% of all birds observed, and therefore are the dominant factors in that usage. Overall, open water was used most (43.9%) by the most abundant birds, followed by riprap (21.3%) and dock pilings (12.8%). The western gull, the most abundant avian species, was observed in all areas of the Port Complex, with the distribution spread among dock/pilings (33.0%), open water (26.8%), riprap (14.2%), and building/structures (12.3%). Similarly, rock pigeon, elegant tern, Heermann's gull, and double-crested cormorant species showed a relatively equal distribution in most frequented habitat types, with large numbers associated with multiple feature types.

In contrast, some of the other abundant avian species identified within the Port Complex show a preference for one or two specific types of physical features. For example, the western grebes and surf scoters were observed only in open water, and brown pelicans and California gulls showed a specific affinity for it (83.5% and 55.2%, respectively). Brown pelicans were observed most often on riprap (78.7%) and open water (10.1%).

Open water at a depth greater than 1 foot is by far the most extensive natural physical feature in the Port Complex and is available in all survey zones. During the 2023 Biosurvey, 42.0% of all birds were observed in this feature (Appendix F). A total of 72.6% of all Waterfowl (primarily surf scoter, along with Brandt's cormorant and western grebe), 31.4% of all Gulls (a combination of mainly western gull and California gull), and 20.7% of all Aerial Fish Foragers (largely elegant tern and brown pelican) were observed using open water. Overall, the heaviest usage occurred during the Waterfowl non-breeding months (November 2023 through April 2024) when large rafts of surf scoters and western grebes used the sheltered waters within the Port Complex for roosting and foraging.

Riprap was the second most frequently used feature within the Port Complex, accounting for 20.9% of all bird observations during the 2023 Biosurvey. This habitat is widespread and available in at least 47 of the 54 survey zones. Riprap was a popular roosting resource for many of the most abundant avian species, including the brown pelican, Brandt's cormorant, and western gull. These three species combined for 83.2% of all birds observed along the riprap. Riprap was also an important resting, foraging, and in some cases, nesting (black oystercatcher) resource for other avian guilds. A total of 90.7% of Large Shorebirds (mainly black oystercatcher), 76.5% of Small Shorebirds, and 53.2% of Aerial Fish Foragers (primarily roosting brown pelican) were observed on riprap.

Docks/pilings were the third most used feature, accounting for 12.0% of the total bird observations. This feature was used in 43 of 54 survey zones, sometimes comprising substantial portions of zones' perimeters. Docks/pilings were most heavily used by roosting gulls, which represented 51.7% of all observations on this feature. Collectively, Upland species (predominantly rock pigeons) represented 22.5% of the total birds observed on docks/pilings. Within the Port Complex, rock pigeons showed a strong affinity for the dock/piling features and were most populous in zones within the slips and channels of the Inner Harbor. The remaining five avian guilds collectively made up 25.6% of the observations on dock and piling features, with most of the usage coming from roosting great blue herons, cormorants, and snowy egrets (*Egretta thula*).

The remaining 14 types of physical features accounted for only 25.1% of avian observations. Among these less-used features, abundance was greatest in the building/structure feature. This feature type accounted for 12.0% of the observations, with western gull (43.1%), rock pigeon (20.3%), and great blue heron (5.1%) being the prominent species. Upland habitats and barges/boats accounted for 4.5% and 4.4% of observations, respectively, and provided roosting locations primarily for western gulls and rock pigeons.

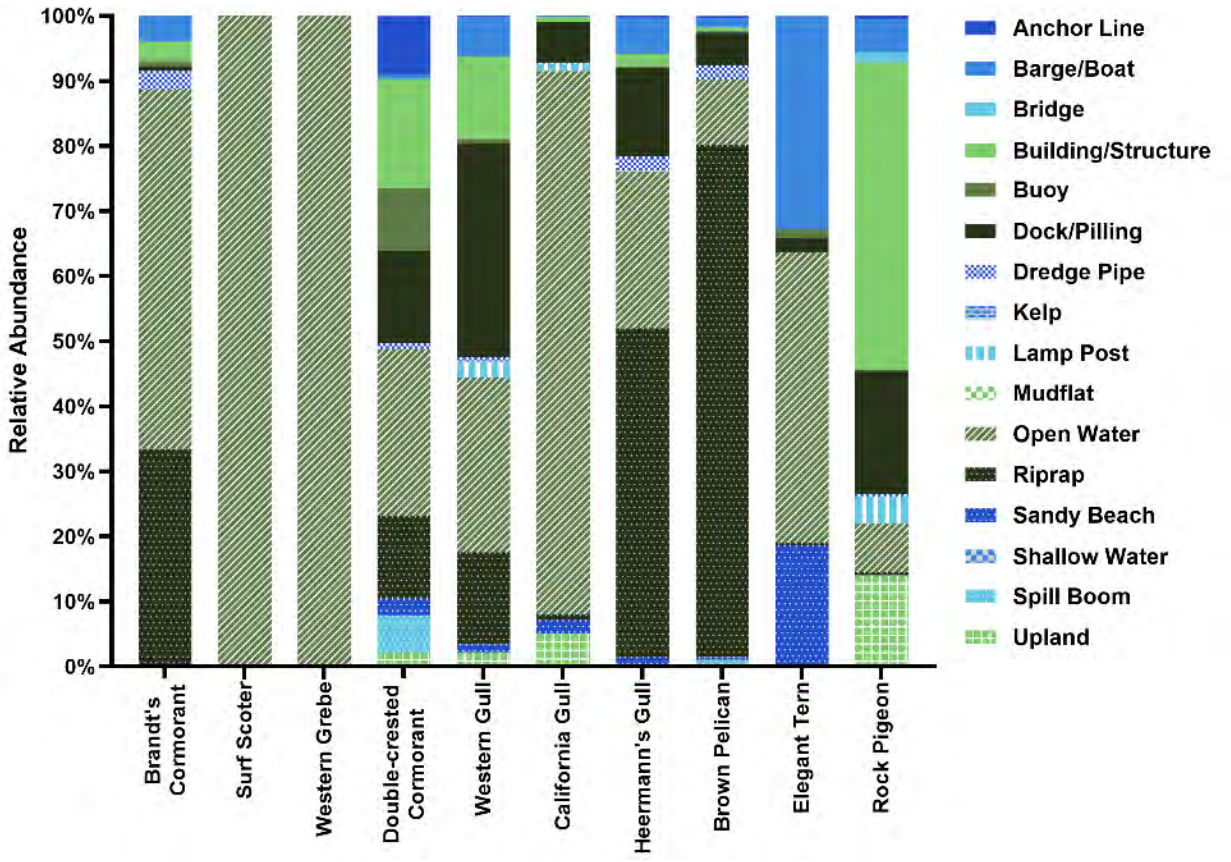


Figure 6-9. Total and Relative Abundance of the 10 Most Common Avian Species by Location of Observation

Although only a small fraction of bird observations occurred on sandy beach (1.7%) and dredge pipe (1.4%), these features provided roosting locations for a diverse set of avian species (26 and 14 species, respectively). The area of sandy beach and dredge pipe is insignificant in terms of the size of the Port Complex as a whole. Nevertheless, 1,135 birds were observed along the sandy beaches, and 911 birds were documented on dredge pipes. Together, these two physical features combined included 30 (30.6%) of the 98 documented species, despite encompassing only approximately 0.2% of the total acreage of the available habitat.

Avian Activity/Behavior

Bird activities were divided into one of five categories: foraging, resting, courting, nesting, or flying. In the 2023 Biosurvey, most birds (46,960), accounting for 70.7% of total observations, were observed resting (Figure 6-10). Flying, foraging, and nesting accounted for 21.1%, 7.4%, and 0.7% of the total observations, respectively. Flying birds included those traveling from one location to another. Only three species were observed courting: two pairs of western gulls performing courtship activities in Zones 13 (Outer Pier J South) and 1b (Cabrillo Beach South), one pair of western grebes performing their courtship dance in Zone 32 (Port of Long Beach West Basin), and rock pigeon displays in 13 different zones.



Western gull chicks on a buoy in the Pier J Slip (Zone 21)

Nesting locations for many species are often difficult to detect without targeted efforts because they are typically well concealed to avoid predation and disturbances. The vessel-based survey protocol used during the Biosurveys was not specifically designed to identify nesting sites. Nevertheless, numerous nesting activities were observed during the 2023 Biosurvey (434 total observations).

Species from seven of the eight avian guilds were observed nesting within the Port Complex. Nesting activity was observed for five Upland bird species: barn swallow (nesting under dock pilings in Zones 23 [Port of Long Beach West Basin], 34a [Port of Los Angeles Main Channel], and 34d [S.P. Slip]), rock pigeon (11 different zones), house sparrow (*Passer domesticus*) (Zones 4b [Fish Harbor] and 2c [East Channel]), house finch (Zone 23), and black phoebe (*Sayornis nigricans*) (nesting in the uplands in Zone 23). Western gulls were observed nesting on buildings and dock pilings in sheltered locations throughout the Port Complex (no other members of the Gull guild were observed nesting). The only nesting Waterfowl species observed was the double-crested cormorant, which nested in the newly constructed Southern California Edison transmission towers now in Zone 25b (Inner Harbor Turning Basin; previously in Zone 26a [Cerritos Channel]). Great blue heron was the only Wading/Marsh Bird species observed nesting in the Port Complex (83 total observations in 10 different zones). Osprey in two nests (in Zone 24b [East Basin Pier E-D]and 25b [Inner Harbor Turning Basin], on lamp posts) were the only Raptors observed nesting during the 2023 Biosurvey period. The only species of Large Shorebird observed nesting in the Port Complex was the black oystercatcher (one recently fledged bird still being fed in Zone 12 [Port of Long Beach West Breakwater]). No Small Shorebird nesting was documented.

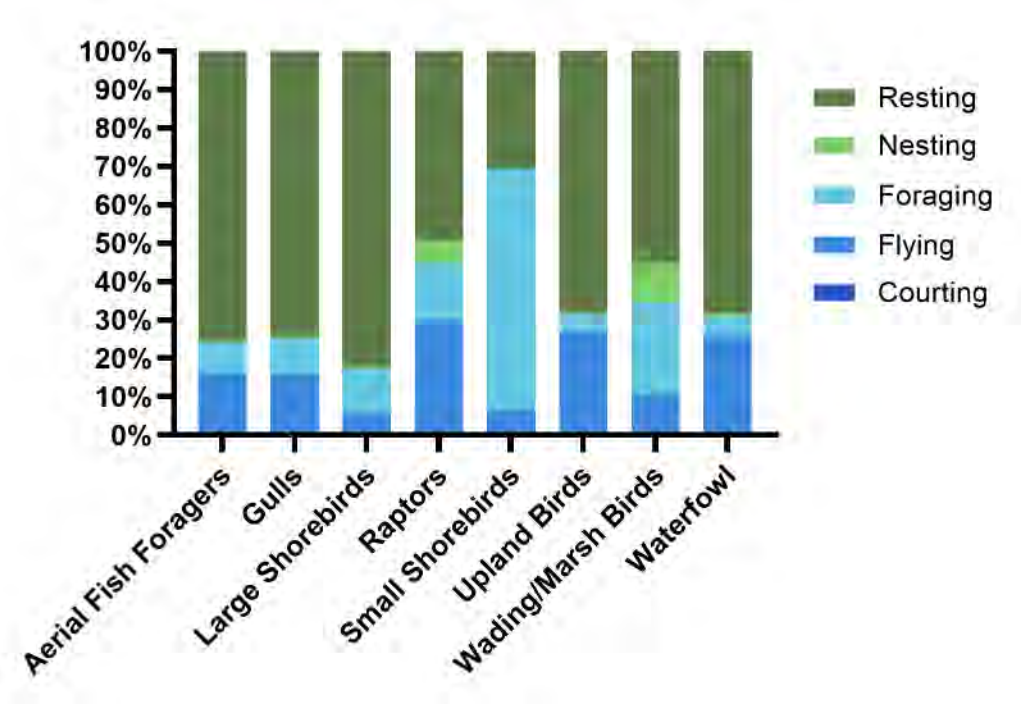


Figure 6-10. Percentage of Total Abundance of Avian Guilds by Activity

6.6 HISTORICAL COMPARISONS

The Port Complex has supported eight major avian studies over 5 decades dating back to at least 1973. These surveys have varied widely in methodology, duration, and survey areas, and many physical changes to the Port Complex have occurred in the past 50 years. For example, surveys conducted during the 1970s implemented only quarterly surveys, focusing on only 31 of the 43 zones. Studies in the 1980s implemented weekly and biweekly surveys, sectioned the Port Complex into 7 to 10 large survey zones of the Outer Harbor, and never included Inner Harbor areas. However, since 2000, similar methodologies have been used across all Biosurveys, with the same method used from 2013 onward, allowing for direct comparisons of species composition, total and mean observations, and diversity from 2013 to the present. The 2000 Biosurvey (MEC, 2002) and 2008 Biosurvey (SAIC, 2010) followed similar protocols but increased survey frequency during fall and winter, making precise comparisons for some metrics unreliable – though certain mean values can still be inferred. The 2013, 2018, and 2023 Biosurveys provide the primary basis for discussions on total abundance, current trends, and individual species comparisons. Although incorporating studies with differing methodologies, protocols, and geographic focus could lead to inaccuracies, comparisons results for the 2000 and 2008 Biosurveys are sometimes included, specifically for guild and species composition analyses for which accurate comparisons are possible.



Brown pelicans resting on riprap along Outer Pier 400 (Zone 8a)

6.6.1 ABUNDANCE

The results for the 2000, 2008, 2013 and 2023 Biosurveys indicated consistent species richness and abundance, recording from 87 to 99 species and 5,878 to 6,365 individuals per survey (Figure 6-11). The number of species observed in the 2023 Biosurvey (98) was comparable to numbers for previous Biosurveys. However, the total abundance (66,447) and abundance per survey (5,537) for the 2023 Biosurvey were 36.0% higher than in the 2018 Biosurvey, aligning more closely with earlier survey results and yet still reflecting a 13% decrease from the maximum number observed in 2013 (Table 6-4).

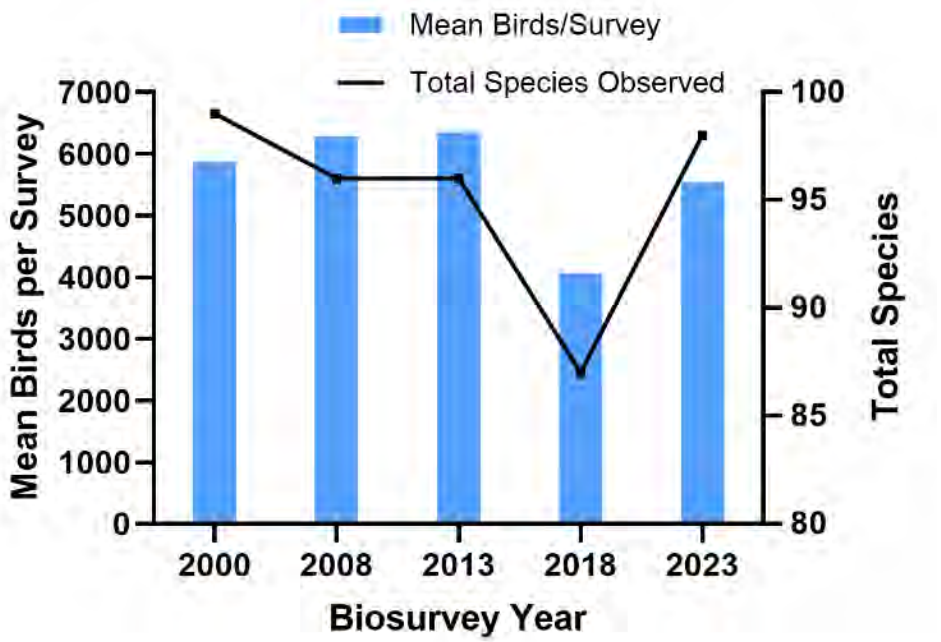


Figure 6-11. Historical Comparison of Mean Abundance and Total Number of Species Observed in the Port Complex

Table 6-4. Comparison of Avian Observations (by Guild) Among 2013, 2018, and 2023 Biosurveys

Avian Guild	Total Number of Observations		
	2013	2018	2023
Aerial Fish Foragers	16,168	8,973	9,450
Gulls	29,137	18,327	20,201
Large Shorebirds	389	414	525
Raptors	34	67	116
Small Shorebirds	651	552	603
Upland Birds	5,052	5,334	8,844
Wading/Marsh Birds	1,122	900	807
Waterfowl	23,707	14,187	25,901
Total	**76,260**	**48,754**	**66,447**

Avian abundance historical trend data from the 2013, 2018, and 2023 Biosurveys showed clear shifts in species composition and abundance within the Port Complex, with widespread declines recorded in the 2018 Biosurvey and partial recovery observed in the 2023 Biosurvey. The 2013 Biosurvey recorded the highest total number of avian observations (76,260), compared with 48,754 in the 2018 Biosurvey (−36%) and 66,447 in the 2023 Biosurvey (−13% relative to 2013; +36% relative to 2018) (Table 6-4).

Several avian guilds experienced substantial declines in the 2018 Biosurvey compared with the 2013 Biosurvey (Table 6-4). Aerial Fish Foragers decreased by 44%, Gulls by 37%, and Waterfowl by 40%, relative to the 2013 Biosurvey. For the 2023 Biosurvey, Waterfowl showed strong recovery, increasing by 83% compared with the numbers in the 2018 Biosurvey and even exceeding the numbers in the 2013 Biosurvey total by 9%. Numbers of Aerial Fish Foragers and Gulls also increased in the 2023 Biosurvey (+5% and +10%, respectively, relative to 2018); however, they remained 41% and 31% below 2013 Biosurvey levels, respectively.

The trends observed among individual species were in line with those recorded across these guilds. Brown pelican numbers decreased by 62% in the 2018 Biosurvey but increased by 129% in the 2023 Biosurvey, nearly returning to 2013 Biosurvey numbers. Surf scoter numbers declined by 41% in the 2018 Biosurvey and then increased by 406% in the 2023 Biosurvey, exceeding 2013 values. Brandt's cormorant showed the most substantial increase in number, rising from 3,921 in the 2018 Biosurvey to 12,813 in the 2023 Biosurvey – more than 3 times the number recorded in the 2013 Biosurvey. In contrast, Western grebe numbers declined across all three Biosurveys, with a 46% reduction in the 2018 Biosurvey followed by an additional 60% drop in 2023, resulting in a cumulative 79% decline compared with numbers recorded for the 2013 Biosurvey. Elegant tern showed a similar pattern, with numbers declining by 37% in the 2018 Biosurvey and 57% in the 2023 Biosurvey (−73% overall). Ring-billed gull numbers declined steadily across all three Biosurveys (−77%), and Heermann's gull numbers dropped by 68%. California gull numbers declined by 94% in the 2018 Biosurvey but rebounded to 1,790 individuals in the 2023 Biosurvey, though their numbers are still 60% below 2013 Biosurvey levels.

In contrast, numbers of Upland birds increased by 6% in the 2018 Biosurvey and by an additional 66% in the 2023 Biosurvey, resulting in a 75% overall increase compared with numbers in the 2013 Biosurvey. Raptor numbers increased by 97% in the 2018 Biosurvey and by another 73% for the 2023 Biosurvey. Large Shorebirds also exhibited steady growth (+6% in 2018; +27% in 2023), for a total increase of 35% compared with numbers in the 2013 Biosurvey. Of the individual species observed, rock pigeon and European starling experienced the most significant increases of 45% and 560%, respectively, across all survey years.

Numbers of Small Shorebirds and Wading/Marsh Birds declined across the 2013-2023 Biosurveys, although they represented a smaller portion of total observations. Small Shorebirds observations dropped by 15% in the 2018 Biosurvey, followed by a 9% increase in the 2023 Biosurvey, resulting in a net decline of 7% compared with numbers

in the 2013 Biosurvey. Wading/Marsh Bird numbers declined by 20% in the 2018 Biosurvey and by an additional 10% in the 2023 Biosurvey, for a total decrease of 28%. In contrast, observations of Large Shorebirds and Raptors – comprising the smallest represented groups – increased across the three Biosurveys.

Given these changes in avian guild abundances, the following discussion focuses on the species with the most notable changes (with at least 1,000 observations during a Biosurvey period), along with relevant regional trends for context (Table 6-5).

Table 6-5. Comparison of the Avian Species with the Largest Changes from 2013, 2018, and 2023 Biosurveys *

Species	Total Number of Observations		
	2013	2018	2023
Eared Grebe	1,454	129	120
Western Grebe	11,039	5,949	2,370
Ring-billed Gull	1,236	501	285
Elegant Tern	8,083	5,127	2,199
Heermann's Gull	4,867	1,740	1,536
California Gull	4,510	261	1,790
Double-crested Cormorant	3,905	1,894	1,705
Brown Pelican	7,320	2,780	6,364
Western Gull	17,961	15,810	16,128
Rock Pigeon	4,134	4,461	6,010
Surf Scoter	2,535	1,490	7,541
Brandt's Cormorant	3,936	3,921	12,813
European Starling	178	163	1,174

* For species with at least 1,000 observations during any survey period.

The number of eared grebes declined steeply across Biosurvey periods, with populations dropping significantly from 1,454 individuals in the 2013 Biosurvey to just 120 in 2023 (Table 6-5). This represents a 92% decline, making them the species that decreased in population the most during the 2023 Biosurvey. Although eared grebe populations are generally considered stable worldwide, their wintering distributions can shift substantially based on prey availability, leading them to relocate to other water bodies when prey becomes scarce (Boyd et al., 2021). Results of similar avian surveys in San Diego Bay from 2006 to 2017 (Tierra Data, Inc., 2011, 2018) indicated an inverse trend and a 30% increase in total abundance, with the number of birds rising from approximately 16,000 to 25,000 during that timeframe.

Additionally, recent studies have demonstrated that eared grebes are highly susceptible to extreme weather, particularly intense ENSO periods, which can often lead to mass die-offs from starvation. Recent ENSO events from 1982 through 2016 coincided with sharp population declines at California's largest wintering site, Mono Lake. For example, results from the 1997–1998 ENSO event indicated a 50% drop in Mono Lake's eared grebe population, with an estimated 70% of North America's population affected by starvation. Similarly, the strong ENSO from 2015–2016 led to another 50% decline at Mono Lake, indicating possible starvation among overwintering grebes in the Sea of Cortez.

Western grebe observations in the Port Complex have also declined sharply over the past decade. The 2013 Biosurvey recorded 11,039 individuals, but by the 2018 Biosurvey, observations had dropped to 5,949, a decrease of approximately 46%. This decline continued in the 2023 Biosurvey, with only 2,370 western grebes observed – representing a 79% decline from the highs observed in the 2013 Biosurvey, and a reduction of 8,669 observations. This pattern has also been observed in San Diego Bay avian surveys (Tierra Data, Inc., 2018) in which western grebe observations declined by approximately 30% from 17,000 in 2006–2007 to 12,239 in 2016–2017.

In the past few decades, western grebe populations have declined at some breeding and wintering locations, with some populations dropping by up to 50% in the past 20 years (LaPorte et al., 2020; Erickson et al., 2017). Despite these declines, wintering numbers along California's southern coast have risen by 300%, likely because of a southward shift in the core population (from the Pacific Northwest's Salish Sea to coastal California) (Wilson et al., 2013). The authors

of these studies indicate that this shift may be driven by a change in forage prey from Pacific herring (*Clupea pallasii*) to Pacific sardine (*Sardinops sagax*), prompting grebes to travel farther for more productive wintering waters. The results of these studies indicate that declines in regional western grebe observations at certain wintering locations, such as the Port Complex, may reflect geographic redistribution rather than an overall decline in wintering grounds, with many local birds preferring the nearshore waters where Pacific sardines are more abundant.

Several urban-tolerant species showed notable increases in population over the past decade. The number of European starlings, for instance, remained relatively stable in the time between the 2013 and 2018 Biosurveys, but then increased by 620% from the 2018 Biosurvey to the current Biosurvey. Rock pigeons have increased in number since 2013, rising by 8% in the time between the 2013 and 2018 Biosurveys and a further 35% in the current Biosurvey. Similar trends were observed for the Eurasian collared dove and common raven, which increased in numbers by 644% and 270%, respectively, from the 2013 Biosurvey to the 2023 Biosurvey (Appendix F).

The brown pelican has consistently been one of the most abundant species within the Port Complex, accounting for no less than 9% of all birds in every Biosurvey – except during a 1976 study, when the species composed only 3.8% of total observations (Harbors Environmental Projects [HEP] University of Southern California [USC], 1976). This pattern continued until the 2018 Biosurvey, when the species' relative abundance declined to 6%, representing a 62% overall decrease compared with results from the 2013 Biosurvey (Table 6-5).The reason for the decline is unclear; however, collapses at nesting colonies in the past decade were documented in the Gulf of California (Anderson and Gress, 2015; Anderson and Kerlin, 2014) and along the California coast (Jaques, 2016). Additionally, brown pelican populations are known to fluctuate in waters during ENSO years, with low or no productivity, starvation, and near collapses in some nesting colonies, and expansion and contraction of numbers in other locations (Shields, 2020; Anderson et al., 2017, Jaques, 2016). However, brown pelican observations during the 2023 Biosurvey recovered by 87% and represented 9.6% of all bird observations.

Western gulls remained the dominant species throughout all survey periods, with their population remaining relatively stable, though their numbers decreased by 10% in the 2023 Biosurvey from their peak in the 2013 Biosurvey. However, other Gull species showed more dramatic changes. The number of Heermann's gulls declined sharply, dropping by 68% from 4,867 observations in 2013 to 1,536 in 2023. The number of ring-billed gulls also declined significantly, with 25% fewer observations in 2023 than in 2013, although this species of gull has never been as abundant as the other gulls. California gull numbers showed extreme variation, dropping by 94% from 2013 to 2018, before rebounding to approximately 40% of their 2013 numbers in 2024.

Fluctuations in Gull observations are not uncommon; numbers and concentrations are known to change based on anthropogenic factors such as agricultural methods, pest management, and landfill practices (Burns et al., 2018). Western gull and Heermann's gull populations are known to decline with warmer sea surface temperatures, such as the conditions that persisted off coastal California from 2013 through 2019 (Pierotti and Annett, 1995; Velarde and Ezcurra, 2018). Similarly, ring-billed gull populations are known to fluctuate wildly in the western United States because of stressful environmental factors such as drought, with population decreases of 54 to 66% in low-water years (Doster and Shuford, 2018). In recent years, California gull populations have expanded from the main California breeding colony in Mono Lake west and south into San Francisco Bay, but their numbers are thought to be declining overall (Winkler, 2020). The most recent California gull survey at Mono Lake, the largest colony in the world, showed a steep population decline; the numbers of nests and fledged young have decreased over a 41-year study period, and have now been estimated at approximately half its the peak numbers during the mid-1990s.

The reason for the 94% decline in the number of California gulls observed during the 2018 Biosurvey period is unknown, and an opposite trend was noted in San Diego Bay, where Tierra Data Inc. (2018) recorded a significant increase in gull numbers (16,876) in 2016–2017 – more than double the 2006–2007 and 2009–2010 counts (5,948 and 6,682, respectively). Notably, the results of the 2023 Biosurvey indicated a rebound in California gull observations from 2018–2019, with 49% of the observations concentrated near (within 1,000 feet) the Potential Industries Recycling Center near Zone 27b (Consolidated Slip).

Similarly, ring-billed gull numbers declined by 77% from 2013 to 2024. Unlike the California gull, however, the decline in the number of ring-billed gulls was also observed in San Diego Bay (Tierra Data Inc., 2018), where the gulls were at least 50% less abundant than in previous surveys. The current population estimates of western North American ring-billed gulls from 2009–2011 show populations similar to those from the 1990s; however, populations

in California have declined significantly following periods of drought, and ring-billed gull numbers can drastically fluctuate over short periods of extreme environmental variability (Doster and Shuford, 2018).

Populations of avian species such as Brandt's cormorant and double-crested cormorant are also known to fluctuate greatly based on ocean temperature conditions, with nesting success declining during warm-water periods (Wallace and Wallace, 1998; Capitolo et al., 2004; Ainley et al., 2018). Since the 2013 Biosurvey period, the Brandt's cormorant nesting colony that existed in Zone 23 (West Basin) is no longer present. Nesting activity appears to have been declining since at least 2007–2008, when as many as 215 nests were observed (SAIC, 2010); during the next Biosurvey (MBC, 2016), only six nests were found, and subsequent Biosurveys have documented no nesting events. Still, Brandt's cormorants have been ubiquitous among the Biosurveys and have never accounted for fewer than 5% of all observations. In 2013 and 2018 Biosurveys, Brandt's cormorant observations were similar, with a slight decrease of less than 1%. However, the 2023 Biosurvey recorded a dramatic increase, with observations more than tripling. This represents a 227% increase from 2018 to 2023 and an overall increase of 226% from 2013 to 2023.



Double-crested cormorant resting on an anchor buoy

In contrast to Brandt's cormorants, double-crested cormorant observations have declined in every Biosurvey since 2013, with 2018 Biosurvey counts decreasing by 56% compared with the 2013 Biosurvey counts, and numbers remained substantially the same in the 2023 Biosurvey (Table 6-5). The exact reason for the decline is unclear, but installation of the required bird deterrent measures in areas where double-crested cormorants previously nested may have been the main contributing factor. During the 2018 Biosurvey (specifically the 2019 nesting season), the Southern California Edison Transmission Tower Replacement Project installed approximately 100 large Norwegian marine buoys on the transmission towers to deter birds from roosting and nesting in the joints of the metal structure. Because this was the preferred nesting location for double-crested cormorants within the Port Complex, the displaced birds likely traveled outside the Port Complex to find alternative nesting sites during the 2019 nesting season, resulting in no nesting for 2019 at the Port Complex. But given their strong site affinity to previously successful nesting locations (Wallace and Wallace, 2021), the birds quickly established a colony on the newly constructed towers following their completion in 2020. It is unclear whether the 2023 decline reflects an actual population decrease or simply a reduced detection rate because of the new inland tower location, which is approximately 600 feet from the previous in-water sites and just beyond the reliably visible limits of detection for the surveys used as part of this program. The number of double-crested cormorants is likely higher than reported because the inland locations sometimes inhibited observations of bird activity, leading to the potential undercounting of both birds and nests.

The surf scoter population has exhibited notable variations over time, with comparable data available from the 2000 and 2008 Biosurveys, which used the same survey protocol (one survey per month and twice per month from August to April). For the 2000 Biosurvey, only 2,052 surf scoters were observed, but this number dramatically increased to 26,739 in the 2008 Biosurvey, representing a 1,203% increase.

Starting in 2013–2014, the current survey protocol was introduced, which consisted of only one survey per month, making direct comparisons with results from earlier years, 2000 and 2008, less precise. Under the revised methodology, surf scoter observations initially declined from 2,535 observations in 2013 to 1,490 in 2018, reflecting a 41% decrease. However, there was a notable recovery in the current Biosurvey period, with total observations of surf scoters increasing to 7,541 – representing a 198% increase from those documented in 2018.

Surf scoter abundance has fluctuated considerably across Biosurveys, with numbers peaking at 14,122 during the 2008 Biosurvey but dropping to notably low counts in other years. The 2000 Biosurvey documented 4,337 individuals, fewer than any counts in subsequent Biosurveys except 2013 (2,535) and 2018 (1,490), despite the use of more frequent twice-monthly counts. MEC (2002) suggested that dredging activities within the Port Complex in 2000 may have reduced the availability of foraging and roosting habitats, contributing to the observed decline. However, because

dredging in areas of high surf scoter density occurred only during the 2000 Biosurvey period, the variability in surf scoter observations across different survey years indicates that dredging may not be the major factor influencing observations in the Port Complex. For instance, the 2008 Biosurvey recorded a nearly 3-fold increase in surf scoter observations from numbers reported in the previous 2000 Biosurvey, primarily in Zone 23 (Port of Long Beach West Basin), where dredging had occurred during the previous Biosurvey period. Similarly, the 2023 Biosurvey results also showed a significant increase in observations compared with numbers in previous Biosurveys, and more closely aligned with the findings from the 2008 Biosurvey. The 2013 and 2018 Biosurveys (when dredging was not conducted) reflected patterns similar to those observed in the 2000 Biosurvey (when dredging was conducted), showing that fluctuations in surf scoter observations occurred irrespective of dredging activities.

In recent years, the largest wintering location for surf scoters in Southern California, San Diego Bay, has experienced significant population fluctuations. Bay-wide surveys conducted in 2016–2017 indicated a decline of over 50% in surf scoter numbers compared with surf scoter numbers during the previous survey in 2009–2010 (Tierra Data Inc., 2018). This decline aligns with the 41% decrease observed during the previous Port Complex Biosurvey in 2013 and mirrors similar downward trends documented throughout the Pacific Flyway, including in Washington, Oregon, and California (Sea Duck Joint Venture, 2015; Anderson et al., 2020).

Range-wide surf scoter populations have shown considerable variability, with some experiencing drastic changes over the past few decades (Anderson et al., 2020). The reasons for the notable increase observed in the 2023 Biosurvey are unknown. Of note, a recent analysis of surf scoter abundance in San Francisco Bay, which typically hosts 40% to 50% of the Pacific Flyway's wintering surf scoter population, indicated a surprising increase in 2018, with counts surpassing the combined totals of their previous four survey years (2013–2016) (Strong, 2019).

These contrasting trends in surf scoter populations in areas of California indicate that the fluctuations could indicate a redistribution of birds within regions rather than a true population increase. This could be attributed to localized habitat changes or short-term variability, indicating that in future Port Complex surveys, fluctuations, sometimes substantial, may occur in surf scoter observations.



Large aggregation of elegant terns observed during fish sampling in Port of Long Beach Southeast Basin at Pier F (Zone 22)

Elegant tern observations in the Port Complex have declined consistently over the past decade, with a 73% decline from 2013–2014 (Table 6-5). Data from the 2000 and 2008 Biosurveys, although not completely comparable to post-2013 Biosurvey data, indicate that elegant tern observations have declined since at least the 2008 Biosurvey. However, large numbers of elegant terns were observed outside of official avian protocol surveys on the warehouse buildings on Pier F in July 2023, a time when most birds would likely be on their nesting colony (B. Stidum, pers. obs., during fish sampling on July 19, 2023). This number was not observed in the July 2023 sampling effort just 2 weeks prior, nor in any of the subsequent avian surveys. Elegant tern numbers may be higher than what is reported in this report (but not near historical highs from 2008) because of limitations in the current Biosurvey methodology, which may sometimes fail to detect large groups of elegant terns because of their sometimes-transient movements around the Port Complex and the upland locations of their nesting colonies. Additionally, large aggregations have been documented on the roof of the Tesla (formerly Mercedes) storage warehouse on Pier D, though no evidence of nesting has been observed there (J. Luedy, pers. comm.). Still, similar vessel-based surveys have been used since the 2000 Biosurvey, so relative detections are still comparable among Biosurvey periods, and the 73% decline is notable. A more thorough discussion of elegant tern regional trends is presented in Section 6.7.

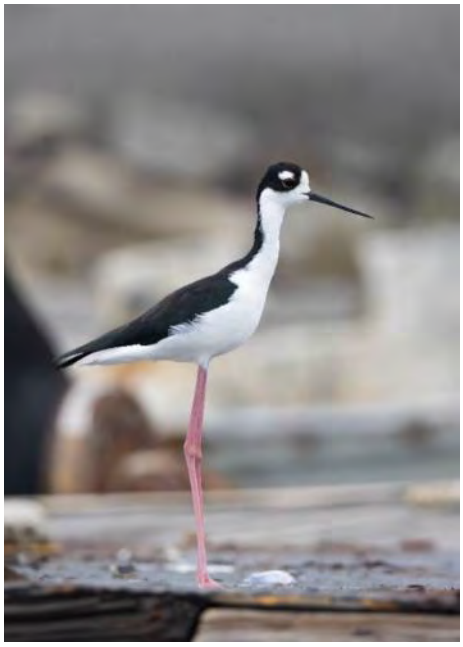
6.6.2 AVIAN GUILD COMPOSITION

Despite the reduced number of birds observed over the past 2 decades, the guild composition within the Port Complex has been relatively consistent for the past five Biosurveys (2000 through 2024). However, observable shifts in guild composition have occurred across Biosurveys, with some showing notable increases and others declining. Across all Biosurveys, Gulls, Waterfowl, and Aerial Fish Foragers composed no less than 84% of the total abundance

(Figure 6-12). Shorebirds, Wading/Marsh Birds, and Upland species combined have never composed more than 17% of the total abundance for any Biosurvey period.

Gulls remain one of the most dominant guilds across all Biosurveys, although their populations have decreased from highs of 44.6% in 2000 to 30.4% in 2023. Although the western gull population has remained relatively stable (albeit slightly declining), other Gull species have experienced notable changes, with numbers of California gull decreasing by 60% and Heermann's gull decreasing by 68% from 2013 to 2023. This decline in gull representation is largely attributed to a compensatory shift in the Waterfowl guild (increasing from 21.4% to 38.98%) and Upland bird guild (from 5.9% to 13.31%) since 2000.

Waterfowl numbers have fluctuated between survey periods, comprising 38.5% of all observations in 2008, 31.1% in 2013, and 29.1% in 2018, before rising to 39.0% in the 2023 Biosurvey period. These changes in Waterfowl representation reflect shifts in their own abundance rather than changes in the abundances of other guilds. Within the Waterfowl guild, trends include a 78% decline in western grebes and a 92% decline in eared grebes since 2000–2001, contrasted by a 197% increase in surf scoters and a 2,104% surge in lesser scaups over the same period, though lesser scaups still constitute less than 1% of total observations.



Black-necked stilt on a barge near the Cerritos Channel (Zone 25d)

Overall, Aerial Fish Forager representation has declined over time (despite a small increase in 2013) from 22.4% in 2000 to 14.2% in 2023. As with the Waterfowl guild, these variations are primarily attributed to changes in just a few species within the guild. For example, brown pelican populations showed volatility, decreasing by 62% from 2013 to 2018, before somewhat rebounding in 2023 (still a 13% decline). Similarly, elegant tern numbers exhibited substantial changes, declining by 73% from 2013 to 2023.

Shorebird (small and large combined) representation has decreased in every Biosurvey period since 2000 (Figure 6-12). Authors of previous Port Complex-wide assessments have hypothesized that the decrease over time may be due to tidal fluctuations at the time of surveys (SAIC, 2010) or a lack of available mudflat habitat (MEC, 2002), although there had been no changes to mudflat habitats within the Port Complex in that time. Recent comprehensive analysis of Shorebird populations has found that their abundances have declined steeply in North America (Smith et al., 2023; Warnock et al., 2021). Collectively, Shorebirds have consistently made up only a small but stable fraction of the total bird community, peaking at just 4.1% in 2000. Given the limited suitable habitat within the Port Complex and the few Shorebird observations, drawing meaningful conclusions about their presence is challenging. Notably, the largest tidal marsh and mudflat area within the Port Complex – the Salinas de San Pedro Wetlands near the Cabrillo Beach Launch Ramp – is excluded from Port-wide biological surveys, and notable Shorebird aggregations go undetected (B. Stidum, pers. obs.). Moreover, high-quality mudflat habitats outside the Port Complex at the Golden Street Marine Reserve and the Los Angeles River at West Willow Street provide superior foraging opportunities for Shorebirds compared with areas currently surveyed within the Port Complex. However, given that North American Shorebird populations continue to decline rapidly (Smith et al., 2023), detections within the Port Complex may follow this downward trend.

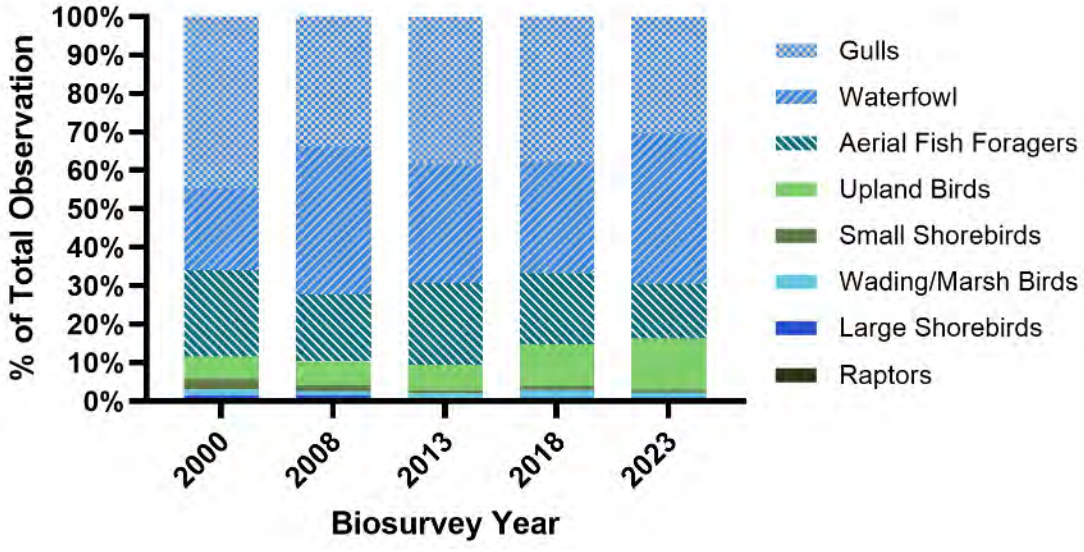
Among individual species, observations of Small Shorebirds, such as the ruddy turnstone (*Arenaria interpres*), willet (*Tringa semipalmata*), and black-bellied plover, have decreased by 100%, 82%, and 78%, respectively, since 2013. In contrast, numbers of Large Shorebirds, including spotted sandpiper, black oystercatcher, and surfbird, have increased by 194%, 110%, and 43%, respectively, over the same period.

Upland bird representation has steadily increased across all survey years (Figure 6-12). Prior to 2018–2019, Upland birds had never accounted for more than 6.5% of observations, but now they compose 13.1%. This increase was primarily driven by the European starling, which increased in number by 560% from numbers in 2013–2014, and to a lesser extent by the rock pigeon, with a 34.7% rise in number over the same period. Eurasian collared doves, although

representing only a small portion of the upland observations, are notable because none were reported from 2000 to 2014, 9 were reported in 2018–2019, and 67 were reported for the 2023 Biosurvey.

Raptors have always represented a small segment of the overall bird population but have shown an overall increasing trend in both observations and species diversity. This change was primarily driven by increases in osprey and peregrine falcon observations, which rose by 240% and 500%, respectively, since 2000. Additionally, red-tailed hawk observations increased by 89% over the same period.

Wading/Marsh Bird observations have remained consistent across survey years, never exceeding 1.9% of total abundance. Great-blue heron has been the dominant species, consistently accounting for at least 68% of the guild. Although observations of snowy egret and black-crowned night heron may increase because of potential growth or persistence of nesting colonies at Newmarks Yacht Centre and Ports O' Call Village, the overall composition of this bird guild is likely to remain similar.



*Small Shorebirds and Large Shorebirds are combined to allow for inter-study comparisons; likewise, Raptors are included with Upland Birds.

Figure 6-12. Historical Comparison of Avian Guilds in the Port Complex Based on the Percentage of Observations

6.6.3 OVERALL SPECIES COMPOSITION

Since the protocol surveys that encompass the entire Port Complex were implemented in 2000, the assemblage of the 10 most abundant species has remained relatively stable, consistently accounting for no fewer than 86% of total observations in each survey (Table 6-6). Although the 10 species have remained consistent in terms of abundance (except in 2018, when the great blue heron replaced the California gull in the top 10), the percentage composition of these species has shown some variability (Figure 6-13).

As discussed in greater detail above, the results of the 2023 Biosurvey identified significant shifts in species composition compared with results from previous years. Still, some trends are apparent. Overall, the western gull has been the dominant species in recent Biosurvey years. For the 2023 Biosurvey period, the western gull was the most dominant species, representing 24.3% of all observations, despite a decline from its peak of 32.4% in 2018. Observations of the brown pelican have remained relatively constant and have accounted for approximately 9.5% of the total observations for all Biosurvey years, with a decrease to only 5.7% in 2018. Similarly, observations of the double-crested cormorant remained within a narrow range of approximately 3% to 5% of the total observations across all survey years. Observations of the California gull were relatively low but stable, accounting for 1% to 3% of the total observations in all Biosurvey periods, except in 2013 when observations of the species reached a high of 6% the

total observations. The other category, which represents fewer common species, ranged in observations from 8% to 13% of the total observations over all Biosurvey years, and observations have been consistent across all Biosurveys.

Observations of the Brandt's cormorant experienced a notable increase, comprising 19.3% of the total observations, nearly quadrupling its representation since 2000. Observations of the rock pigeon increased modestly, from 4.4% of the total observations in 2000 to approximately 9%, remaining stable for the past two Biosurveys.

Observations of the surf scoter also increased substantially in 2023 to 11.4% of the total observations, the species' highest level, increasing from a low of 3.7% and 3.1% in 2000 and 2018 respectively. The number of surf scoter observations in 2000 was exceptionally low (4,337). Even twice-monthly counts led to fewer total observations compared with observations in 2013 (2,535), when surveys were conducted only once per month. From 2000 to 2008, surf scoter observations during surveys increased by 1,200% (to 14,122), and the number of observations for the species increased from 3.7% to 11.3% of the total observations. Similarly, during the 2023 Biosurvey, observations of the surf scoter accounted for 11.3% of the total observations, whereas in the 2013 and 2018 Biosurveys, observations of the surf scoter accounted for only 3% of the total observations.

Most notably, Heermann's gull was the second most abundant species in 2000, comprising 11.9% of the total observations (Table 6-6). However, the species abundance has steadily decreased, dropping to 7.3% in 2008 and further decreasing to 2.3% in 2023, marking a dramatic decrease of over 82%. In 2023, observations of the western grebe reached the lowest recorded level of the total observations (3.6%), down from highs of 14.5% in 2013 and 12.2% in 2018 (Table 6-6). Similarly, observations of the elegant tern declined from highs of 10.6% of the total observations from 2013 to 2018 to just 3.3% for the current survey period.

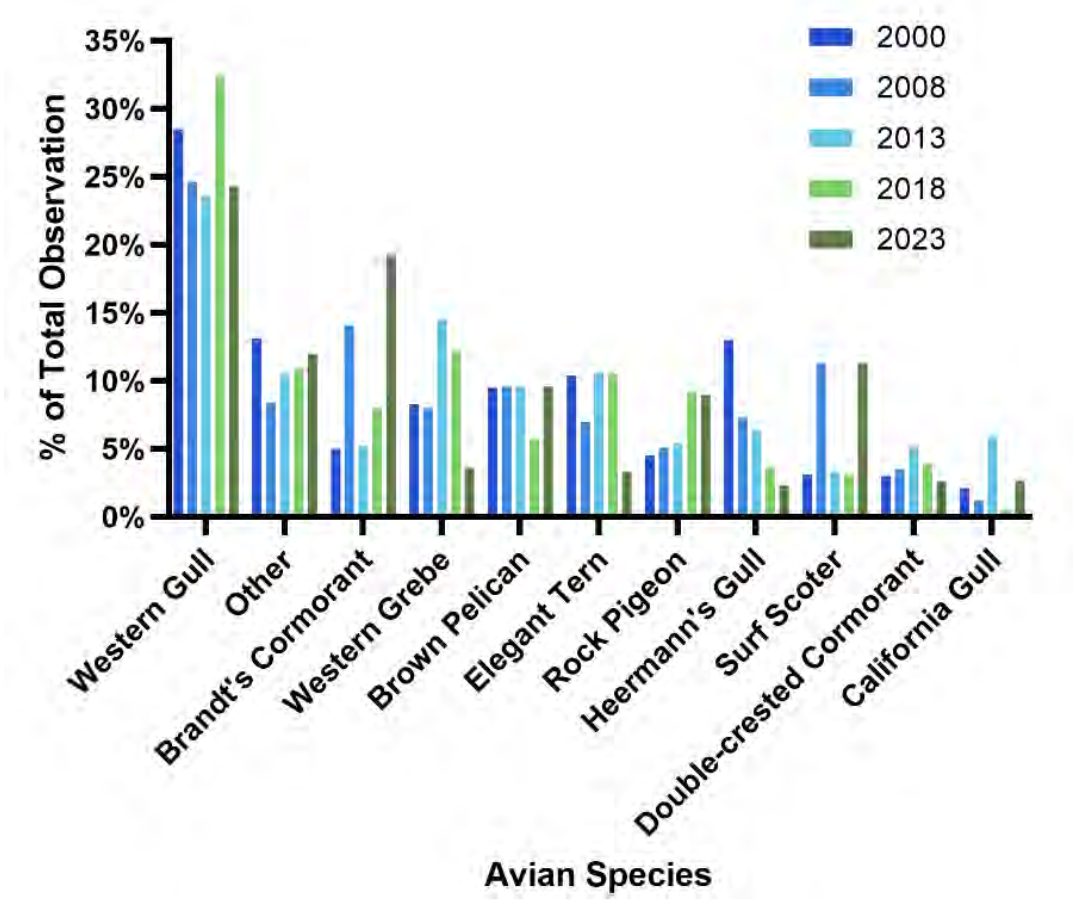


Figure 6-13. Historical Comparison of Composition of the 10 Most Abundant Avian Species in the Port Complex

Table 6-6. Historical Comparison of the Composition of the 10 Most Abundant Avian Species in the Port Complex (as a Percentage of Total Observations)

Species	Biosurvey Event				
	2000	2008	2013	2018	2023
Total Number of Observations	117,559	125,535	76,260	48,754	66,447
Western Gull	29.1% (34,168)	24.6% (30,859)	23.6% (17,961)	32.4% (15,810)	24.3% (16,128)
Western Grebe	8.8% (10,316)	8.0% (10,044)	14.5% (11,039)	12.2% (5,949)	3.6% (2,370)
Elegant Tern	7.6% (8,896)	7.0% (8,761)	10.6% (8,083)	10.5% (5,127)	3.3% (2,199)
Brown Pelican	9.8% (11,468)	9.5% (11,922)	9.6% (7,320)	5.7% (2,780)	9.6% (6,364)
Heermann's Gull	11.9% (13,944)	7.3% (9,122)	6.4% (4,867)	3.6% (1,740)	2.3% (1,536)
California Gull	2.5% (2,933)	1.2% (1,490)	5.9% (4,510)	0.5% (261)	2.7% (1,790)
Rock Pigeon	4.4% (5,171)	5.1% (6,374)	5.4% (4,134)	9.2% (4,461)	9.0% (6,010)
Brandt's Cormorant	5.5% (6,441)	14.1% (17723)	5.2% (3,936)	8.0% (3,921)	19.3% (12,813)
Double-crested Cormorant	3.2% (3,793)	3.2% (4002)	5.1% (3,905)	3.9% (1,894)	2.6% (1,705)
Surf Scoter	3.7% (4,337)	11.3% (14,122)	3.3% (2,535)	3.1% (1,490)	11.4% (7,541)
Other	13.7% (16,092)	8.8% (11,046)	10.5% (7,970)	10.9% (5,321)	12.0% (7,991)

6.7 DISCUSSION

The spatial variations documented during the 2023 Biosurvey were consistent with the other recognized patterns from previous Biosurvey years. The types of zones with the most abundant bird populations have remained relatively consistent over the past four Biosurveys during which the same protocol was used. The larger open-water zones of the Outer Harbor (Zones 10a [Outer Navy Mole], 22a [Southeast Basin], and 23 [West Basin]) have historically supported, and continue to support, large rafts of foraging and resting Waterfowl dominated by surf scoter, western grebe, and several cormorant species. The zones along the Middle Breakwater (Zones 9 [Port of Los Angeles Middle Breakwater], 12 [Port of Long Beach West Breakwater], and 15]Port of Long Beach East Breakwater]) support large flocks of roosting brown pelican, double-crested cormorant, Brandt's cormorant, and multiple gull species. Historically, these three breakwater zones have been among the most populous, and they accounted for the highest densities (birds/acre) during the 2000 Biosurvey (MEC, 2002); Zone 9 was the fourth most populated zone in the 2008 Biosurvey (SAIC, 2010) and the fifth most in the 2013 Biosurvey (MBC, 2016) and the 2023 Biosurvey. Zone 34a (Port of Los Angeles Main Channel) and Zone 4 (Fish Harbor) have historically supported large numbers of resting and foraging gulls, particularly western gulls and Heermann's gulls. Zone 34 was the second most populated zone in the 2008 Biosurvey (SAIC, 2010), the fourth most populated zone in the 2000 (MEC, 2002) and 2013 (MBC, 2016) Biosurveys, and the seventh and sixth for the 2018 and 2023 Biosurveys, respectively. Lastly, Zone 8a (Outer Pier 400 West), adjacent to the tern nesting colony at Pier 400, has supported the largest number of birds for the past three Biosurveys from 2014 to present.

For all years in which the current Biosurvey methods were used, open water, riprap, and dock/pilings have continually been the most heavily used physical features in the Port Complex. Across all Biosurveys since 2000, no fewer than 70% of the observations have occurred in these three types of features, with open water being the most used feature in three of the five recent Biosurveys (it was third during the 2000 Biosurvey). Riprap was the most used habitat during the 2000 Biosurvey, accounting for 25% of the total observations (MEC, 2002), and the second most used

habitat in every other Biosurvey. These findings are expected because riprap and open water are the dominant physical features observed from the survey boats and provide foraging, resting, and refuge locations for many species.

Across all Biosurveys, most birds were observed resting, with shoreline features (e.g., docks, pilings, riprap) used extensively by gulls, pelicans, and cormorants, as well as by small and large shorebirds for resting and foraging.

Special-Status Species

Several special-status avian species – those listed by the USFWS and/or the CDFW – were observed within the Port Complex during the 2023 Biosurvey. Table 6-7 summarizes these observations and details each of these species' regulatory status, the zones in which they were recorded, and the total number of individuals documented. Status designations are based on the CDFW California Natural Diversity Database Special Animals List (CDFW, 2025). All species with federal protections are specifically noted and discussed. Species whose special status applies specifically to nesting colonies or communal roosting sites, rather than to wintering or foraging use, are noted as such and are also addressed in this section.

Several other special-status avian species were observed within the Port Complex during the 2023 Biosurvey (Appendix F) that are protected at nesting sites but are not known to breed within the survey area. Accordingly, there is no sensitive habitat for these species in the Port Complex. These species include California gull, common loon (*Gavia immer)*, and redhead (*Aythya americana*). Species with special status that were not observed during the 2023 Biosurvey, but have historically occurred in the Port Complex, include brant (*Branta bernicla*) (multiple Biosurveys), northern harrier (*Circus hudsonius*) (MBC, 2016), long-billed curlew (*Numenius americanus*) (multiple Biosurveys), Scripps's murrelet (*Synthliboramphus scrippsi*) (MBC, 2016), burrowing owl (*Athene cunicularia*) (MEC, 2002), and loggerhead shrike (*Lanius ludovicianus*) (MEC, 2002). Additionally, great egret (*Ardea alba*) and Cooper's hawk (*Accipiter cooperii*) have protections at nesting locations but have never been documented nesting in the Port Complex even though some suitable habitat is available, particularly areas with large eucalyptus such as those at Zone 23 (Navy Mole Pier). Nine species designated as birds of conservation concern (BCCs) by the USFWS were recorded during the survey period (Table 6-7), and although these species currently lack formal protections, they are noted in Table 6-7 for possible future conservation measures but are not discussed.

Table 6-7. Occurrence of Special-Status Bird Species Observed in the Port Complex in the 2023 Biosurvey

Species	Status	Zones Where Observed	Total Number Observed
Allen's Hummingbird (*Selasphorus sasin*)	USFWS:BCC	10a	1
Black-crowned Night Heron (*Nycticorax nycticorax)*	Nesting – CDFW:SA	19 of 54 total zones (see Appendix F)	55
Black Oystercatcher (*Haematopus bachmani*)	USFWS:BCC	Zones 9, 12, 13, 15, 19, 21, 10a, 3a, 3b, 3c, and 8a	444
Black Skimmer (*Rhyncops niger*)	Nesting – CDFW:SSC USFWS:BCC	Zones 14 and 1a	143
Brown Pelican (*Pelecanus occidentalis*)	State and Federal Delisted Nesting Sites and Communal Roosts – CDFW:SA BLM:S; USFS:S	All zones except 22b, 34b, 34d, 34e, 3d, and 8b	6,364
Brandt's Cormorant (*Urile penicillatus*)	USFWS:BCC	All zones except 24e, 26b, 27c, and 34e	12,813
California Gull (*Larus californicus*)	Nesting – CDFW:WL USFWS:BCC	44 of 54 total zones (see Appendix F)	1,790
California Least Tern (*Sternula antillarum browni*)	FE, SE CDFW:FP	None observed in the current survey period	0
Caspian Tern (*Hydroprogne caspia*)	Nesting – CDFW:SA USFWS:BCC	39 of 54 total zones (see Appendix F)	257
Clark's Grebe (*Aechmophorus clarkii*)	USFWS:BCC	Zones 19, 21, 23, 10a, 1b, 27b, 3b, 3d, and 8a	59
Common Loon (*Gavia immer*)	Nesting – CDFW:SSC	Zones 6, 11, 12, 19, 23, 10a, 1b, 25b, 2b, 8a, and 8b	16
Coopers Hawk (*Accipiter cooperii*)	Nesting – CDFW:WL	Zones 30, 25d, and 27b	4
Double-crested Cormorant (*Nannopterum auritum*)	Nesting – CDFW:WL	All zones except 11,34e,3d, and 8b	1,705
Elegant Tern (*Thalasseus elegans*)	Nesting – CDFW:WL	24 of 54 total zones (see Appendix F)	2,199
Great Blue Heron (*Ardea herodias*)	Nesting – CDFW:SA CDF:S	All zones except 9, 11, 14, 15, 24e, 34e, and 3d	555
Great Egret (*Ardea alba*)	Nesting—CDFW:SA CDF:S	Zones 5, 33, and 27b	5
Heermann's Gull (*Larus heermanni*)	USFWS:BCC	37 of 54 total zones (see Appendix F)	1,536
Marbled Godwit (*Limosa fedoa*)	USFWS:BCC	1a	1
Osprey (*Pandion haliaetus*)	Nesting – CDFW:WL CDF:S	23 of 54 total zones (see Appendix F)	51
Peregrine Falcon (*Falco peregrinus*)	State and Federal Delisted Nesting – CDFW:SA	Zones 12, 19, 21,10b, 22a, 24b, 25d, 26a, 2b, 31a, 34d, 4b, and 8a	18
Redhead (*Aythya americana*)	Nesting – CDFW: SSC	6	4
Snowy Egret (*Egretta thula*)	Nesting – CDFW:SA	30 of 54 total zones (see Appendix F)	178

Table 6-7. Occurrence of Special-Status Bird Species Observed in the Port Complex in the 2023 Biosurvey (continued)

Species	Status	Zones Where Observed	Total Number Observed
Western Grebe (*Aechmophorus occidentalis*)	USFWS:BCC	32 of 54 total zones (see Appendix F)	2,370
Western Snowy Plover *(Anarhynchus nivosus nivosus*)	FT CDFW: SSC	12	1
Western Gull (*Larus occidentalis*)	USFWS:BCC	All zones	16,128
Willet (*Tringa semipalmata*)	USFWS:BCC	Zones 14, 19, 10a, 1a, 1b, 2b, 3b, and 3c	21

FE = Federally Endangered; FT = Federally Threatened; SE = State of California Endangered
BLM:S = Bureau of Land Management – Sensitive
CDF:S = California Department of Forestry and Fire Protection – Sensitive
CDFW:SA = California Department of Fish and Wildlife – Special Animal
CDFW:FP = California Department of Fish and Wildlife – Fully Protected Species
CDFW:WL = California Department of Fish and Wildlife – Watch List
CDFW:SSC = California Department of Fish and Wildlife – Species of Special Concern
CDFW:SA = California Department of Fish and Wildlife – Special Animal, tracked by CDFW but not protected status
USFWS:BCC = United States Department of Fish and Wildlife – Bird of Conservation Concern
USFS:S = United States Forest Service – Sensitive

Western Snowy Plover: The western population of the snowy plover has been listed as threatened under the Endangered Species Act (ESA) since 1993 (USFWS, 1993). This species has never been documented nesting in the Port Complex during any Biosurvey, likely because of the absence of any sizable suitable nesting habitat. Overall observations are rare, with only occasional sightings of transiting birds landing in the California least tern nesting colony at Pier 400 (Keane Biological Consulting, 2007; Rincon, 2022). However, a wintering group of birds currently occurs just outside the survey area along the coastal shoreline at Point Fermin and Cabrillo Beach (Ryan et al., 2021; B. Stidum, pers. obs.).



Western snowy plover on the riprap in the Port of Long Beach West Breakwater (Zone 12)

During the 2023 Biosurvey period, one western snowy plover was observed resting on the western middle breakwater in Zone 12 on April 7, 2024, which was presumed to be a bird transiting to a nesting location outside the Port Complex.

California Least Tern: The California least tern was listed as an endangered species under the ESA in 1970 (USFWS, 1973) and under the California Endangered Species Act (CESA) in 1980 (California Department of Fish and Game [CDFG], 1976). This species is a spring and summer visitor to the Port Complex, and California least terns have nested at this location since at least 1976 (Keane Biological Consulting, 1999). Since 1997, the species has nested at a managed site on Pier 400 (SAIC, 2010). California least terns usually arrive at the Pier 400 nesting site in mid to early April and remain until all chicks have fledged, which can be as late as September.

No California least terns were observed during the 2023 Biosurvey. Nesting surveys conducted by Rincon (2024b) during the 2023 nesting season documented 56 nests but no chicks or fledglings. Rincon surmised that predation by common ravens and possible human disturbances led to a significant reduction in adult activity, with the nests later abandoned.

Peregrine Falcon: The peregrine falcon (*Falco peregrinus*) was previously listed as endangered at both the federal and state levels. The species was federally delisted in 1999 (USFWS, 1999) and subsequently removed from the California endangered species list in 2023 following the passage of Senate Bill 147. Falcons have historically nested within the Port Complex on both the Schuyler F. Heim Bridge and the former (now demolished) Gerald Desmond

Bridge during the 2000 and 2008 Biosurveys (MEC, 2002; SAIC, 2010). Following initial completion of the newly constructed International Gateway Bridge in 2020, peregrine falcons were once again observed nesting in a small expansion joint on the southwestern approach of the bridge (J. Luedy, pers. comm.).

Although no nesting was observed during the 2023 Biosurvey (limitations of the current Biosurvey method limit the detections of Upland and Raptor species), peregrine falcons were observed on and near the new International Gateway Bridge (Zones 24b [East Basin Pier E-D] and 25d [Channel 2]), the Schuyler F. Heim Bridge (Zone 26a [Cerritos Channel]), and the Vincent Thomas Bridge (Zones 31a [Turning Basin] and 31b [West Basin South]). Additional observations of peregrine falcons include four observations in Zone 21 (Pier J Slip) and one observation in each of Zones 12 (Port of Long Beach West Breakwater), 19 (Queensway Bay), 10b (Port of Long Beach SWH), 22a (Southeast Basin), 2b (Cabrillo Marina), 4b (Fish Harbor), and 8a (Outer Pier 400 West).

Brown Pelican: The brown pelican, previously listed as endangered or threatened at both federal and state levels, has now been removed from federal protection lists (USFWS, 2009). Following the passage of California Senate Bill 147 in 2023, all state protections were also eliminated. Brown pelicans do not nest within the Port Complex; the only large nesting colonies in the western United States are on the Channel Islands and the Los Coronados Islands (Shields, 2020). However, the Port Complex has historically provided important roosting and foraging habitat for this species, which rests on the breakwaters and forages in the protected waters of the Port Complex.



Aggregation of elegant terns on the Pacific Tugboat Service barge in the Port of Long Beach West Basin (Zone 23)

Brown pelicans were observed consistently in large numbers within the Port Complex on every sampling day during 2023–2024. The species ranked fourth most abundant, composing 9.6% of total bird observations. Brown pelicans were least abundant in January through April 2024 (199, 190, and 213 observations, respectively), when breeding birds are gathered at their island nesting colonies. Abundance notably increased after the breeding season as the birds returned from their nesting colonies and migrated northward, reaching highs of 1,170 and 2,100 individuals in July and September 2023, respectively. Brown pelicans were observed primarily in the Outer Harbor, with large concentrations of birds roosting on the riprap along the Port periphery in Zones 9 (Port of Los Angeles Middle Breakwater), 12 (Port of Long Beach West Breakwater), 3b (Cabrillo SWH – Phase 1), 8a (Outer Pier 400 West), 15 (Port of Long Beach East Breakwater), and 3a (Cabrillo SWH – Phase 2). Smaller numbers of birds were observed resting on the dredge pipe in Zone 23 (West Basin) and the Bait Barge in Zone 3b and foraging in the shallow water habitats of Zones 6 (Pier 300 SWH) and 23.

Elegant Tern: The elegant tern is not listed as threatened or endangered, but is on the CDFW Watch List. Populations are not formally monitored in the Port Complex, so exact numbers are unknown. At least 4,500 elegant terns nested on Pier 400 in 2018 (LBC, 2019), but none have nested there since (LBC, 2021a, 2021b, 2021c; Rincon, 2022, 2024a). The reason for the absence of current nesting activity at Pier 400 is unclear because very large aggregations of elegant terns were observed within the Port Complex during the nesting season (B. Stidum, pers. obs.; made during Biosurvey fish sampling on July 19, 2023). Potential factors may include predation, broader oceanographic changes, or the implementation of nocturnal lasers beginning in 2018 to reduce conflicts between larger terns and California least terns at the Pier 400 nesting site. Large aggregations of elegant terns were also observed in other areas of the Port Complex where they have not been documented in such numbers in other Biosurveys, including the Pacific Tugboat Barges in Zone 10a (Port of Long Beach West Basin) and the warehouse building at the southern end of Pier F.

During the 2023 Biosurvey, the elegant tern was the seventh most abundant avian species, accounting for 3.3% of total observations. This species was observed only from April through October 2023, with the peak number of individuals (999) recorded in June 2023. The greatest concentrations were observed, along with Caspian terns, on moored barges in Zone 10a. Elegant terns were also regularly observed foraging in Zone 6 (Pier 300 SWH) and the areas surrounding Pier F, particularly in Zones 14 (Port of Long Beach Outer Harbor Main Channel) and 19 (Queensway Bay). In June 2021, a drone crash caused an estimated 3,000 elegant terns to abandon their eggs at Bolsa Chica Ecological Reserve in Orange County. Many of these birds were thought to have relocated to two commercial

barges in Long Beach Harbor, where they ultimately nested on rock storage barges owned by Connolly-Pacific Co. A large aggregation of elegant terns (720 birds) was observed in the same area in June 2023 on the Pacific Tugboat Barges in Zone 10a (Outer Navy Mole Pier). An inspection of the barge using a camera with a large telephoto lens confirmed nesting activity by Caspian terns, but was inconclusive for elegant terns. A more thorough inspection was not conducted to avoid disturbing the colony and potentially causing abandonment. Subsequent surveys showed that the barges were no longer used by any tern species, though abandoned eggs were discovered.

Since 2021, no confirmed elegant tern nesting has been recorded in the Port Complex, though varying observations of other colonies in Southern California have been documented. Bolsa Chica Ecological Reserve has not had a nesting colony since the birds abandoned the site following the drone crash in 2021, although other factors such as predation may have caused additional stressors (R. Griswold, pers. comm.). Meanwhile, San Diego Bay, which has historically supported the largest elegant tern colony in California, experienced a significant decline in nesting, with numbers dropping from an average of 35,000 nests from 2000 through 2023 to just 709 to 857 in 2024 (R. Patton, pers. comm.). Notably, a new colony emerged on West Ski Island in Mission Bay (San Diego County), growing from zero nests in 2019 to approximately 7,500 nests in 2024, with the most substantial increase occurring from 2023 to 2024. Results of recent studies indicate that elegant tern nesting activities can fluctuate greatly based on warm ocean conditions (Velarde et al., 2018). A significant portion of the population currently nests in the Gulf of California, but an increasing number of these birds relocate to colonies in coastal Southern California, especially in ENSO years (Veit et al., 2021; Velarde et al., 2015). Additionally, Perez et al. (2020) demonstrated that individual elegant terns travel readily between nesting sites in the Gulf of California and Southern California, possibly in response to local food availability conditions, indicating that population fluctuations – sometimes substantial – within the Port Complex may be expected as ocean conditions vary year to year.

Caspian Tern: The Caspian tern is not listed as threatened or endangered. Instead, the species is designated as a Special Animal at the nesting sites. Within the Port Complex, Caspian terns have historically nested at Pier 400 since at least 1997 (Keane Biological Consulting, 2007). LBC (2019) estimated that 300 Caspian terns nested at this site in 2018, 100 in 2019, and none since (LBC, 2021a, 2021b, 2021c; Rincon, 2022, 2024a). In 2020, Caspian terns began nesting on Piers 12 and 16 in the Port of Long Beach, but they were deterred during the following breeding season and ultimately relocated to the Navy Mole Pier (J. Luedy, pers. comm.). The reasons for the initial shift from Pier 400 to other areas of the Port Complex in 2020 are unclear but may be associated with predation and nocturnal roost deterrent measures at Pier 400 to protect California least terns, coupled with reduced activity across the Port Complex during the COVID-19 pandemic and the vacancy of adjacent leased properties. These factors may have made Piers 12 and 16 more favorable to the birds during that period.

The current status of nesting Caspian terns in the Port Complex is unknown. Caspian terns were observed sitting on presumed nests, as well as on apparently abandoned eggs, on Pacific Tugboat Barges in Zone 10 (Outer Navy Mole Pier) in June 2020 Subsequent surveys of the barges indicated no tern activity – nesting or otherwise – and no Caspian tern nesting was documented for the 2023 Biosurvey period. Similar to the other tern species, Caspian terns were primarily observed from April through October 2023 (with five observations from September through October 2023). They were recorded in 39 of 54 survey zones (68%) but were most abundant in Zones 6 (Pier 300 SWH), 10a (Outer Navy Mole), and 23 (West Basin). These zones are proximate to historical nesting sites at Piers 300/400 and Piers 12 and 16, a current nesting location at moored barges in Zone 10a, and sandy beach roosting areas such as Cabrillo Beach and Seaplane Lagoon. Caspian tern abundance was highest in April 2023 (51 observations) and July 2023 (77 observations), which correspond to the breeding and post-breeding dispersal periods (Unitt, 2004).

Pacific Coast populations of Caspian terns are generally considered to be increasing, with the center of the population shifting northward from California to the Columbia River estuary (Collis et al., 2012; Cuthbert and Wires, 2020). This broader trend may imply that although the species is expanding in its core range, it may be contracting along the southern periphery, including Southern California.

Within the Port Complex, observations have increased from 60 in 2013 to 210 in 2018 and 257 in 2023, despite no evidence of nesting since 2019. However, long-term counts for San Diego Bay, another major site within southern California, indicate a different pattern. According to R. Patton (pers. comm.), Caspian tern numbers there peaked at over 500 individuals around 2000 and averaged 300 to 400 birds annually through the late 2000s and early 2010s. Numbers subsequently dropped to approximately 50 to 60 birds in 2022 and just 6 to 7 birds in 2023.

These data may indicate that although detections in the Port Complex have recently increased, it is uncertain whether this represents a genuine rebound in regional use or is primarily the result of improved detection. Roosting and nesting birds previously displaced from sites such as Pier 400 and the Navy Mole Pier by the approved deterrent measures may now be more visible on undisturbed, moored barges within the basins, where survey coverage is more comprehensive.

Black Skimmer: Black skimmers are not currently listed as threatened or endangered but are designated as a Species of Special Concern (SSC), particularly at their nesting locations. Within the Port Complex, black skimmers have historically nested at the Pier 400 site, with an estimated 90 nests in the Tern Management Area West in 2018 (LBC, 2019) and20 in 2019 (LBC, 2021a), but with only one failed nest since (K. Prickett, pers. comm.). No other nesting sites in the Port Complex have been documented since 2019.

Observations of black skimmers have fluctuated, ranging from a low of 116 in 2013–2014 to 184 in 2018–2019. During the 2023 Biosurvey, 143 black skimmer observations were recorded on three monitoring days (June 2023, February 2024, and April 2024), all in Zone 1a (Cabrillo Beach North). As many as 83 birds were observed resting on the sand at the Cabrillo Beach swim area, where they have been routinely observed since 2013–2014 (MBC, 2016; Wood, 2021).

Great Blue Heron: The great blue heron is not listed as threatened or endangered but is designated as an SSC at the nesting colonies. Nesting colonies of great blue herons continue to occur within the Port Complex, consistent with observations dating back to the first comprehensive baseline Biosurvey in 2000 (MEC, 2002; SAIC, 2010; MBC, 2016; Wood, 2021).

The great blue heron was the 13th most abundant species observed during the 2023 Biosurvey period, representing 0.8% of total avian abundance. This resident species was ubiquitous, recorded during every survey event, and documented in all but seven survey zones. Observations of great blue herons ranged from a low of 35 in April 2023 to 73 in September 2023. During the 2023 Biosurvey period, great blue herons were observed nesting from February through July 2023, with the highest nest densities recorded in Zone 34a (Port of Los Angeles Main Channel), Zone 32 (Port of Los Angeles West Basin), and Zone 23 (Port of Long Beach West Basin). A noticeable shift in the primary concentration of great blue heron nests occurred, moving away from Zone 34e (Port of Los Angeles Main Channel E Slip during the 2018 Biosurvey to Zone 34a (Port of Los Angeles Main Channel) during the 2023 Biosurvey.



Great blue heron nesting within the lamp post structures near the Port of Los Angeles Main Channel (Zone 34a)

This shift was driven by a change in the former nesting habitat from the abandoned cranes and buildings near SoCal Ship Services at Berth 240 to the LED light structures at Everport Terminal Services, and to a lesser extent, at the Yusen and TraPac terminals in the Port of Los Angeles West Basin. The conical umbrella shape of these newer LED lamps allows great blue herons to nest at the base, offering improved stability over the flat and open lamp posts. This design seems to be preferred by great blue herons in the Port Complex because it likely provides better shelter and support, thus reducing risks from high winds and predation.

Black-crowned Night Heron: The black-crowned night heron is not a listed species but is classified as Special Animal at its nesting locations. This species has historically nested at the Navy Mole Pier (MEC, 2002), with one nest documented in 2002 (MBC, 2007; SAIC, 2010), but no nesting has been recorded during any subsequent Biosurveys.

Although no active nests were detected within the limits of current survey methods during the 2023 Biosurvey, black-crowned night herons have recently been observed nesting in nearby areas not captured by current survey methods, including ornamental trees on Ferry Street at Terminal Island and Ports O' Call Village, between Zone 34a (Port of Los Angeles Main Channel) and Zone 34d (S.P. Slip) (SAIC, 2010; Hamilton and Cooper, 2019; B. Stidum, pers. obs.), and in Ficus trees on Via Cabrillo-Marina and Queensway Bay, just outside the official survey area (B. Stidum, pers. obs. 2024). The largest known colony is currently in the Ficus trees at Newmarks Yacht Centre in Zone 27c (East

Basin Marina) (Hamilton and Cooper, 2019; R. Hamilton, pers. comm.), just outside the viewable limits of the current survey methods.

Black-crowned night herons were mainly observed in Zones 27b (Consolidated Slip) and 27c (East Basin Marinas), which are near the Newmarks Yacht Centre nesting colony, and in Zones 34a (Port of Los Angeles Main Channel) and 2b (Cabrillo Marina), also adjacent to other nesting colonies. Observations in these zones collectively accounted for 45.6% (25 of 55) of all black-crowned night heron observations.

Snowy Egret: The snowy egret is not a listed species but is considered a Special Animal at the species' communal nesting locations. Within the Port Complex, snowy egrets have never been observed nesting during any Biosurvey period. However, a new nesting colony, with as many as 14 nests, has recently been documented at Newmarks Yacht Centre in Zone 27c (East Basin Marinas) (Hamilton and Cooper ,2019; R. Hamilton, pers. comm.).

Nests were not observed during the 2023 Biosurvey because they are deep within dense Ficus trees in the uplands. Overall, the number of snowy egret observations has varied across survey periods, with a 43% decline from 253 individuals in 2013–2014 to 145 in 2018–2019, followed by an increase to 199 during the 2023 Biosurvey period. Non-nesting birds were observed in several zones (Table 6-7), with most sightings in Zones 27b (Consolidated Slip) and 26a (Cerritos Channel), both near the current nesting colony.

Double-crested Cormorant: The double-crested cormorant is CDFW watch list species and a widespread resident within the Port Complex. However, nesting activity is strictly confined to the metal framing of the Southern California Edison transmission towers near the Cerritos Channel. The original towers, previously in Zone 26a, were demolished and replaced with larger towers now more visible from Zone 25a (Port of Long Beach Back Channel), which continue to support the nesting colony.

During the 2023 Biosurvey, the double-crested cormorant was the ninth most abundant species, accounting for 2.6% of total observations. Nesting activity was observed regularly on the new towers from May through July 2023, with a peak count of 38 nesting birds. This number represents a decline compared with counts of 160 and 150 during the 2013 and 2018 Biosurveys, respectively. It is uncertain whether this decline reflects an actual population decrease or differences in detection because of the new tower location. Because the current towers are larger and could support more nests, additional birds may be recruited to the area in future nesting seasons.



Black oystercatcher with chick on the Port of Long Beach West Middle Breakwater (Zone 12)

Black Oystercatcher: The black oystercatcher has no designation under the CDFW but is listed as a SSC by the USFWS. It is a resident shorebird within the Port Complex and the most abundant species in the Large Shorebird guild. Nesting activity has been documented across multiple surveys, including the 2018 Biosurvey, with primary nesting along the Middle Breakwater (Zones 15 [Port of Long Beach East Breakwater], 12 [Port of Long Beach West Breakwater], and 9 Port of Los Angeles Middle Breakwater]).

Black oystercatchers were observed in every Biosurvey month, with counts ranging from a single individual in November 2023 to highs of 126 individuals in July during the 2013 Biosurvey, 320 in the 2018 Biosurvey, and 444 in the 2023 Biosurvey – representing a 110% increase over observations in 2013–2014. During the 2023 Biosurvey, nesting was confirmed only in Zone 12 (Port of Long Beach West Middle Breakwater), where one juvenile bird was documented. A hybrid black × American oystercatcher was also recorded in Zones 15 (Port of Long Beach East Breakwater) and 12 (Port of Long Beach West Breakwater) in August and September 2023.

Osprey: The osprey is not a listed species but is designated as a Watch List species by the CDFW. Nesting within the Port Complex was first documented during the 2018 Biosurvey, when one nest was recorded on a lamp post at Pier D in Zone 24b (Port of Long Beach East Basin Pier E-D).

Nesting observations continued during 2023, with two chicks observed in the Pier D nest and a second nest recorded on a lamp post among shipping containers on Pier C (viewed from Zone 25b [Port of Long Beach Inner Harbor Turning Basin]). Osprey detections have steadily increased across Biosurvey periods, rising from 15 observations in the 2013 Biosurvey to 51 for the 2024 Biosurvey period; however, most of these 51 observations likely represent repeated sightings of the same nesting birds occupying the two active nests. Ospreys were recorded during every Biosurvey in 22 of 54 zones.

Western Gull: In 2021, the USFWS listed the western gull as a Bird of Conservation Concern because of its limited range and vulnerability to climate fluctuations, such as ENSO. Other concerns include generally low population numbers, limited breeding colonies, extensive hybridization with the glaucous-winged gull (*Larus glaucescens*), and threats from oil spills and pesticide-related impacts on health and reproduction (Pierotti et al., 2024; USFWS, 2021). Despite this designation, no formal agency protections are currently in place.

Western gulls have historically nested within the Port Complex during every Biosurvey period. In recent years, the largest colonies have been observed on warehouse rooftops at the southeastern end of Pier F (observed from Zone 22a [Southeast Basin]) and on buildings along the northern shoreline in Zone 2c (Berths 58–60) (MBC, 2016; Wood, 2021). Nesting has also been reliably documented on old dock pilings in Zones 25b (Inner Harbor Turning Basin) and 25d (Channel 2), as well as on channel markers at the ends of riprap jetties and breakwaters.

During the 2023 Biosurvey, fewer western gulls were recorded nesting on these structures because of the active and previous installation of solar panels on the building roofs. Despite this reduction on buildings, the overall number of nesting observations has increased compared with earlier Biosurveys. Counts rose from 21 instances (adults and chicks) in 2013–2014 to 44 in 2018–2019, reaching 111 nesting observations in 2023–2024. Current total counts of western gulls remain roughly 10% below the highs observed in the 2013 Biosurvey**.**

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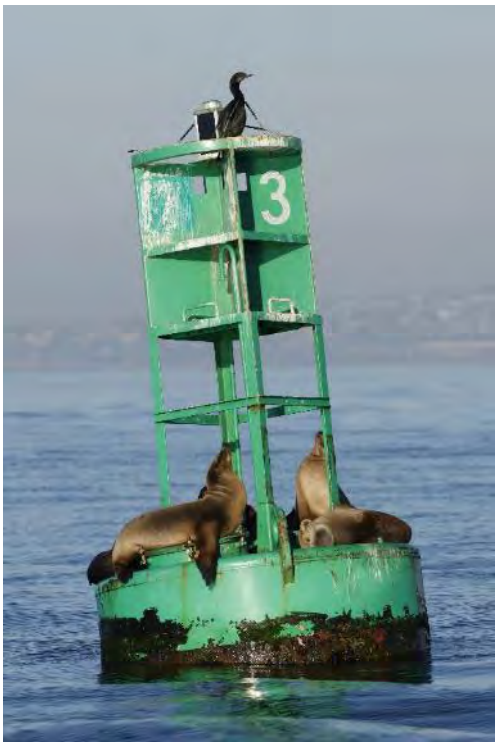
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7 MARINE MAMMALS

During the 2023 Biosurvey, marine mammal surveys were conducted concurrently with the monthly avian surveys using the same methodologies applied for birds (Appendix A). Observational information recorded included species identification, location (same 54 avian survey zones described in Section 1.1), number of individuals, activity, and habitat (physical feature type). Surveys of marine mammals in the Port Complex were conducted over 2 consecutive days per month from April 2023 through March 2024 (note that the March 2024 survey was conducted in April 2024 because of adverse weather conditions – Appendix A lists survey dates and conditions). Each survey event commenced in the morning and continued until the survey was completed in all zones.



California sea lions loafing on a channel marker buoy

Pinnipeds that are commonly observed within the Port Complex include the California sea lion (*Zalophus californianus*) and harbor seal (*Phoca vitulina*). Cetaceans known to occur within the Port Complex include common bottlenose dolphin (*Tursiops truncatus)* and common dolphins (*Delphinus* spp.). The gray whale (*Eschrichtius robustus*) is an uncommon visitor to the Port Complex waters but is more frequently observed nearshore along coastal California during migration periods. However, gray whales sometimes enter harbors and embayments to forage for benthic organisms in the soft sediments (Tremor, 2017).

The Port Complex provides resting and foraging habitat to pinnipeds and cetaceans. Many of these species acquire large amounts of opportunistic food at fishing docks, fishing boats, and the Bait Barge within the sheltered waters of the Port Complex. Haul-out and resting areas for pinnipeds include docks, pier pilings, boats/barges, and buoys. Additionally, the Port Complex provides a consistent and sheltered environment, making it an attractive stopover location for these marine mammals during their regular movements along the coast. No species of pinniped or cetacean is known to breed within the Port Complex.

7.1 RESULTS

A total of 1,141 marine mammal observations and 4 species were recorded during the 12 harbor-wide 2023 Biosurvey (Table 7-1, Figure 7-1). Tables listing species observed by survey month and survey zone are provided in Appendix F.



Harbor seal resting on the riprap along Pier 400

The California sea lion was the most observed marine mammal, with observations representing 71.5% of all sightings. Present year-round, California sea lions were typically observed resting on buoys, docks, and the bulbous bows of large container ships in the Outer Harbor. They were especially abundant in Zone 23 (Port of Long Beach West Basin), which accounted for 41.7% of observations (Figure 7-2). California sea lions were also observed frequently on container ships in Zone 7 (Pier 400 West and Pier 300 Channel) and on channel marker buoys in Zones 20 (Port of Los Angeles Outer Main Channel) and 14 (Port of Long Beach Outer Harbor Main Channel).

Harbor seal observations made up 25.3% of total marine mammal sightings in the 2023 Biosurvey. They were most often observed resting or foraging along extended stretches of riprap, particularly in the semi-sheltered Zone 8a (Outer Pier 400 West), which accounted for 53.7% of observations (Figure 7-3). Other areas frequented by harbor seals included the entire length of the Long Beach breakwater, which accounted for 35.0% of all observations.

The common bottlenose dolphin and gray whale were the only cetaceans observed during the survey. Common bottlenose dolphins were sighted in small groups of three to six individuals throughout the year, accounting for 2.9% of total marine mammal observations. They were observed in both the Outer Harbor and in SWH (Figure 7-4), with most sightings occurring in Zone 3b (the current Bait Barge area in the Port of Los Angeles Cabrillo SHW – Phase 1).

Two gray whale encounters were recorded during the 2023 Biosurvey period: the first on May 7, 2023, and the second on April 6, 2024. The May 7, 2023, observation involved two whales in Zone 14 (Port of Long Beach Outer Harbor Main Channel), presumed to be a mother and calf traveling north. The April 6, 2023, the sighting was a single adult whale feeding in Zone 3b (Port of Los Angeles Cabrillo SHW – Phase 1) (Figure 7-5).

Table 7-1. A Comparison of Marine Mammals Observed in the Port Complex in Biosurveys 2013, 2018, and 2023

Species	2013	Percentage of Total	2018	Percentage of Total	2023	Percentage of Total
California Sea Lion (*Zalophus californianus*)	587	67.5%	598	58.8%	816	71.5%
Harbor Seal (*Phoca vitulina*)	223	25.7%	298	29.3%	289	25.3
Common Dolphin (*Delphinus* spp.)	40	4.6%	75	7.4%	0	0%
Common Bottlenose Dolphin (*Tursiops truncatus*)	18	2.1%	43	4.2%	33	2.9%
Gray Whale (*Eschrichtius robustus*)	0	0%	1	0.1%	3	0.3%
Unidentified Dolphin	1	0.1%	1	0.1%	0	0%
Unidentified Marine Mammal*	0	0%	1	0.1%	0	0%

* Only a small spout was observed.



Gray whale forging near the San Pedro Company Bait Barge at the Cabrillo Shallow Water Habitat – Phase 1 (Zone 3b) on April 24, 2024

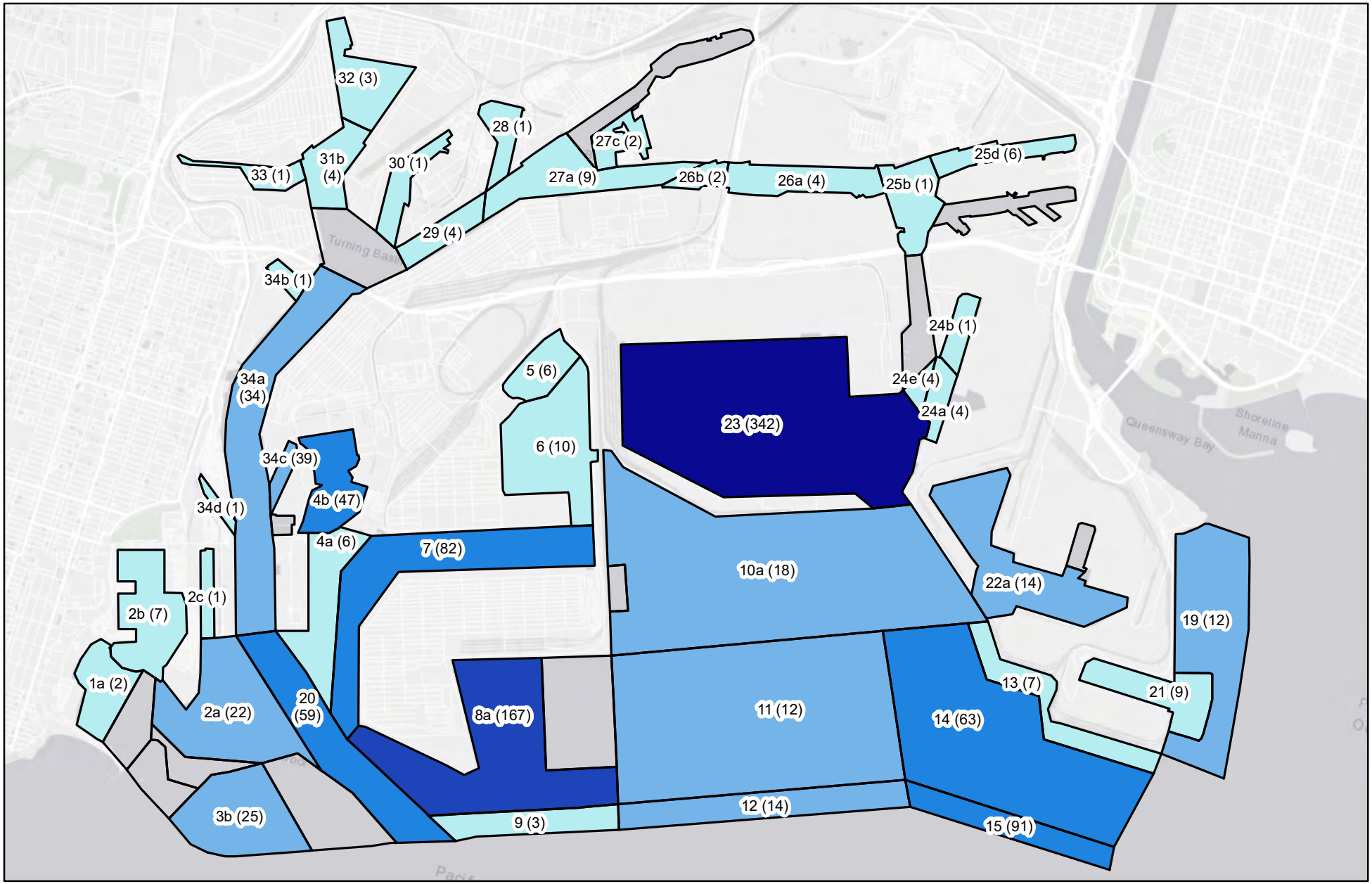


Figure 7-1. Total Abundance of Marine Mammals by Survey Zone
Total Mammal Counts - Label = Zone # (Total Count)

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Kilometers

2023 Biological Survey
Long Beach and Los Angeles Harbors
Port of Long Beach and Port of Los Angeles

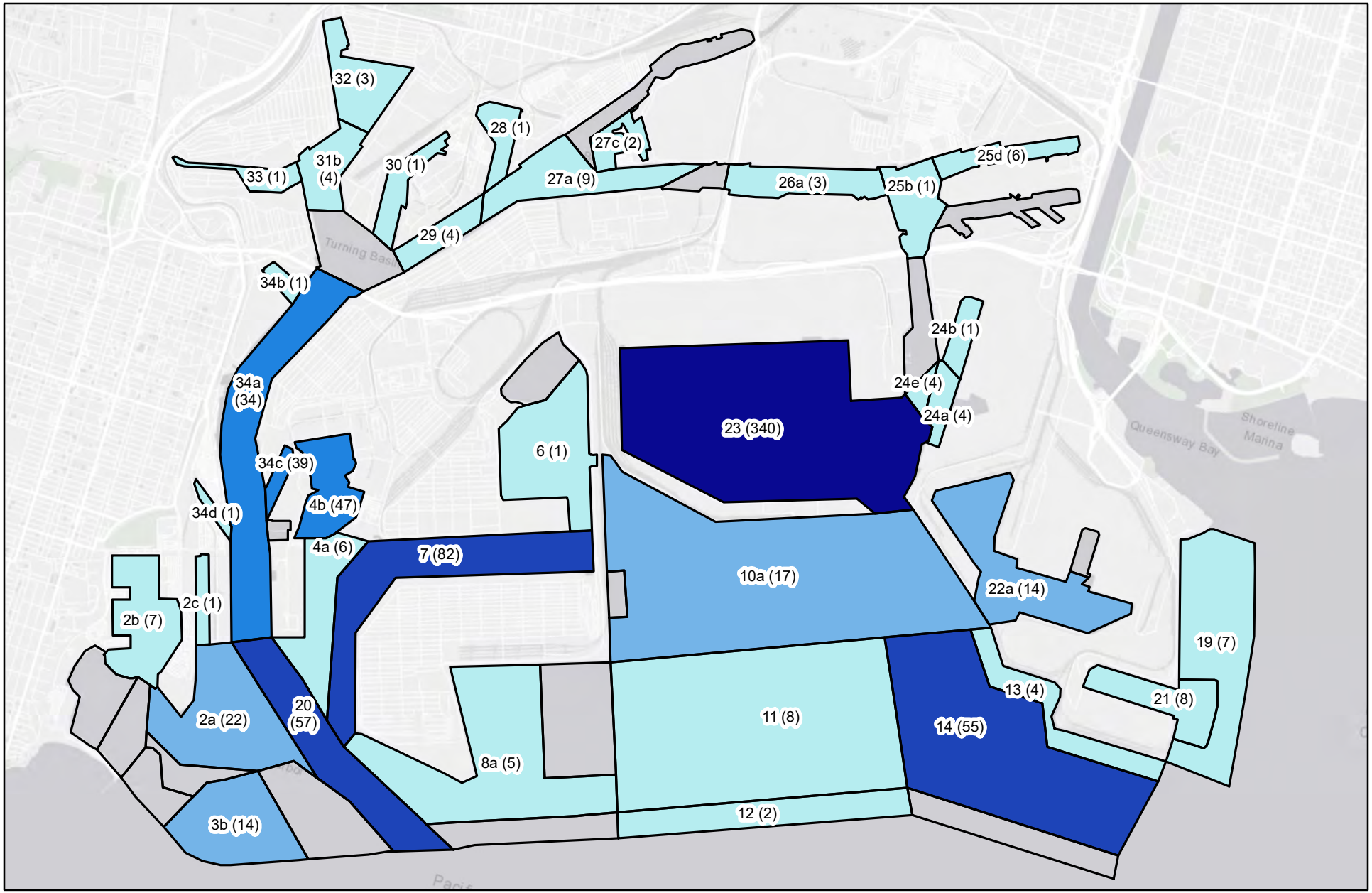


Figure 7-2. Total Counts in (Color Scale) and (in Parentheses) of California Sea Lions by Survey Zone

Total California Sea Lion Counts - Label = Zone # (Total Count)

2023 Biological Survey
Long Beach and Los Angeles Harbors
Port of Long Beach and Port of Los Angeles

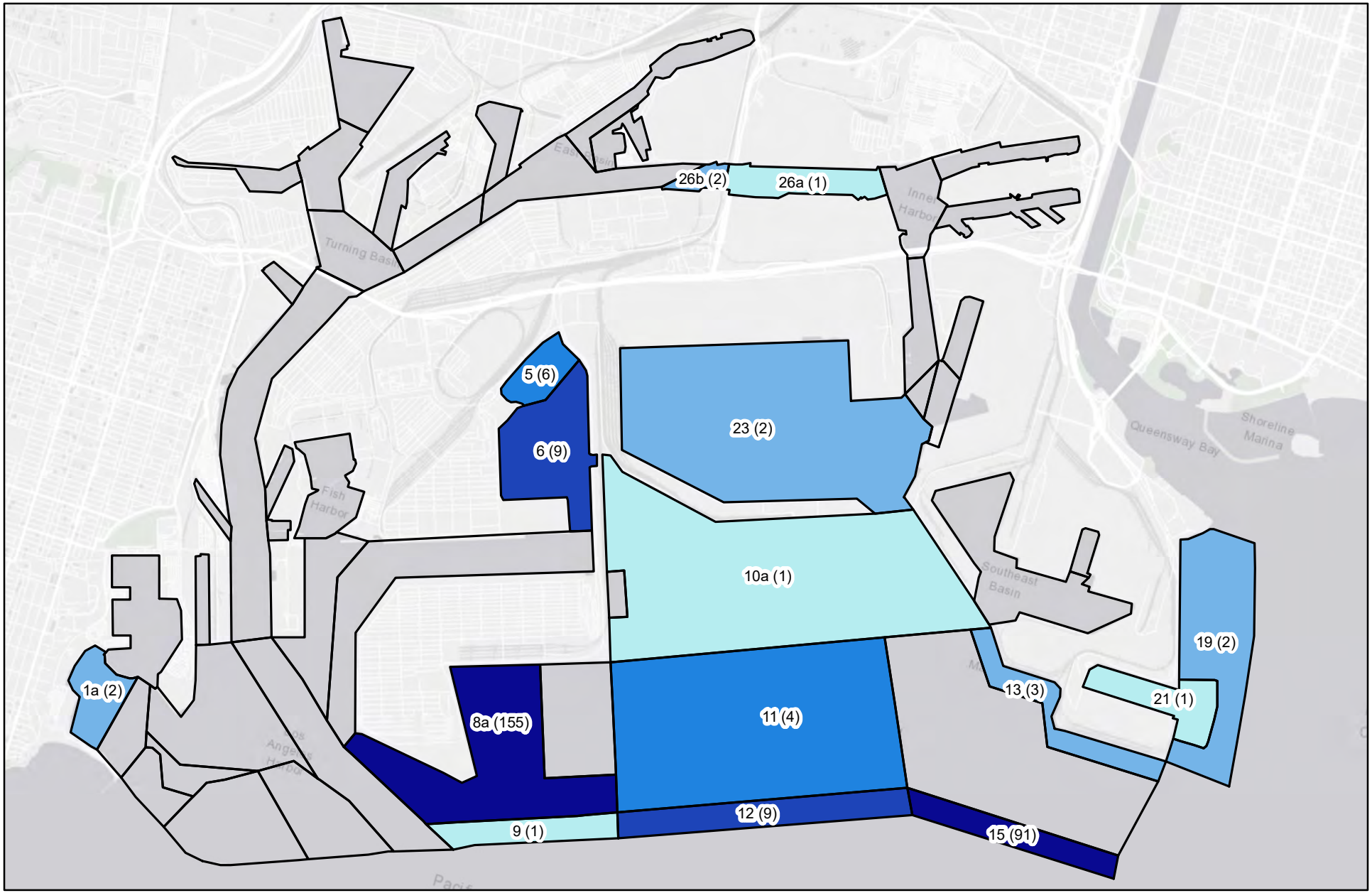


Figure 7-3. Total Counts in (Color Scale) and (in Parentheses) of Harbor Seals by Survey Zone
Total Harbor Seal Counts - Label = Zone # (Total Count)

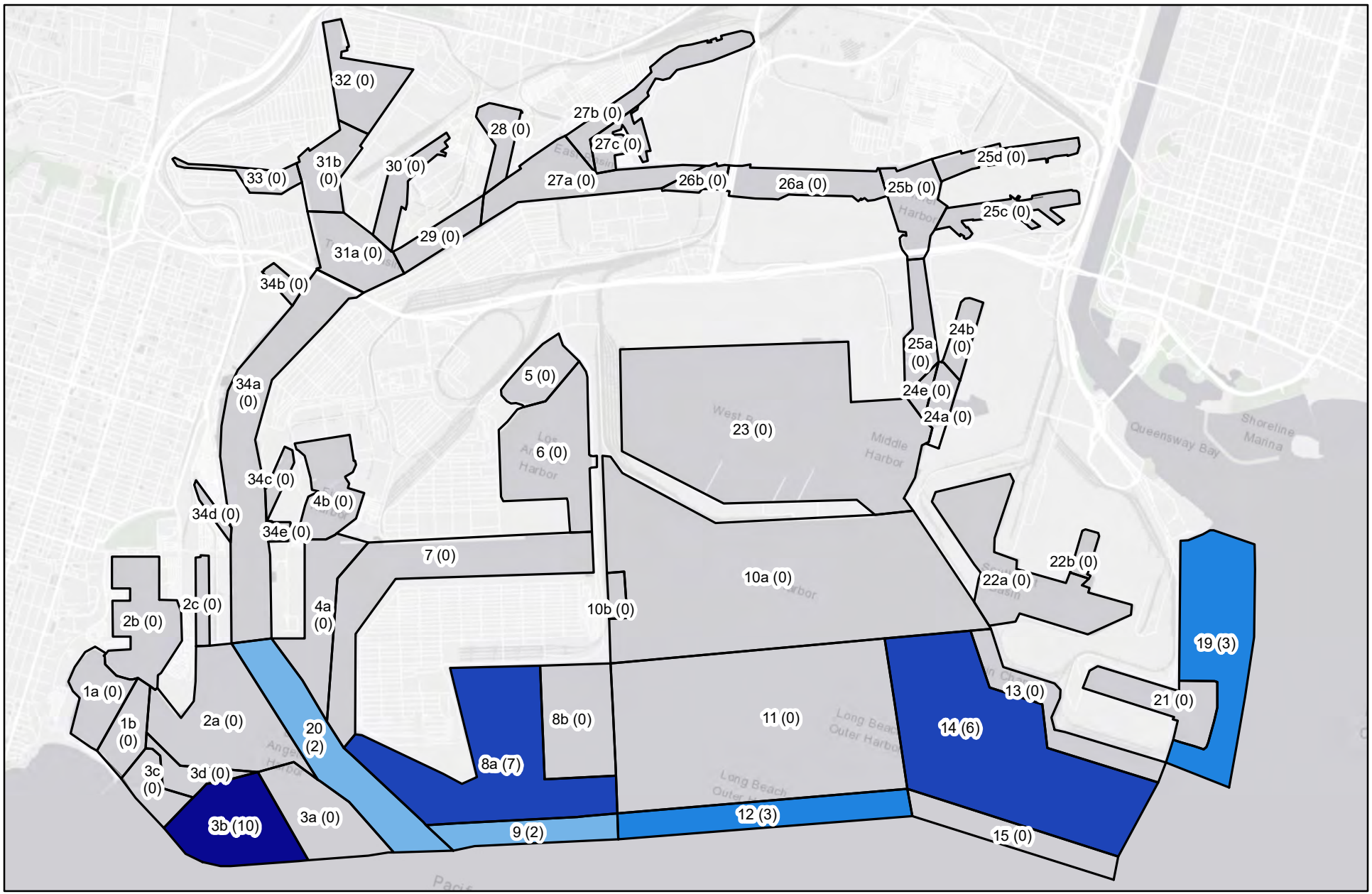


Figure 7-4. Total Counts in (Color Scale) and (in Parentheses) of Common Bottlenose Dolphins by Survey Zone

Total Common Bottlenose Dolphin Counts - Label = Zone # (Total Count)

2023 Biological Survey
Long Beach and Los Angeles Harbors
Port of Long Beach and Port of Los Angeles

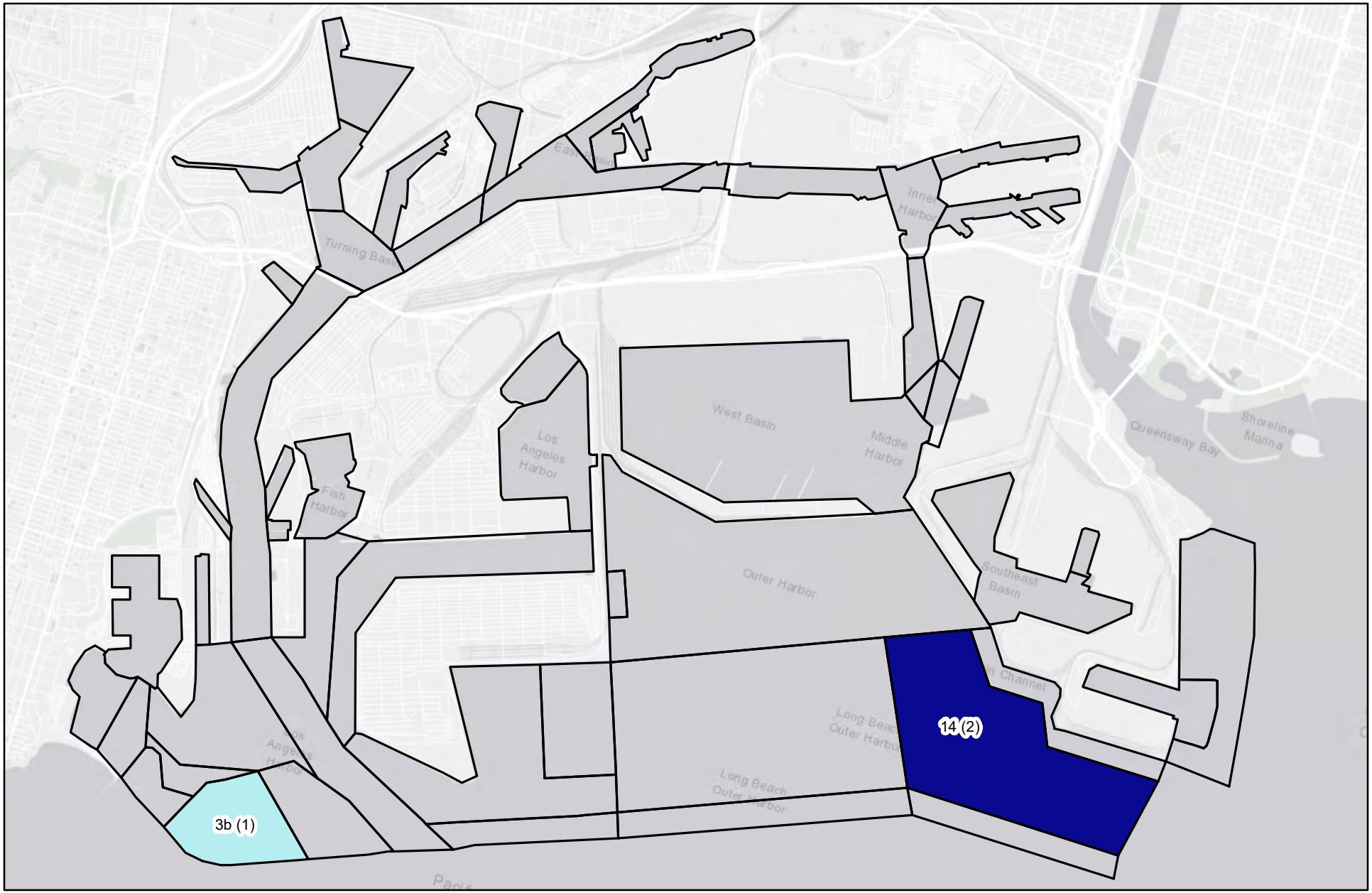


Figure 7-5. Total Counts in (Color Scale) and (in Parentheses) of Gray Whales by Survey Zone

Total Dolphin Counts - Label = Zone # (Total Count)

7.2 HISTORICAL COMPARISONS

Before the 2013 Biosurvey (MBC, 2016), marine mammal observations were incidental and occurred only during bird and fish surveys, rather than as part of a structured, quantitative effort with an established protocol. Although this lack of standardization limited the analysis, a review of earlier data was still conducted, though it allowed only for discussion of broad, general trends rather than detailed, Port Complex-wide comparisons. However, all subsequent Biosurveys have used the same methodology, facilitating more robust comparisons since that time.

All studies documenting marine mammals in the Port Complex have consistently identified the California sea lion as the most abundant species of marine mammal, with observations steadily increasing since 2013–2014. The most significant increase in observations occurred during the 2023 Biosurvey, with a 37.7% increase (816 observations) compared with the averages in 2013–2014 (587 observations) and 2018–2019 (598 observations). This species is widespread throughout the Port Complex, but was most commonly observed resting on docks, buoys, boats, and barges in the Outer Harbor, as well as near bait barges, fishing vessels, and fish packing plants within the Port of Los Angeles. By contrast, Harbor seals, have consistently been most abundant in Zone 8a (Outer Pier 400 West), where they have been observed primarily on or near riprap, typically resting on the rocks or foraging in the kelp along the Outer Harbor breakwaters.

In previous studies, small numbers of Pacific white-sided dolphins (*Sagmatias obliquidens*), common dolphins (*Delphinus* spp.), and gray whales were observed within the Port Complex (United States Army Corps of Engineers [USACE], 1992; MEC, 2002; SAIC, 2010; Wood 2021). The common dolphin is the most frequently encountered dolphin species in California waters, where it prefers nearshore environments (Hammond et al., 2020). No common dolphins were documented during the 2023 Biosurvey period, but sightings were documented in 2013–2014 and 2018–2019 – all single encounters with single pods in the Outer Harbor. Gray whales were observed inside the breakwaters during both the 2023 Biosurvey and the 2000 and 2018 Biosurveys but were not documented during the 2008 or 2013 Biosurvey periods. Observations of Pacific white-sided dolphins in the Port Complex waters are rare because this species prefers waters over the continental shelf and slope, outside the harbors (Tremor, 2017). Most detections of this species historically have been of only one pod.

7.3 DISCUSSION

Overall, results from the 2023 Biosurvey are similar to results for Biosurveys using comparable methodologies (i.e., the 2013 and 2018 Biosurveys), with California sea lions, harbor seals, and common bottlenose dolphins comprising at least 92% of all sightings, and the remaining observations consisting of sporadic encounters with species such as the gray whale that are not typically found in harbor environments.

The 2013 Biosurvey was the first in which marine mammals were formally documented with a standardized protocol and also occurred during a period when the number of sea lion strandings on the California coast was well above average (MBC, 2016; NOAA, 2019). From 2013 to 2017, NOAA declared an "Unusual Mortality Event" for sea lions linked to changes in prey availability. Specifically, sardine spawning grounds shifted offshore in 2012 and 2013, leading sea lions to forage for less nutritious prey such as squid and rockfish. This dietary shift resulted in a significant increase in stranded sea lions, with numbers in early 2015 more than double those in early 2013. After peaking in 2015, stranding numbers declined in 2016 and returned to pre-2013 averages in 2017.



Common bottlenose dolphins near the San Pedro Company Bait Barge at the Cabrillo Shallow Water Habitat (Zone 3b)

Although the lack of quantitative data before 2013 makes it unclear whether these stranding events affected sea lion populations in the Port Complex in the long term, the 2018 Biosurvey reported sea lion abundance similar to that during the 2013 Biosurvey. During the 2023 Biosurvey, however, a 37.7% increase (an increase of 234 observations) in California sea lion detections was reported, compared with the 2013 and 2018 Biosurvey averages, with similar usage patterns.

California sea lion populations have increased since passage of the Marine Mammal Protection Act of 1972. Current estimates indicate that the range-wide population is 40% above its maximum net productivity level but is still within the optimum sustainable population size (Carretta et al., 2024). The observed increase in sea lion numbers in the 2023 Biosurvey may reflect the overall population trend, but other factors – such as changes to nearby coastal or nearshore foraging or resting areas – could also be influencing their presence in the Port Complex.

During the 2023 Biosurvey, three individual gray whales were observed during two separate monitoring events (and another during Biosurvey fish sampling outside protocol marine mammal surveys). California gray whale populations have fluctuated significantly in recent years, primarily linked to environmental changes in their Arctic feeding grounds. In December 2018, NOAA declared an Unusual Mortality Event (UME) for eastern North Pacific gray whales that lasted until November 2023. The UME led to a significant population decline due to malnutrition (NOAA, 2024) and is believed to have forced gray whales to modify their migratory behavior, leading to an increased presence in bays and nearshore waters along the California coast as they searched for alternative food sources (Stewart et al., 2024).

This behavior became more frequent during the UME when disruptions in prey availability pushed gray whales into less common foraging areas. In 2023–2024, individuals were observed in San Diego Bay, Mission Bay, Marina del Rey, Morro Bay, and San Francisco Bay, as well as in most California harbors over the past decade (Greenman 2024, pers. comm.). The observations during the 2023 Biosurvey may reflect this ongoing trend as disruptions in prey availability during the UME pushed gray whales into less typical foraging habitats, such as the Port Complex.



Gray whale and calf in the Port of Long Beach Outer Harbor Main Channel (Zone 14) on May 23, 2024

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8 MANAGED AND OTHER SPECIAL-STATUS SPECIES

Among the key objectives of the Biosurvey program are to describe key biological communities found in the Port Complex and assess how they change over time, including those species managed and/or protected under state or federal special status and non-native species that are monitored for their potential impact on native communities. The special-status fish and bird species described in the previous sections are summarized in this section. Note that all marine mammals in the Port Complex are protected under the Marine Mammal Protection Act, passed in 1972 to prevent harassment and decline of marine mammal species and stocks (i.e., population units of individual species) from declining beyond the point at which the species cease to be significant functioning elements of the ecosystems in which they are part. Marine mammals are therefore not summarized in this section (see Section 7).

8.1 MANAGED AND SPECIAL-STATUS SPECIES

8.1.1 FISH

Impacts on fish in the Port Complex often focus on species under NOAA Fisheries' CPS and PCG FMPs managed under the Magnuson-Stevens Act, 50 CFR 600 (added by the interim final rule published at 62 Federal Regulations 66531; December 19, 1997). This extends to certain habitats, deemed EFH, which is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

A total of 15 species managed under NOAA Fisheries' FMPs were observed at the Port Complex during the 2023 Biosurvey. Table 8-1 summarizes the occurrence of the 24 managed species over the five Biosurveys since 2000, including the primary FMP and Ecosystem Component Species for both the CPS and PCG FMPs.

Of the four CPS FMP species observed in the Port Complex in 2023, only the northern anchovy appears to use the Port Complex during both day and night; Pacific sardine (*Sardinops sagax*), jack mackerel (*Trachurus symmetricus*), and Pacific mackerel (*Scomber japonicus*) were captured almost exclusively at night. These four pelagic species appear to use the Port Complex as a nursery habitat before larger individuals move offshore because published length at maturity data indicate that most of the fish of all four species captured were juveniles. This trend is consistent with observations of these species in the 2018 Biosurveys.

Of the 11 PCG FMP species observed in 2023, vermillion rockfish (*Sebastes miniatus*; 87 individuals), chilipepper rockfish (*S. goodei*; 36 individuals), and bocaccio (*S. paucispinis*; 19 individuals) were the most abundant. All three rockfish species captured during trawls were juveniles (<14 cm standard length [SL]), with most collected in the Outer Harbor, usually in deep habitats near eelgrass and kelp habitats. English sole (*Parophrys vetulus*; 2 individuals collected at station LA5 [West Basin]) and California skate (*Raja inornata*; 1 individual at station LA6 [East Basin]) were the only PCG FMP species observed in the Inner Harbor.

Table 8-1. Managed FMP Species Historically Present in the Port Complex

Common Name	Scientific Name	Occurrence[1]	Preferred Habitat
Pelagic FMP Species			
Jack Mackerel	*Trachurus symmetricus*	Common	Open water, young over shallow banks and around kelp beds
Northern Anchovy	*Engraulis mordax*	Abundant	Open water
Pacific Mackerel	*Scomber japonicus*	Abundant	Open water, juveniles off sandy beaches and around kelp beds
Pacific Sardine	*Sardinops sagax*	Abundant	Open water
Coastal Pelagic Species Ecosystem Component Species			
Jacksmelt	*Atherinopsis californiensis*	Abundant	Open water, juveniles off sandy beaches and around kelp beds
Smelts	*Osmeridae*	Abundant	Open water, juveniles off sandy beaches and around kelp beds
Groundfish FMP Species			
Big Skate	*Raja binoculata*	Rare	Soft-bottom habitats
Black Rockfish	*Sebastes melanops*	Rare	Along breakwaters, deep piers and pilings, kelp, eelgrass, and reefs
Bocaccio	*Sebastes paucispinis*	Rare	Multiple habitats – soft and hard bottom, kelp, eelgrass
Brown Rockfish	*Sebastes auriculatus*	Rare	Prefer hard substrata and rocky interfaces
Cabezon	*Scorpaenichthys marmoratus*	Rare	Prefer hard substrata and rocky interfaces
Calico Rockfish	*Sebastes dallii*	Rare	Prefer hard substrata and rocky interfaces
California Scorpionfish	*Scorpaena guttata*	Common	Benthic, on soft and hard bottoms, as well as around structures
English Sole	*Parophrys vetulus*	Uncommon	Soft-bottom habitats
Grass Rockfish	*Sebastes rastrelliger*	Rare	Common on hard substrate, kelp, and eelgrass habitats
Leopard Shark	*Triakis semifasciata*	Rare	Multiple habitats – soft-bottom, kelp, eelgrass, structures
Lingcod	*Ophiodon elongatus*	Rare	Prefer hard substrata and rocky interfaces
Pacific Sanddab	*Citharichthys sordidus*	Common	Soft-bottom habitats
Spiny Dogfish Shark	*Squalus acanthias*	Rare	Pelagic and on muddy bottoms
Vermillion Rockfish	*Sebastes miniatus*	Common	Juveniles over soft bottom and kelp, adults associated with hard substrate
Chilipepper Rockfish	*Sebastes goodei*	Rare	Prefer hard substrata and rocky interfaces
Black-and-Yellow Rockfish	*Sebastes chrysomelas*	Rare	Prefer hard substrata and rocky interfaces
Olive/yellowtail rockfish[2]	*Sebastes flavidus/serranoides*	Rare	Prefer hard substrata and rocky interfaces
Groundfish Ecosystem Component Species			
California Skate	*Raja inornata*	Uncommon	Soft-bottom habitats

1. Occurrence during historical Biosurvey years 2000–2023. 2000 = 4 seasons, 2008 = 3 seasons [winter/spring/summer], 2013 = 2 seasons [spring/summer], 2018 = 2 seasons [spring/summer], 2023 = 2 seasons [spring/summer] (Wood, 2021; MBC, 2016; SAIC, 2010; MEC, 2002)
   Note: Occurrence based on average total abundance per season across five historical Biosurveys. Rare (0–5), Uncommon (5–10), Common (10–100), Abundant (100+)
2. Observed during dive surveys, likely olive or yellowtail rockfish

8.1.2 BIRDS

A total of 25 special-status (i.e., listed by the USFWS or the CDFW) bird species were observed within the Port Complex during the 2023 Biosurvey (Table 8-2). Four of the special-status species (brown pelican [*Pelecanus occidentalis*], elegant tern [*Thalasseus elegans*], double-crested cormorant [*Phalacrocorax auratus*], and western gull [*Larus occidentalis*]) have been consistently abundant across previous Biosurveys. The persistence of these species over time, and the numbers of special-status birds observed, indicates that the Port Complex provides important foraging and roosting opportunities for these species. Notably, the Pier 400 site provides an important nesting opportunity for all three special-status tern species (elegant tern, California least tern [*Sterna antillarum browni*], and Caspian tern [*Hydroprogne caspia*]), and the breakwaters have consistently supported large numbers of foraging and resting brown pelicans and black oystercatchers (*Haematopus palliates*).

The total bird species and mean abundance of birds per monthly survey during the 2023 Biosurvey were similar to historical observations from the 2000 through 2013 Biosurveys, indicating that the low diversity and abundance observed in 2018 may have been a result of regional oceanographic phenomena such as the 2014–2016 heatwave event.

Table 8-2. Occurrence of Special-Status Bird Species Observed in the Port Complex in the 2023 Biosurvey

Species	Status	Zones Where Observed	Total Number Observed
Allen's Hummingbird (*Selasphorus sasin*)	USFWS:BCC	10a	1
Black-crowned Night Heron (*Nycticorax nycticorax)*	Nesting – CDFW:SA	19 of 54 total zones (see Appendix F)	55
Black Oystercatcher (*Haematopus bachmani*)	USFWS:BCC	Zones 9, 12, 13, 15, 19, 21, 10a, 3a, 3b, 3c, and 8a	444
Black Skimmer (*Rhyncops niger*)	Nesting – CDFW:SSC USFWS:BCC	Zones 14 and 1a	143
Brown Pelican (*Pelecanus occidentalis*)	State and Federal Delisted Nesting Sites and Communal Roosts – CDFW:SA BLM:S; USFS:S	All zones except 22b, 34b, 34d, 34e, 3d, and 8b	6,364
Brandt's Cormorant (*Urile penicillatus*)	USFWS:BCC	All zones except 24e, 26b, 27c, and 34e	12,813
California Gull (*Larus californicus*)	Nesting – CDFW:WL USFWS:BCC	44 of 54 total zones (see Appendix F)	1,790
California Least Tern (*Sternula antillarum browni*)	FE, SE CDFW:FP	None observed in the current survey period	0
Caspian Tern (*Hydroprogne caspia*)	Nesting – CDFW:SA USFWS:BCC	39 of 54 total zones (see Appendix F)	257
Clark's Grebe (*Aechmophorus clarkii*)	USFWS:BCC	Zones 19, 21, 23, 10a, 1b, 27b, 3b, 3d, and 8a	59
Common Loon (*Gavia immer*)	Nesting – CDFW:SSC	Zones 6, 11, 12, 19, 23, 10a, 1b, 25b, 2b, 8a, and 8b	16
Coopers Hawk (*Accipiter cooperii*)	Nesting – CDFW:WL	Zones 30, 25d, and 27b	4
Double-crested Cormorant (*Nannopterum auritum*)	Nesting – CDFW:WL	All zones except 11,34e,3d, and 8b	1,705
Elegant Tern (*Thalasseus elegans*)	Nesting – CDFW:WL	24 of 54 total zones (see Appendix F)	2,199
Great Blue Heron (*Ardea herodias*)	Nesting – CDFW:SA CDF:S	All zones except 9, 11, 14, 15, 24e, 34e, and 3d	555
Great Egret (*Ardea alba*)	Nesting – CDFW:SA CDF:S	Zones 5, 33, and 27b	5
Heermann's Gull (*Larus heermanni*)	USFWS:BCC	37 of 54 total zones (see Appendix F)	1,536

Table 8-2. Occurrence of Special-Status Bird Species Observed in the Port Complex in the 2023 Biosurvey (continued)

Species	Status	Zones Where Observed	Total Number Observed
Marbled Godwit (*Limosa fedoa*)	USFWS:BCC	1a	1
Osprey (*Pandion haliaetus*)	Nesting – CDFW:WL CDF:S	23 of 54 total zones (see Appendix F)	51
Peregrine Falcon (*Falco peregrinus*)	State and Federal Delisted Nesting – CDFW:SA	Zones 12, 19, 21,10b, 22a, 24b, 25d, 26a, 2b, 31a, 34d, 4b, and 8a	18
Redhead (*Aythya americana*)	Nesting – CDFW: SSC	6	4
Snowy Egret (*Egretta thula*)	Nesting – CDFW:SA	30 of 54 total zones (see Appendix F)	178
Western Grebe (*Aechmophorus occidentalis*)	USFWS:BCC	32 of 54 total zones (see Appendix F)	2,370
Western Snowy Plover *(Anarhynchus nivosus nivosus*)	FT CDFW: SSC	12	1
Western Gull (*Larus occidentalis*)	USFWS:BCC	All zones	16,128
Willet (*Tringa semipalmata*)	USFWS:BCC	Zones 14, 19, 10a, 1a, 1b, 2b, 3b, and 3c	21

FE = Federally Endangered; FT = Federally Threatened; SE = State of California Endangered
BLM:S = Bureau of Land Management – Sensitive
CDF:S = California Department of Forestry and Fire Protection – Sensitive
CDFW:SA = California Department of Fish and Wildlife – Special Animal
CDFW:FP = California Department of Fish and Wildlife – Fully Protected Species
CDFW:WL = California Department of Fish and Wildlife – Watch List
CDFW:SSC = California Department of Fish and Wildlife – Species of Special Concern
CDFW:SA = California Department of Fish and Wildlife – Special Animal, tracked by CDFW but not protected status
USFWS:BCC = United States Department of Fish and Wildlife – Bird of Conservation Concern
USFS:S = United States Forest Service – Sensitive

8.2 NON-NATIVE SPECIES

In total, 49 non-native species were identified in the 2023 Biosurvey (Table 8-3), an increase over the 46 species observed in 2018, 27 species observed in 2013, 19 species in 2008, and 25 species in 2000. Although species referenced in this section are those listed in the Cal-NEMO database (Fofonoff et al., 2018), the database is regularly updated but may not include newly discovered species, such as the ascidian *Corella japonica* identified for the first time within the Port Complex in 2023, that are still undergoing investigation.

The expanded methods and habitat types surveyed in 2018 and 2023 may have contributed to the increase in number of non-native species detected. In addition, climate-mediated change in invertebrate communities may have resulted in new species appearing in new locations as their range expands with increasing water temperatures and events such as marine heatwaves (Weiskopf et al., 2020; Pinsky et al., 2020; Lonhart et al., 2019). Many of the non-native species observed for the first time in the 2023 Biosurvey were represented by only a few individuals; in contrast the European ascidian (*Ascidiella aspersa*), a solitary sea squirt, contributed 6.9% of the total biomass collected across all trawls after first being identified in the Port Complex in 2019 (see Section 4.7.2). It is not clear whether these are the result of range shifts or of introductions through other vectors such as ballast water or recreational vessel activity (Lonhart et al., 2019). Continued monitoring could help to determine the persistence of these newly observed species and their effects, if any, on native species.

As in the previous four Biosurveys, in 2023, yellowfin gobies (*Acanthogobius flavimanus*) were captured as adults in trawl surveys and as larvae in ichthyoplanton tows. In past surveys, a larval tripletooth goby species (*Tridentiger* sp.), most likely *Tridentiger trigonocephalus* (chameleon goby) was captured in ichthyoplankton and trawl surveys, and during the diver surveys in 2023, adult chameleon gobies were positively identified at five Inner Harbor stations, although no larvae or adults were captured during trawl sampling. The 2023 Biosurvey was the first to positively identify larvae of the Shimofuri goby (*Tridentiger bifasciatus*), a species native to Asia that prefers fresh and brackish water. It has a very wide range of thermal and salinity tolerance (USFWS, 2019), although it is suggested that their spawning is limited to salinities up to 19 PSU. These gobies were first introduced in the San Francisco Bay estuary circa 1985 and have spread more than 500 km through the aqueducts of the

California State Water Project into lakes and coastal drainages in Southern California. Given their preference for fresh and brackish waters, it is likely that the adults of this species are now present in the watersheds and tributaries that feed into the Inner Harbor and that the heavy rainfall in 2023–2024 washed them into the Port Complex for the first time in high densities (15.5% of all larvae collected across all seasons).

The non-native macroalgae, *Sargassum horneri*, *Sargassum muticum*, and *Undaria pinnatifida*, have been present on riprap and pilings throughout the Port Complex in all five Biosurveys, with highest densities at Inner Harbor areas**.**

Table 8-3. Number of Non-Native Species by Community Type in 2023

Phyla		# Non-Native Species	Ichthyoplankton	Demersal Fishes	Epibenthic Invertebrates	Benthic Infauna	Riprap Epifauna	Piling Epifauna
Chordates	Fishes	3	2	2				
	Sea Squirts	14			7	5	7	12
Invertebrates	Annelids	6				3	4	5
	Arthropods	13				7	12	12
	Bryozoa	3					3	3
	Cnidaria	1					1	
	Mollusca	5			3	4	3	3
Macroalgae	Ochrophyta	3					2	
	Rhodophyta	1					1	1
Total Non-Native Species		**49**	**2**	**2**	**10**	**19**	**33**	**36**

The Biosurveys have been monitoring infauna and riprap communities since 2000, and comprehensive surveys of concrete pilings were added for the first time in 2018 and monitored again in 2023. From these samples, the total number of taxa, number of non-native, and relative abundance of non-native species can be compared with results of other studies in the Port Complex and in the region (Tables 8-4 and 8-5).

The percentage of non-native benthic infauna species in the Port Complex has ranged from 2.2% to 5.2%, which is lower than Ranasinghe et al. (2005) observed in a regional study of southern California harbors and bays in 1998 (7.2% in the Port Complex, 7.2–12.4% across all harbors) and is lower than the range observed in San Diego Bay, Mission Bay, Oceanside Harbor, and Dana Point Harbor in 2023 (7.4–11.6%; WSP, 2026). The relative abundance of non-native benthic infauna in the Port Complex (12.5–33.4) is consistent with the range observed across southern California harbors in 1998 (26.2% in the Port Complex, 12.5–31.9% across all harbors) and San Diego regional harbors in 2023 (13.5–32.4%). As with the results for the 2023 Biosurvey, the most abundant non-native infauna species across San Diego regional harbors in 2023 was the polychaete worm *Pseudopolydora paucibranchiata* that was especially abundant in marinas across all harbors (WSP, 2026).

For the 2023 Biosurvey, combining data on invertebrates and algae in benthic infauna with riprap and piling communities sampled with quadrats resulted in a total of 769 taxa, 46 of them (6.0%) non-native species. When compared with other Southern California bays and harbors (CDFW, 2014) that percentage is similar to the percentage for Avalon Harbor (4.5%) and lower than the percentage for other harbors and bays. Not all artificial habitats (e.g., floating docks, booms, wooden fender piles, etc.) were sampled during the 2023 Biosurvey, as has occurred in other studies (Cohen et al., 2005, CDFW, 2014), meaning that the abundance and distribution of some non-native species could be underestimated if those species preferentially settle on a substrate type not sampled.

Of the habitats quantitatively surveyed with quadrat scrapings and benthic grabs during the 2023 Biosurvey, soft-bottom surfaces had the lowest percent of non-native species (5.1%), and pilings had the highest (10.1%; Tables 8-4 and 8-5). Note that one species observed by divers on pilings and riprap (the algae *Undaria pinnatifida*) was not included in this analysis because the species was observed during visual diver surveys and not captured in quadrat scrapings. In terms of the relative abundance of non-native organisms, however, riprap and pilings were similar (10.7% and 13.1%, respectively) and composed less than half of the relative abundance of non-natives in

soft-bottom habitats (33.4%). One species, a tube-dwelling worm (*Pseudopolydora paucibranchiata*), accounted for 26% of the non-native abundance, although it occurred in only a few locations. Heavy rainfall and disturbance of the seafloor from vessel activity may have promoted disturbance-tolerant and opportunistic species such as *P. paucibranchiata*, which can modify benthic habitats with their tubes in such a way to exclude other species and create localized patches of high densities (Dagli and Cinar, 2008; Fofonoff et al., 2018).

Table 8-4. Non-Native Species Richness and Dominance in Benthic Infauna Communities Sampled During Biological Surveys of the Port Complex

Benthic Infauna	2000	2008	2013	2018	2023
Species Richness	361	258	344	369	372
# Non-Native Species	8	9	8	19	19
% Species Non-Native	2.22	3.49	2.33	5.15	5.11
% Abundance Non-Native	30.6	15.8	12.5	18.0	33.4

Table 8-5. Non-Native Species Richness and Dominance in Epifaunal Communities Sampled During Quadrat Scrapings Biological Surveys of the Port Complex

Marine Growth Community	Riprap					Pilings	
	2000	2008	2013	2018	2023	2018	2023
Species Richness	238	211	352	491	394	435	356
# Non-Native Species	5	7	12	24	33	27	36
% Species Non-Native	2.10	3.32	3.41	4.89	8.38	6.21	10.1
% Abundance Non-Native	7.45	6.07	14.9	8.12	10.7	8.85	13.1

The non-native algae *Undaria pinnatifida* not included because it was not captured in quadrats.

The 2023 Biosurvey results for soft-bottom, riprap, and piling sampling confirm that these habitats offer different opportunities for non-native species. Riprap and pilings are more heterogeneous and extend through the water column, exposing their communities to a range of abiotic conditions that are conducive to more total species, whereas the more homogeneous soft-bottom habitats offer a narrower range of abiotic conditions. Soft-bottom habitats support greater relative abundances of non-native species, which could be a result of a few species that become very abundant and modify the substrate to be more conducive to larger populations of that particular species (Ranasinghe et al., 2005).

Although non-native species are present in most anthropogenically influenced coastal habitats in southern California, it does not appear that they are displacing native species within the Port Complex because the diversity and abundance of fish, invertebrates, and algae has remained high across the habitats examined in the 2023 Biosurvey.

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9 HABITAT COMPARISONS, NOTABLE TRENDS, AND CONCLUSIONS

The Port Complex contains a wide variety of habitats supporting diverse biological communities that coexist with commercial and industrial operations in the nation's largest port complex. Biological monitoring of those habitats dates back to the 1950s, with regularly scheduled surveys of the entire Port Complex starting in 2000. The 2023 Biosurvey identified more than 1,000 taxa living throughout the Port Complex, including 97 species of fish (87 adult species and 41 larval taxa), 842 invertebrate taxa, 40 algae taxa, 110 species of birds, and 4 species of marine mammals. Eelgrass beds in the Port Complex have doubled in size since 2018, with more than 160 acres providing extensive foraging and nursery habitat to wildlife and also acting as a local buffer against ocean acidification (Ricart et al., 2021a), making them potentially beneficial to species that may be sensitive to rising pH levels, such as oysters (Ricart et al., 2021b).

Kelp survey efforts delineated more than 40 acres of kelp canopy on the riprap and breakwaters in the Outer Harbor area. The use of new, high-resolution remote sensing and adapted survey methods on riprap and pilings expanded understanding of canopy-forming kelp distribution on artificial structures (e.g., breakwaters and dikes) across the Port Complex. Rocky-reef monitoring protocols from the regional PISCO were adapted to survey fish communities on riprap and pilings in the Biosurveys for the first time in 2023. These new methods provide new opportunities to understand connectivity between habitats and their used by different life stages of the core fish community that is present in the Port Complex. It also provides opportunities to better compare fish communities in the Port Complex with those observed on coastal rocky reefs, nearby coastal rocky reef mitigation sites, offshore oil rigs, and other urbanized environments.

The 2023 Biosurvey had the same key objectives as past Biosurveys: describe (1) how key biological community metrics vary among different habitats and sub-regions within the Port Complex, (2) how those metrics have changed over time, (3) how biological communities of the Port Complex compare with those throughout the southern California region, and (4) how prevalent non-native species are throughout the Port Complex. The conclusions in this section summarize the findings of the 2023 Biosurvey in the context of the key objectives, with key summary points in bullets followed in most cases by supporting information. In those cases, the discussion presents data from different sections of this report to draw conclusions across subjects (e.g., comparisons of soft-bottom communities [Section 4] with hard-substrate communities [Section 5]) that could not be considered in either of those chapters alone.

9.1 COMPARISON OF COMMUNITIES BY HABITAT AND DEPTH

During the 2023 Biosurvey, observed spatial differences in biological communities were generally related to habitat type (Inner Harbor, Outer Harbor, and SWH) and depth (Shallow [0–7 meters], Deep [7.1–18 meters], and Very Deep [18+ meters]) as the factors that most strongly influenced the distribution of species. Outer Harbor areas consist primarily of deeper, open-water navigational areas, but also include enhanced SWH areas that support eelgrass and kelp forest habitats along the breakwaters and riprap shorelines. The connectivity with coastal habitats and presence of kelp and eelgrass beds in these areas make the Outer Harbor and nearby SWH areas the most productive and diverse areas within the Port Complex. Inner Harbor areas are relatively constrained with less water circulation, which may affect the distribution of the many species that prefer habitats that rarely or never occur in the Inner Harbor areas (e.g., kelp, reef-sand interfaces). Inner Harbor communities are more similar to other nearby embayments, which usually have lower diversity and productivity compared to the Outer Harbor. Soft-bottom habitats and hard substrates such as riprap and pilings support diverse invertebrate communities that share some species, but that overall have different species assemblages. The communities on concrete pilings are relatively consistent across the harbor, with the growth of giant kelp on pilings in the Outer Harbor as the key difference that primarily affects the fish communities. Riprap habitats are more variable across the harbor and the communities present on them are shaped by substrate size, water movement, and deposition of sediments that affects the types of species that can settle and attach (e.g., kelp in Outer Harbor, eelgrass growing on riprap with high sediment deposition in the Inner Harbor). Key differences in these subareas of the Port Complex are outlined in this section and in Table 9-1 for in-water habitats.

Table 9-1. Characteristics of Port Complex Habitats

Habitat	Inner Harbor	Outer Harbor	Shallow Water Habitat
Water Column Physical Characteristics	• Deep navigation channels • Limited tidal exchange, seasonal freshwater influence from watersheds, seasonal thermoclines • Largest swings in temperature and salinity, watershed inputs with large seasonal influence	• Very deep navigation channels, deep anchorages • Regular tidal exchange and water column mixing from wind-driven waves, seasonal thermoclines • Water quality parameters stable and strongly linked to nearshore conditions	• Shallow areas designed by mitigation • Usually in areas with good tidal exchange, water column well mixed • Water quality parameters stable and influenced by nearshore conditions
Seafloor Physical Characteristics	• Higher TOC and percent fines than OH • Depositional environment, resuspension through boat activity and seasonal disturbance from watershed flushing	• Mix of sandy and silty sediments • Some basins depositional, resuspension through boat activity and wind/swell driven waves	• Primarily sandy sediments, increased TOC from eelgrass • Eelgrass that promotes deposition of fine grains, resuspension through wind-/swell-driven waves
Benthic Communities	• Eelgrass along shallow slopes of channels and slips, representing less than 10% of total Port Complex-wide acreage • Lower diversity and abundance of benthic fishes than OH and SWH • Epibenthic invertebrates with low diversity and abundance compared to OH and SWH, higher proportion of tunicates and sponges • Benthic infauna with abundance and diversity similar to communities in OH and SWH, community composition similar to that of OH	• Depth generally excludes eelgrass from these areas • Highest abundance and biomass of benthic fish, occasional dominance of white croaker and queenfish in navigation channels that drive down diversity • Epibenthic invertebrates highly abundant, occasional dominance of shrimps that drives down diversity in deep navigation channels • Benthic infauna abundance and diversity similar to those in IH and SWH, community composition similar to IH	• Extensive eelgrass coverage, especially Pier 300 and Cabrillo Beach area • Highest diversity of benthic fishes, high proportion of juvenile fishes that emphasizes nursery function • Epibenthic invertebrates most diverse, unique community shaped by presence of eelgrass • Benthic infauna abundance and diversity similar to those other areas, community composition unique due to influence of eelgrass and shallow depths
Pelagic Communities	• Larval fish abundant, dominated by gobies and blennies with NNS seasonally abundant • Adult fish with lowest diversity and abundance, dominated by topsmelt • Marine mammals uncommon, primarily sea lions	• Larval fish less abundant than IH and SWH, dominated by anchovies • Adult fish with high diversity and abundance with primarily smelt and anchovies • Adult fish community composition changes between day/night as coastal species migrate in Port Complex to feed at night • Highest abundance and diversity of marine mammals, including sea lions, harbor seals, dolphins, and whales	• Larval fish abundant, lowest diversity and unique assemblage • Adult fish highest diversity and abundance, unique community compared with other habitats due to depth and influence of eelgrass for foraging and nursery habitat • Marine mammals uncommon, higher diversity than IH with occasional whales and dolphins near Cabrillo SWH

Table 9-1. Characteristics of Port Complex Habitats (continued)

Habitat	Inner Harbor	Outer Harbor	Shallow Water Habitat
Riprap and Piling Communities	• Riprap composed primarily of boulders and cobble, highest sediment deposition • Riprap communities with low invertebrate and fish abundance and diversity; dominated by perch, topsmelt, snails, and bat stars • Non-native algae *Sargassum* dominant, eelgrass growing in high-sediment-deposition areas • Pilings with low diversity and abundance of fish, high density of filter feeding gorgonians and rock scallops	• Riprap composed primarily of large boulders (>1 meter), little sediment deposition • Riprap with high abundance and diversity of fish and invertebrates; dominated by bass, topsmelt, garibaldi, and lobsters • Canopy-forming algae (giant kelp and feather boat kelp) on riprap strongly influences the invertebrate and fish communities present • Pilings with giant kelp, high abundance and diversity of fish, gorgonians, rock scallops, lobsters, and sea stars • Marine mammals, especially harbor seals, haul out on riprap	• Stations only designated Inner Harbor or Outer Harbor

OH – Outer Harbor, IH – Inner Harbor, SWH – Shallow Water Habitat, NNS – Non-native Species

Benthic Infauna Versus Epifaunal Invertebrate and Algal Communities

During the 20203 Biosurvey, benthic infauna and invertebrates on pilings and riprap were surveyed using similarly rigorous taxonomic methods, allowing for a detailed comparison of the similarity of the communities for each type of substrate. At riprap stations sampled using quadrat scrapings, 394 invertebrate species were documented; piling stations had 356 invertebrate species. Benthic infauna sampling across spring and summer identified 372 invertebrate species, with a combined total of 769 taxa represented by all three habitats.

As Table 9-2 and Figure 9-1 show, riprap and pier pilings had, on average, higher species richness, abundance, biomass, and diversity than soft-bottom benthic habitats, although riprap and pier pilings did not differ from one another in those summary metrics. Distinct algal communities were observed on the riprap compared with pier pilings (Figure 9-2): coralline algae were overwhelmingly dominant on riprap, and pilings supported a more diverse algal assemblage dominated by red and green algae.

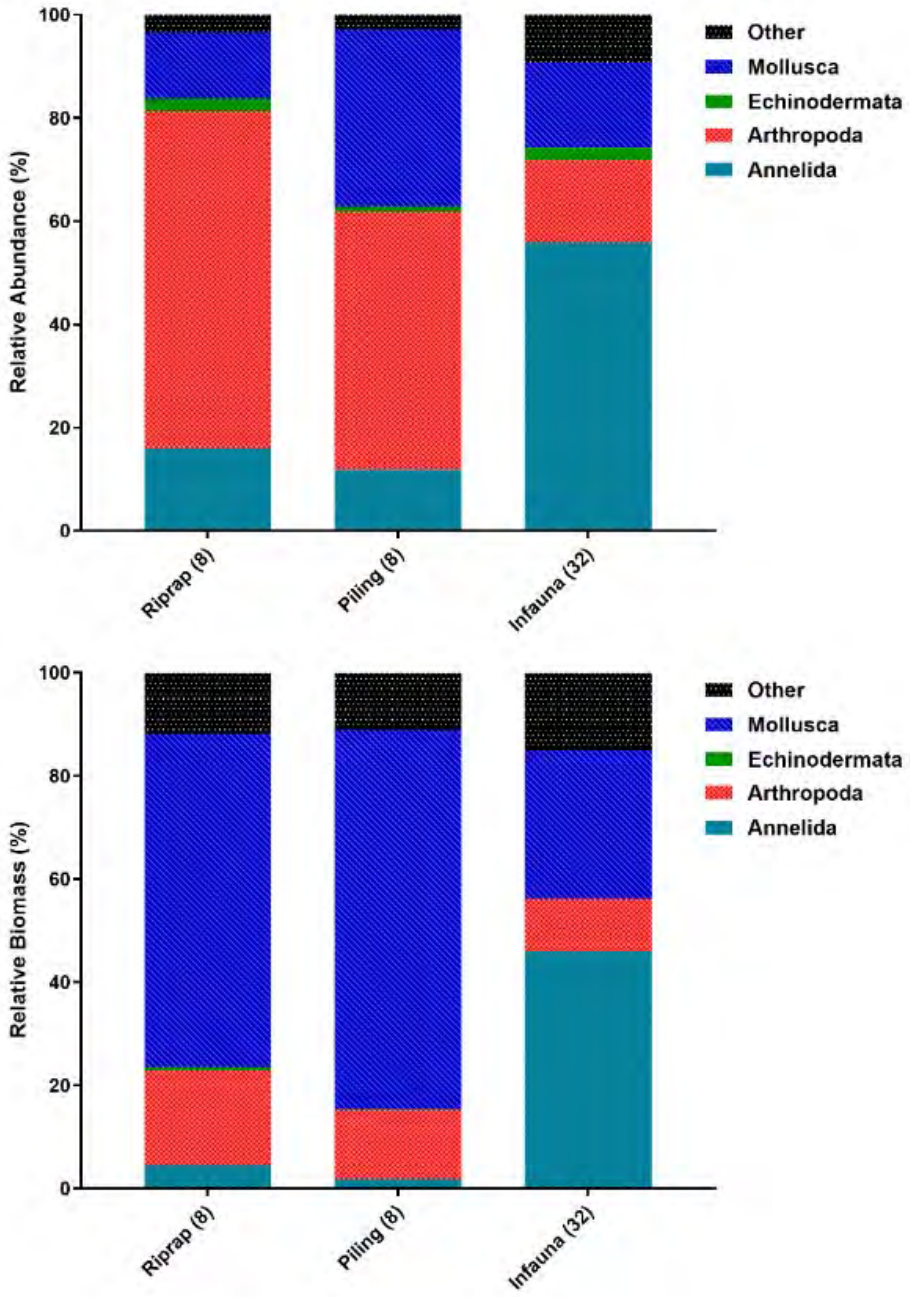
Table 9-2. Invertebrate Species Richness, Abundance, Biomass and Diversity in Quadrat Scrapings for Riprap, Piling and Soft-Bottom Infauna Stations

Metric	Substrate	Maximum	Mean	Median	Minimum
Species Richness	Riprap	207	138	159	52
	Pilings	208	161	158	120
	Infauna	114	36	33	8
Abundance (#/m^2)	Riprap	46,540	22,421	19,461	2,508
	Pilings	48,590	32,266	29,420	22,226
	Infauna	20,850	2,863	1,080	220
Biomass (grams/m^2)	Riprap	1,236	724	771	155
	Pilings	6,090	2,917	2,152	1,127
	Infauna	1,486	108	51	2.5
Shannon-Weiner Diversity Index	Riprap	4.11	3.43	3.55	2.13
	Pilings	4.00	3.29	3.42	2.11
	Infauna	4.19	3.06	3.08	0.99

m^2 = square meter(s)

Riprap and piling stations were relatively similar in terms of major phyla (Figure 9-2), both dominated by arthropods such as small shrimps and amphipods. Percentage of total biomass was similar for riprap and piling, with both dominated by mollusks (mostly mussels and scallops), which thrive on vertical habitats within the water column and take advantage of their exceptional efficiency at filtering large quantities of water. High densities of these filter-feeding species may contribute to increased water clarity throughout the water column (Firth et al., 2024).

Results for soft-bottom habitats were quite different, with abundance and biomass dominated by annelids that burrow into the seafloor. Differences in the invertebrate community can affect macroinvertebrate and fish species occur in these habitats based on feeding strategies and prey preferences.



"Other" includes chordata, bryozoans, and other minor phyla. Numbers in parentheses of x-axis labels represent number of stations.

Figure 9-1. Relative Abundance and Biomass of Invertebrates by Phyla Averaged Across All Stations for Riprap, Pilings, and Soft-bottom Habitats Sampled During the 2023 Biosurvey

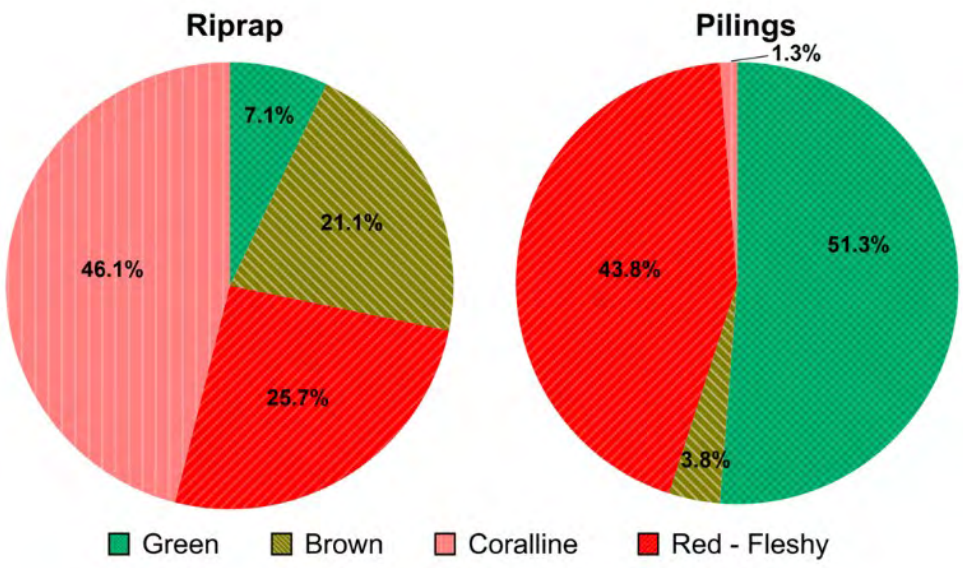


Figure 9-2. Relative Biomass of Algae at Riprap and Piling Stations from Quadrat Scrapings

Although the composition of the invertebrate community differs substantially by substrate type, there is a considerable amount of overlap in species between substrates. The combined list for riprap, pilings, and soft-bottom habitat, not including algae, contains 769 taxa (Table 9-3, Figure 9-3). The soft-bottom habitat (infauna) had the highest proportion of species identified only in that habitat type (261 species, 34% of the total number of species), and riprap and pilings shared the highest proportion of species (163 species, 21%), consistent with results from 2018. There were 79 species (10% of the total) that were identified on all three substrate types and an additional 31 species (4%) that overlapped with soft-bottom habitats and either riprap or pilings. Of the 33 algal species identified on riprap and piling habitats, 10 species were identified in both; riprap had more unique species (17) compared with pilings (6).

The observed differences in species composition between the riprap/pilings and soft-bottomed benthic substrate invertebrates are not surprising given the obvious habitat differences (seafloor versus substrates ranging from high intertidal to subtidal depths) and the nature of available habitat types on the soft bottom versus hard substrates for invertebrates to use for shelter and foraging. The ecological functioning and value of one substrate type compared with the others is not well understood and requires further study to understand impacts on an ecosystem level. However, results of the 2018 and 2023 Biosurveys indicate that there is some plasticity for some benthic invertebrates and the substrates they can inhabit, with 10% of species in all three habitat types in 2023.

Table 9-3. Invertebrate Taxa Found on Different Substrates During the 2023 Biosurvey

Substrate Type	Number of Taxa	Percentage of Total Taxa
Only Riprap	136	17.7
Only Pilings	99	12.9
Only Soft-Bottom	261	33.9
Pilings + Riprap	163	21.2
Riprap + Soft-Bottom	16	2.10
Pilings + Soft-Bottom	15	1.95
Pilings + Riprap + Soft-Bottom	79	10.3
Total	**769**	**100**

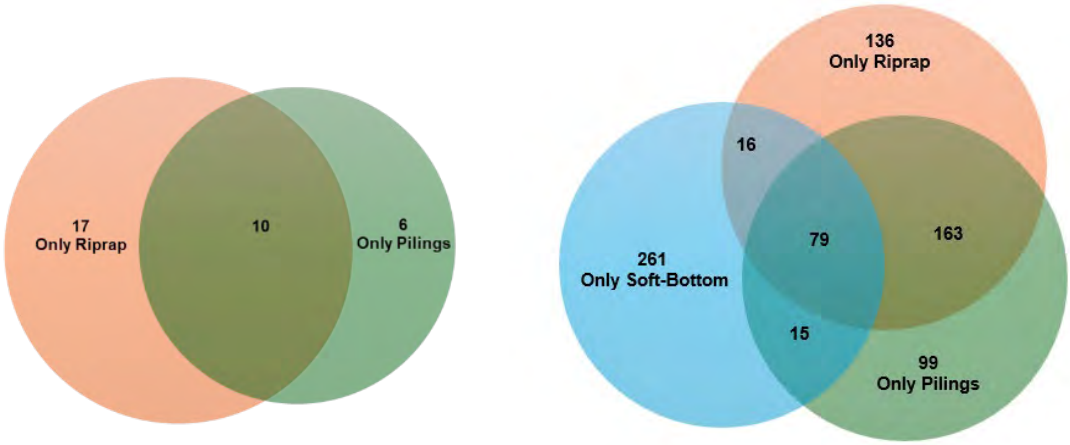


Figure 9-3. Venn Diagram of Number of Algae (left) and Invertebrate (right) Taxa Found in Soft-Bottom, Riprap, and Piling Habitats

9.2 HISTORICAL AND REGIONAL CONTEXT

9.2.1 REGIONAL CLIMATE EVENTS

As described in Section 2.4, one of the most notable trends affecting biological communities within the Port Complex is long-term climate patterns, such as "El Niño" and "La Niña" measured by the ONI, and the more recently recognized phenomenon of marine heatwaves that can evolve and persist in the northeastern Pacific Ocean (Jacox et al., 2019). Over the course of historical Biosurveys in 2000, 2008, 2013, and 2018, the ENSO reflects colder waters in 2000 and neither strong El Niño nor La Niña conditions in 2008, 2013, and 2018, despite 2018 following a significant marine heatwave event in 2014–2016. In 2023, however, ONI values indicated strong El Niño conditions by mid-2023. The 2023 Biosurvey period experienced the most rainfall of any of the past Biosurvey periods, including the wettest single month in 25 years, with nearly 12 inches of rainfall in February 2024. Heavy rainfall lowered the salinity in the Inner Harbor (Section 2.3.2), delivered larval fish from the watersheds (Section 3.4.1.2), and potentially disturbed benthic habitats within the Inner Harbor (e.g., by scouring, exposure to low salinity) that could have resulted in pollution- and disturbance-tolerant species becoming seasonally abundant until native benthic communities recovered (Sections 4.3 and 4.7.1).

Using new technologies such as remote sensing, continuing long-term monitoring with CTDs to document surface and bottom conditions in the Port Complex, and relying on the ever-expanding network of nearshore buoys to understand changing ocean conditions will continue to help inform biological resource management of critical habitats and managed species present in the Port Complex in the face of predicted changing ocean conditions.

9.2.2 EELGRASS

Eelgrass bed acreage more than doubled in 2023 compared with acreage in 2018, with the largest expansion in the Pier 300 Basin and at Cabrillo Beach. These two core areas of eelgrass have supported the vast majority (over 93%) of all eelgrass acreage throughout the past five Biosurveys. However, since the 2013 Biosurvey, the eelgrass beds in Slip 1 have remained steady, and the expansion of beds in the East Basin yacht marinas and Consolidated Slip has continued. The observed trend in 2018 of eelgrass occurring at deeper depths and in more areas of the Inner Harbor continued in 2023, with nearly 7 acres combined at the Consolidated Slip and East Basin Yacht Marinas, concurrent with a trend of improving water clarity.

An interesting observation in 2018 and 2023 is that deeper margins of eelgrass were generally located in Inner Harbor areas, such as along Cerritos Channel and within marina basins, rather than Outer Harbor areas, which have more oceanic influence. This observation may indicate improved water clarity in the Inner Harbor, which may be a factor in the recent expansion of eelgrass within the Inner Harbor areas since the 2008 Biosurvey. Similar observations of deep eelgrass beds have been made within the industrialized portions of San Diego Bay, where it is believed that water clarity is enhanced by less wind-induced sediment suspension, relatively slow water turn-

over (and thus continued settlement of suspended particulates), and trapping and removal of sediment particles by oysters, mussels, and other filter-feeders (Firth et al., 2024).

9.2.3 BENTHIC INFAUNA, HARD-SUBSTRATE FAUNA, AND EPIBENTHIC INVERTEBRATES

The 2023 Biosurvey showed high diversity of benthic invertebrates, both infauna and larger epibenthic invertebrates such as shrimp and crabs, similar to results for the 2018 Biosurvey. The invertebrate community diversity on pilings and riprap was consistent with that in 2018; however, the mean biomass and abundance were higher in 2023 than in any past Biosurvey period.

In recent Biosurveys, pollution-intolerant (i.e., sensitive) species have become more common in the 10 most abundant species in the Port Complex than in historical studies, with the pollution-sensitive amphipod *Amphideutopus oculatus* among the top two most abundant infauna species in the past three Biosurveys. Although some non-native infauna species have remained abundant, they are not widespread; for example, the worm *Pseudopolydora paucibranchiata* and the amphipod *Grandidierella japonica* are abundant only in a few areas of the Port Complex (e.g., Cabrillo Marina, Fish Harbor, and Consolidated Slip), and their presence and abundance are consistent with results for regional harbor and marina monitoring in 2023 (WSP, 2026).

The target shrimp (*Sicyonia penicillata*) was first noted in coastal environments in the Southern California Bight in 1998 (Estrada-Ramirez and Calderon-Aguilera, 2001; Montagne and Cadien, 2001) and is now a dominant species in embayments and inner shelf habitats in the Southern California Bight (Wisenbaker et al., 2021). The species was first collected in the Port Complex during the 2008 Biosurvey and has since become the dominant epibenthic species over the past three Biosurveys; it represented over 50% of the total epibenthic invertebrates captured with trawls in 2023. This pattern likely represents long-term range shifts by species, with typically southern distributions becoming more abundant at the northern end of their ranges.

9.2.4 PELAGIC AND DEMERSAL FISH

The core community of pelagic and demersal fishes in the Port Complex has remained remarkably consistent over the past 2 decades, with anchovy, topsmelt, and California grunion the most common pelagic species and queenfish, white croaker, barred sand bass, and California halibut the most common demersal fish species.

Results of regional monitoring in 2023 indicated that San Pedro Bay (including the Port Complex) had more than twice as many demersal fish species as Mission Bay and San Diego Bay (WSP, 2026).

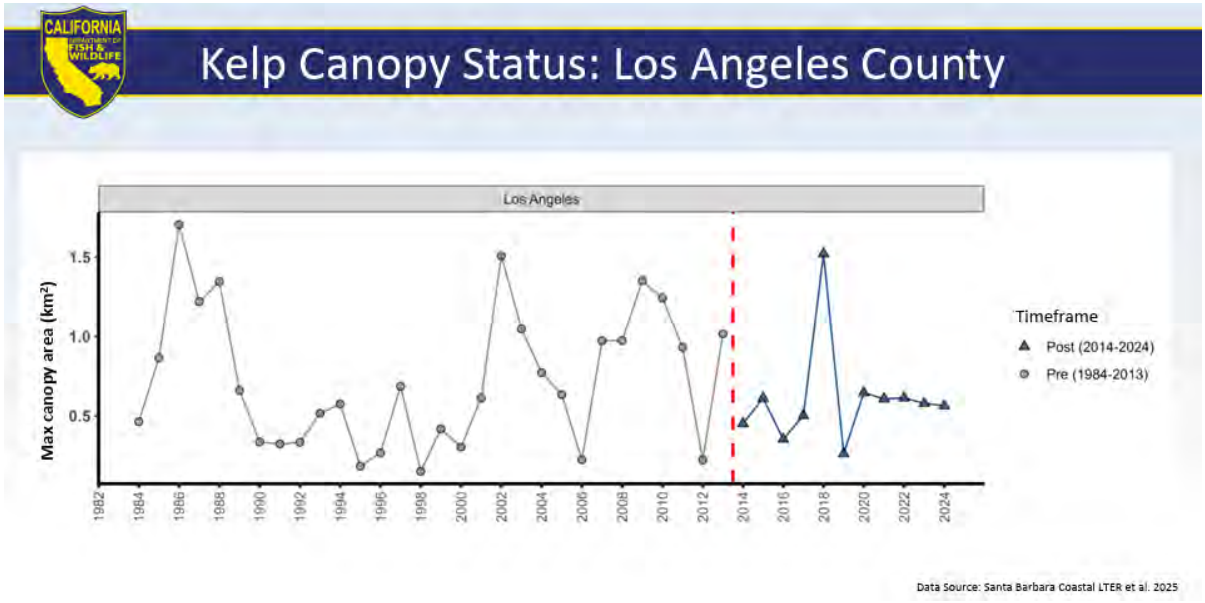
Pelagic fish have been highly variable in abundance across Biosurveys because of the naturally patchy distribution of schooling fish, which leads to occasional extremely large catches of, for example, northern anchovy. In 2023, larval and adult pelagic fish species richness was consistent with results for past surveys. The composition of the 10 most abundant species has remained consistent across Biosurveys, defining the core pelagic fish community consisting primarily of anchovy (Engraulidae), topsmelt (*Atherinops affinis*), and California grunion (*Leuresthes tenuis*).

Demersal fish species in soft-bottom and shallow subtidal habitats have remained remarkably consistent throughout the years in terms of species richness and composition of the 10 most abundant species. Of the 104 total species, 29 were captured in all five Biosurveys; many of the species are abundant and commonly encountered during sampling and thus can be considered as characteristic of the Port Complex. White croaker has remained the top species in terms of the EI, which balances total abundance, total biomass, and frequency of occurrence of each species across all stations as a metric to assess how the community is structured. Queenfish (*Seriphus politus*), northern anchovy, barred sand bass (*Paralabrax nebulifer*), specklefin midshipman (*Porichthys myriaster*), and California halibut (*Paralichthys californicus*) are the other members of the core demersal fish community across all surveys.

Regional monitoring in other Southern California embayments in 2023 using daytime benthic trawls (WSP, 2026) indicated that the Port Complex has the highest diversity of fishes (45 species in daytime benthic trawls only) compared with San Diego Bay (19 species) and Mission Bay (11 species). More intensive fish surveys in San Diego Bay in 2019 that sampled multiple habitat types (similar to the Biosurveys) for larval fishes and adult fishes using beach seines, fish traps, trawls, and purse seines captured 45 fish species (Williams et al., 2019), which was roughly half of the 88 total fish species captured in all survey types in the Port Complex during the 2018 Biosurvey.

9.2.5 RIPRAP AND PILING COMMUNITIES

The 2023 Biosurvey was the first to incorporate satellite imagery to map kelp canopy, with archive imagery from 2018 providing historical comparisons. This new methodology provides a foundation for future kelp mapping efforts within the Port Complex to continue to build the kelp canopy database moving forward. The kelp canopy database and further understanding of the dynamics between remote and *in situ* measurements of kelp density and areal coverage provide critical baseline data for when the California Ocean Protection Council (OPC) and CDFW implement the new Kelp Restoration and Management Plan (KRMP), currently scheduled for implementation in 2027 (CDFW, 2025). The intent of the KRMP is to develop a robust, adaptive, climate-ready approach for managing, protecting, and restoring giant and bull kelp forest ecosystems statewide using an ecosystem-based management and adaptive harvesting framework, while also providing a restoration toolkit. State-wide monitoring of kelp canopy changed from aerial imagery to satellite imagery in 2016, using Landsat (30-meter resolution) in addition to developing high-resolution (3-meter resolution) monitoring in northern California around areas that have experienced the worst decline in bull kelp coverage (CDFW and OPC, 2023). The incorporation of satellite-derived kelp canopy measurements into the Biosurveys prepares the Port Complex to integrate the kelp management goals of the KRMP using the same technology, with data that have been validated in the unique habitats within the Port Complex (Wood, 2021; WSP, 2023, 2024). The kelp canopy data in the Port Complex from 2018 through 2023 indicate that 2018 had the highest annual maximum kelp canopy acreage of any of the years surveyed, with 71 acres compared with 25 to 60 acres from 2019 through 2023 (see Section 5.2.2 and Appendix E), which is consistent with regional observations of kelp canopy in Los Angeles County over the same time period (CDFW, 2025, Figure 9-4).



Red line indicates when data switches from aerial to satellite imagery

Figure 9-4. Historical CDFW Kelp Canopy in Coastal Los Angeles County

For the first time, in 2023, a quantitative survey of fish density and size class on riprap and piling surveys provided new insights into fish communities that use these habitats and a comparison of the habitats with nearby pelagic and soft-bottom habitats. In total, 37 fish species at riprap stations and 14 species at piling stations were identified in 2023, an increase over 2018 results, with 29 species at riprap stations and 7 species at piling stations. The diversity of fishes at these habitats overlaps with those at nearby shallow (<17-meter depth) oil platforms on the San Pedro shelf (Martin and Lowe, 2010); the presence of large sand bass and kelp bass at these habitats was consistent with the presence of bass tracked around pier and kelp habitats at Catalina Island, with larger individuals defending high-value habitat and foraging in nearby habitats (Lowe et al., 2003). This indicates that the high occurrence of kelp bass, barred sand bass, and surfperches (among others) within the Port Complex associated with pilings and riprap may represent positive habitat selection of areas that provide refuge from predators and increased foraging opportunities.

Riprap habitats have continued to support canopy-forming kelp (giant kelp *Macrocystis pyrifera* and to a lesser extent feather boat kelp *Egregia menziesii*), consistent with results for past surveys. Diver survey methods were expanded in 2023 to include additional surveys in the lower intertidal zone that better characterized the presence

of canopy-forming kelp, especially feather boa kelp. Swath surveys on pilings for the first time in 2023 captured high densities of filter feeders such as gorgonians and rock scallops, and kelp growing on all pilings in the Outer Harbor. The new methods used in the 2023 Biosurvey help fill a data gap identified in previous Biosurveys and provide additional insight into kelp distribution on artificial structures within the Port Complex.

9.2.6 BIRDS AND MARINE MAMMALS

The 10 most abundant bird species have remained consistent over all Biosurvey years and have typically accounted for at least 86% of the total observations. Western gulls (*Larus occidentalis*) were the most abundant birds in 2023, followed by Brandt's cormorants (*Urile penicillatus*) and surf scoters (*Melanitta perspicillata*). The number of species observed in the 2023 Biosurvey (98) was comparable to results for previous Biosurveys. However, total avian abundance from the 2013, 2018, and 2023 Biosurveys showed widespread declines recorded in the 2018 Biosurvey and partial recovery in the 2023 Biosurvey, with the 2023 total abundance (66,447) and abundance per survey (5,537) 36% higher than in the 2018 Biosurveys. The abundance results for the 2023 Biosurvey align more closely with earlier historical survey results, yet are still 13% lower than the maximum abundance observed in 2013. Oceanographic fluctuations and climatic events, such as ENSO and marine heatwaves, are known to cause year-to-year variations in the numbers, productivity, life span, and behavior of breeding Pacific seabirds (Hyrenbach and Veit, 2003; Cavole, et al. 2016; Ainley et al., 2018).

Marine mammals have only been quantified since 2013, with previous surveys only recording them as ancillary observations during bird surveys. California sea lions (*Zalophus californianus*) have consistently been the most abundant species within the Port Complex, followed by harbor seals (*Phoca vituline*), common dolphins (*Delphinus delphis*), and bottlenose dolphins (*Tursiops truncates*). While not year-round visitors, during their migratory period in the spring gray whales (*Eschrichtius robustus*) have occasionally been observed in Outer Harbor areas.

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APPENDIX

A METHODS

APPENDIX

APPENDIX A
METHODS OVERVIEW

This appendix provides detailed methods and materials for each survey component and statistical analysis as a supplement to report Section 1. Dates for spring 2023, summer 2023 and sinter 2024 sampling events are listed in Table A-1.

Table A-1. Dates for Spring 2023, Summer 2023, and Winter 2024 Sampling Events

Survey Type	Spring 2023 Sampling Dates	Summer 2023 Sampling Dates	Winter 2024 Sampling Dates
Physical Characteristics (Water)	May 18–19	September 21–22	March 7–8
Physical Characteristics (Sediment) and Benthic Infauna[1]	April 11–12	August 10–14	Not Sampled
Ichthyoplankton	May 2–5	September 5–8	January 23–24
Demersal Fishes and Epibenthic Invertebrates (Otter Trawl)	Day: April 17–20 Night: April 23–26	Day: August 17–19 Night: July 10–13	Not Sampled
Pelagic Fishes (Lampara Net)	Day: May 1–3 Night: May 7–10	Day: July 24–25 Night: July 31–August 2	Not Sampled
Shallow-water Fishes (Beach Seines)	April 13	July 7–9	Not Sampled
Swath and UPC Diver Surveys on Riprap and Pier Pilings	June 12–16	August 7–11	Not Sampled
Riprap and Pier Piling Quadrat Sampling	April 10–13	August 7–11	Not Sampled
Eelgrass	May 1–3	September 7–8	Not Sampled
Birds and Marine Mammals	Monthly for 12 months; April 2023–March 2024[2]		
Satellite images	Monthly for 12 months[3]; April 2023–March 2024		

1. Sampling conducted by Anchor QEA as part of the Harbor Toxics TMDL Program.
2. March 2024 surveys were completed in April 2024 because of weather conditions.
3. Because of extended cloudy conditions, no images were available from May through June 2023.

TMDL = total maximum daily load; UPC = uniform point contact

A.1 WATER QUALITY

The field team collected vertical profiles of the water A column at 33 total stations (Figure A-1) using WSP's Sea-Bird SBE-19 Plus Conductivity-Temperature-Depth (CTD) profiler. The CTD profiler is equipped with an SBE 43 dissolved oxygen sensor, Wetlab C-star light transmittance sensor, fluorometer to measure chlorophyll-a, and Sea-Bird pH, depth, conductivity, and temperature probes (Table A-2). To maintain consistency with previous Biosurveys, transparency of the surface waters was also measured using a secchi disk at each station.



Figure A-1. Water Quality Characteristics and Benthic Infauna Stations

APPENDIX

Table A-2. Water Column Physical Parameters Measured

Physical Parameters	
Temperature (°C)	Salinity (PSU)
Dissolved Oxygen (mg/L)	Light Transmission (%)
pH	Specific Conductivity (µS/cm)
Chlorophyll-a (µg/L)	Secchi Depth (meters)
Turbidity (NTU)	

°C = degree(s) Celsius; µg/L = microgram(s) per liter; µS/cm = micro-Siemen(s) per centimeter; mg/L = milligram(s) per liter; NTU = nephelometric unit(s); PSU = practical salinity unit(s)

To maximize comparability with results for the 2018 Biosurvey, the WSP team conducted physical water quality measurements on the following dates: May 18–19, 2023 (spring), September 21–22, 2023 (summer), and March 7–8, 2024 (winter).

New methods to characterize Port Complex-wide water quality patterns included monthly satellite images from Sentinel-2 (10-meter resolution) processed for turbidity, chlorophyll-a, and satellite-derived secchi disk depth data; Landsat-8/9 (30-meter resolution) images were processed for sea surface temperature. Based on comparisons with field surveys using a CTD profiler, surface water quality metrics historically show significant correlation between both methods for sea surface temperature, turbidity, and water clarity (Wood, 2021; WSP, 2023).

An additional sea surface temperature (SST) data set from a Moderate Resolution Imaging Spectroradiometer (MODIS), a key instrument aboard National Aeronautics and Space Administration (NASA) Terra and Aqua satellites, was also accessed. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, and Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS view the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths (see MODIS Technical Specifications). More than 4,100 images were accessed and analyzed as a rolling 9-day average to provide near daily SST coverage from 2013 through 2024. With a resolution of 1 kilometer (km), there is too much shoreline interference within the Port Complex so the imagery was captured just offshore of Cabrillo Beach and Point Fermin, southwest of the Port Complex.

A.2 SEDIMENT CHARACTERISTICS AND BENTHIC INFAUNA

The Biosurvey sediment sampling took place across two distinct efforts during spring (April 2023) and summer (August 2023) 3. Samples were collected at 33 stations within the Port Complex (Figure A-1).

Based upon direction from the Port Complex, benthic infauna sampling and laboratory analyses were performed by Anchor QEA to coordinate the Biosurvey sampling effort with the Greater Harbor Waters Toxic TMDL Regional Monitoring Coalition (RMC) Program and the Bight 2023 Regional Monitoring Program. The Biosurvey sampling stations include seven that are co-located with RMC stations, and the Biosurvey also included a spring sampling effort in addition to the RMC summer sampling effort. For consistency and fiscal responsibility, Anchor QEA, contracted to perform the RMC sampling, performed all sediment and benthic infauna sampling and provided information to WSP to incorporate into this report. All data delivered to WSP were entered into a central database and was subjected to a 100% quality assurance check.

Anchor QEA sampling procedures followed those in the Sediment Quality Assessment Draft Technical Support Manual (Bay et al., 2021). Sediment samples were collected using a 0.1-meter square (m^2) Van Veen grab sampler that was decontaminated prior to sample collection at each sampling location. Once the grab was onboard, a subsample for grain size and sediment total organic carbon (TOC) analysis was removed from the upper 5 centimeters (cm) of the grab sample, and the remainder of the grab sample was washed through a 1.0-millimeter (mm) sieve with filtered site water onboard the vessel.

The material retained on the 1.0-mm sieve was placed into pre-labeled sample containers, with care taken to avoid damaging the organisms. Each sample container was then treated with a relaxant solution of Epsom salts for

approximately 30 minutes, and then fixed with a 10-percent buffered formalin solution. Samples were stored in a cooler without ice until delivery to the taxonomic laboratory for analysis. After being fixed in formalin for a minimum of 72 hours but no longer than 2 weeks, the samples were transferred to 70% ethanol. The taxonomy laboratory sorted the organisms into major taxonomic groups, counted them, and then identified each organism to the lowest taxonomic level possible.

Sediment was analyzed for grain size using method ASTM International D464(M) and for total organic carbon using United States Environmental Protection Agency (EPA) Method 9060A.

Data received by WSP from the Anchor/RMC team were reviewed for consistency with past data from the Biosurveys. Taxonomic designations from prior Biosurveys were reviewed to ensure that any updates to taxonomic nomenclature were applied to facilitate comparison with the newly acquired data. Consistent with previous Biosurvey analyses, abundance and biomass values were converted to densities per square meter. Summary metrics generated included species richness, diversity, abundance, and biomass (per station, per season, total), as well as the Southern California Benthic Response Index (BRI). In 2013, the BRI was calculated according to a paper by Smith et al. (2003), with the slight modification of using the fourth root of species abundance to transform data in place of the cube root, as outlined in the Smith et al. paper. This method excludes species from the abundance-weighted mean tolerance calculation if they are not in Table D-3 of the Smith et al. 2003 document (i.e., the species does not have an assigned pollution tolerance value). In 2018, the method of BRI calculation was updated to follow the guidance in the 2014 Sediment Quality Assessment Technical Support Manual (Bay et al., 2014). This method, used again in the 2023 Biosurvey, used a spreadsheet calculator tool developed by the Southern California Coastal Water Research Project (SCCWRP) which allows for improved comparison to other regional monitoring efforts. Species were cross-checked with an updated species taxa pollution tolerance lookup list, which included additional new taxa not included in the Smith et al. 2003 list, as well as updated pollution tolerance values for some taxa.

Various advanced statistical procedures, including multivariate analysis, were used to discern differences in community assemblages. Maps of the station cluster groups identified by the advanced statistical procedures were generated to show spatial patterns in species composition that coincide with obvious habitat breaks. Additionally, the data gathered in the 2023 Biosurvey were compared with the 2000, 2008, 2013, and 2018 Biosurvey data to evaluate whether station clustering had changed or remained consistent over time.

A.3 DEMERSAL FISH, PELAGIC FISH, AND SHALLOW SUBTIDAL FISH AND EPIBENTHIC INVERTEBRATES

As in the 2018 Biosurvey, demersal fish and epibenthic macroinvertebrates were sampled at 26 stations, 13 in each port. Collections were made from the R/V Earlybird II using a 7.6-meter semi-balloon otter trawl (Figure A-2). The otter trawl was constructed with 2.5-cm side mesh and fitted with a 1.3-cm mesh cod end and was towed along the seafloor behind the survey vessel. For each haul, the survey vessel towed the net at approximately 2 knots for a period of 5 minutes, sampling an area approximately 2,348 m2 per trawl. Detailed maps of trawl net sampling locations are provided in Appendix D. Debris captured during trawls was documented and classified (e.g., kelp, eelgrass, trash, etc.), and kelp was weighed to the nearest 0.1 kg.

Pelagic species were sampled at the same stations as demersal species using a lampara net similar to those used in previous Port Complex-wide studies (i.e., 166-meter cork line and a depth of 22 meters, as was used for the 2008, 2013, and 2018 Biosurveys). In 2000, the lampara net had a 273-meter cork line and a depth of 36 meters). Each deployment of the 166-meter lampara net samples an area of approximately 2,193 m2, with total volume sampled dependent on the station depth (net depth extends to 22 meters) but a maximum volume sampled of approximately 48,267 m3 per deployment. For the spring 2023 lampara sampling, the 166-meter net was used successfully for all stations during the day. During the spring night sampling, 11 of the 26 stations were sampled with the 166-meter net before the net snagged on an obstruction on the seafloor and was severely damaged, with a timeline for repairs beyond the window to finish sampling within the same season. A smaller 90-meter lampara net was available for immediate use, with a sampling area of approximately 645 m2. This smaller net was used for the remaining 15 stations to complete the required seasonal sampling.

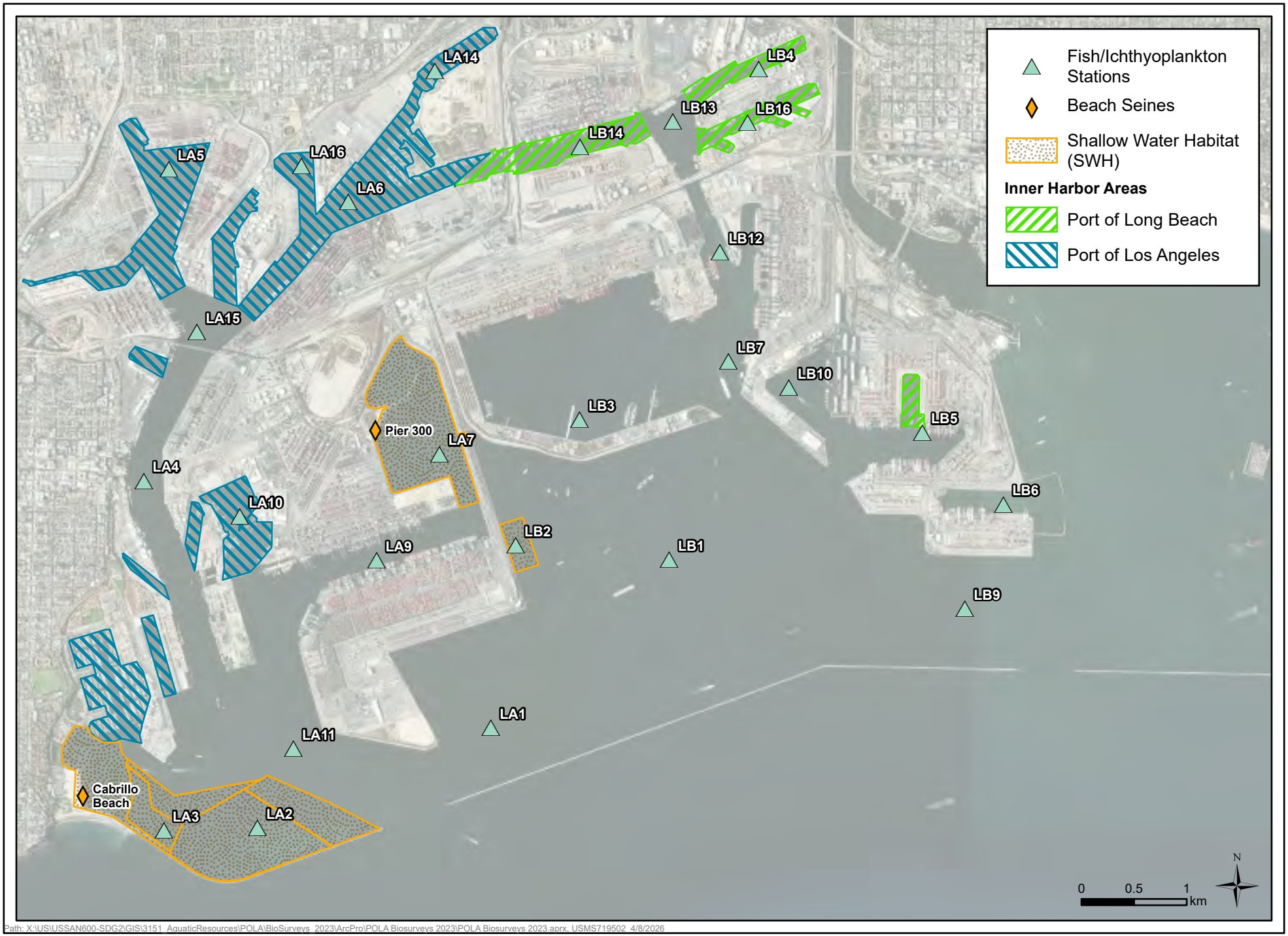


Figure A-2. Locations of Fish and Epibenthic Invertebrate, Ichthyoplankton, and Beach Seine Sampling

The diversity of the fish captured at the stations using the smaller net was compared to the summertime when the larger 166 m net was back in service and the diversity was consistent with both nets at those stations. To make the data from the smaller net comparable with the data from the larger one, the abundance of fish captured with the smaller net was multiplied by an area sampled correction factor of 3.4 (2,193-m2 area large net/645-m2 area small net=3.4). The catch data from the smaller net and the area adjusted abundances are listed in a table in Appendix C. All organisms captured in each haul were transferred to tubs filled with seawater, processed (i.e., identified, weighed, and measured), and released. Detailed maps of lampara net sampling locations are in Appendix C.

Shallow subtidal fishes were sampled with a beach seine (15.2 meters long, 2 meters tall, with ¼" mesh), with two replicates at each station per season. The net was deployed to a water depth of approximately 1.5 meters at low tide to sample within the shallow eelgrass beds. The slopes of the beaches sampled were variable, but assuming the net was recovered over a distance of 15 meters, each haul sampled an area approximately 225 m^2 in total. All organisms captured in each haul were transferred to tubs filled with seawater, processed (i.e., identified, weighed, and measured), and released.

For demersal and pelagic sampling, individuals were identified to species level (when feasible), measured, and weighed. For any single taxon, the total number of individuals was recorded, and the measuring and weighing procedure was conducted according to Table A-3. Fish and invertebrate health and physical anomalies (e.g., tumors, parasites, or deformations) were noted.

Table A-3. Procedures for Measuring and Weighing

Abundance of Single Taxa	Measured to Nearest Centimeter by Individual[1]	Weighed to the Nearest 0.1 Kilogram	Comments
0–30	Yes	Individually	–
31–250	Yes	Batch Weight	–
251+	No	Batch Weight	Batch weights were determined based on size classes

1. Invertebrate lengths were not measured; weight only.

A.4 ICHTHYOPLANKTON

Field Collections

Ichthyoplankton samples were collected at the same stations as the fish/invertebrate trawls, with 13 stations in each port (Figure A-2). Both epibenthic (near-bottom) and water column samples were collected at each station. Surveys took place in spring, summer, and winter (Table A-1) and were performed only at night to minimize visually based net avoidance by the larger larvae. A total of 52 ichthyoplankton samples (one at each depth stratum, totaling two at each station) were collected per season, resulting in 156 samples overall. The 2023 Biosurvey used the same vessel (R/V *Scorpaena*), operations crew, and sampling gear used in the 2018 Biosurvey, which ensured maximum data comparability between surveys.

Samples were collected using a bongo net apparatus, which has paired cylinder-cone nets with a 70-cm diameter opening, 0.333-mm mesh Nitex netting, and a removable cod-end. Aluminum wheels 1 meter in diameter were attached to the side of the net frame for epibenthic sampling to maintain the net at a consistent height above the bottom. For water column sampling, the bongo net was towed in an oblique pattern, which began with the net deployed at the bottom and retrieved diagonally toward the surface at a consistent rate over the length of the tow. A General Oceanics flowmeter was mounted at the opening of each net to record water flow per haul, and the volume of water sampled was calculated immediately upon retrieval to ensure that a minimum target water volume of 30 cubic meters (m^3) was collected. All tows were conducted at a speed of approximately 1 knot and for sufficient time to collect the target volume. For oblique samples, two or three hauls were typically necessary to attain the target volume while maintaining the necessary speed and remaining within the station area.

APPENDIX

Samples collected from the tows were placed in sample jars and preserved with a mixture of 10% buffered formalin in filtered seawater. Each sample was a combination of material from both sides of the bongo net. Samples were labeled with the station identifier, gear type, tow type (oblique, epibenthic), date, and time of sampling. Before each station was abandoned, a quality control checklist was filled out to ensure that all sampling procedures were completed. Station occupation data were recorded on field data sheets and included the coordinates of net deployment and retrieval, and the flow meter start and end values.

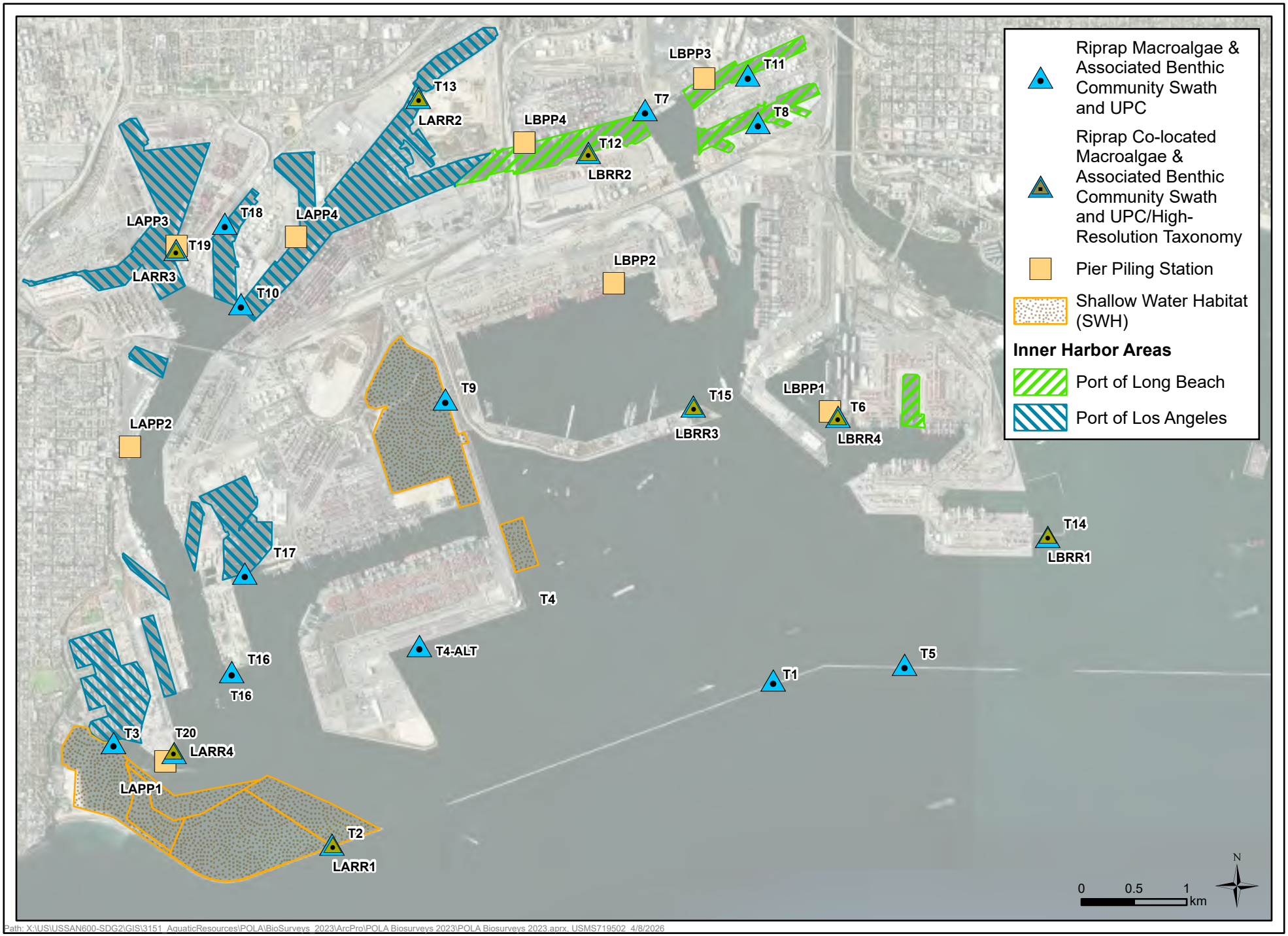
Laboratory Processing

Fish eggs and larvae were sorted from the samples, identified to the lowest practicable taxon (usually species, but in some cases species complex [see below], genus, or family, as described below), and counted. Large samples were split so that subsamples could be sorted to remove as near to, but not less than, 100 fish larvae and 100 fish eggs. A subsample of 100 fish larvae and 100 eggs has been found to be suitable for statistical analysis in ichthyoplankton studies (Bay et al., 2014). Although many egg samples were split, very few larval samples had greater than 100 individuals. Counts of fish eggs and larvae were standardized to number per 100 m^3 of seawater using flowmeter data taken at the time of sampling. Identifications were based primarily on The Early Life Stages of Fishes in the California Current Region, CalCOFI Atlas No. 33 (Moser, 1996), and other taxonomic references. Taxonomic resolution was calibrated through consultation with Southwest Fisheries Science Center experts.

Several taxa of fish larvae are difficult or impossible to separate into discrete species in the early developmental stages. Very few larvae of the family Scorpaenidae (rockfishes) are identifiable to species level. Pre-flexion stage larvae of *Hypsoblennius gentilis*, *Hemilepidotus gilberti*, and *Hypsoblennius jenkinsi* (bay, rockpool, and mussel blenny, respectively) are not distinguishable until the opercle spines become well developed; accordingly, early-stage larvae were left at *Hypsoblennius* spp. Some goby species are easily identified in preflexion stage, with the exception of *Clevelandia ios*, *Ilypnus gilberti*, and *Quietula y-cauda* (arrow, cheekspot, and shadow goby, respectively). Pre-flexion larvae of these three sympatric species are very similar and most immature specimens cannot be distinguished. These were designated *Clevlandia/Ilypnus*/*Quietula* (CIQ) gobies in the data. The Chaenopsidae (tube blennies), Labrisomidae (kelpfishes), and *Gibbonsia* spp. (kelpfish) may also be difficult to differentiate in the early stages and were sometimes left at higher taxonomic levels. Identification of fish eggs was limited to four taxa: engraulid eggs, *Pleruonichthys* spp. eggs, atherinid eggs, and all other (unidentified) fish eggs. Engraulid eggs are identified by their ovoid shape, *Pleuronichthys* eggs by hexagonal sculpturing on the surface, and atherinid eggs by filaments on the surface.

A.5 HARD SUBSTRATE ASSOCIATED COMMUNITIES

The goal of the hard-substrate-associated community surveys was to map the extent of kelp canopy within the Port Complex, quantify the density of canopy forming and understory macroalgae, and characterize the associated fish and invertebrate communities on riprap and concrete pilings (Figure A-3). Two types of sampling were employed: satellite imagery analysis of kelp canopy extent and diver surveys at specific stations for macroalgae, invertebrates and fishes.



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Figure A-3. Riprap/Pier Piling Community Stations

APPENDIX

Kelp Canopy Estimates from Satellite Imagery

Kelp canopy at the surface and canopy near the surface (<1 meter deep) was monitored via high-resolution satellite imagery in the Port Complex for the first time as part of the Biosurvey in place of aerial imagery (Figure A-4). Based on comparisons with existing visual survey methods, satellite imagery appears to be highly accurate in detecting viable kelp canopy (Wood, 2021; WSP, 2023, 2024).

Satellite imagery was obtained through WSP's vendor EOMAP, the same vendor used for the pilot study (Wood, 2021), validation study (WSP, 2023), and historical studies (WSP, 2024). The area of interest (AOI) mapped for kelp canopy was 102 km^2 to meet minimum AOI requirements from the satellite vendors, and 83 km^2 for water quality parameters (reference areas were not included). Based on results from the pilot study and the desire to quantify kelp canopy within each individual port, a new approach to compare kelp canopy in different areas was used that included the Port Complex (Zones 1–9) as well as in nearby reference areas (Refs A–C; Figure A-5). Zones in the Port Complex all included at least one field station for visual kelp canopy surveys. Reference areas were selected to provide comparison data from nearby kelp habitat outside of the Port Complex jurisdiction, including the Palos Verdes coastline from White's Point to Cabrillo Beach (Ref A), the east breakwater (Ref B), and the Long Beach waterfront and nearby artificial THUMS islands (Ref C).



Figure A-4. Kelp 102-km^2 (in red) Area of Interest and Water Quality 83-km^2 (in pink) Area of Interest

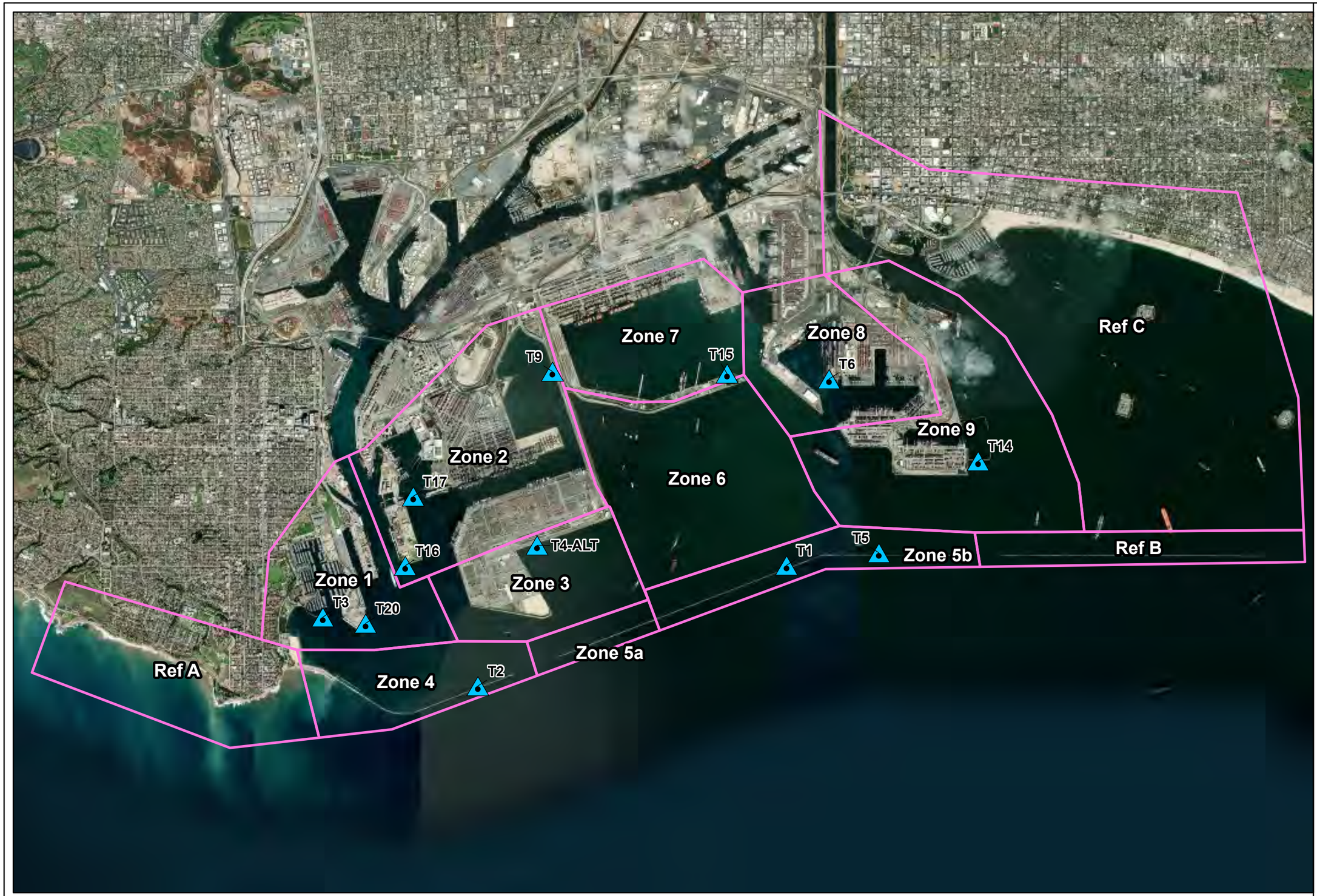


FIGURE A-5
Kelp Canopy Zones and Kelp Survey Stations

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The preferred sensor for the 2023 Biosurvey was the Pleiades NEO, which has 6-band multispectral capabilities, and a resolution of 1.2 meters. Satellite tasking was requested through Airbus with an expectation that successful imagery would be taken within a +/- 10-day window of the field survey dates. There are environmental factors involved that impact the viability of using satellite data on a particular date. For instance, cloud cover can block satellite transmission and thus effectively eliminate numerous dates because of lack of usable data. Other variables that could affect the quality of the image include floating objects (e.g., ships) and substances (e.g., oil films), water clarity, recording geometries to minimize sun glint, and waves breaking at the surface. For maximum comparability, satellite imagery date proximity to the spring and summer field surveys was the highest priority for satellite date selection criteria.

In the spring 2023, the Pleiades NEO was not available in the target window because of extended periods of overcast weather. Previous studies indicated that imagery could be obtained from WorldView-2 (8-band sensor with a resolution of 2 meters) or SkySat/Pleiades-1 (4-band multispectral sensors with 2-meter resolution), all of which were shown to provide results very comparable to kelp estimates from the Pleiades NEO (WSP, 2023, 2024) and provide good alternative imagery sources. An image from the Pleiades NEO from July 8, 2023, was combined with an archive WorldView-2 image from June 20, 2023, to make the spring composite image (Table A-4). Tasking for the Pleiades NEO was successful in the summer, with images from August 6 and August 22, 2023, combined to make the summer composite image.

Table A-4. Date, Tide, Sensor and AOI Coverage of Satellite Kelp Imagery in Spring and Summer 2023

Season	Spring 2023	Summer 2023
Date of Imagery	6/20 and 7/8	8/6 and 8/22
Tide (meters MLLW) at Time of Capture	+1.04 and +0.88	+1.32 and +1.38
Sensor(s)	Pleiades NEO and WorldView-2	Pleiades NEO
Resolution	1.2 meters and 2 meters	1.2 meters
AOI Coverage	98%	100%

Diver Surveys

Throughout the Port Complex, 20 stations (Figure A-3) were surveyed by divers for a more detailed assessment of riprap and piling epifaunal community (fish, macroalgae, and subtidal invertebrates) structure; note that 8 of the stations were co-located with stations used for sampling as part of the Riprap/Pier Piling element of the Biosurvey.

Dive surveys were performed in spring and summer (Table A-1). Three to five depth zones were surveyed by the dive team across all stations as station depth allowed (Table A-5) to maximize comparability across locations. Three types of diver surveys were performed: (1) fish surveys to determine density and species richness, (2) uniform point contact (UPC) surveys to quantify the percent cover of algae and invertebrates, and (3) swath surveys to quantify the density of target organisms within functional community groups.

Fish Surveys

At each target depth, a 10-meter band transect was laid out across a target depth contour on the riprap while the diver identified and counted fish within a survey area of 1 meter on either side of the transect and 2 meters from the bottom following protocols adapted from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and Reef Check Kelp Program (Figure A-6). Fish were counted only if they entered the survey window from the front or sides, with divers taking care to not count fish that entered the survey window from behind because they may have been attracted by the activities of the divers. During all survey activities, all fish species observed on station were documented in a manner similar to that for the summer 2018 surveys, allowing for comparisons with 2018 data; the density data from the transect survey are a new data type for the 2023 Biosurvey.

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UPC Surveys

In each depth zone, a 10-meter band transect was laid out across a depth contour on the riprap (Figure A-7). A diver then swam the transect and identified the cover category every 0.2 meter along the transect (i.e., 50 sampling points on each 10-meter transect). A modified PISCO species list was used to quantify the biological communities (Tables A-6 and A-7). At riprap stations, the depth of sediment deposition (cm) was recorded every meter.

Table A-5. Target Depth Zones for Rocky Reef-Associated Community Surveys

Station Depth (meters MLLW)	Target Depths for Swath/UPC Surveys (MLLW [meters])			
	1.5	3.5	7.0	11.0
4	x	x		
5	x	x		
6	x	x		
7	x	x		
8	x	x	x	
9	x	x	x	
10	x	x	x	
11	x	x	x	
12	x	x	x	x
13	x	x	x	x
14	x	x	x	x
15	x	x	x	x

MLLW = mean lower low water; UPC = uniform point contact

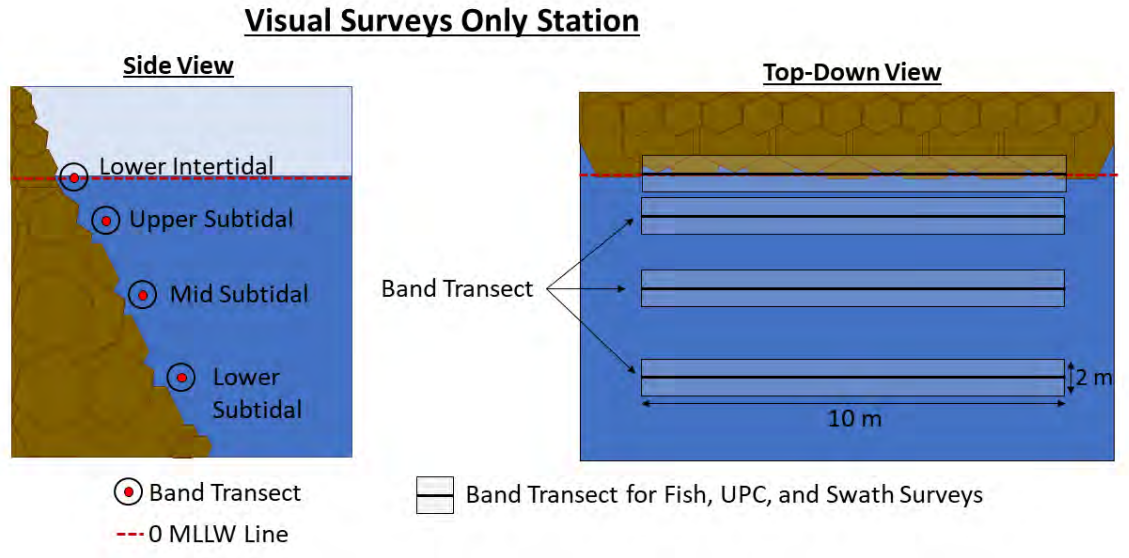


Figure A-6. Overview of Fish, Macroalgae, and Associated Benthic Invertebrate Community Sampling Scheme

APPENDIX

Table A-6. Invertebrate Categories for UPC Surveys

Phylum	Class	Common Name	Species
Porifera	Demospongiae	Sponge	Many
	Calcarea		
Cnidaria	Hydrozoa	Ostrich-plume hydroid	*Aglaophenia struthionides*
		Hydroid	Many
	Anthozoa	Gorgonian	Many
		Anemone	Many
		Club-Tipped Anemone	*Corynactis californica*
		Cup Coral	Many
Bryozoa	Gymnolaemata	Bryozoans	Many
		Non-native Bryozoan	*Watersipora* spp.
		Southern Staghorn Bryozoan	*Diaperoecia californica*
Mollusca	Gastropoda	Scaled Worm Shell	*Serpulorbis squamiger*
		Snails	Many
	Polyplacophora	Chiton	Many
	Bivalvia	Clam	Many
		Rock Scallop	*Crassadoma gigantea*
		California Mussel	*Mytilus californianus*
		Mediterranean Mussel	*Mytilus galloprovincialis*
		Olympia Oyster	*Ostrea lurida*
		Pacific Oyster	*Magallana gigas*
Arthropoda	Crustacea	Barnacle	*Chthamalus sp.*
		Gooseneck Barnacle	*Pollicipes polymerus*
Echinodermata	Holothuroidea	Sea Cucumber	Many
	Asteroidea	Sea Star	Many
	Echinoidea	Urchin	Many
Annelida	Polychaeta	Tube Worms	Many
		Colonial Tube Worm	Many
Chordata	Urochordata	Solitary Tunicate	Many
		Colonial Tunicate	Many

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Table A-7. Algae and Seagrass Categories for UPC Surveys

Class	Common Name	Species
Phaeophyceae (Brown Algae)	Giant Kelp	*Macrocystis pyrifera*
	Understory Kelp	*E. arborea, P. californica, L. farlowii*
		Stephanocystis osmondacea
	Asian Kelp	*Undaria pinnatifida*
	Feather Boa Kelp	*Egregia menziesii*
		Desmarestia ligulata
	Dictyotales	*Dictyota binghamiae*
		Sargassum muticum
		Sargassum horneri
	Dead Holdfast of kelps	
	Other Brown	Many
Rhodophyta (Red Algae)	Branching Red Algae	Many
	Bushy Red Algae	Many
	Leafy Red Algae	Many
	Lacy Red Algae	Many
	Turf Red Algae	Many
	Encrusting Red Algae	Many
	Articulate Coralline Algae	Many
	Crustose Coralline Algae	Many
Chlorophyta (Green Algae)	Sea Lettuce	*Ulva* spp.
	Other Green Algae	Many
Tracheophyta (Flowering Plants)	Surfgrass	*Phyllospadix scouleri/torreyi*
	Common Eelgrass Pacific Eelgrass	*Zostera marina* *Zostera pacifica*

Swath Surveys

Swath surveys along each transect were used to quantify algae and invertebrates based on functional community groups (Table A-8). Combined with the UPC survey, this approach quantified species of particular interest at each station in a more holistic way by cataloging some of the larger, mobile invertebrates that may have been missed during the UPC survey. Divers traveled along the same transect lines as the UPC survey surveying a 2-meter swath (1 meter on each side of the transect; Figure A-7) to cover an area of 20 m^2 at each depth. Individual animals were counted if any part of the individual was within the 2-meter swath. Giant kelp (*Macrocystis pyrifera*) was quantified as individuals, and stipes greater than 1-meter tall were quantified as a secondary measure of kelp density. This community-based assessment provided density estimates of key biological communities on riprap habitat and site-specific verification of kelp canopy abundance identified via satellite imagery.

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Table A-8. Target Species for Swath Surveys

Functional Community Group	Common Name	Species
Canopy Forming Kelp	Giant Kelp	*Macrocystis pyrifera*
	Feather Boa Kelp	*Egregia* sp.
Understory Kelp	Laminaria	*Laminaria* sp.
	Bladder Chain Kelp	*Stephanocystis osmundacea*
	Southern Sea Palm	*Eisenia arborea*
	Pterygophora	*Pterygophora californica*
Non-native Algae	Sargassum	*Sargassum muticum*
	Sargassum	*Sargassum horneri*
	Wakame	*Undaria pinnatifida*
Herbivores	Green Abalone	*Haliotis fulgens*
	Pink Abalone	*Haliotis corrugata*
	Red Abalone	*Haliotis rufescens*
	Black Abalone	*Haliotis cracherodii*
	White Abalone	*Haliotis sorenseni*
	Purple Urchin	*Strongylocentrotus purpuratus*
	Red Urchin	*Mesocentrotus franciscanus*
	White Urchin	*Lytechinus pictus*
	Crowned Urchin	*Centrostephanus coronatus*
Filter Feeders	Rock Scallop	*Crassadoma gigantea*
	Brown/Golden Gorgonian	*Muricea* spp.
	Red Gorgonian	*Leptogorgia chilensis*
	Large (<10 centimers) Anemones	*Anenome* spp.
Carnivores/Scavengers	California Spiny Lobster	*Panulirus interruptus*
	Bat Star	*Asterina miniata*
	Ochre Star	*Pisaster ochraceus*
	Giant Spined Sea Star	*Pisaster giganteus*
	Kellet's Whelk	*Kelletia kelletii*
	Red/Wavy Turban Snail	*Pomaulax gibberosus/ Megastraea undosa*
Detritivore	Warty Sea Cucumber	*Apostichopus parvimensis*
	California Sea Cucumber	*Apostichopus californicus*

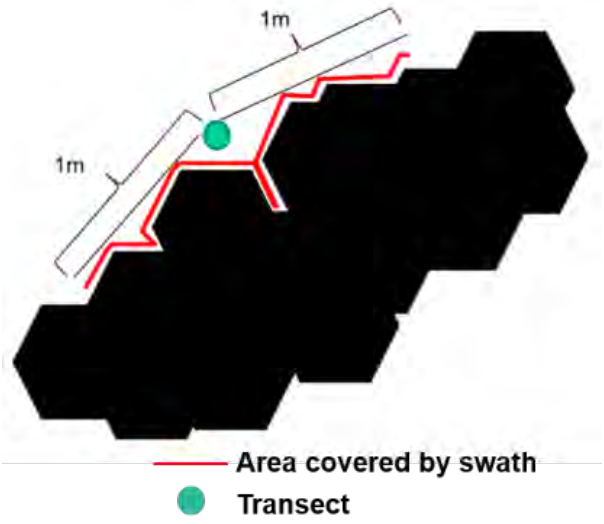


Figure A-7. Swath Survey Coverage Area for Band Transect

APPENDIX

A.6 RIPRAP AND PIER PILING QUADRAT SAMPLING, FISH SURVEYS, AND UPC RAPID-ASSESSMENT

Riprap and concrete pier pilings were sampled by certified divers in three depth zones (upper intertidal, lower intertidal, and subtidal) using scraped quadrats, band transect surveys, and photography. The eight riprap sampling stations were co-located with a subset of macroalgae and associated benthic invertebrate community stations (Figure A-3). Consequently, the riprap samples were collected during the visual diver surveys (Table A-1) in summer 2023.

At each riprap station, divers laid a transect along the contour of four depth zones that remained consistent among stations, as shown in Figure A-8. At concrete piling stations, the transect extended from the 0-foot mean lower-level water (MLLW) line to the bottom of the piling near the mudline (Figure A-8). The depth zones for both riprap and piling stations were delineated using on a combination of biological and tidal factors. The upper intertidal zone represented the high tide zone characterized by barnacles. The lower intertidal zone represented the mid- to low-tide zone frequently characterized by the presence of mussels. The subtidal zone was at the deepest extent of the riprap, approximately 1 to 2 meters above the soft-bottom interface to minimize the influence of sedimentation on organism recruitment. Note that depending on station depth, there were 2 or 3 total subtidal transects, but quadrat scrapings were always collected at the lowest subtidal target depth at each station.

Eight total pile stations were sampled, four in each port. At four of the concrete piling stations (LAPP1, LAPP3, LBPP1, and LBPP4), the depth of quadrat scraping in the subtidal zone was matched to the depth of the subtidal scraping at the nearby riprap stations (LARR4, LARR3, LBRR4, and LBRR2, respectively). At the remaining four piling stations, there was no nearby riprap station with which to match depths. Accordingly, these stations had the subtidal quadrat scrapings taken 1 to 2 meters above the soft-bottom interface.

Prior to sample collection, fish surveys using an adapted PISCO and Reef Check Kelp Program protocol were performed on station to ensure that the collection events did not attract or deter fish in the area. At riprap stations, fish surveys were performed at all subtidal station, as described in Section A-5. At piling stations, a fish survey was first performed close to the surface, with the transect anchored at a depth of 2 meters to the target pile, with the survey window extending 1 meter on either side of the transect tape and up to the water's surface. The transect was deployed across the face of the pier for 10 meters (Figure A-8), with any fish observed within the survey window identified to species and sized to the nearest cm. The same protocol was then repeated at the piling/sediment interface, with the transect tape deployed along the bottom in the same direction as on the surface. Following the fish surveys, the transect was deployed vertically down the piling for subsequent UPC and swath surveys and quadrat sampling.

Duplicate quadrat scrapings were collected at two random locations along each of the three depth zones (six total per station). The quadrats were 7.5 cm by 15 cm (0.01125 m^2), with photos of each quadrat taken prior to removal of organisms. Samples were collected into a fine mesh bag that was then put into a plastic bag underwater for transport back to the sampling vessel. Once onboard, the mesh bag containing the sample was transferred to a clean, pre-labeled sampling container. The sample containers were filled 85 to 90% with filtered site water and a relaxant (Epsom salt) for approximately 30 minutes before fixation, and then fixed with a 10% buffered formalin solution.

In addition to scraped quadrats, a rapid assessment method was used to compare with the scrapings data along each riprap transect depth zone, using 10-meter-long band transects and a UPC survey to determine percent cover of algae and invertebrates. The divers used a modified species list prepared and used by PISCO to classify cover type. At the piling stations, divers conducted the UPC survey vertically, classifying the cover type at every 0.2 meter along the transect (Tables A-6 and A-7). Piles were sampled for large and mobile invertebrates and macroalgae using a modified swath method, where the "faces" of the piling were surveyed for the same species listed in Table A-8. The diver, when facing the octagonal piling, surveyed only the surfaces that made up the front half (outer 180 degrees) of the pile.

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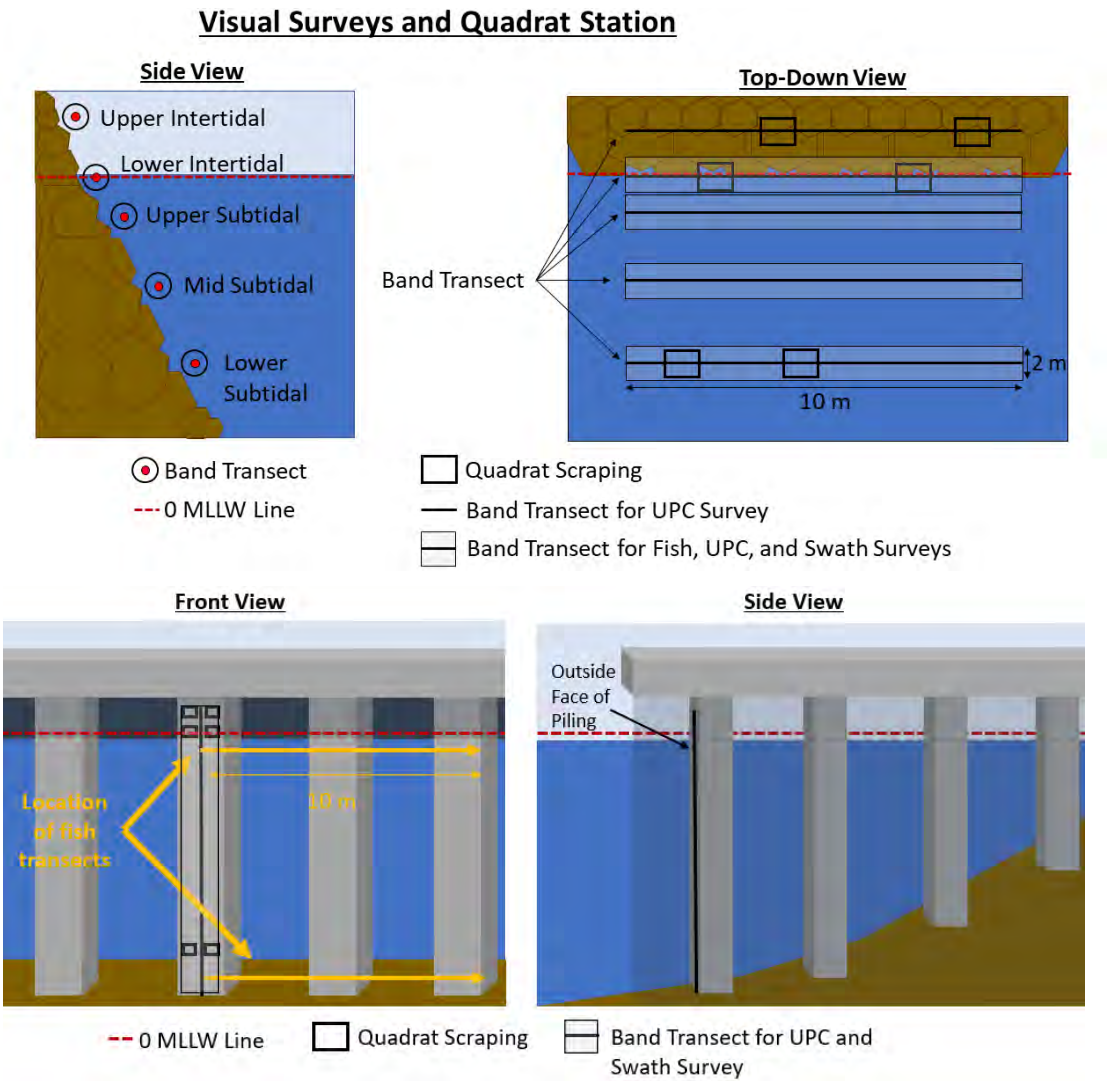


Figure A-8. Riprap and Concrete Pier Piling Scraping Site Schematic

APPENDIX

A.7 EELGRASS

Eelgrass surveys for the 2023 Biosurvey were conducted over two seasons using a combination of acoustic techniques (interferometric sidescan sonar), diver surveys, and remotely operated vehicle (ROV) surveys. The surveys were conducted both in spring and at the height of the summer growing season to assess potential short-term changes in eelgrass distribution and density. Acoustic surveys of all shorelines and waters shallower than -30 feet MLLW within the Port Complex were conducted on May 1 and 3, 2023 (spring). Surveys were again conducted on September 7 and 8, 2023 (summer). Acoustic records of eelgrass were ground-truthed using diver and ROV surveys on May 1 and 3, 2023 and September 7 and 8, 2023. Ground-truthing was conducted as a focused effort to verify areas of eelgrass mapping that can be most problematic rather than random sampling of beds. These follow-up surveys were conducted in areas that had unclear or anomalous signatures based on the sidescan data due to complex physical environments or very small patches of eelgrass in proximity to features of similarly high acoustic reflectivity. These follow-up surveys were used to determine eelgrass bed density and qualitatively characterize eelgrass health and vigor throughout the identified distribution by recording data on eelgrass height, color, leaf turgor, epiphytic and sediment loading, and evidence of disease.



Survey vessel used to map eelgrass provided for bathymetric and sidescan waterfall data collection. Targeted ground truthing followed, based on clarity of the acoustic imagery and need for visual inspections

Interferometric Sidescan Surveys

Acoustic survey techniques generally followed those that have been developed and continually advanced since the mid-1980s. These methods provide for saturation coverage of all areas within potentially suitable bathymetric ranges to support eelgrass. Eelgrass was subsequently mapped by interpretation of acoustic signatures from rectified swath records. The methods used have been used extensively for system-wide mapping and represent a slight refinement of methods applied in the 2013 Biosurvey (MBC, 2016) and an evolution of the methods used in the earlier 2000 and 2008 Biosurveys (MEC, 2002; SAIC, 2010).

Sonographic surveys were undertaken in navigable waters of the Port Complex using an interferometric sidescan sonar system operated from the Merkel and Associates survey vessel, OceanKing 1. The interferometric sidescan system is a dual-channel, hull-mounted swath sonar operating at 468 kilohertz that integrates an inertial motion sensor to correct for vessel pitch and roll; a sound velocity sensor that corrects for speed of sound in water related to density differences resulting from changes in temperature and salinity; and a dual-antenna real-time kinematic global positioning system (RTK-GPS) that provides sub-meter vessel positioning and correction for vessel heave and yaw. Because the position of the interferometric sidescan sonar head is rigidly fixed to the vessel, the positional error is dramatically reduced from that associated with other mapping methodologies, such as towed sidescan sonar. With the survey system used in this effort, absolute positional error for eelgrass mapping was approximately ±1 meter. The relative positional error was estimated at ±0.25 meter because the positional and heading error was substantially nullified across short distances.

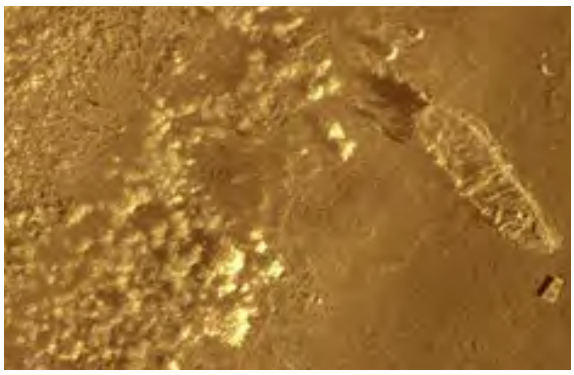
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The interferometric sidescan was set to survey 31 meters (102 feet) on the port and starboard channels so that the full swath width was nominally 62 meters (203 feet). Surveys were conducted by navigating parallel track lines such that with each pass of the sonar swath, the nadir gap that occurs directly below the survey vessel sensor from the prior pass was covered with the subsequent pass. The nadir gap results in an area of missing data, hence the need to overlap transect paths. Swath transects were run until the entire survey area was covered by sonar.

Shallow areas were surveyed at high tide to provide sonar coverage to the shoreline beyond any eelgrass beds. Within tight marinas, multiple passes were made at differing angles, and the survey vessel's thruster was used to pivot the vessel slowly at the ends of dock fingers to obtain full and precise sonar coverage of the marina bottom.

Spatial Data Analysis

Following completion of the sidescan surveys, the digital sonar traces exhibiting acoustic backscatter intensity were processed together into a single mosaic and geographically registered using the recorded navigational and vessel positional data. Eelgrass was then digitized by a geographic information system (GIS) specialist, who inspected the sonar mosaic and delineated the eelgrass boundary.



Interferometric sidescan sonar swath showing eelgrass and vessel debris (bright reflections with shadows) on the unvegetated soft bottom in Seaplane Lagoon

Because of linear air vacuoles (lacunae) within eelgrass leaves, plants are highly reflective to sound generated by sonar. As a result, plants have a bright acoustic signature with many characteristics that are readily detectible in high-frequency, interferometric sidescan sonar. In some instances, the eelgrass signature was masked by other highly reflective surfaces, such as debris, rock, or air vacuoles within the introduced alga *Sargassum muticum*. In such cases, characters such as growth form, shadow density, feature height and form, and bathymetric elevation and variance were used to separate eelgrass from other acoustic targets. Where there remained questions in mapping, the features were marked for the subsequent ground-truthing visual inspections as described previously.

Eelgrass was mapped as spatially discrete patches defined by plant margins, rather than aggregations of plants, to define beds of differing extent of bottom coverage. Under this methodology, each patch of eelgrass was mapped by digitizing the boundary of the beds. Gaps within eelgrass beds that exceeded 1 meter across were cut out of the mapped bed to create a spatially accurate representation of both the bottom coverage of eelgrass and the total area of vegetated bottom.

This mapping methodology is consistent with that applied during the 2013 and 2018 Biosurveys, but differs from that applied during the 2000 and 2008 Biosurveys. During the 2000 Biosurvey, eelgrass patches were aggregated into bottom cover classes of 5 to 20% (sparse eelgrass), 20 to 40% (moderate eelgrass), and greater than 40% (dense eelgrass) cover (MEC, 2002). In the 2000 Biosurvey, a minimum coverage of 5% was used for polygon mapping purposes and to define aggregations of eelgrass plants that constituted a bed. In instances in which individual plants were too far apart to constitute 5% plant cover, they were individually mapped and placed into the dense eelgrass cover class. During the 2008 Biosurvey, eelgrass was mapped more generically as high-density and low-density eelgrass beds, but the extent of eelgrass within the high and low-density eelgrass classifications was not presented separately (SAIC, 2010). The 2008 mapping included a number of bare-bottom inclusions within the mapped beds. Very sparse eelgrass appears to have been either absent in 2008 or omitted from the mapping.

Mapping by cover class is typically used for regional eelgrass inventories and has been applied to prior baseline surveys. However, with improvements in positional control and the desire to conduct greater analyses into vertical distribution patterns, discrete mapping was used for the 2013 Biosurvey (MBC, 2016), 2018 Biosurvey (Wood, 2021) and the 2023 Biosurvey over the use of the multiple cover-class mapping technique of the 2000 Biosurvey (MEC, 2002) and the 2008 Biosurvey (SAIC, 2010). This mapping enhances information value from the mapping but should be considered before making comparisons with data from prior survey years. However, the change in cover classes

from three classes to the simplified two classes between the 2000 and the 2008 Biosurveys has already affected the ability to evaluate temporal trends in a numeric manner. Further exacerbating the difficulty in comparing areal extent data across survey periods is that the 2008 Biosurvey data did not use a percent bottom cover numeric range when defining the classes.

In addition to spatial patterns, eelgrass distribution was also compared with bathymetry within the Port Complex. The bathymetry of the Port Complex was obtained from the hydrodynamic model input data for the Dominguez Channel Estuary Model Study (Port of Los Angeles and Everest International Consultants, 2006). Although this bathymetric data set is now aging, it is the most current comprehensive data set for the entire Port Complex. Histograms of the depth distribution were plotted as percentages of the total water area. The bathymetric data for eelgrass beds were developed from the interferometric sidescan data collection as a more refined data set than were available from the coarser grid used in the Port Complex-wide hydrodynamic model.

Ground-Truthing and Density Surveys

Divers and an ROVs were used to ground-truth acoustic records of eelgrass, characterize the health and vigor of the eelgrass, and collect eelgrass shoot density data within identified patches of eelgrass. Ground-truthing was conducted in a non-random manner and was used to characterize conditions in persistent beds, verify acoustic signature interpretations, and evaluate features for which classification was not possible from the originally collected acoustic records. Ground-truthing was performed concurrently with acoustic data collection activities, but also included a subsequent visit after the spring survey acoustic record processing was completed to inspect areas where it was not practicable to interpret survey data without additional site inspection.



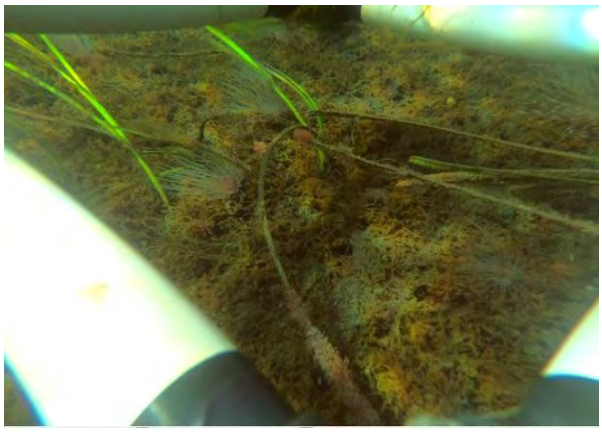
ROV quadrat framing eelgrass in debris field at the Long Beach Generating Station intake structure in the Port of Long Beach Back Channel

Following the initial mapping and ground-truthing effort in May 2023, a new field navigation map was prepared and loaded into the vessel's navigation system. The ground-truthing team then visited the questionable eelgrass targets to verify their identity, typically within complex debris-laden areas and areas where overwater structure would indicate that shading should limit eelgrass. Target field maps were prepared and loaded into the survey vessel navigation system to direct crews back to locations requiring additional follow-up inspection. In total, 11 areas of shoreline were resurveyed during the ground-truthing effort. Ground-truthing was again conducted in a similar manner following the fall surveys.

Concurrently with the ground-truthing, eelgrass was examined at 12 locations of eelgrass beds within the Port Complex. These sites were investigated to characterize the condition of eelgrass beds, including plant vigor, silt and epiphyte loading, disease blemishes, and turion (shoot) density across the eelgrass distribution. Turion density was determined by counting all of the shoots within 1/16-m^2 quadrats distributed widely through sampled beds. Beds that were sampled represented nearly the full distribution of eelgrass through the Port Complex no matter how limited eelgrass may be within a particular site. This sampling array provided a wide spatial representation of bed density rather than proportional sampling based on extent of eelgrass, which would cluster nearly all of the sampling into the Cabrillo Beach and Pier 300 Basin areas. The eelgrass sites were examined in May 2023 and September 2023. In

general, density was sampled within 20 quadrats within each area where adequate eelgrass existed at the time of sampling.

It is important to note that turion density is a characteristic of plants, and gaps in the bed between plants are a spatial metric of eelgrass beds and area addressed as bottom coverage and not density. As a result, turion density cannot be measured as a zero count, but random sampling must include at least a portion of the above-ground plant and thus would include at least one turion in any sample. This is relevant because it is possible to have both a low density of turions and a continuous bottom coverage wherein at least one turion is present per square meter of the harbor bottom. The density of eelgrass beds cannot be used to assess the extent of bottom coverage, nor is the reciprocal true. Throughout the eelgrass section, density and bottom cover and percent coverage have explicit meaning and are not used interchangeably.



Quadrat sampling within sparse eelgrass of East Basin Yacht Marina

A.8 BIRDS AND MAMMALS

Bird and marine mammal surveys were conducted throughout the Port Complex monthly from April 2023 through March 2024, although the March 2024 survey was delayed until early April 2024 because of adverse weather conditions. Surveys recorded species composition, abundance, behavior, and location (and habitat zone) of birds and marine mammals (Figure A-9).

Saturation surveys were completed by boat in all zones. Boat travel within survey zones was conducted in a manner that minimized the flushing of birds to avoid double counts or observer-induced changes in bird behavior or habitat use. The survey team consisted of a boat captain, an observer, and a data recorder. The observer was a trained ornithologist responsible for species identification and counts. The recorder was also a trained ornithologist and was responsible for assisting with bird counts and for completing and managing data sheets. Binoculars and spotting scopes were used to identify birds. The boat captain assisted with both avian and marine mammal survey observations, which were performed concurrently.



Biologists conducting avian surveys along the Port of Los Angeles Middle Breakwater

All survey data were recorded in the field on hard copy data sheets and later compiled into Microsoft Excel spreadsheets. Original data forms were maintained to allow for quality assurance and error checking. Each observed bird species was assigned to one of eight avian ecological guilds: Aerial Fish Foragers, Gulls, Large Shorebirds, Raptors, Small Shorebirds, Upland Birds, Wading/Marsh Birds, and Waterfowl.

Cormorants, loons, mergansers, and grebes were assigned to the Waterfowl guild to be consistent with previous studies. The database was then queried to extract summary information for tables and figures. Data were analyzed to identify spatial and temporal trends in total avian abundance and density, numbers of species, and patterns of habitat usage, activity, and seasonal variation of species and guilds.

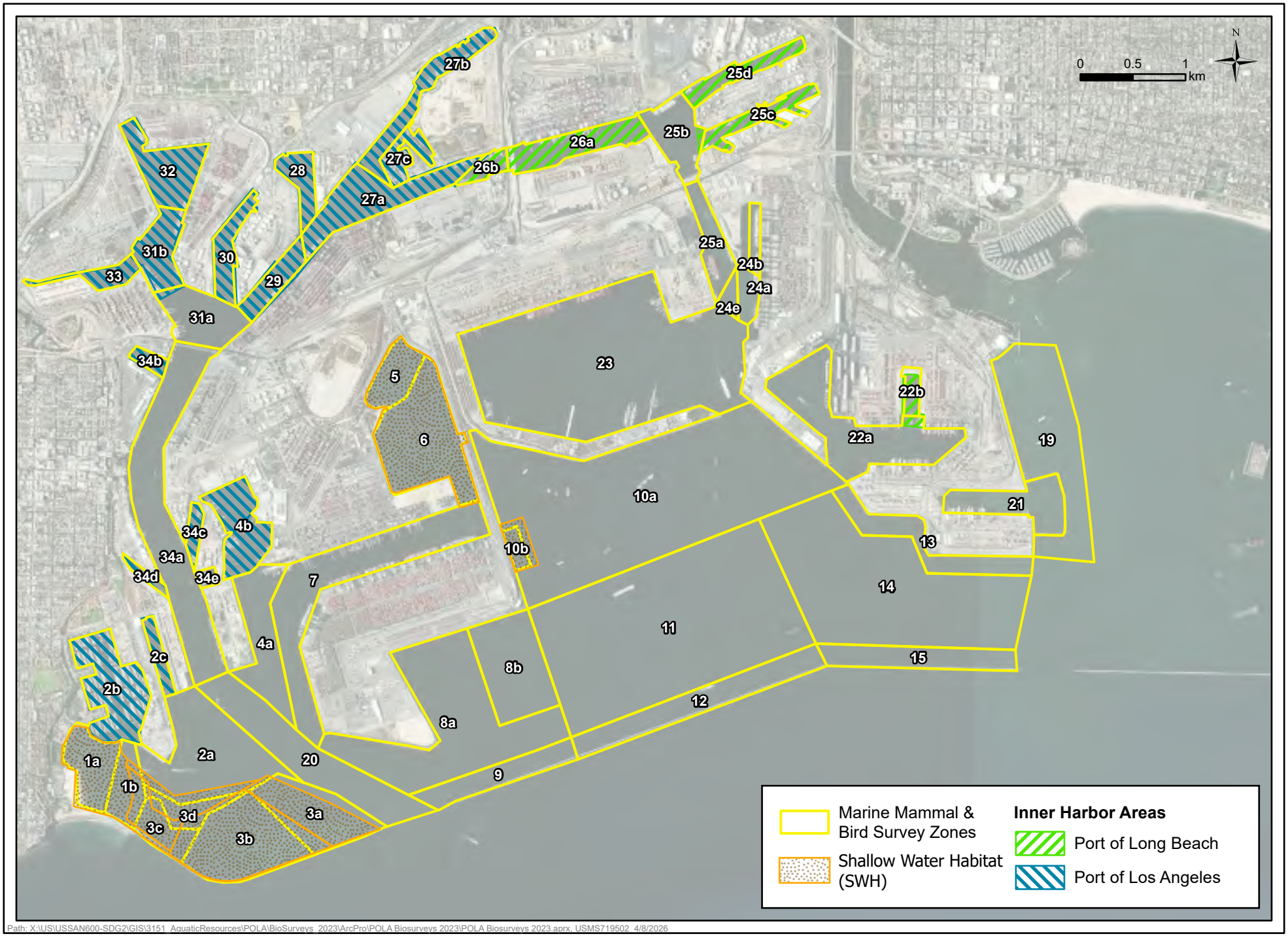


Figure A-9. Bird and Marine Mammal Survey Zones

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At the start of each survey event, the date, survey time, team members, and weather conditions (i.e., air temperature, water temperature, wind speed, wind direction, cloud cover, precipitation, and visibility) were recorded. Data recorded for each observation included the location (survey zone), time of observation, species identity, numbers of individuals, the environmental feature where the birds were observed, and bird activity. Other relevant information (e.g., injured or dead birds, banded birds, harbor activity that affected bird behavior, presence of nests or chicks, etc.) was also recorded. The environmental feature designations included both natural and man-made elements and included the following: Aerial, Anchor Line, Barge/Boat, Spill Boom, Bridge, Buoy, Building/Structure, Dock/Piling, Dredge Pipe, Kelp, Lamp Post, Open Water (>1 foot deep), Shallow Wading Depth Water (<1 foot deep), Riprap, Sand Beach/Intertidal, and Upland habitat. Bird activities included foraging, resting, flying, courting, and nesting.

Data were summarized in tabular and GIS formats and were analyzed to identify spatial and temporal trends in total abundance and density, numbers of species, patterns of habitat usage and activity, and seasonal variation of species and guilds.

Limitations of the Survey

When surveying by vessel, counting of moving birds is inherently variable and is limited by avian movement within and around habitat features that can hinder observations. Such variability could result in undercounting. Also, given the size of the Port Complex and the ability of avian species to easily fly between different survey zones, it is possible that observers counted individual birds or groups moving between zones more than once. Although efforts were made to avoid double-counting of birds that may be moving around during and between survey events, it was not always possible to do so because the surveys were conducted on two consecutive days and the survey zones were not separated by any hard boundary. This could result in an increased probability of double counting birds moving between zones, especially in the large zones that neighbor each other but were surveyed on different days (Zones 6 and 23; 26a and 26b, and 7 and 10a) and zones that border the Port of Los Angeles/Port of Long Beach boundary (Zones 9, 12, 3a, and 3b). Thus, adding the results from multiple zones or throughout the survey area may produce artificially high totals. Combined numbers of individual avian observations from multiple zones are better interpreted as comparative abundance (between survey zones) that approximates the numbers of individual birds in those zones, rather than an exact count of birds.

It is important to note that these surveys were not designed to detect secretive avian species such as green heron (*Butorides virescens*) or nocturnal species such as black-crowned night heron; thus, these species were likely underrepresented. Although the survey methods were also not designed to detect upland species or water-associated species that use the upland habitat for nesting (e.g., black-crowned night heron, snowy egret, and osprey), the large expanse of the Port Complex did provide suitable nesting and foraging opportunities for these species whose abundance would be more accurately assessed with a land-based survey approach. Similarly, although avian nesting was documented during the 2023 Biosurvey, the intended protocol was not intended to provide an exact assessment of the breeding bird populations and nesting locations within the Port Complex. Instead, these observations should be interpreted as cursory data of nesting activity rather than true abundance.

A.9 DATA QUALITY ASSURANCE/QUALITY CONTROL

Data quality assurance (QA)/quality control (QC) was a priority for all survey components. Data quality was maintained by ensuring that data entered by crews in the field were legible, clear, and accurate and that any issues encountered were discussed promptly with the project manager and Port Complex personnel to determine corrective action to obtain data in the desired seasons. Data entry from field data sheets to electronic databases was subject to a 100% QA/QC check prior to analysis. In addition, project-specific QA/QC protocols were followed for taxonomic analysis of benthic infauna and riprap scraping samples, as described in this section.

A.9.1 BENTHIC INFAUNA QA/QC

Benthic infauna laboratory QA/QC included re-sorting of samples to ensure accuracy for sorting and taxonomy, taxonomic identification verifications by a third-party laboratory to ensure precision, and collection of voucher specimens in accordance with the Sediment Quality Assessment Draft Technical Support Manual (Bay et al., 2021). Data quality objectives (DQOs) for benthic infauna laboratory performance were set at 95% for both sorting efficiency and taxonomic identification accuracy. Taxonomic QA/QC was performed by Anchor QEA in accordance with the

procedures in the Southern California Bight 2023 Regional Monitoring Program Sediment Quality Assessment Workplan (Bight '23 Sediment Quality Planning Committee, 2023).

A.9.2 RIPRAP/PIER PILING TAXONOMIC QA/QC

Taxonomic QC is the validation of infaunal taxa identification and abundance accuracy through the re-identification of samples. Following sample analysis and data submission, a subset (10%) of the total number of samples processed were reexamined by designated QC taxonomists. Discrepancies noted in the re-examination were subjected to a process (see below) that resulted in a resolved data set for a station. Changes to the original data were noted, tallied, and used in taxonomic efficiency calculations (see below). The efficiency target for taxonomic assessment measurement quality objective (MQO) criteria were ≥ 90.0% or a ≤10.0% error rate. A failing score resulted in the corrective actions described below.

Resolution Process

The resolution process began with a comparison of the original and QC data sets to identify areas of agreement and non-agreement. A QC tool developed by Dancing Coyote Environmental (DCE) produced a match/non-match spreadsheet from the two data sets. The form had columns for discrepancy and resolution codes, identification and abundance adjustments (±) to the original data, changes to original species identifications and abundances, and a final resolved data set with comments entered. Any changes from the original data in identification or abundance required proper notation on the original bench sheet in red pen and logging of the appropriate value. Misidentifications determined to be consistently misapplied throughout the entire survey required bench sheet and data changes for all other occurrences.

Changes to the original species identifications and abundances were tallied and entered on the spreadsheet for each station by the designated QC officer only. Misidentifications involving one-to-one name changes (species A was replaced with species B) were counted as one change. Misidentifications involving multiple (one to X) name changes (e.g., species A was distributed between "species A, species B, and species C, etc.") were counted as X number of species changes. Abundance count changes were tallied on the absolute changes (±) to the count data. When all misidentification and abundance count changes were tallied, the efficiency equations were automatically calculated by program run commands.

Efficiency Equations

Three QC MQO efficiency equations (taxa discriminated, count accuracy, and identification accuracy) were used to assess taxonomic performance. Efficiency percentages were presented on a separate calculations page by individual station, aggregate QC station average, and overall performance. The taxa discriminated equation calculated overall sample speciation accuracy. The count accuracy equation addressed abundance accuracy of a sample. The third equation, identification accuracy, assessed accuracy errors caused by misidentification of individual species.

Corrective Actions

The efficiency target for QC assessment MQO equation was ≥90.0% or a ≤10.0% error rate. A score below 90% resulted in corrective actions. Specific problem areas in taxonomy were identified and reviewed by the original taxonomist to determine the reason for an identification error. Likely reasons for counting errors were determined and reported in the Taxonomic QC Report supplied with the final revised data set.

A.10 ICHTHYOPLANKTON TAXONOMIC QA/QC

Sample sorting information and final ichthyoplankton determinations were recorded on laboratory bench sheets and retained for QA/QC purposes. Taxonomic QC was performed on 10% of the sample lot by an outside expert (Ernesto Calix of Ecoanalysts, Inc.). All data were entered into a database for tabulation and statistical analyses. Data analyses were based on the standardized density of organisms per volume of seawater sampled.

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A.11 DATA ANALYSIS METHODS

For each survey element, stations were grouped for analysis by habitat (SWH, Inner Harbor, and Outer Harbor) and location (SWH, channel, basin, slip, Outer Harbor, and breakwater). Additionally, trawls were also grouped by depth strata (Shallow – <7 meters, Deep – 7–18 meters, and Very Deep – >18 meters). Analyses varied by survey and data type, but generally station groups were analyzed for species richness, number of unique taxa, total abundance, total biomass, diversity indices (e.g., Benthic Response Index [BRI], Shannon-Weiner Diversity Index, etc.), and dominance.

Data were also analyzed for species trends across all stations, primarily comparing abundance, biomass, and size class. The Ecological Index (EI) has been demonstrated in other regional studies such as in the Port of San Diego (Williams et al., 2016) and 2018 Bight Regional Monitoring (Wisenbaker et al., 2021) and was used in the 2018 Biosurvey. The EI takes into account the percent of total abundance, percent of total biomass and frequency of trawl capture to calculate the index:

EI = (% of Total Abundance + % of Total Biomass) * Frequency of Trawl Capture

This weighted approach emphasized species that were abundant and caught at many stations such as white croaker and northern anchovy but also gave weight to solitary larger species that were not caught at many stations such as the Pacific electric ray and giant black seabass.

Multivariate Analysis

Data analysis methods varied by survey and gear type, but in general the approach was consistent across communities. Descriptive summary statistics such as minimum, maximum, means, medians, and confidence intervals were used where appropriate to give a broad sense of the data. Communities were then broken down into station groups according to survey type to investigate trends across different areas, habitats, and depth strata within the Port Complex.

Differences in sampling results between seasons and between day and night were analyzed using paired t-tests and one-way analyses of variance (ANOVAs). When differences occurred, data were separated and analyzed separately using multivariate analysis. If there were no differences in sampling results between day and night or between seasons, data were combined for multivariate analysis.

Multivariate analysis was performed using the Plymouth Routines in Multivariate Ecological Research (Primer) version 7 software package. Non-metric multivariate analysis is often called for in studies that result in multiple measurement variables (in this case, species) recorded for each sample unit (stations), resulting in large species-by-samples matrices. In-depth descriptions of the multivariate options available and the rationale behind the choices of tests to use are provided in papers by Clarke et al. (2014) and Clarke and Gorley (2015).

Briefly, community data were first transformed depending on the data type (e.g., abundance, density, concentration, etc.) to normalize the distribution of the data. The first step in multivariate analysis was to calculate the Bray-Curtis similarity coefficient for the species-by-samples matrices. These similarity matrices could then be visualized using cluster analysis, which produced a dendrogram displaying a hierarchical grouping of stations.

Stations were grouped according to station, habitat, and depth strata for various datasets, but a similarity profile (SIMPROF) permutation test was also used to identify related stations based on their respective community compositions. The test compared each branch point (node) in the dendrogram to determine whether any significant differences existed at the subsequent nodes. This analysis ignored *a priori* groups and instead grouped stations based on the assemblage of species. Although this method at times can act as a validation of *a priori* groups, it also can call attention to patterns or outliers that otherwise would not be apparent.

Analysis of similarity (ANOSIM) tests were run on each station grouping to test the null hypothesis that there were no assemblage differences between the groups against an alternative hypothesis that specified that there were differences. This non-parametric test is similar to a one-way ANOVA. The global test indicates whether the groups have significant differences, but does not order them according to ranks, relying instead on the significance of the sample statistic for interpretation. If the results of global test are statistically significant, the permutation-based pairwise comparison is used to interpret the strength of differences between the pairs. The analysis is based upon the R statistic, which is the difference of average rank dissimilarities between and within the two groups, scaled so that R

varied between roughly 0 (there are no differences) and 1 (all dissimilarities between samples are larger than any dissimilarity among variables and are almost entirely different). The p-value that accompanies the R statistic should be interpreted with caution because it is very dependent on the number of replicates in the comparison. For example, two groups that have an R value of 0.250 and a p-value of 0.002 appear to be highly significant, but those values imply that although they are not exactly the same, there is a large amount of overlap due to the low R value. Low numbers of replicates can also result in an R that equals 1 but has a non-significant p-value, which indicates that although the groups have no overlap there is not sufficient replication to determine significance.

Non-metric multidimensional scaling (nMDS) was used to visualize cluster analyses by translating the relative dissimilarities, as measured by the resemblance matrix produced by ANOSIM, into distances between points. The interpretation of nMDS is straightforward: the closer the points are to each other the more similar their community composition.

Shade plots were used as a visual representation of the data matrix itself, in which the larger the entry in a specific cell, the darker the shade plotted, with white representing the absence of that species and the darkest shade representing the greatest entry in the entire matrix. The shade plot is also useful when other tests such as ANOSIM or SIMPROF have demonstrated structure in the matrix. These plots can help to distinguish cases in which a clear gradient on an nMDS plot is the result of a small number of species with strongly increasing or decreasing abundances across the full gradient, or a larger number of taxa that occupy different parts of the gradient (Clarke and Gorley, 2015).

To add to the interpretive power of the shade plot, similarity percentages (SIMPER) analysis helped to determine the precise contribution that each species makes to major groupings determined either *a priori* by ANOSIM or *a posteriori* by SIMPROF tests. The analysis provided two pieces of information: one set of tables for each group defining the typical species (based on Bray-Curtis similarities) and one table for each pair of groups defining the discriminating species based on Bray-Curtis dissimilarities.

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D SOFT BOTTOM HABITAT

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E RIPRAP AND PIER PILINGS

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F BIRDS AND MAMMALS

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