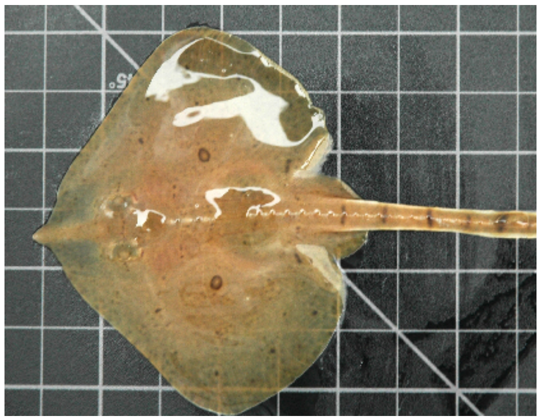
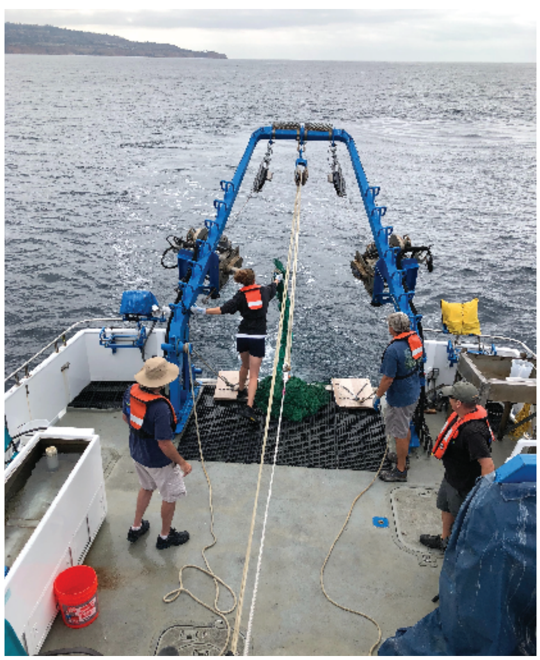
BIGHT '18

Demersal Fishes and Megabenthic Invertebrates





Southern California Bight
2018 Regional Monitoring Program
Volume IV

SCCWRP Technical Report 1183

Southern California Bight 2018 Regional Marine Monitoring Program: Volume IV. Demersal Fishes and Megabenthic Invertebrates

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FOREWORD

The Southern California Bight 2018 Regional Monitoring Program (Bight '18) is an integrated, collaborative effort to provide large-scale assessments of the Southern California Bight (SCB). The Bight '18 survey is an extension of previous regional assessments conducted every five years dating back to 1994. The collaboration represents the combined efforts of nearly 100 organizations. Bight '18 is organized into five elements: 1) Sediment Quality (formerly Contaminant Impact Assessment/ Coastal Ecology); 2) Microbiology; 3) Ocean Acidification; 4) Harmful Algal Blooms; and 5) Trash. This assessment report presents the results of the demersal fishes and megabenthic invertebrates sub-element of the Sediment Quality element. Copies of this and other Bight '18 reports, as well as work plans and quality assurance plans, are available for download at www.sccwrp.org.

Citation

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EXECUTIVE SUMMARY

Regional monitoring is an important tool to assess status and trends of coastal resources while also providing critical context for local monitoring efforts. The Southern California Bight 2018 Regional Marine Monitoring Program (Bight ’18) is the sixth in a series of regional marine monitoring efforts beginning with a pilot project in 1994 and repeated in 1998, 2003, 2008, and 2013. More than 80 different organizations encompassing regulatory, regulated, academic, and non-governmental agencies collaborated in the Bight ’18 Program. A cornerstone of this program is an assessment of the health of coastal ecosystems through an assessment of sediment quality indicators. The Sediment Quality Element utilizes multiple lines of evidence, including sediment toxicity, sediment chemistry, benthic infauna, and demersal fish and megabenthic invertebrate communities. This report presents the results of the Demersal Fishes and Megabenthic Invertebrates sub-element.

Demersal Fishes and Megabenthic Invertebrates Study Questions:

1. What is the extent and magnitude of contaminant exposure in Bight Strata as measured by trawl sampling?
2. What are the temporal trends in exposure?

A stratified random sampling design was used to ensure an unbiased sampling approach to assess areal extent of environmental condition. Five strata were selected for the trawl-based study including three continental shelf strata (4-30 m, 31-120 m, 121-200 m), an upper slope stratum (201-500 m), and an embayment stratum. A total of 136 trawl stations were sampled, capturing more than 46,000 fishes from 50 families and 133 species, and more than 237,000 invertebrates from 96 families and 201 species.

Significant Findings:

- **Southern California Bight trawl-caught fish communities are in good condition.** Based on the Fish Response Index (FRI), a measure of fish community response to pollution, 99% of fish communities found on the Bight’s soft bottom habitat along the continental shelf were in reference condition, suggesting they are relatively unimpacted by contaminant exposure. While we did not apply the FRI to embayment and upper slope strata because the tool was not calibrated for these habitats, other indicators of fish community health and diversity suggest healthy fish communities region-wide. Overall fish anomalies, particularly those associated with stress, were few and Shannon diversity (H') and taxonomic richness showed no spatial patterns that were suggestive of local impacts.

- **Extent of SCB in reference condition has remained consistently high over the six Bight surveys spanning 24 years.** Percent of reference area based on the FRI has ranged from 93% in Bight ’03 to 99% in both Bight ’94 and ’18. Over the years, few sites have scored a “non-reference” FRI, but there is generally no clustering of these sites, with the notable exception of the Santa Barbara Channel. Similarly, fish community metrics, abundance, biomass, taxonomic richness and Shannon diversity (H') have also remained comparable throughout the history of the Program.

- **Fish anomalies have decreased over time.** Though low in all surveys, fish anomalies have decreased from ~1.5% in Bight '98 to ~0.25% in Bight '18. Tumors made up the most common anomaly indicative of stress for all Bight surveys. The most significant reduction in stress-related anomalies occurred between the 1994 and 1998 surveys.

- **Northern Anchovy, Pacific Sanddab and Slough Anchovy had the highest abundance in Bight '18 (9,914; 7,438; 4,744 individuals, respectively).** Record high numbers of both Northern and Slough Anchovy were collected during Bight '18 (next highest abundance was 3,105 (Bight '98) and 697 individuals (Bight '13), respectively). Pacific Sanddab had the second highest abundance in Bight '18; however, it fell within the range of other Bight surveys (4,125 in Bight '94 to 19,004 individuals in Bight '13). The record high California Lizardfish abundance observed in Bight '13 (13,434 individuals) decreased to 796 individuals in Bight '18. Fish abundances and ecological indices were most highly variable in embayments, inner shelf and middle shelf strata, with outer shelf and upper slope strata remaining more consistent from survey to survey.

Recommendations. This report includes four recommendations to improve the next regional survey. A review of the FRI is recommended to update this important assessment tool and determine its applicability in embayments and the upper slope. To understand community composition changes from survey to survey, oceanographic data and model outputs should be utilized to provide the context of changing temperature, dissolved oxygen, and acidification regimes on benthic communities. Finally, the continued improvement of information management and the continued support of regional taxonomic societies is recommended to maintain the high level of quality assurance and quality control this program is renowned for.

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I. INTRODUCTION

The Southern California Bight (SCB) is an important ecological resource, providing economic, cultural and recreational services to large populations living along the coast. The SCB is situated within an eastern boundary upwelling system, wherein seasonal upwelling of nutrient-rich waters supports large-scale primary productivity along the coastline (Chavez and Messié 2009; Capone and Hutchins 2013). Soft-bottom (mud) substrates within the SCB are diverse, relating to a complex topography, with harbors, sandy nearshore areas, submarine canyons, offshore islands, ridges, and basins (Dailey et al. 1993; Piacenza et al. 2015). This diversity of habitats coupled with high productivity, sustains a biologically diverse coastal ocean environment (Dailey et al. 1993; Love et al. 2009). The SCB also represents a transitional area influenced by cold northern currents, temperate ocean waters, and occasional warm tropical waters from the south punctuated by recurring climate patterns such as the El Niño Southern Oscillation (Hickey 1993; Bograd and Lynn 2003; McGowan et al. 2003; Horn et al. 2006). The mixing of currents, episodic oceanographic events, and the multiple habitats allow for the coexistence of a broad spectrum of species, including more than 500 species of fish (Cross and Allen 1993) and thousands of invertebrate species (Thompson et al. 1993). Many of these species separate themselves by depth, habitat, and feeding guilds to reduce food competition and allow multi-species coexistence (Allen 2006; Allen et al. 1998, 2002a, 2007).

The SCB is also subject to significant pollutant inputs due to a highly urbanized coastal environment. More than 20 million people live within an hour's drive of the coastal counties and the infrastructure along the coast includes 17 major wastewater treatment facilities, the nation's two largest commercial ports, more than 20 pleasure craft harbors, and the third largest U.S. naval facility in the US (Lyon and Stein 2009). Additionally, there are 17 major watersheds that discharge largely untreated surface runoff from urban and agricultural land uses to the SCB. As a result of these strong human influences, the SCB coast has had a long history of sediment contamination. Sediment quality impacts have been at the forefront of environmental management efforts for nearly five decades and, as a result, sediment quality has been steadily improving in the SCB. However, some areas continue to have poor sediment quality, particularly those areas closest to anthropogenic influence (Schiff et al. 2016). The SCB is also subject to large-scale climatic changes such as marine heat waves (Leising et al. 2015), low oxygen conditions (Bograd et al. 2008; Booth et al. 2014) and low pH and aragonite saturation state (McLaughlin et al. 2018), which may be altering habitats along the coast (Sato et al. 2017; Howard et al. 2020).

Historically, monitoring had been focused on areas nearest to regulated discharges associated with National Pollutant Discharge Elimination System (NPDES) permits, providing a potentially biased perspective (Schiff et al. 2002). Beginning in 1994 and conducted every five years since, the SCB Regional Marine Monitoring Program (the Bight Program) is a probabilistic survey implemented by nearly 100 regulated, regulatory, non-governmental and academic organizations with the intention to assess regional condition of SCB habitats to provide much needed context for NPDES monitoring (Schiff et al. 2016).

The sediment quality element of the Bight Program evaluates potential impacts on marine benthic communities through multiple lines of evidence: sediment chemistry, biological assemblages, and sediment toxicity. This report discusses the results of the demersal fishes, megabenthic invertebrates and community assessment. Marine community attributes such as species composition and abundance are affected by a variety of natural and anthropogenic factors. Natural forces such as oceanographic variability, current patterns, and habitat availability have historically shaped these communities (Dayton et al. 1998; Miller and McGowan 2013). In some cases, anthropogenic factors such as fishing, pollution, habitat degradation, etc. have contributed to the community structure now observed in some areas of the region (Hidalgo et al. 2011; Mora et al. 2011) and global climate change is also seen to be having an impact on coastal communities (Sato et al. 2017; Howard et al. 2020). Disentangling these interacting forces requires robust data on both large spatial and temporal scales (Scavia et al. 2002; Harley et al. 2006; Hsieh et al. 2008). The Southern California Bight Regional Monitoring Program provides a platform to evaluate anthropogenic discharges on the SCB's soft-bottom marine ecology at a greater-than-local scale.

The demersal fish and megabenthic invertebrate portion of Bight '18 was designed to address two questions:

1. What is the extent and magnitude of contaminant exposure in Bight strata as measured by trawl sampling?
2. What are the temporal trends in exposure?

The probabilistic design of the Bight Program allows for characterization of the breadth and depth of variability in epibenthic communities for multiple habitats and the region overall, providing much needed context for local NPDES monitoring. Furthermore, because communities were evaluated in five habitats, or strata, during Bight '18, relative habitat quality between habitats can also be described. Four strata represent the offshore region: Inner, Middle, Outer Shelf and Upper Slope; and Bays & Harbors represent the embayment strata.

This report is structured in seven chapters. Chapter II of this report describes the methods used to assess epibenthic communities. Chapter III describes the study results for habitat condition and temporal trends. Discussion and interpretation of the results is contained in Chapter IV. Conclusions from the study are presented in Chapter V, and recommendations for future studies are presented in Chapter VI. References are contained in Chapter VII. Comparisons between indicators will be addressed in the Bight '18 Sediment Quality Synthesis Report.

II. METHODS

Study Design

The design of this study followed those of the previous Bight trawl surveys, of which this is the fifth. The survey area for Bight '18 covered the SCB from Point Conception, CA in the north, to the U.S.-Mexico border in the south, and from coastal embayments out to the upper slope (Figure 1). The trawlable soft bottom portions of this region were divided into five strata based upon established biogeographic breaks in community composition (Table 1). These strata include: Embayments (Bays & Harbors, 4-30 m); Inner Shelf (4-30 m); Middle Shelf (31-120 m); Outer Shelf (121-200 m); and Upper Slope (201-500 m). A stratified random sampling design was selected to ensure an unbiased sampling approach to generate areal assessments of environmental condition (Stevens 1997). Stratification ensured that an appropriate number of samples were allocated to each stratum to characterize the strata with adequate precision. The goal was to allocate approximately 30 stations to each stratum, yielding a 90% confidence interval of about ±10% around estimates of areal extent. Area weights were used for calculating unbiased areal assessments of condition in the survey area (Stevens 1997). To assist in assessing temporal trends between surveys, nearly half of the stations were revisited from previous surveys (Table 1).

Table 1. Summary of subpopulations sampled during the Bight '18 trawl survey.

Habitat	Stratum	Depth Range (m)	Area (km^2)	Percent Area of Region	Number of Stations	Percent Revisit Sites
Embayments	Bays & Harbors	4-30	7	0.00%	26	50%
Continental Shelf	Inner Shelf	4-30	1172.5	17.00%	29	45%
	Middle Shelf	31-120	2019.8	29.00%	30	40%
	Outer Shelf	121-200	605.5	9.00%	26	38%
Continental Slope	Upper Slope	201-500	3130.6	45.00%	24	44%
	Total		**6935.4**	**100.00%**	**135**	**43%**

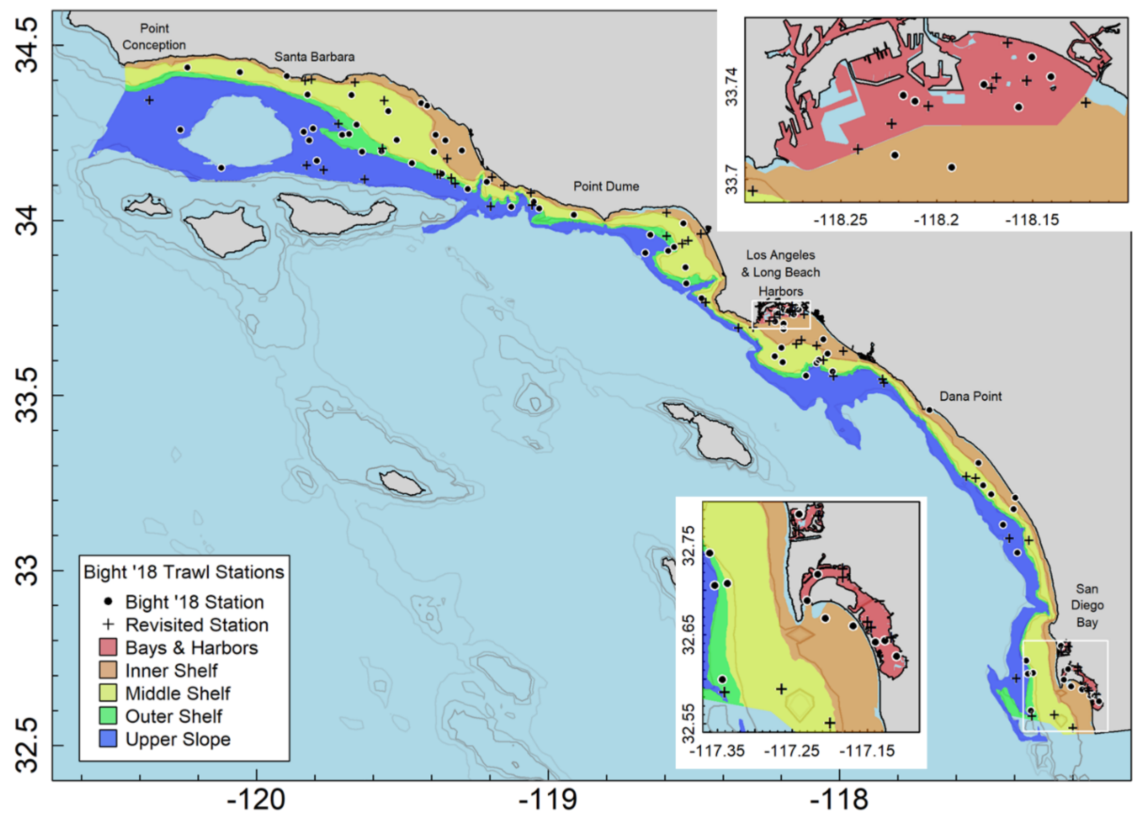


Figure 1. Distribution of marine fish and invertebrates sampled during the Bight '18 trawl survey.

Field Methods

Trawling

Demersal fish and megabenthic invertebrate samples were collected from 135 trawl stations between July 1 and September 30, 2018 (Table 1, Figure 1). Station coordinates, depths, and the stratum classification of each station are given in Appendix A.

Trawl samples were collected according to standard methods described in the Bight ’18 Sediment Quality Assessment Field Operations Manual (Bight ’18 Sediment Quality Planning Committee 2018). Stations were located by global positioning system (GPS) via the research vessel’s differential global positioning system (DGPS) or wide area augmentation system (WAAS). If a station could not be trawled or was too deep, it was relocated up to 100 m from the nominal station coordinates not to exceed 10% of the nominal station depth. Overdraw sites were assigned to sites that were unacceptable and therefore abandoned.

Samples were collected with 7.6-m head-rope, semi-balloon otter trawls with a 1.3 cm cod-end mesh. Trawls were towed along isobaths for 10 minutes (5 – 10 minutes in Bays & Harbors) at 0.8 – 1.0 m/sec (1.5 – 2 kts) as determined by GPS/DGPS. These tows covered an estimated distance of 300 and 600 m for 5- and 10-minute trawls, respectively. Agencies used a pressure-temperature (PT) sensor attached to one of the otter boards throughout the survey to provide net on-bottom data. Stations were re-trawled if the on-bottom time, as measured by the PT sensor, was less than 8 minutes for a 10-minute trawl.

Processing the Fish and Invertebrate Catch

Demersal fishes and megabenthic invertebrates from the trawls were identified and processed. Megabenthic invertebrate species with a minimum dimension of 1 cm were included; specimens less than 1 cm were excluded from analysis. Other excluded species were pelagic invertebrates, infaunal, or colonial, as well as unattached fish parasites (e.g., leeches, cymothoid isopods). Fishes and invertebrates were identified, counted, and batch weighed to the nearest 0.1 kg using spring or digital scales. Species weighing less than 0.1 kg were recorded as “< 0.1 kg”. Weights were used to calculate total biomass of the fish and invertebrate catches.

Lengths of individual fish were measured to centimeter size class on measuring boards. Bony fish were measured for standard length (anterior tip of head to end of caudal peduncle at the posterior border of the hypural plate). Cartilaginous fish and some bony fishes (e.g., eel-like fish) size measurements were total lengths, from the anterior end of the head to the posterior end of the tail. Wingspan was measured for stingrays and whip tailed rays.

Each organism was examined for gross external anomalies. Targeted fish anomalies included fin erosion, lesions, tumors, ambicoloration, leeches, monogeneans (flukes), skeletal deformities, eye parasites, and external parasites. Targeted invertebrate anomalies included burnspot disease, echinoderm wasting disease, and external parasites. Field crews had the option to use the aliquot method for single species catches with over 250 individual fish and invertebrate specimens. The abundance of these individuals was estimated using an aliquot by selecting a representative subsample of the catch and counting and weighing a minimum of 250 specimens to estimate the total number of individuals. An alternative method for enumerating invertebrates was to add an unknown number of specimens to a bucket until a weight of 1 kg was reached and the number of individuals comprising the weight were counted. The remaining specimens were weighed to estimate the total number of individuals.

Voucher specimens, fish and invertebrate specimens of unknown identity, and those with anomalies that required further examination were either fixed in the field with 10% buffered formalin-seawater solution, frozen, or photographed and returned to the laboratory for further identification or vouchering. At least one voucher specimen of each species captured by each agency was retained to confirm identifications.

Laboratory Analysis

Sample Preservation for Collections

Retained fish and invertebrate specimens requiring further identification (FID) were either frozen or preserved with buffered formalin in the field, transferred to water in the laboratory, then to 70% ethyl alcohol for final storage according to Bight '18 Field Operation Manual (Bight '18 Sediment Quality Assessment Committee 2018a). Specimens taken as vouchers were either preserved as the FID samples or photographed for verification.

Voucher and Further Identification Sample Analysis

A group consensus approach was used to validate vouchers and FID samples with the expertise from two referee organizations: the Southern California Association of Ichthyological Taxonomists and Ecologists (www.SCAITE.org) and the Southern California Association of Marine Invertebrate Taxonomists (www.SCAMIT.org). Preserved samples or photographs were examined at SCAITE or SCAMIT meetings to identify species characteristics. Samples for which no consensus could be achieved were sent to specialists and classified at a less specific level (fewer than 1%). Further details on this process are provided in Appendix B.

Quality Assurance and Quality Control (QA/QC)

A Quality Assurance/Quality Control (QA/QC) plan was developed to ensure comparability among participating organizations within the survey. QA/QC activities included an intercalibration cruise for taxonomists, a taxonomy proficiency examination on common trawl fish and invertebrate species, an on-board field audit, on-board rechecks of species measurements, and a post-survey taxonomic review of voucher specimens. Other QA/QC checks involved checking station data relative to nominal survey design strata. Detailed standardized field protocols and QA/QC procedures are described in the Contaminant Impact Assessment QA Manual (Bight '18 Sediment Quality Planning Committee 2018) and Field Operations Manual (Bight '18 Sediment Quality Planning Committee 2018).

Participating organizations met or exceeded the measurement quality objectives established for the Bight '18 regional survey (Appendix B). Trawl sampling was complete and representative. Taxonomic identifications were complete, accurate, and precise. Counting, measuring, and weighing were also complete, accurate, and precise. No deviations in procedures occurred that required exclusion of data.

Information Management

Collection of trawl data (identifications, measurements, etc.) was predominantly a field activity, with exception of voucher and FID samples. Agencies were permitted to use field computers or standardized datasheets for data collection. Sampling agencies submitted their data electronically to a centralized Southern California Coastal Water Research Project (SCCWRP) database through a data portal with a series of data checkers designed to expedite the QA/QC process. Submitted datasets were provided to the Bight ’18 Trawl Committee for review, additional QA/QC checks, and analysis.

Data Analysis

Most data analysis methods are similar to those used in previous regional sampling reports (Allen et al. 1998, 2002, 2007, 2011; Walther et al. 2017). Unless otherwise noted, data wrangling and analyses were performed using the following packages in R 3.6.1 (R Core Team 2019): tidyverse (Wickham et al. 2019), broom (Robinson 2014), dplyr (Wickham et al. 2018), reshape2 (Wickham 2007), ggplot2 (Wickham 2009), ggpubr (Kassambara 2018), isotone (de Leeuw et al. 2009), vegan (Oksanen et al. 2017), grid (R Core Team 2015), quantreg (Koenker 2016), scales (Wickham 2016), MASS (Venables and Ripley 2002), geoR (Ribeiro and Diggle 2016), gridExtra (Auguie 2016), Plotrix (Lemon 2006), PBSmapping (Schnute et al. 2015), gpclib (Peng et al. 2013), rgdal (Bivand et al. 2016), maptools (Bivand and Lewin-Koh 2017), lubridate (Grolemund and Wickham 2011), and clustsig (Whitaker and Christman 2014). R code is available from SCCWRP upon request.

Habitat condition was assessed using demersal fish and megabenthic invertebrate community metrics including abundance, biomass, taxonomic richness (number of species present), and Shannon diversity (H', a diversity index accounting for both abundance and evenness of species present) (Shannon 1948), and with population measures including signs of disease.

Pollution impacts on the shelf were assessed using the Fish Response Index (FRI) (Allen et al. 2001). The FRI was created as a tool for gauging anthropogenic impacts on fish assemblages in the SCB inhabiting soft-bottom habitats on the continental shelf in depths ranging from 9 to 215 m (Allen et al. 2001). The FRI was applied to the shelf strata (Inner, Middle and Outer Shelf), for which it was calibrated using almost 30 years of data around wastewater outfalls in depths between 20 and 215 m. In addition to the calibration, index values were validated by applying the index to the 60-Meter Survey data (Word and Mearns 1979) taken in 1977. FRI values ≤ 45 are indicative of reference or unimpacted conditions on the shelf. Previous Bight trawl reports included FRI values for the Shelf and Bays & Harbors; however, the Bight ’18 Demersal Fish and Megabenthic Invertebrates Technical Committee excluded Bays & Harbor FRI scores from this report because the index was not calibrated in this stratum. The FRI is representative of generalized disturbance gradients; however, the purpose of this index is not meant to be indicative of fluctuations in the total standing stock of fish species.

An Ecological Index (E.I.) rank was determined using the total catch for each species during this study and incorporated three ecological variables: % Number, % Weight, and % Frequency of Occurrence, by stratum (E.I. = (%N + % Wt) * % F.O). This index is indicative of the relative importance of each species to the energy flow within each stratum (Allen et al. 2002b; Williams et al. 2015b).

As in the previous regional surveys (Allen et al. 2007, 2011; Walther et al. 2017), some stations in the Bight ’18 survey were trawled for 5 min rather than 10 min due to inadequate space in some bays or harbors. The approach used in Allen et al. (2007) was also used in the present study. The following two points were considered: 1) the time that the net was on the bottom during a trawl is uncertain (Diener and Rimer 1993), and 2) the distribution of the fishes and invertebrates in the trawl path varies by species, ranging from random to clumped. A 10-minute trawl has a higher catch than a 5-minute trawl and to account for this in data analysis, fish and invertebrate abundance and biomass values for 5-minute trawls were doubled to be more comparable to 10-minute trawl values. Numbers of fish and invertebrate species between 5- and 10-minute trawls were adjusted by multiplying species values by 1.4. This latter adjustment was used for calculating mean values for each stratum as was used in previous Bight survey reports. To determine total species in a stratum, unadjusted species (or taxa) counts were used. This approach was also used to perform the diversity and ecological index calculations.

Multivariate Analyses

Multivariate analyses were performed in PRIMER v7 software using demersal fish and megabenthic invertebrate data collected from trawls conducted during Bight ’94, Bight ’98, Bight ’03, Bight ’08, Bight ’13, and Bight ’18 (Clarke 1993; Warwick 1993; Clarke et al. 2014). A one-way analysis of similarity (ANOSIM) was conducted to confirm that demersal fish and megabenthic invertebrate communities differed between embayments and offshore regions. Additional analyses included ordination (non-metric multidimensional scaling; nMDS), as well as hierarchical agglomerative clustering (cluster analysis) with group-average linking. The Bray-Curtis measure of similarity was used as the basis for the ordination and cluster analysis, and abundance data were transformed to lessen the influence of the most abundant species and increase the importance of rare species. Similarity profile analysis (SIMPROF) was used to confirm the non-random structure of the resultant cluster dendrogram (Clarke et al. 2008), with major ecologically-relevant clusters receiving SIMPROF support retained as cluster groups. A BEST test using the BVSTEP procedure was conducted to determine which subset of species best described patterns within the resulting cluster dendrograms. Similarity percentages analysis (SIMPER) was used to determine which species were responsible for > 70% of the contributions to within-group similarity (i.e., characteristic species) by location (to support ANOSIM tests) and by cluster group (to support cluster group selection). A more detailed analysis and supporting tables and figures are presented in Appendix F.

Multi-Survey Temporal Trends

Temporal trends in fish and invertebrate community metrics were calculated with two complementary techniques: a multi-survey approach and a revisit-site approach. The multi-survey approach is a higher-level approach to temporal analysis that focused on the proportional change in each of the assessment metrics across the survey area through time. This included analysis of changes in the areal extent estimates of each metric within each stratum from 1994 – 2018. Trends were characterized by survey-to-survey increases or decreases in each metric. This approach provided a greater number of stations (Table 1) and greater confidence about the applicability of the trend across the whole stratum. However, because many of these sites were randomly selected within the stratum for each survey, the observed differences represented a mix of both spatial and temporal variability. The revisit-sites approach complemented the multi-survey approach by providing a more granular measure of condition change by focusing solely on the temporal variance at sites with three or more reoccupations between 1998 and 2018. This approach measured the trend in FRI scores at 38 of the 72 revisit sites (FRI was not applied in Bays & Harbors and Upper Slope Strata revisited sites), which were sampled three or four times in 2018, 2013, 2008, and either 2003 or 1998. Simple linear regression was used to model the trend in FRI scores along the data points for each site (Appendix E). All linear regressions were done using the "tidyverse" and "broom" packages in R (R Core Team 2019). The slope and p-values of the trend line at each site was obtained from the linear regression model and used to characterize the trend at that site (e.g., Gillett et al. 2017) using the following guidelines:

- If slope negative, p-value ≤ 0.05, then the trend was characterized as improving
- If slope negative, p-value > 0.05, then the trend was characterized as stable
- If slope positive, p-value > 0.05, then the trend was characterized as stable
- If slope positive, p-value ≤ 0.05, then the trend was characterized as declining.

As each site had an area weight, the percent area with improving, declining, or stable trends was estimated. This approach had a relatively low data density per stratum (14 sites Inner Shelf, 13 sites Middle Shelf, 10 sites Outer Shelf), but because the station location was held constant, most of the change in FRI score was attributable to temporal variance (Urquhart and Kincaid 1999; Olsen and Peck 2008). Trends in other metrics are also explored using a similar approach as applied to the FRI; however, trends are characterized only by the sign of the slope (increasing if the slope is positive or decreasing if the slope is negative) and are given in Appendix E.

III. RESULTS

2018 Southern California Bight Habitat Condition in 2018

Demersal Fish Community Attributes

A total of 46,179 fish were collected during Bight '18, with an overall median abundance of 219 individuals per trawl (Figure 2, Table 2). The number of fishes collected per trawl ranged from 2 to 4,699 individuals. Median abundances per haul ranged from 78 in the Bays & Harbors to 306 on the Upper Slope. A total of 983.2 kg of fishes were collected during the Bight '18 survey, with an overall median biomass of 6 kg per haul. Median biomass ranged from 3.7 kg on the Inner and Middle Shelf to 9.1 kg on the Upper Slope. Median H' diversity was 1.44 for all strata and ranged from 0 on the Outer Shelf to 2.39 in Bays & Harbors, and there was no clear pattern in regional distribution of fish diversity in the Bight (Figure 3). Median taxonomic richness was 11 for all strata and ranged from 7 in the Bays & Harbors to 14 on the Middle Shelf. Taxonomic richness increased offshore, with lower taxonomic richness in Bays & Harbors and Inner Shelf stratum and higher values in Middle and Outer Shelf strata and Upper Slope.

Based on the Fish Response Index (FRI), 98.8% of the SCB shelf area was in reference condition, with the percentage of area in reference condition ranging from 92.3% on the Outer Shelf to 100% on the Inner and Middle Shelf (Table 2, Figure 2). This is similar to the percent of sites in reference condition in the SCB (97.6%), with the shelf ranging from 92.3% in the Outer Shelf to 100% on the Inner and Middle Shelf. Only two sites, located in the northern Bight, had FRI scores associated with non-reference conditions (Figure 4).

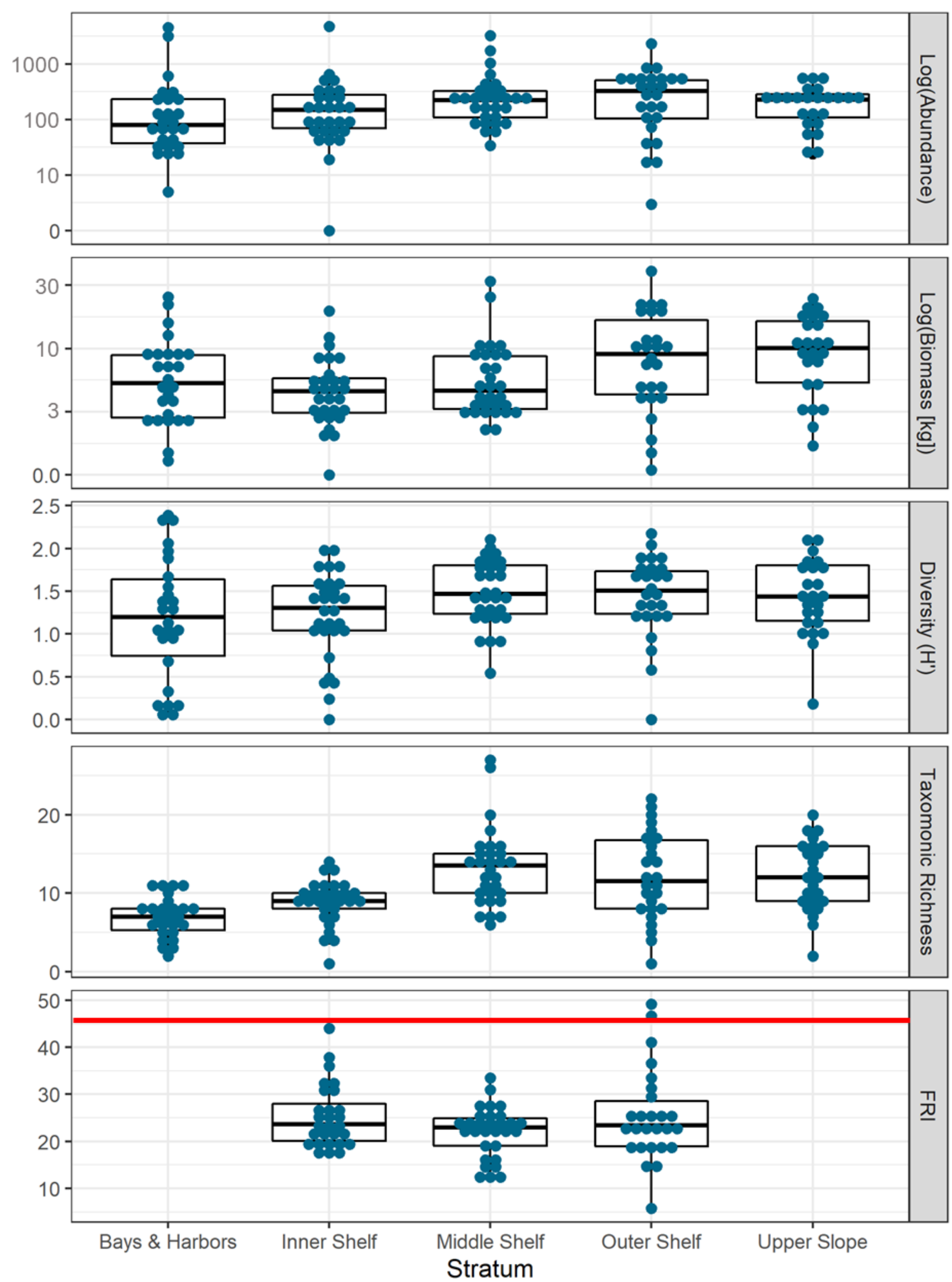


Figure 2. Area-weighted demersal fish community metrics by stratum: Log abundance, log biomass, Shannon diversity (H'), taxonomic richness, and Fish Response Index (FRI) during the Bight '18 trawl survey. Data are median, upper and lower quartiles, and results (represented by blue dots). For FRI, the red line represents maximum FRI score (45) associated with reference community; FRI is not applicable in Bays & Harbors and at Upper Slope depths.

Table 2. Demersal fish community metrics by stratum: Abundance, biomass, taxonomic richness, Shannon diversity (H'), and Fish Response Index (FRI) during the Bight '18 trawl survey. FRI scores less than or equal to 45 are associated with a reference fish community.

				Abundance			
Stratum	**N Trawls**	**Median**	**Mean**	**Min**	**Max**	**Total**	
All Strata	135	219	305	2	4,699	46,179	
Bays & Harbors	26	78	412	4	4,563	10,722	
Inner Shelf	29	148	347	18	4,699	9,723	
Middle Shelf	30	221	392	37	3,197	11,770	
Outer Shelf	26	306	328	2	1,146	8,531	
Upper Slope	24	222	226	32	590	5,433	
				Biomass (kg)			
	N Trawls	**Median**	**Mean**	**Min**	**Max**	**Total**	
All Strata	135	6	8	0.1	40.1	983.2	
Bays & Harbors	26	4.4	6.3	0.3	24.5	163.8	
Inner Shelf	29	3.7	4.6	1	18.9	128.3	
Middle Shelf	30	3.7	6.1	1.3	33	181.6	
Outer Shelf	26	8.1	10.2	0.1	40.1	266.1	
Upper Slope	24	9.1	10.1	1	24	243.4	
				Shannon Diversity (H')			
	N Trawls	**Median**	**Mean**	**Min**	**Max**		
All Strata	135	1.44	1.45	0	2.39		
Bays & Harbors	26	1.2	1.18	0.02	2.39		
Inner Shelf	29	1.35	1.26	0.24	1.98		
Middle Shelf	30	1.47	1.49	0.54	2.22		
Outer Shelf	26	1.5	1.44	0	2.17		
Upper Slope	24	1.44	1.49	0.89	2.11		
				Taxonomic Richness			
	N Trawls	**Median**	**Mean**	**Min**	**Max**	**Total**	
All Strata	135	11	12.1	1	27	133	
Bays & Harbors	26	7	7	2	11	40	
Inner Shelf	29	9	9.1	4	14	37	
Middle Shelf	30	14	13.3	6	27	56	
Outer Shelf	26	12	12.2	1	22	56	
Upper Slope	24	12	12.5	5	20	58	
					FRI		
		Median	**Mean**	**Min**	**Max**	**% Reference Sites**	**% Reference Area**
All Shelf	85	23.1	23.4	5.8	49.2	97.6	98.8
Inner Shelf	29	23.6	25.2	17	44	100	100
Middle Shelf	30	22.8	21.8	11.7	33.5	100	100
Outer Shelf	26	23.4	25.3	5.8	49.2	92.3	92.3

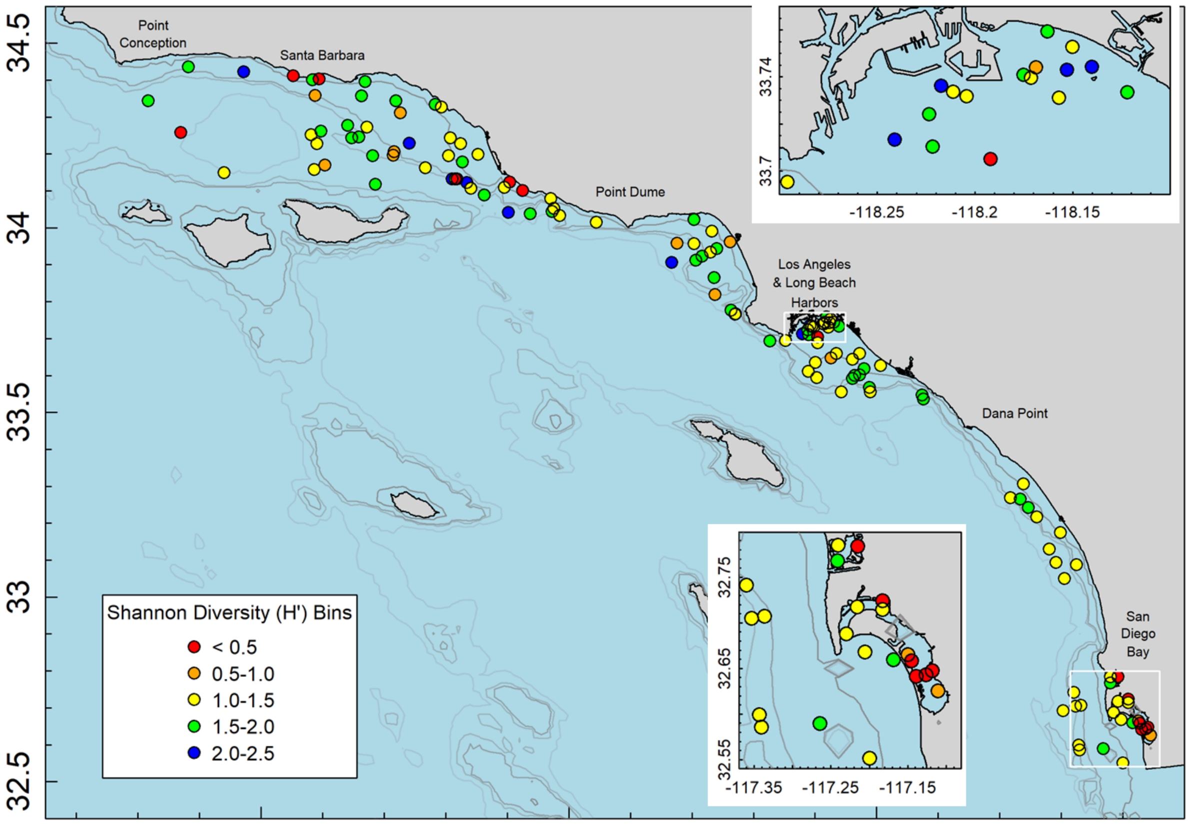


Figure 3. Distribution of demersal fish Shannon diversity (H') per haul during the Bight '18 survey. Sites are binned by diversity.

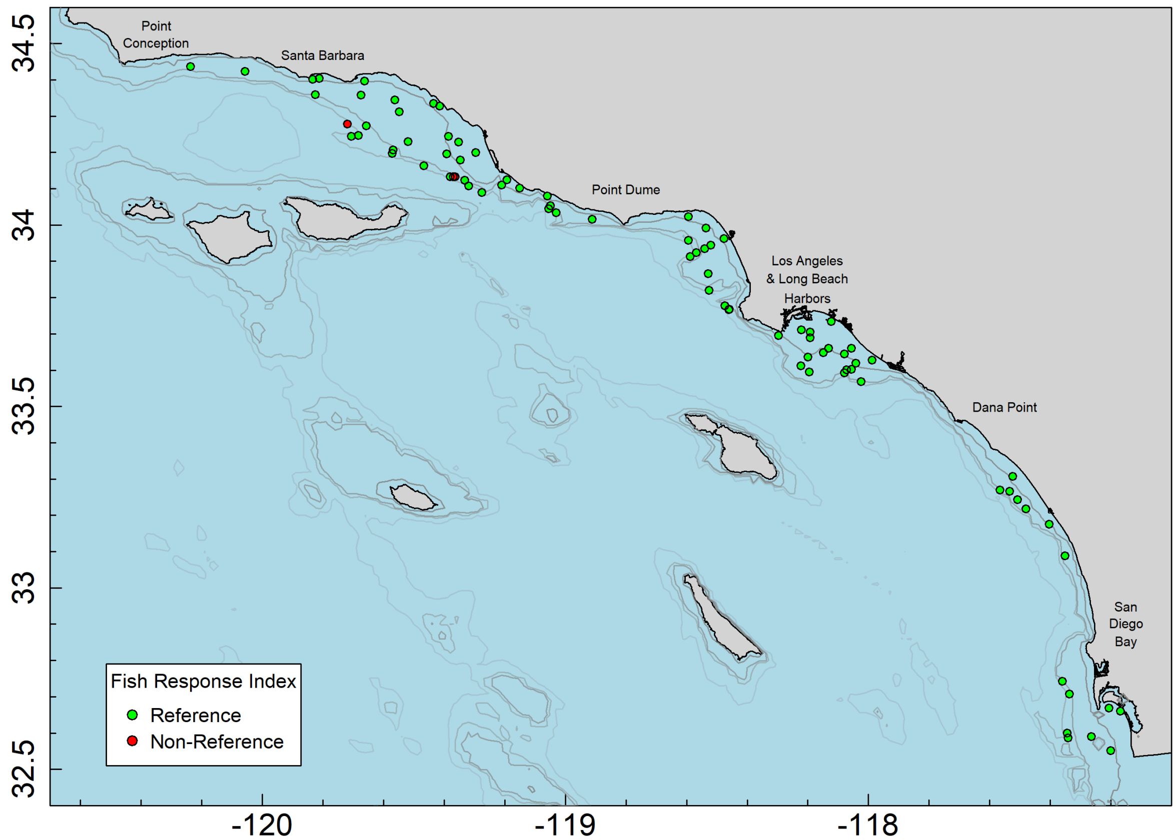


Figure 4. Distribution of Fish Response Index (FRI) scores during the Bight '18 trawl survey. An FRI score ≤ 45 is associated with a fish community in reference condition.

Demersal Fish Population Attributes

Demersal Fish Abundance and Ecological Index

A total of 133 species representing 51 families were identified during Bight '18 (Table C19). The top 10 most abundant fish in the Bight were represented by 6 families and accounted for over 85% of all fish sampled (Figure 5, Table 3). In each stratum, just two species comprised over 50% of the catch. Northern Anchovy (*Engraulis mordax)* and Pacific Sanddab (*Citharichthys sordidus*) were the most abundant fish collected during Bight '18 (9,914 and 7,438 individuals, respectively). Slough Anchovy (*Anchoa delicatissima*) was the most abundant fish found in Bays & Harbors (4,748 individuals) but was not encountered in any other Bight '18 stratum. Northern Anchovy was second most abundant in Bays & Harbors (4,421 individuals) and first most abundant on the Inner Shelf (4,482 individuals). Speckled Sanddab (*Citharichthys stigmaeus*) was second most abundant on the Inner Shelf (2,919 individuals). Halfbanded Rockfish (*Sebastes semicinctus*) was most abundant on the Middle Shelf (3,627 individuals). Pacific Sanddab was the most abundant fish on the Outer Shelf (3,871 individuals) and was the second most abundant fish on the middle shelf (2,856 individuals). Slender Sole (*Lyopsetta exilis*) was most abundant on the Upper Slope (2,388 individuals) and was second most abundant on the Outer Shelf (1,480 individuals).

The Ecological Index (E.I.) of species uses three ecological variables (abundance, biomass, and frequency of occurrence) to determine the ecological importance of species to energy flow within each stratum (Allen et al. 2002b; Williams et al. 2015b). Similar to abundance, one or two species dominated the E.I. for each stratum (Figure 6, Table 4, Table C20, Table C21, Table C22, Table C23). Pacific Sanddab ranked first in the SCB (E.I. 90) and was most important on the Middle Shelf (E.I. 3,482) and Outer Shelf (E.I. 6,584). Slough Anchovy ranked highest in Bays & Harbors (E.I. 1,832), followed by White Croaker (*Genyonemus lineatus*) (E.I. 1,785). Speckled Sanddab ranked highest on the Inner Shelf (E.I. 4,048), and the E.I. was over four times greater than the next highest ranked fish, Hornyhead Turbot *(Pleuronichthys verticalis*) (E.I. 949). Slender Sole was the highest ranked fish in the Upper Slope (E.I. 6,406), followed by Dover Sole (E.I. 3,101).

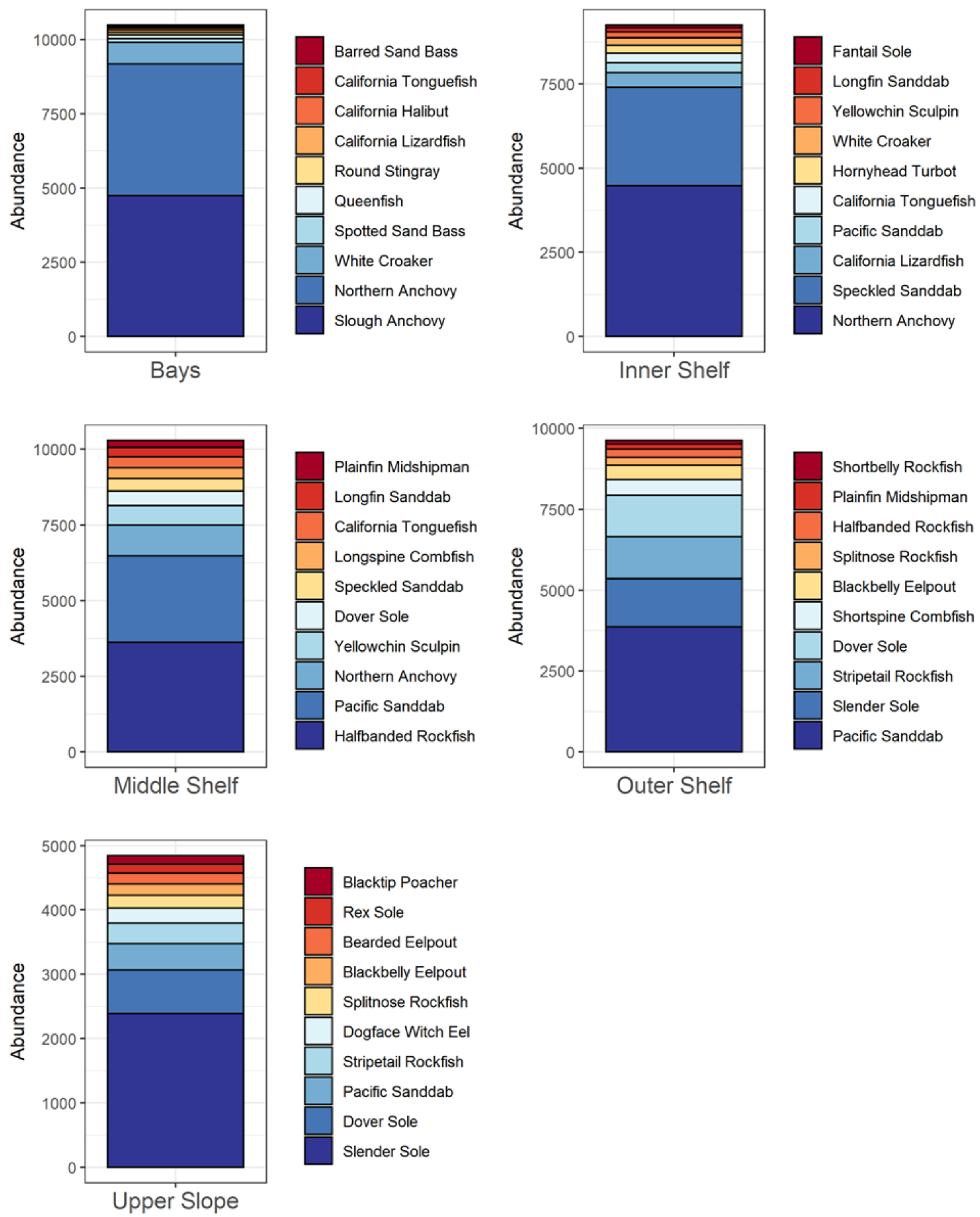


Figure 5. Top ten demersal fish species by abundance for each stratum collected during the Bight '18 trawl survey. The fish species are sorted from most abundant (bottom) to least abundant (top).

Table 3. Top ten demersal fish species by abundance for each stratum collected during the Bight '18 trawl survey. The table is sorted by overall abundance rank. Shaded areas indicate species ranked in the top ten in a given stratum.

					Abundance					
Common Name	**Family**	**Abundance Rank**	**Biomass Rank**	**Frequency Rank**	**Southern California Bight**	**Bays & Harbors**	**Inner Shelf**	**Middle Shelf**	**Outer Shelf**	**Upper Slope**
Northern Anchovy	Engraulidae	1	16	59	9,914	4,421	4,482	1,007	-	10
Pacific Sanddab	Paralichthyidae	2	1	3	7,438	-	299	2,856	3,871	412
Slough Anchovy	Engraulidae	3	39	114	4,744	4,748	-	-	-	-
Slender Sole	Pleuronectidae	4	3	2	3,982	-	-	114	1,480	2,388
Halfbanded Rockfish	Scorpaenidae	5	5	12	3,891	-	-	3,627	248	16
Speckled Sanddab	Paralichthyidae	6	8	21	3,377	47	2,919	411	-	-
Dover Sole	Pleuronectidae	7	2	1	2,435	-	-	479	1,280	676
Stripetail Rockfish	Scorpaenidae	8	6	4	1,805	-	-	183	1,300	322
White Croaker	Sciaenidae	9	4	66	958	734	223	1	-	-
Yellowchin Sculpin	Cottidae	10	35	18	876	-	165	654	57	-
California Lizardfish	Synodontidae	11	13	7	749	88	427	219	14	1
California Tonguefish	Cynoglossidae	12	19	5	694	56	289	349	-	-
Shortspine Combfish	Hexagrammidae	13	15	13	627	1	-	41	492	93
Blackbelly Eelpout	Zoarcidae	14	20	10	621	-	-	13	429	179
Longfin Sanddab	Paralichthyidae	15	10	17	455	3	134	316	2	-
Splitnose Rockfish	Scorpaenidae	16	25	9	454	-	-	-	253	201
Plainfin Midshipman	Batrachoididae	17	22	19	421	-	20	239	162	-
Longspine Combfish	Hexagrammidae	18	42	22	386	1	5	358	21	1
Hornyhead Turbot	Pleuronectidae	19	14	6	333	7	232	81	13	-
Dogface Witch Eel	Nettastomatidae	21	45	26	228	-	-	-	-	228
Blacktip Poacher	Agonidae	23	43	25	215	-	-	-	88	127
Rex Sole	Pleuronectidae	24	24	11	212	-	-	-	64	148
Bearded Eelpout	Zoarcidae	26	53	15	178	-	-	3	13	162
Queenfish	Sciaenidae	27	27	86	170	118	52	-	-	-
Spotted Sand Bass	Serranidae	29	12	112	127	127	-	-	-	-
Fantail Sole	Paralichthyidae	29	18	20	127	25	83	19	-	-
Shortbelly Rockfish	Scorpaenidae	31	33	53	120	-	-	2	115	3
California Halibut	Paralichthyidae	32	7	38	108	59	45	4	-	-
Round Stingray	Urotrygonidae	33	11	113	91	91	-	-	-	-
Barred Sand Bass	Serranidae	41	34	52	63	50	11	2	-	-

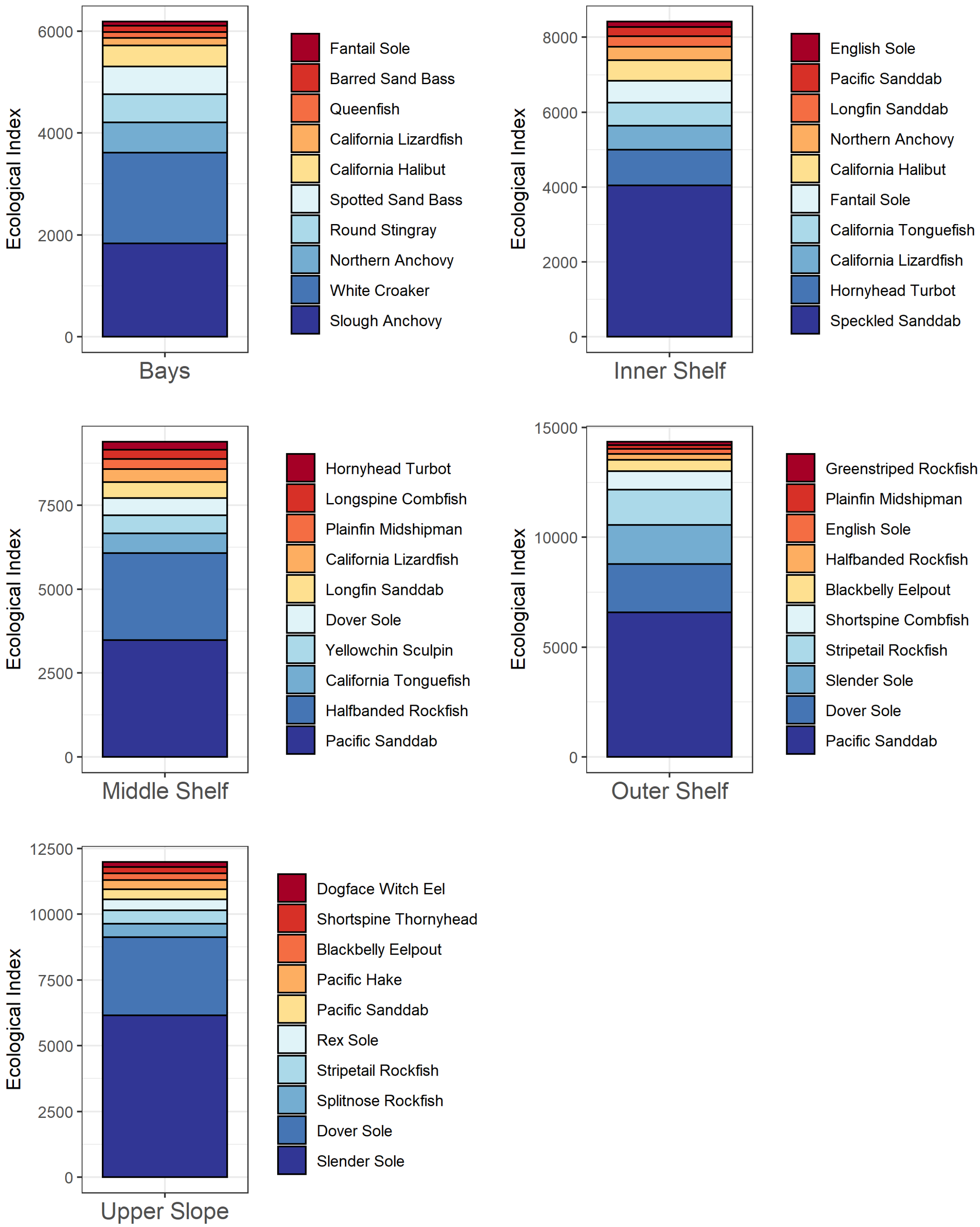


Figure 6. Top ten demersal fish species ranked by Ecologic Index (E.I.) for each stratum collected during the Bight '18 trawl survey. The fish species are sorted from highest E.I. (bottom) to lowest E.I. (top).

Table 4. Top ten demersal fish species scored by Ecological (E.I.) Index for each stratum collected during the Bight '18 trawl survey. The table is sorted by overall E.I. score for the southern California Bight. Shaded areas indicate species that were top ten most abundant in a given stratum.

Common	EI Rank	Ecological Index					
		Southern California Bight	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Pacific Sanddab	1	90	-	238	3482	6584	391
Northern Anchovy	2	64	591	359	66	-	1
Dover Sole	3	55	-	-	521	2191	3101
Slender Sole	4	53	-	-	15	1784	6406
Halfbanded Rockfish	5	36	-	-	2596	263	11
Slough Anchovy	6	35	1832	-	-	-	-
White Croaker	7	29	1785	69	0	-	-
Speckled Sanddab	8	25	17	4048	129	-	-
Stripetail Rockfish	9	22	-	-	96	1606	526
California Halibut	10	15	410	548	17	-	-
Longfin Sanddab	11	13	1	285	476	22	-
English Sole	12	12	-	151	143	230	63
California Lizardfish	13	11	147	642	389	20	0
Round Stingray	14	11	554	-	-	-	-
Shortspine Combfish	15	10	0	-	32	853	70
California Tonguefish	16	9	73	621	588	-	-
Hornyhead Turbot	17	9	5	949	245	15	-
Spotted Sand Bass	18	9	542	-	-	-	-
Blackbelly Eelpout	19	9	-	-	8	511	270
Plainfin Midshipman	20	8	-	7	291	183	-
Longnose Skate	21	8	-	1	0	9	191
Fantail Sole	22	8	87	582	64	-	-
Splitnose Rockfish	23	7	-	-	-	81	533
Pacific Hake	24	7	-	-	-	37	369
Rex Sole	25	6	-	-	-	39	444
Yellowchin Sculpin	27	6	-	45	528	2	-
Queenfish	28	5	123	18	-	-	-
Greenstriped Rockfish	32	4	-	-	2	147	1
Longspine Combfish	34	3	0	0	275	9	0
Shortspine Thornyhead	36	3	-	-	-	-	247
Barred Sand Bass	37	3	117	29	3	-	-
Dogface Witch Eel	41	2	-	-	-	-	200

Demersal Fish Anomalies

The prevalence of fish anomalies was extremely low and spatially scattered through the SCB. Anomalies reported in this study included ambicoloration, eye parasites, other parasites, fin erosion, leeches, lesions, monogeneans (flukes), tumors, and "other" (Figure 7, Figure 8, Table D31). Fish that were not examined for anomalies during the processing of trawls were excluded from analysis. During the Bight '18 survey, just 57 individual fish out 37,751 examined were collected with anomalies present. These fish were from 12 different species out of 133 taxa collected during the survey. Most of the anomalies (0.048% of individuals) were eye parasites found on 17 Pacific Sanddab, followed by tumors (0.034% of individuals) found on 1 Spotted

Sand Bass (*Paralabrax maculatofasciatus*), 3 Splitnose Rockfish (*Sebastes diploproa*), and 8 Dover Sole. Of the remaining anomalies, ambicoloration was the most prevalent, followed by "other", leeches, and fin erosion. Lesions (n =2), monogeneans (n =2), and parasites (n =2) were least prevalent and were found on 0.006% of fish.

Fishes that had pathologies including tumors, lesions, or fin erosion, are considered potential symptoms of stressed individuals (Allen 1977; Mearns 1973, 1975; Sindermann et al. 1982). These anomalies were found on 0.050% of fishes examined during the Bight '18 survey, at 8 stations distributed throughout the Bight (Figure 9, Table D31). These stations included 1 Bay & Harbor station, 2 Middle Shelf stations, 4 Outer Slope stations, and 1 Upper Slope station. No anomalies were recorded on fishes on the Inner Shelf.

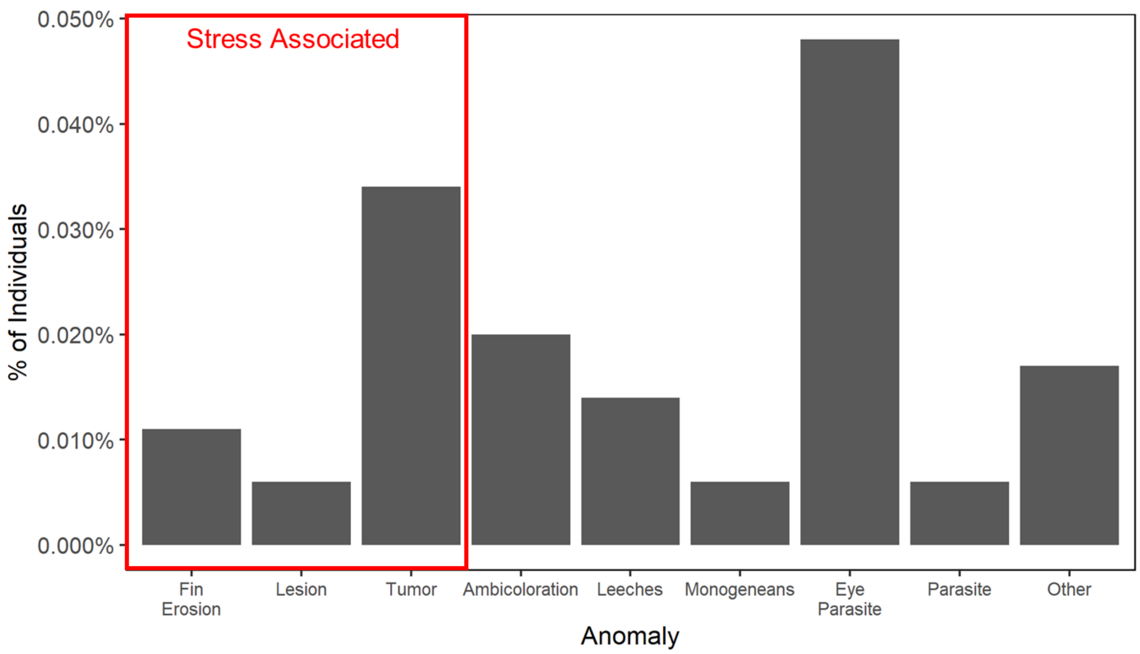


Figure 7. Percent demersal fish anomalies by type during the Bight '18 trawl survey.

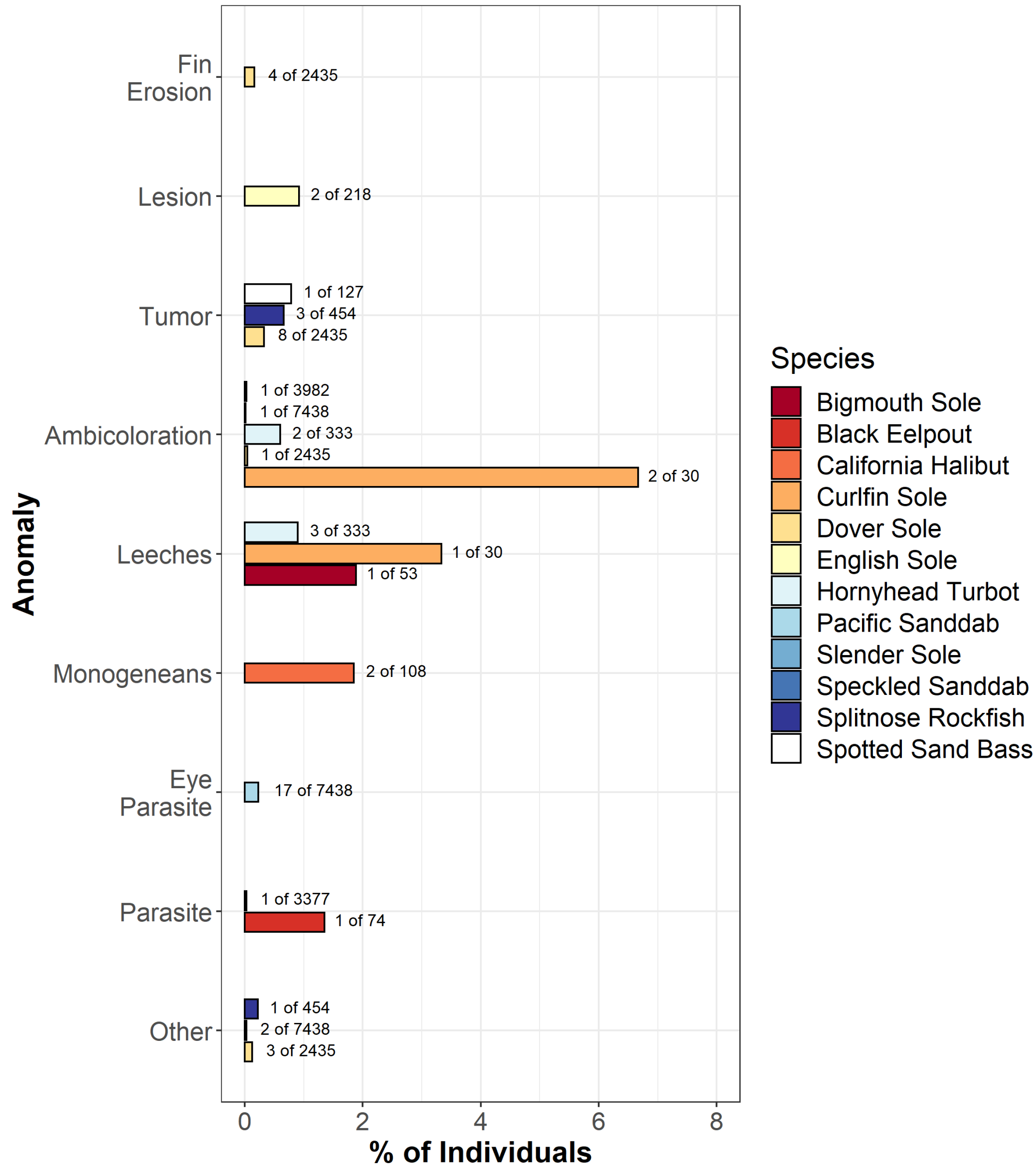


Figure 8. Percent of fish individuals presenting with anomalies within a species. Color represents the fish species. Numbers beside the bars represent the number of individuals within a species with anomalies and the total number of individuals of each species caught.

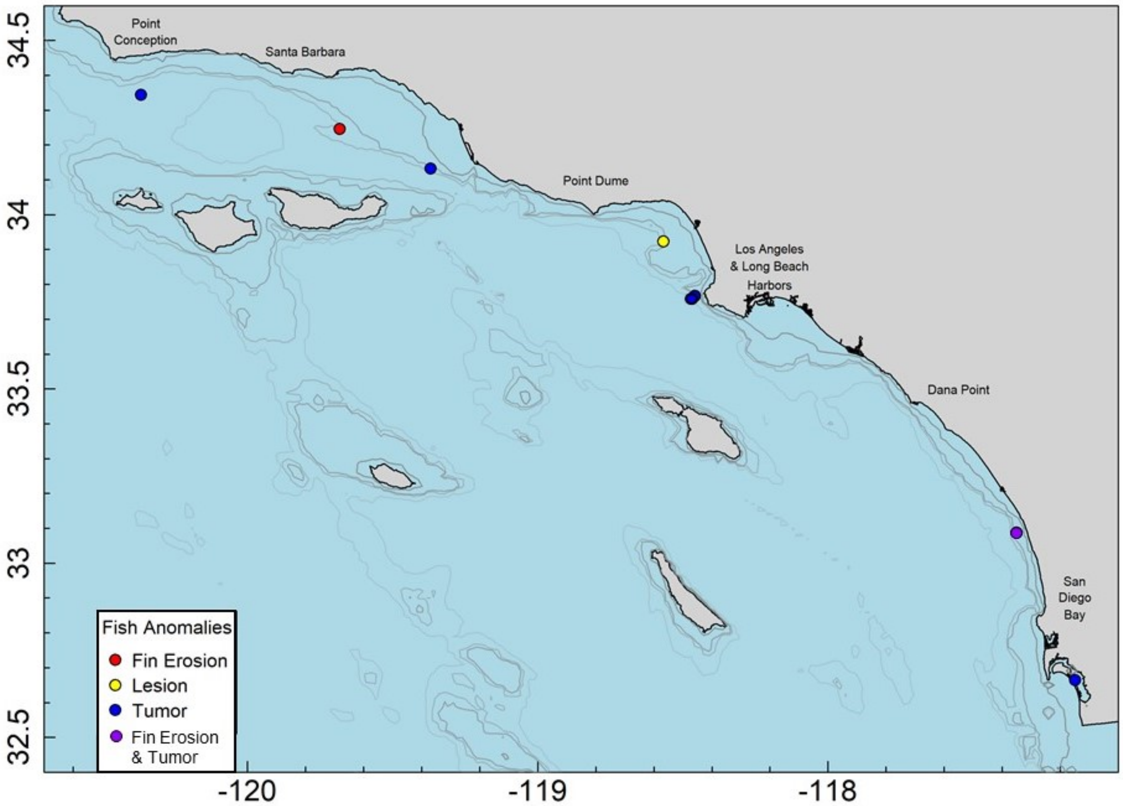


Figure 9. Distribution of demersal fishes collected during Bight '18 trawl survey with anomalies indicative of disease or stress.

Megabenthic Invertebrate Community Attributes

A total of 237,251 megabenthic invertebrates were collected during Bight '18 with an overall median abundance of 328 per trawl (Figure 10, Table 5). The lowest total abundance was in the Bays & Harbors (2,750 individuals) and the greatest was on the Upper Slope (165,159 individuals). Median abundance per trawl ranged from 21 on the Inner Shelf to 2,838 on the Upper Slope. A total of 2,721.82 kg of megabenthic invertebrates were collected during the Bight '18 survey, with an overall median of 3.6 kg per trawl. Median biomass ranged from 0.3 kg on the Inner Shelf to 44.4 kg on the Upper Slope. Median Shannon diversity (H') was lowest on the Upper Slope (0.78 per trawl) and greatest on the Outer Shelf (1.21 per trawl). The Upper Slope had the greatest abundance and biomass, with a median abundance 19 times higher and biomass 10 times higher than that of the next highest stratum (Outer Shelf) but, had the lowest Shannon diversity (H') of all strata. There was no clear pattern in regional distribution of invertebrate diversity in the Bight (Figure 11). Median taxonomic richness was 9 per trawl across the SCB and was lowest in Bays & Harbors (5 per trawl). Median taxonomic richness was greatest on the Outer Shelf and Upper Slope (13 and 12, respectively).

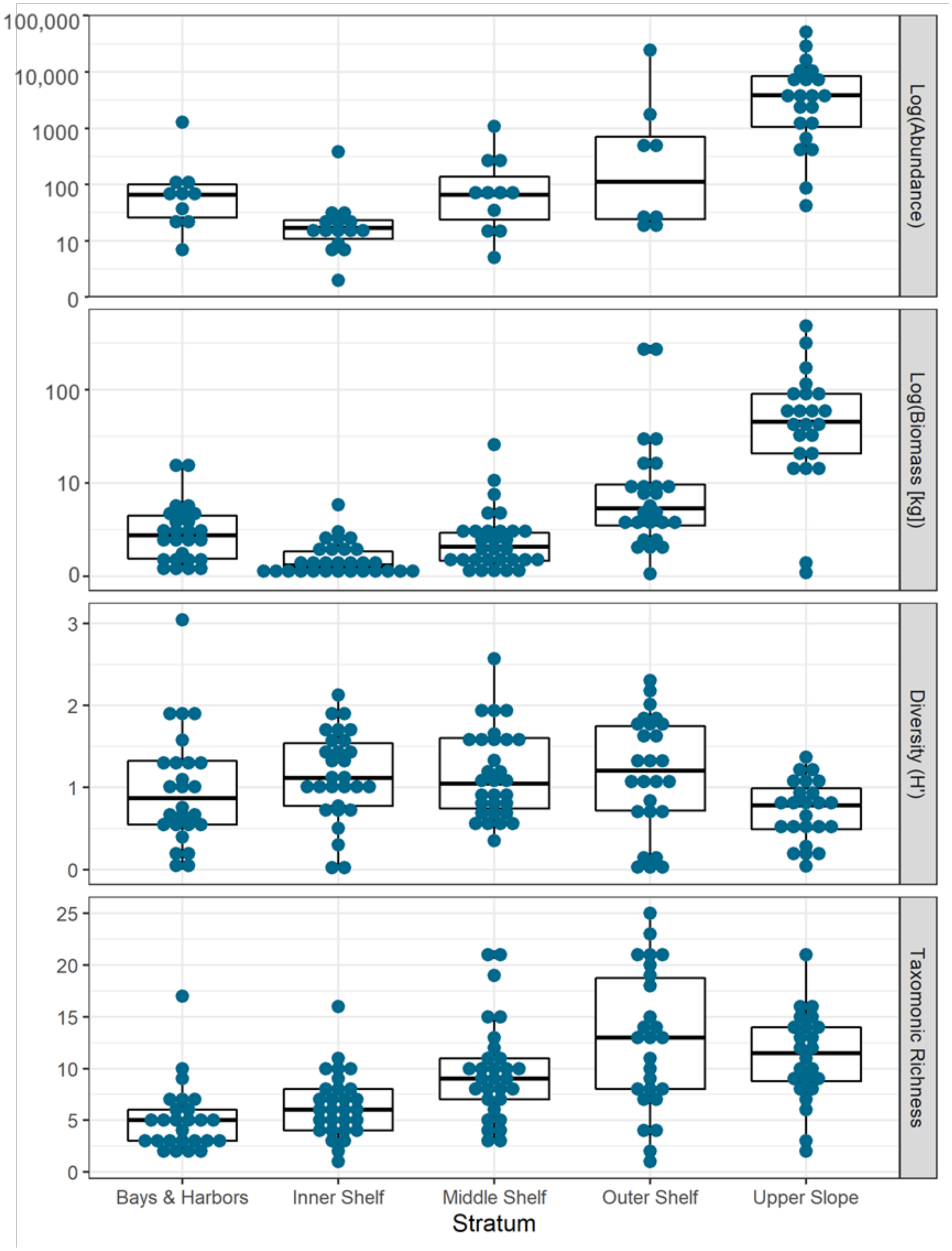


Figure 10. Area-weighted megabenthic invertebrate community metrics by stratum from the Bight '18 trawl survey: Log abundance, log biomass, Shannon diversity (H'), and taxonomic richness.

Table 5. Demersal megabenthic invertebrate community metrics by stratum: Abundance, biomass, richness, and Shannon diversity (H') during the Bight '18 trawl survey.

				Abundance		
Stratum	**N Trawls**	**Median**	**Mean**	**Min**	**Max**	**Total**
All Strata	135	328	3,323	1	51,182	237,251
Bays & Harbors	26	44	106	6	1,280	2,750
Inner Shelf	29	21	115	1	2,126	3,322
Middle Shelf	30	80	208	4	1,026	6,251
Outer Shelf	26	152	2,299	15	27,474	59,769
Upper Slope	24	2,838	6,882	41	51,182	165,159
				Biomass (kg)		
	N Trawls	**Median**	**Mean**	**Min**	**Max**	**Total**
All Strata	135	3.6	38.1	0.03	480.2	2,721.82
Bays & Harbors	26	1.7	2.8	0.12	15.3	72.36
Inner Shelf	29	0.3	0.7	0.03	4.8	20.02
Middle Shelf	30	1.1	2.4	0.09	24.8	72.54
Outer Shelf	26	4.4	27	0.06	268.6	701.68
Upper Slope	24	44.4	80.7	0.09	480.2	1,855.22
				Shannon Diversity (H')		
	N Trawls	**Median**	**Mean**	**Min**	**Max**	
All Strata	135	0.9	0.96	0	3.04	
Bays & Harbors	26	0.87	0.98	0	3.04	
Inner Shelf	29	1.12	1.14	0	2.12	
Middle Shelf	30	1.05	1.16	0.35	2.57	
Outer Shelf	26	1.21	1.17	0	2.3	
Upper Slope	24	0.78	0.72	0.04	1.37	
				Taxonomic Richness		
	N Trawls	**Median**	**Mean**	**Min**	**Max**	**Total**
All Strata	135	9	10	1	25	200
Bays & Harbors	26	5	5.1	2	17	53
Inner Shelf	29	6	6.4	1	16	53
Middle Shelf	30	9	9.7	3	21	90
Outer Shelf	26	13	12.7	1	25	73
Upper Slope	24	12	11.1	2	21	54

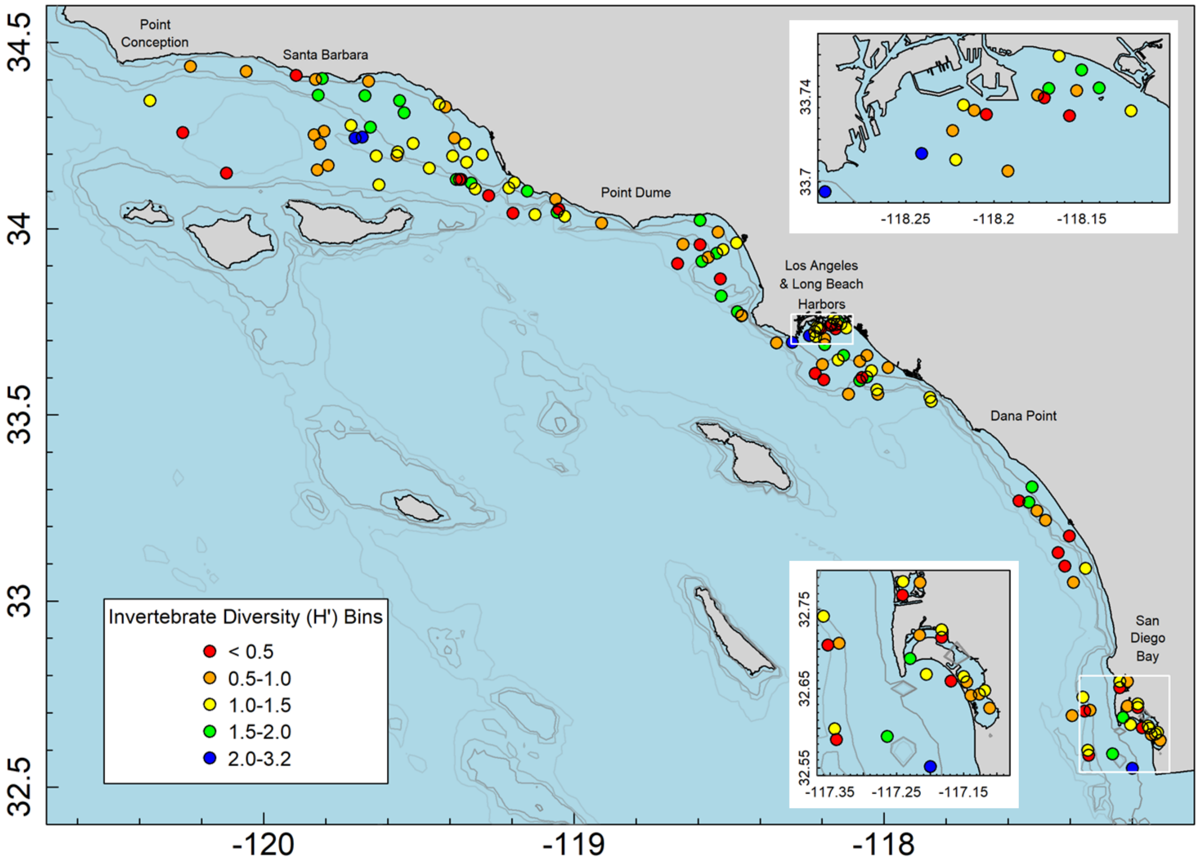


Figure 11. Distribution of megabenthic invertebrate Shannon diversity (H') per haul during the Bight ’18 survey. Calculated diversity for each station is sorted into bins and the colors represent the range of diversity values captured in each bin.

Megabenthic Invertebrate Population Attributes

Megabenthic Abundance and Ecological Index

A total of 201 megabenthic invertebrate taxa representing 96 families were identified during Bight ’18 (Table C25). The top ten most abundant invertebrates in the Bight were represented by species in 2 phyla (Echinodermata and Arthropoda), 9 families, and accounted for 95% of all invertebrates sampled (Table 6). *Pleuroncodes planipes* (Pelagic Red Crab) was the most abundant invertebrate collected during Bight ’18 and accounted for 56% of all invertebrates sampled (Figure 12). The most abundant invertebrate sampled in the Bays & Harbors and Inner Shelf was *Dendraster excentricus* (Pacific Sand Dollar; 1,236 and 2,117 individuals, respectively); however, it was not encountered in any other stratum during Bight ’18. *Lytechinus pictus* (White Urchin) was the most abundant on the Middle Shelf (2,012 individuals) and *Pleuroncodes planipes* was most abundant on the Outer Shelf and Upper Slope (51,724 and 80,248 individuals, respectively).

The Ecological Index (E.I.) rank of species uses three ecological variables (abundance, biomass and frequency of occurrence) to determine the ecological importance of species to energy flow within each stratum (Allen et al. 2002b; Williams et al. 2015b). *Pleuroncodes planipes* had the highest E.I. in the SCB overall (E.I. 8,383; Figure 13, Table 7). *Sicyonia penicillata* (Target Rock Shrimp) ranked first in Bays & Harbors (E.I. 3,150; Table C26), with an E.I. that was over 10 times greater than the next highest invertebrate, *Dendraster excentricus* (E.I. 282). Despite *Dendraster excentricus* having the highest abundance in Bays & Harbors, *Sicyonia penicillata* ranked higher due to their higher overall biomass and because they were caught at a majority of embayment stations. *Dendraster excentricus* ranked first on the Inner Shelf (E.I. 1,016) followed by *Sicyonia penicillata* (E.I. 813; Table C27). *Sicyonia ingentis* ranked highest on the Middle Shelf (E.I. 3,117; Table C28) followed by *Lytechinus pictus* (White Urchin; E.I. 2,305). *Pleuroncodes planipes* ranked first on the Outer Shelf and Upper Slope (E.I. 6383 and 6315, respectively; Table C29, Table C30) followed by *Strongylocentrotus fragilis* (Fragile Urchin; E.I. 2,275). The E.I. of *Pleuroncodes planipes* was over 12 times greater than *Strongylocentrotus fragilis* on the Outer Shelf; however, this dominance was less pronounced on the Upper Slope.

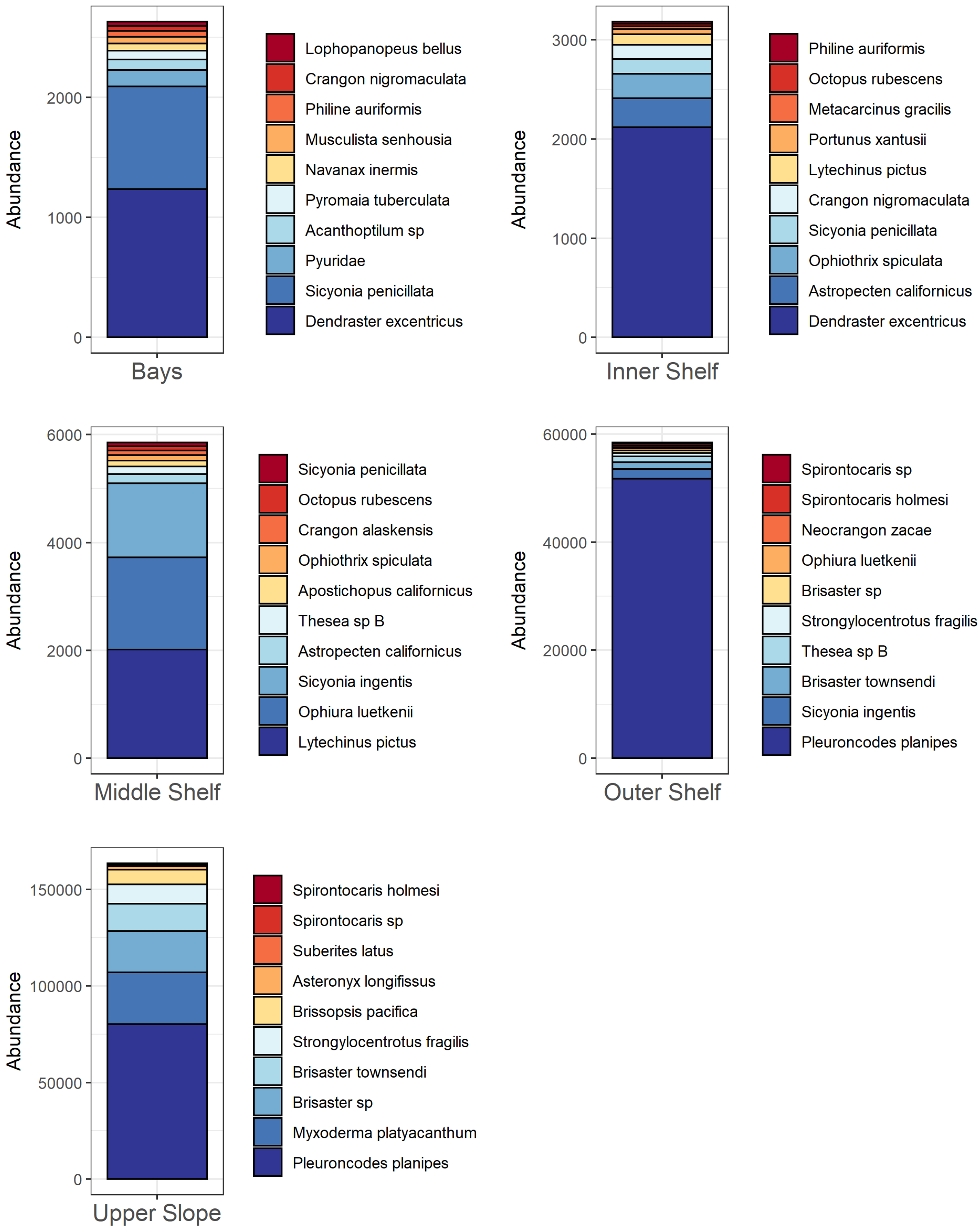


Figure 12. Top ten megabenthic invertebrate species by abundance for each stratum collected during the Bight '18 trawl survey. The invertebrate species are sorted from most abundant (bottom) to least abundant (top).

Table 6. Top ten megabenthic invertebrate species by abundance for each stratum collected during the Bight '18 trawl survey. The table is sorted by abundance rank. Shaded areas indicate species was top ten most abundant in a given stratum.

						Abundance				
Species	**Phylum:Family**	**Abundance Rank**	**Biomass Rank**	**Frequency Rank**	**Southern California Bight**	**Bays & Harbors**	**Inner Shelf**	**Middle Shelf**	**Outer Shelf**	**Upper Slope**
Pleuroncodes planipes	Arthropoda:Munididae	1	1	10	131,995	-	-	23	51,724	80,248
Myxoderma platyacanthum	Echinodermata:Zoroasteridae	2	8	28	26,833	-	-	-	-	26,833
Brisaster sp	Echinodermata:Schizasteridae	3	4	16	21,684	-	-	-	506	21,178
Brisaster townsendi	Echinodermata:Schizasteridae	4	3	8	15,386	-	-	-	1,208	14,178
Strongylocentrotus fragilis	Echinodermata:Strongylocentrotidae	5	2	1	10,758	-	-	26	618	10,114
Brissopsis pacifica	Echinodermata:Brissidae	6	5	4	7,773	-	-	-	74	7,699
Sicyonia ingentis	Arthropoda:Sicyoniidae	7	6	7	3,382	16	-	1,377	1,832	157
Dendraster excentricus	Echinodermata:Dendrasteridae	8	14	110	3,353	1,236	2,117	-	-	-
Lytechinus pictus	Echinodermata:Toxopneustidae	9	22	12	2,210	14	104	2,012	76	4
Ophiura luetkenii	Echinodermata:Ophiuridae	10	29	21	2,167	-	-	1,709	458	-
Asteronyx longifissus	Echinodermata:Asteronychidae	11	25	42	1,580	-	-	-	-	1,580
Thesea sp B	Cnidaria:Plexauridae	12	46	22	1,227	-	12	140	1,075	-
Sicyonia penicillata	Arthropoda:Sicyoniidae	13	10	20	1,076	856	148	72	-	-
Spirontocaris holmesi	Arthropoda:Hippolytidae	14	51	19	861	-	-	-	393	468
Spirontocaris sp	Arthropoda:Hippolytidae	15	52	13	765	-	-	-	228	537
Suberites latus	Silicea:Suberitidae	16	13	23	623	-	-	2	3	618
Neocrangon zacae	Arthropoda:Crangonidae	17	48	11	556	-	-	-	405	151
Astropecten californicus	Echinodermata:Astropectinidae	18	35	5	492	-	293	171	26	2
Ophiothrix spiculata	Echinodermata:Ophiotricidae	20	41	14	394	14	249	106	23	2
Acanthoptilum sp	Cnidaria:Virgulariidae	22	52	37	245	88	-	11	146	-
Crangon nigromaculata	Arthropoda:Crangonidae	23	54	26	190	42	145	3	-	-
Octopus rubescens	Mollusca:Octopodidae	25	30	9	161	-	26	77	50	8
Pleurobranchaea californica	Mollusca:Pleurobranchidae	27	15	3	142	-	5	40	63	34
Pyuridae	Chordata:Pyuridae	28	58	191	136	136	-	-	-	-
Apostichopus californicus	Holothuroidea: Stichopodidae	29	9	24	121	2	-	107	12	-
Philine auriformis	Mollusca:Philinidae	30	59	40	108	48	21	39	-	-
Octopus californicus	Mollusca:Octopodidae	31	19	6	99	-	-	-	9	90
Pyromaia tuberculata	Arthropoda:Inachoididae	32	50	44	98	74	14	10	-	-
Astropecten sp	Echinodermata:Astropectinidae	34	71	38	93	-	21	72	-	-
Crangon alaskensis	Arthropoda:Crangonidae	37	92	58	84	-	-	84	-	-
Portunus xantusii	Arthropoda:Portunidae	39	27	50	81	32	49	-	-	-
Metridium farcimen	Cnidaria:Metridiidae	43	7	33	70	-	-	-	59	11
Navanax inermis	Mollusca:Aglajidae	46	68	181	60	60	-	-	-	-
Musculista senhousia	Mollusca:Mytilidae	48	68	181	56	56	-	-	-	-
Lophopanopeus bellus	Arthropoda:Panopeidae	52	76	184	36	36	-	-	-	-
Metacarcinus gracilis	Arthropoda:Cancridae	54	32	49	33	-	32	1	-	-
Cymothoidae	Arthropoda:Cymothoidae	203	33	2	NA	-	-	-	-	-

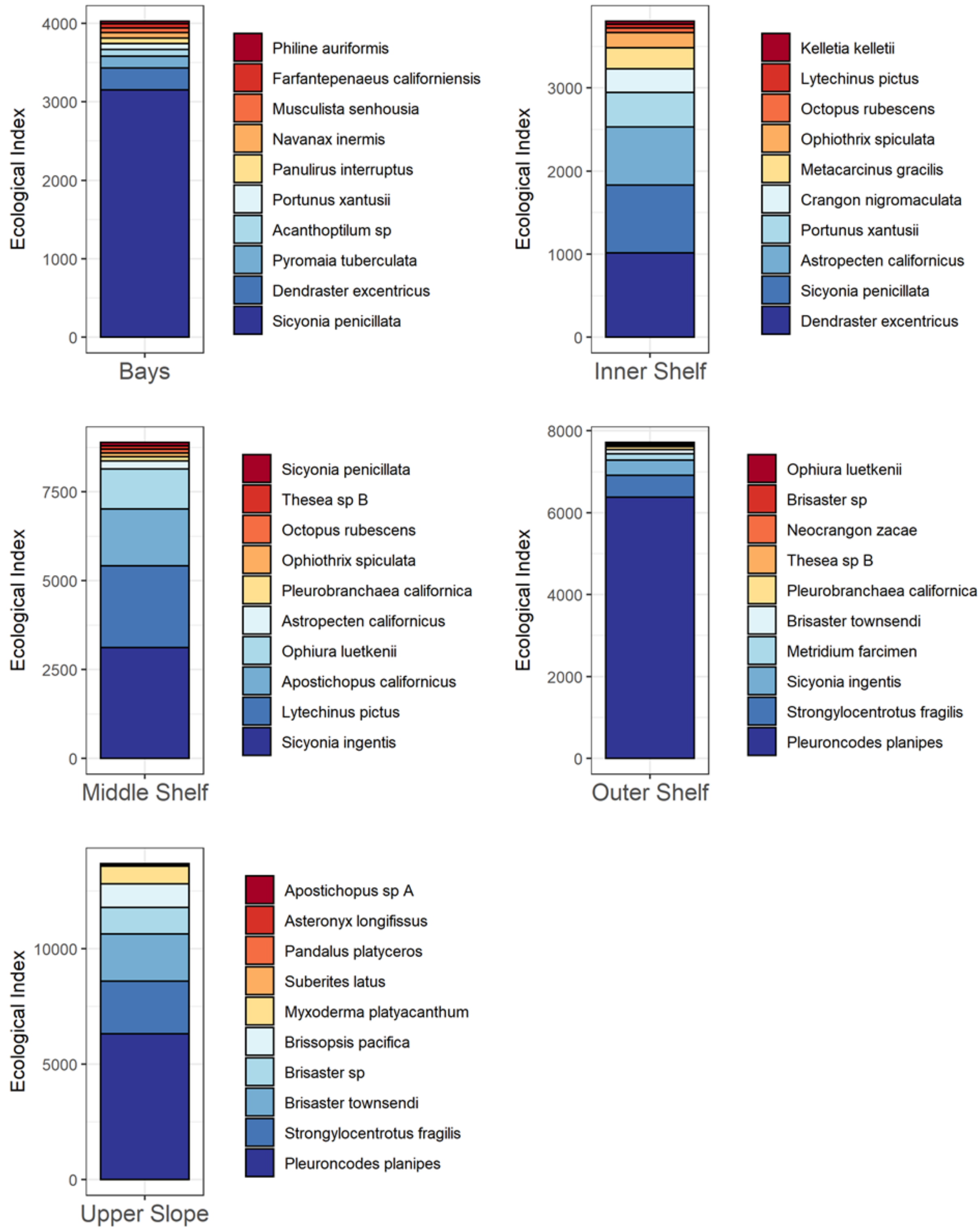


Figure 13. Top ten megabenthic invertebrate species by Ecological Index (E.I.) for each stratum collected during the Bight '18 trawl survey. The invertebrate species are sorted from highest E.I. (bottom) to lowest E.I. (top).

Table 7. Top ten megabenthic invertebrate species ranked by Ecological Index (E.I.) for each stratum collected during the Bight '18 trawl survey. The table is sorted by overall E.I. rank. Shaded areas indicate species ranked in the top ten in a given stratum.

Species	EI Rank	Southern California Bight	Ecological Index: Bays & Harbor	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Pleuroncodes planipes	1	8383	-	-	2	6383	6315
Brisaster sp	2	1531	-	-	-	21	1149
Myxoderma platyacanthum	3	1405	-	-	-	-	777
Brisaster townsendi	4	1241	-	-	-	101	2046
Strongylocentrotus fragilis	5	1012	-	-	5	530	2275
Brissopsis pacifica	6	538	-	-	-	10	1017
Sicyonia ingentis	7	173	6	-	3117	373	5
Dendraster excentricus	8	167	282	1016	-	-	-
Asteronyx longifissus	9	72	-	-	-	-	21
Metridium farcimen	10	68	-	-	-	153	5
Lytechinus pictus	11	65	2	46	2305	1	0
Sicyonia penicillata	12	62	3150	813	94	-	-
Ophiura luetkenii	13	59	-	-	1123	19	-
Apostichopus californicus	14	59	1	-	1601	17	-
Suberites latus	15	58	-	-	0	0	37
Thesea sp B	16	56	-	7	100	36	-
Apostichopus sp A	17	33	-	-	-	-	21
Pandalus platyceros	18	28	-	-	-	11	24
Pleurobranchaea californica	19	27	-	6	122	73	8
Spirontocaris holmesi	20	23	-	-	-	9	7
Spirontocaris sp	21	20	-	-	-	4	9
Spatangus californicus	22	19	-	-	-	3	17
Neocrangon zacae	23	16	-	-	-	27	4
Astropecten californicus	24	15	-	701	220	1	0
Octopus californicus	25	14	-	-	-	8	20
Lopholithodes foraminatus	26	13	-	-	-	11	0
Ophiothrix spiculata	27	12	6	182	107	0	0
Platymera gaudichaudii	28	12	-	-	10	14	-
Spirontocaris sica	29	11	-	-	-	0	5
Paralithodes californiensis	30	10	-	-	-	-	7
Octopus rubescens	31	8	-	54	105	12	0
Portunus xantusii	32	8	75	417	-	-	-
Acanthoptilum sp	33	7	88	-	10	4	-
Brisaster latifrons	34	7	-	-	-	7	0
Panulirus interruptus	35	7	70	2	-	-	-
Gorgonocephalus eucnemis	36	7	-	-	-	11	-
Crangon nigromaculata	37	6	30	282	2	-	-
Glyptolithodes cristatipes	38	6	-	-	-	-	4
Luidia foliolata	39	5	-	2	12	9	0
Munida hispida	40	5	-	-	-	0	1
Pyuridae	41	4	23	-	-	-	-

Table 7. Continued.

Species	EI Rank	Southern California Bight	Ecological Index				
			Bays & Harbor	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Metacarcinus gracilis	42	4	-	256	1	-	-
Brissopsis sp LA1	43	4	-	-	-	-	0
Pyromaia tuberculata	44	4	148	32	3	-	-
Loxorhynchus grandis	45	4	-	-	10	-	-
Philine auriformis	46	4	33	20	13	-	-
Desmophyllum dianthus	47	4	-	-	-	2	-
Pseudarchaster pusillus	48	3	-	-	-	-	1
Apostichopus parvimensis	49	3	15	-	0	-	-
Astropecten sp	50	3	-	20	26	-	-
Metacarcinus anthonyi	51	3	-	28	4	-	-
Neocrangon resima	52	3	-	-	-	3	0
Rossia pacifica	53	3	-	-	1	4	0
Farfantepenaeus californiensis	54	2	52	9	-	-	-
Stylasterias forreri	55	2	-	-	-	0	0
Crangon alaskensis	56	2	-	-	18	-	-
Astyris permodesta	57	2	-	-	-	-	0
Navanax inermis	58	2	66	-	-	-	-
Musculista senhousia	59	2	63	-	-	-	-
Kelletia kelletii	63	2	-	36	0	-	-

Megabenthic Invertebrate Anomalies

The overall occurrence of invertebrate anomalies was low during Bight '18, with anomalies found on just 0.11% of the invertebrates examined (Table 8). A total of 28 anomalies were found on 8 species of invertebrates. The most prevalent anomaly were parasites found on *Paralithodes californiensis* (California King Crab), *Paralithodes rathbuni* (Rathbun's King Crab) and *Crangon nigromaculata* (Spotted Bay Shrimp). Burnspot disease occurred on nine *Sicyonia ingentis* on the Outer Shelf. Invertebrates that were not examined during the processing of trawls were excluded from analysis.

Table 8. Number of megabenthic invertebrate anomalies by type, species and shelf zone during the Bight '18 trawl survey.

Anomaly	Species	*Zone*						Total Examined Invertebrates	Percent Anomaly
		Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope	All Zones		
Burnspot disease	*Sicyonia ingentis*	-	-	-	9	-	9	2,806	0.3
Other	*Apostichopus californicus*	-	-	1	-	-	1	120	0.2
Other	*Astropecten californicus*	-	5	-	-	-	5	492	0.5
Other	*Brissopsis pacifica*	-	-	-	-	1	1	1011	0.1
Other	*Randallia ornata*	-	1	-	-	-	1	3	33.3
Parasite	*Crangon nigromaculata*	4	2	-	-	-	6	169	3.6
Parasite	*Paralithodes californiensis*	-	-	-	-	4	4	8	50.0
Parasite	*Paralithodes rathbuni*	-	-	-	-	1	1	3	33.3
All Anomalies	All Species	4	8	1	9	6	28	24,893	0.11

Multi-Survey Temporal Trends

Trends in Demersal Fish Community Attributes

Trends in the condition of the SCB from 1994 to 2018 were assessed using the Fish Response Index (FRI; Allen et al. 2001). Fish abundance, biomass, taxonomic richness, and Shannon diversity (H') are presented in Appendix E, Figure E35, Figure E36, and Figure E37.

Over 90% of the SCB shelf survey areas were in reference condition during the six Bight regional monitoring surveys (Table 9). The percentage of stations in reference condition ranged from 90% in Bight '03 to 99% in Bight '94. The percentage of area in reference condition ranged from 93% in Bight '03 and Bight '13 to 99% in Bight '94 and Bight '18. Six percent of stations (n=45) had FRI scores associated with non-reference conditions out of a total of 739 shelf stations sampled during the six Bight surveys. Thirty-three non-reference stations were located in the northern Bight, from Point Dume to Point Conception (Figure 14, Figure 15). The majority of sites associated with non-reference conditions occurred in the Inner Shelf (n=39), while the Middle and Outer Shelf had 5 sites in non-reference condition (Figure 15). Fish abundance, biomass, taxonomic richness and Shannon diversity (H') showed no clear increasing or decreasing trends within a stratum for the six surveys.

Table 9. Percent of stations and area in reference condition as measured by the Fish Response Index (FRI) scores in the SCB by survey.

Survey	Number of Reference Stations	Number of Non-Reference	Percent of Reference Stations	Percent of Reference Area
Bight '94	110	1	99%	99%
Bight '98	227	16	93%	98%
Bight '03	140	15	90%	93%
Bight '08	81	5	94%	95%
Bight '13	99	6	94%	93%
Bight '18	82	2	98%	99%
All Surveys	739	45	94%	96%

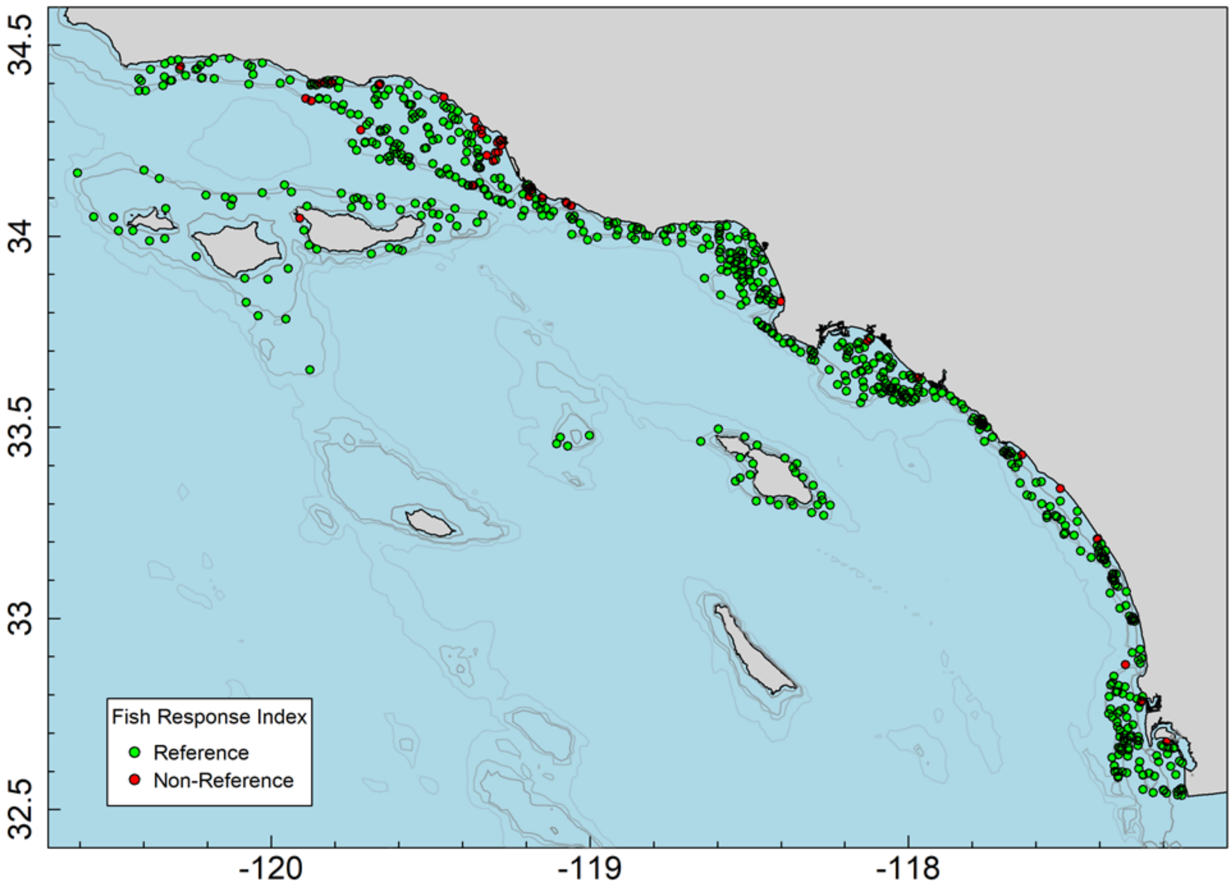


Figure 14. Distribution of Fish Response Index (FRI) scores for all Bight surveys (1994 – 2018). An FRI score ≤ 45 is associated with a fish community in reference condition.

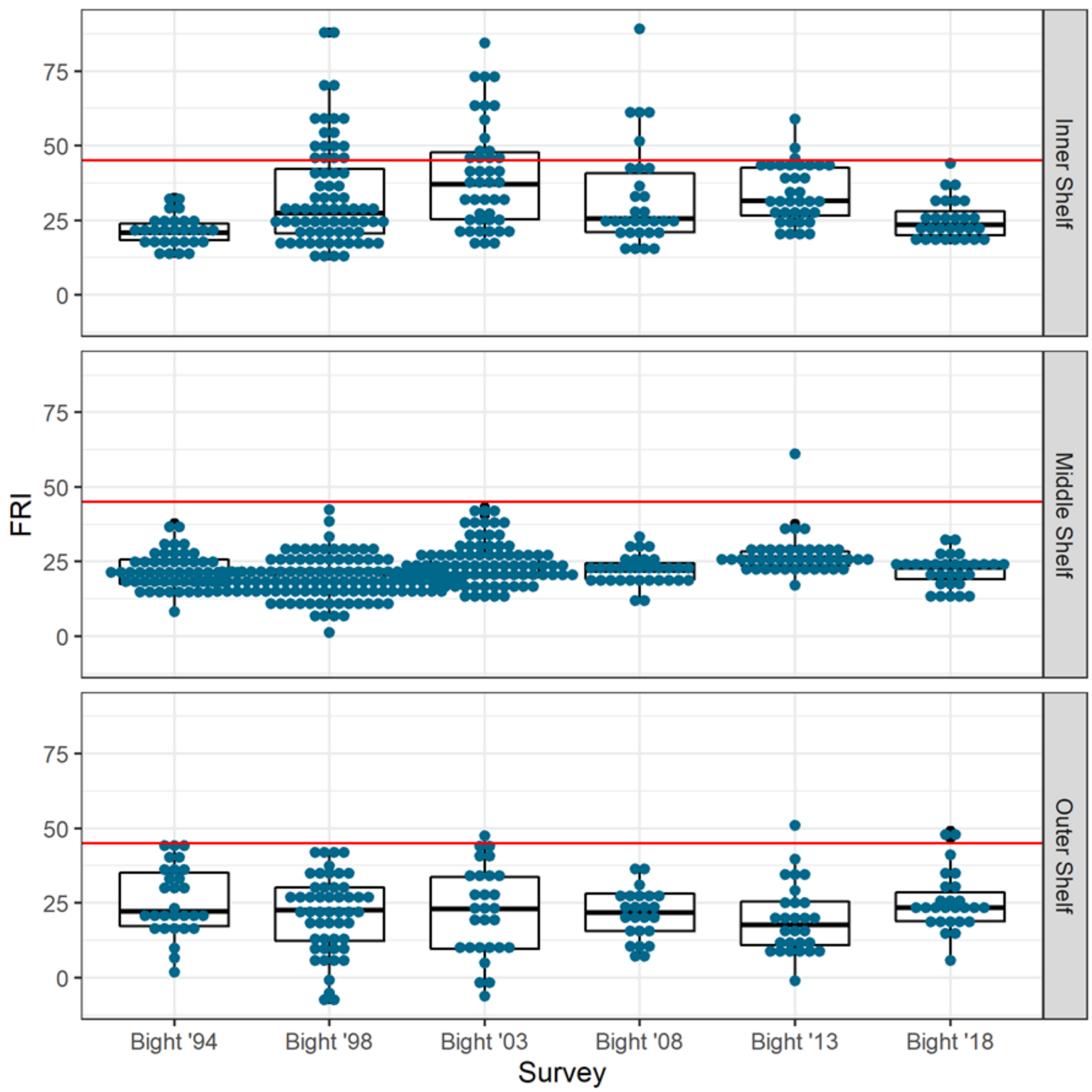


Figure 15. Fish Response Index (FRI) scores in the SCB by shelf stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots). The red line represents FRI score associated with reference community (≤ 45); FRI is not applicable in Bays & Harbors and at Upper Slope depths.

Site Revisit Temporal Trends of Demersal Fish

Based upon sites revisited from 1998 through 2018, the majority of the SCB shelf were considered "stable" based on no significant trend in FRI scores over time (89.3% of area). On the shelf, 4.4% of area showed a trend towards improving condition (i.e., better FRI scores) and 6.3% had a trend of declining condition (Figure 16, Table 10). The Inner Shelf was the only stratum with improving condition (14.3% of area), while a declining condition was apparent in both the Inner Shelf (7.1%) and Middle Shelf (7.7%). The Outer Shelf was stable. Revisit sites with significant trends in FRI scores, either improving or declining, were all in reference condition for all site reoccupation events. The only revisited sites that were ever in non-reference condition were in the Inner Shelf sites prior to 2013. No revisited site was in non-reference category in 2018 (Figure 16, Table E51).

Other fish metrics, Shannon diversity (H') and taxonomic richness, showed similarly stable trends in the SCB. Trends in H' diversity were considered “stable” in 92.4% of the SCB area, ranging from 90% of the Outer Shelf to 92.9% of Inner Shelf and Upper Slope areas (Figure E39, Table E52, Table E53). Diversity was only increasing in Bays & Harbors (9.1% area increasing). Diversity was decreasing in less than 10% of the area in the Inner, Middle and Outer Shelf and Upper Slope. Trends in taxonomic richness were considered “stable” in 95.7% of the SCB area, ranging from 90% of the Outer Shelf to 100% of Bays & Harbors, Inner Shelf, and Middle Shelf area (Figure E40, Table E54, Table E55). Only the Outer Shelf and Upper Slope had area (less than 10%) that had increasing richness.

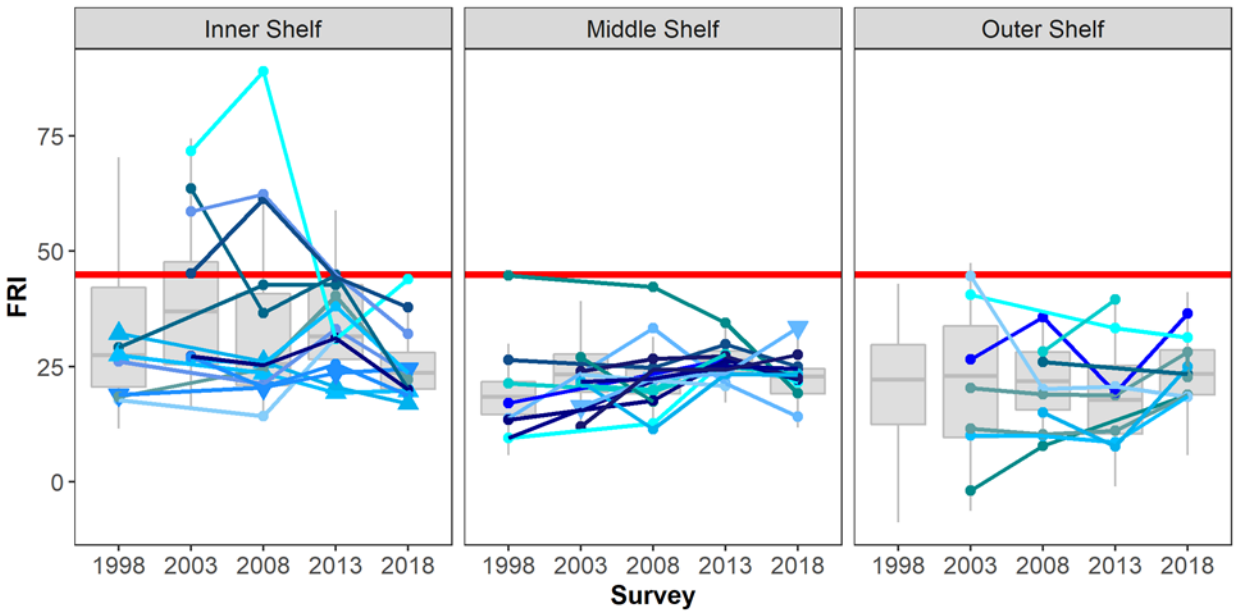


Figure 16. Trends in individual revisited sites across surveys for the three shelf strata. Red line is an FRI score of 45, sites greater than 45 are considered “non-reference”, sites less than 45 are “reference”. Grey box plots represent all Bight data collected during that survey. Blue lines are individual revisited sites, where circles indicate “stable” condition, upward triangles indicate “improving condition” (negative slope, p-value ≤ 0.05), and downward triangles indicate “declining condition” (positive slope, p-value ≤ 0.05).

Table 10. Percent of area characterized as improving, stable or declining based on the trend in FRI scores between 1998/2003 and 2018 for each stratum and for the entire SCB shelf.

Stratum	# of Sites	Improving	Stable	Declining
Inner Shelf	14	14.30%	78.60%	7.10%
Middle Shelf	13	0%	92.30%	7.70%
Outer Shelf	9	0%	100%	0%
Entire Shelf	36	4.40%	89.30%	6.30%

Multivariate Analyses of Demersal Fish Assemblages

Multivariate analyses were used to discriminate between demersal fish assemblages from a total of 1,081 trawls conducted during Bight surveys (Bight '94 – Bight '18). A total of four stations were excluded from these analyses because no demersal fishes were collected in these trawls. Fish assemblages located within Bays & Harbors were found to be significantly different than those located on the coastal shelf and Upper Slope of the SCB (one-way ANOSIM, $\rho = 0.507$, $p \leq 0.001$, number of permutations = 999). Based on SIMPER analysis, the two regions had an average dissimilarity of 94%. Based on these results, subsequent multivariate analyses were performed separately on data from each region.

Bays & Harbors

Multivariate analysis of demersal fish communities in Bays & Harbors included a total of 139 trawls conducted during Bight surveys (Bight '94 – Bight '18). Fish assemblages located in each embayment were found to be significantly different from one another, including all three ecoregions of San Diego Bay (SDB) (one-way ANOSIM, $\rho = 0.715$, $p \leq 0.001$, number of permutations = 999). Ordination analysis showed the most distinct separation was between Port of LA/Port of Long Beach (POLA/POLB) and all other embayments (Figure 17, Figure 18) supported by higher average dissimilarity based on SIMPER analysis. Survey years were also significantly different from one another (one-way ANOSIM, $\rho = 0.112$, $p = 0.001$, number of permutations = 999), with pairwise comparisons finding that 1998 was significantly different from all years while 2013 was significantly different from all years except 2018. Differences between years may in part be driven by the distribution and number of stations within each bay, as 1998 had nearly double the number of stations in POLA/POLB compared to SDB and Mission Bay while subsequent surveys were more balanced. The dominance of California Lizardfish (*Synodus lucioceps*) was the primary factor separating 2013 from other survey years. These analyses resulted in 16 ecologically-relevant SIMPROF-supported cluster groups, or fish assemblages (cluster groups A-P; Table 11, Figure 17, Figure 18), which were overlaid on station maps to examine spatial distribution. These assemblages represented from 1 to 53 trawls each and ranged from 29 to 62% similarity (mean = 48%) for cluster groups with $n > 1$. A BEST/BVSTEP test ($\rho = 0.952$, $p = 0.001$, number of permutations = 999) implicated California Lizardfish, California Tonguefish (*Symphurus atricaudus*), California Halibut (*Paralichthys californicus*), White Croaker, Round Stingray (*Urobatis helleri*), Spotted Sand Bass (*Paralabrax maculatofasciatus*), Barred Sand Bass (*Paralabrax nebulifer*) and Slough Anchovy as being influential to the overall pattern (gradient) seen in Figure 17. Five of the cluster groups (groups A, B, D, G, N) were small "outlier" clusters ($n = 1 – 2$ trawls) that were composed of stations from only one survey year, with 1998 having three of these outlier cluster groups. SIMPROF groups largely supported spatial gradients of fish communities based on habitat type (e.g., shallow eelgrass, deep sandy bottom, etc.), oceanographic influence, and proximity to a harbor mouth. SIMPER results of dominant fish species are discussed in more detail in Appendix F. There were no discernible patterns for demersal fish assemblages associated with areas that may be more impacted (e.g., marinas, constricted channels) within the larger embayments. This could be in part due to the limitation of trawl sampling in more open areas that are not usually the most impacted compared to constricted, shallow areas and in part due to the transient nature of fishes within and between embayment and coastal habitats.

Coastal Shelf and Slope Strata

Multivariate analyses of demersal fish communities on the SCB shelf and slope included a total of 906 trawls conducted during Bight surveys (Bight '94 – Bight '18). These analyses resulted in 16 main ecologically-relevant SIMPROF-supported groups, or types of demersal fish assemblages (cluster groups A–P; Figure 19, Figure 20, Table 12). These assemblages represented from 1 to 296 trawls each and ranged from 24 to 41% similarity (mean = 35%) for cluster groups with more than one trawl. A BEST/BVSTEP test ($\rho = 0.952$, $p \leq 0.001$, number of permutations = 999) implicated California Lizardfish, Dover Sole, English Sole (*Parophrys vetulus*), Hornyhead Turbot, Longfin Sanddab (*Citharichthys xanthostigma*), Pacific Sanddab, Slender Sole, Speckled Sanddab, Stripetail Rockfish (*Sebastes saxicola*), and Yellowchin Sculpin (*Icelinus quadriseriatus*) as being influential to the overall pattern (gradient) of the cluster dendrogram. There were no discernible patterns in the demersal fish assemblages associated with survey year or proximity to known pollution sources (e.g., major POTW discharge sites). Instead, assemblages appeared to be influenced primarily by depth (Figure 21) and most likely unique characteristics of specific station locations (e.g., habitat differences), and/or the unique composition of fish assemblages. Eleven of the cluster groups (groups A, B, D, F, H, I, J, L, M, N, O) were small "outlier" clusters with ≤ 11 trawls in each group. Ninety-three percent (n = 41) of these trawls were conducted at stations located north of Point Dume and/or proximal to one of the Channel Islands (Figure 20A), and only 10% of these trawls from appropriate depths (n = 4) had FRI values indicative of non-reference conditions (Table 12). With the exception of groups F and O, the "outlier" groups had lower mean abundance than the larger cluster groups (i.e., ≤ 29 versus ≥ 130 fishes per haul), and several also had very low species richness (i.e., ≤ 5 species per haul). The remaining clusters (groups C, E, G, K, P) each spanned the entire SCB (Figure 20B), representing the transition of common fish assemblages from the Inner Shelf to the Upper Slope. The species composition and main descriptive characteristics of each cluster group are included in Appendix F, along with additional analyses of group E, G, and K sub-groups.

Table 11. Description of bays and harbors fish cluster groups A–P defined in Figure 17 and Figure 18.

	Cluster Group															
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
No. of Trawls	1	1	6	2	3	5	1	3	53	4	2	19	6	2	5	25
Average Similarity (%)	*	*	38	50	41	52	*	55	51	36	29	50	51	62	62	52
Mean Species Richness	1	3	5	8	8	9	7	10	8	6	3	7	3	9	10	6
Mean Abundance	1	4	34	34	59	403	25	106	268	48	5	596	6	37	93	25
Depth (m)																
Min	15	7	5	10	15	4	16	5	7	3	5	2	3	11	11	3
Max	15	7	18	18	24	19	16	12	27	7	11	12	12	16	15	14
Mean	15	7	11	14	19	11	16	8	15	4	8	5	5	13	12	7
%Trawls by Survey																
1998	100	0	33	50	0	80	100	67	40	25	0	0	50	100	0	48
2003	0	0	0	50	33	0	0	0	9	25	0	21	17	0	0	12
2008	0	0	0	0	33	20	0	0	8	0	100	11	33	0	0	24
2013	0	0	33	0	0	0	0	0	26	25	0	32	0	0	60	8
2018	0	100	33	0	33	0	0	33	17	25	0	37	0	0	40	8

* Similarity only calculated for groups with >1 trawl

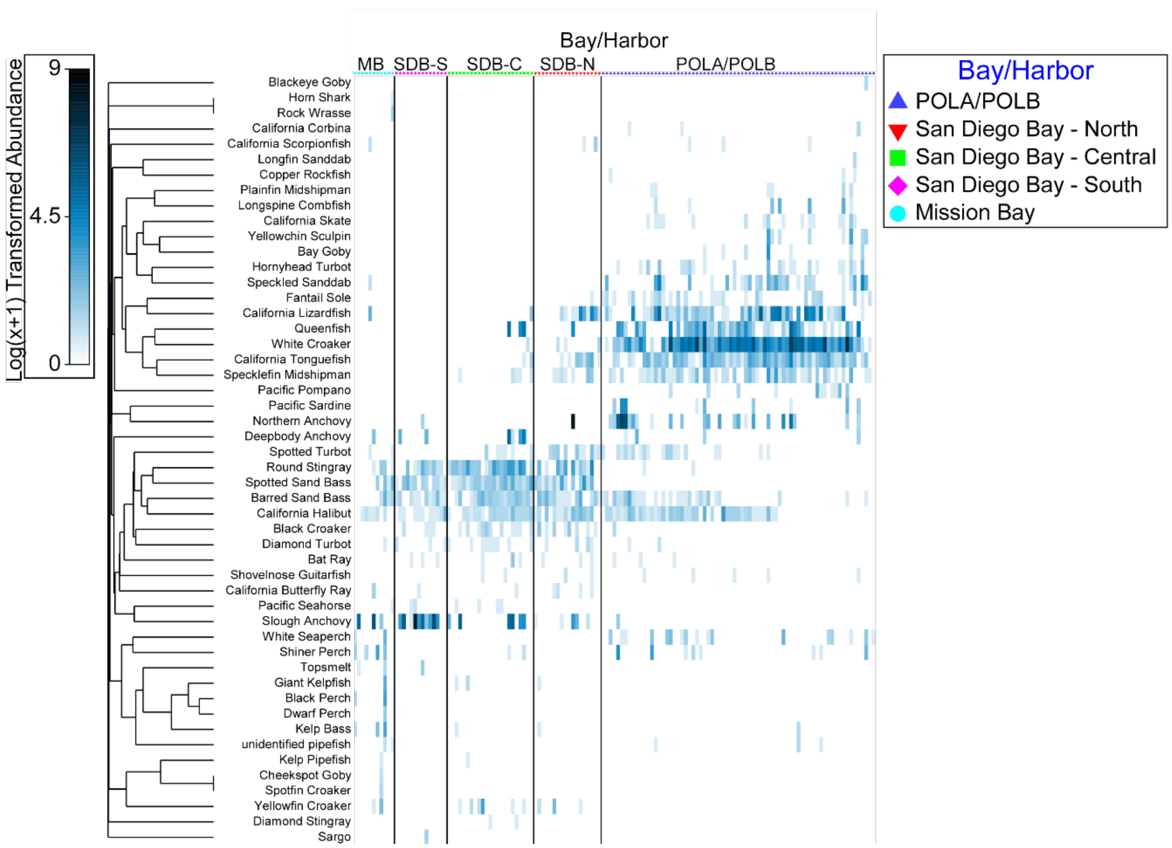


Figure 17. Shade plot of the top 50 demersal fish species by embayment.

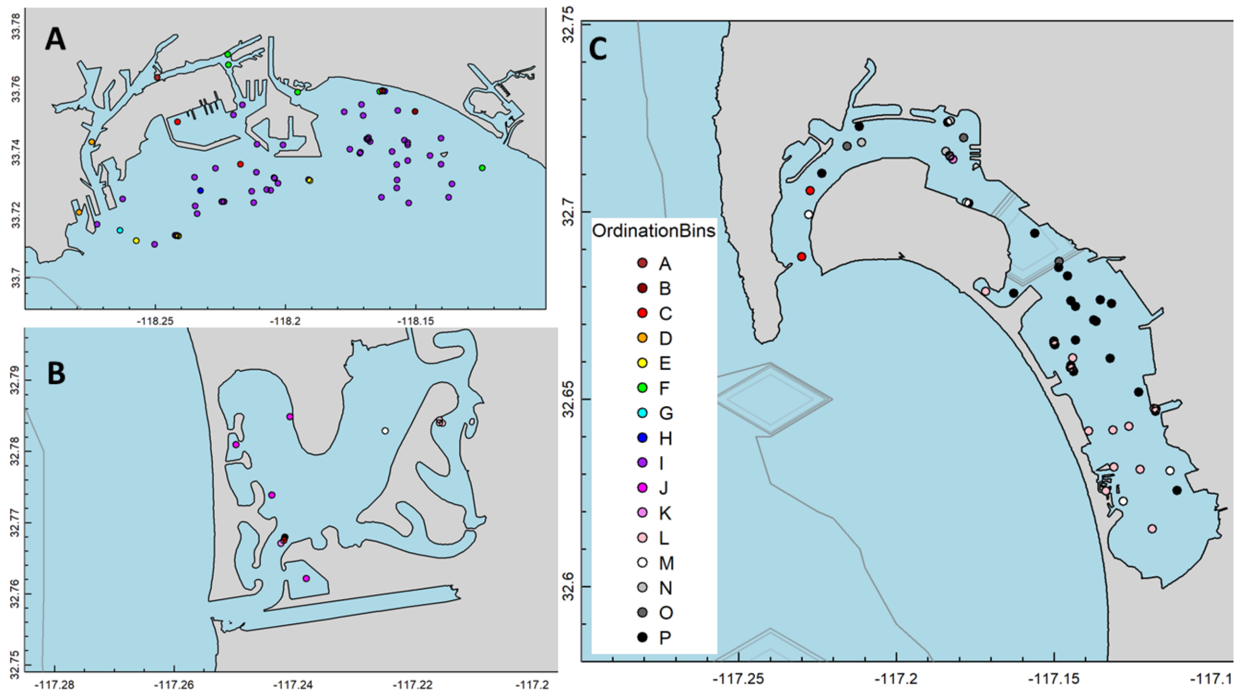


Figure 18. Demersal fish SIMPROF groups within POLA/POLB (A), Mission Bay (B) and San Diego Bay (C).

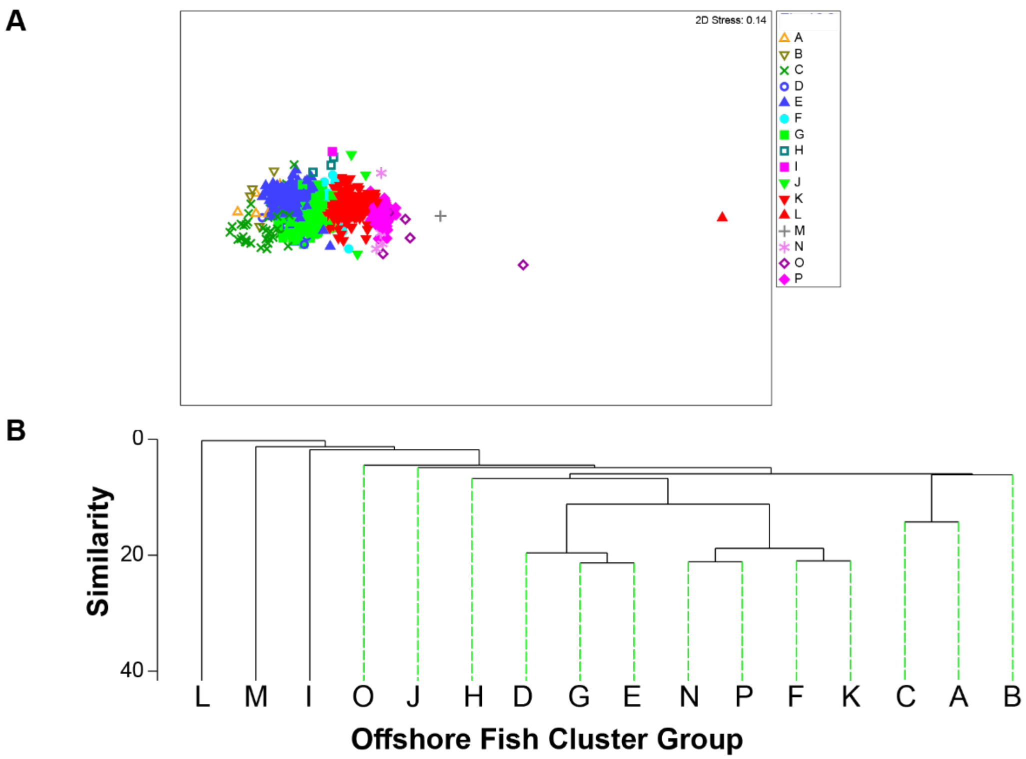
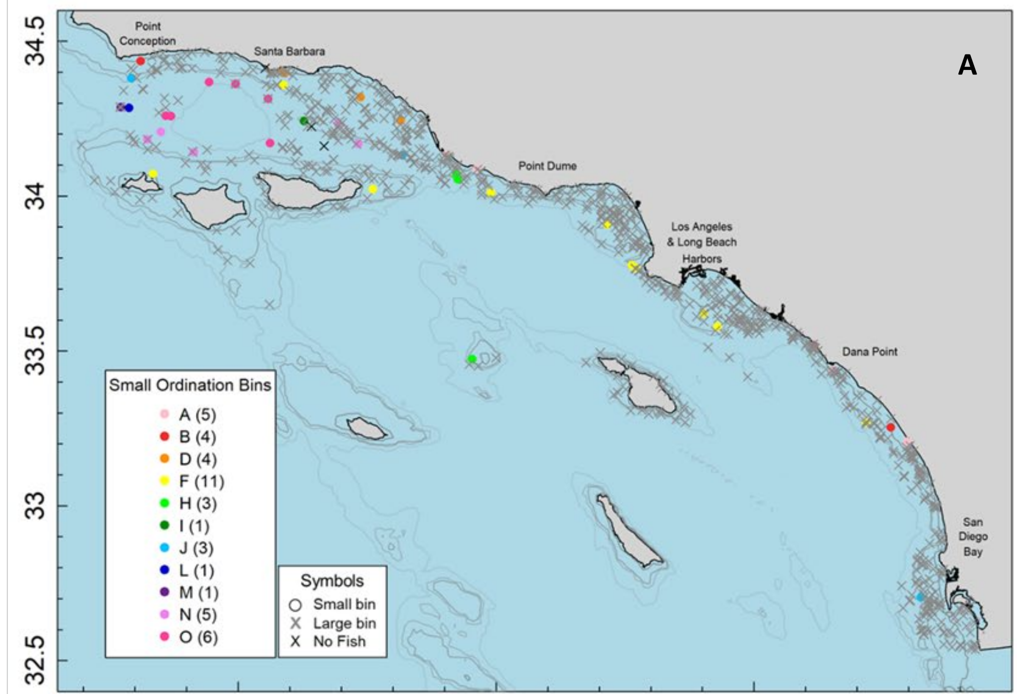


Figure 19. Results of ordination and cluster analysis of demersal fish assemblages from Bight trawl stations sampled in 1994, 1998, 2003, 2008, 2013, and 2018. Data are presented as (A) nMDS ordination and (B) a dendrogram of main cluster groups. Groups were named to increase with mean depth.

Table 12. Description of offshore fish cluster groups A-P defined in Figure 19. N/A category under FRI is the number of sites for which FRI is not applicable due to depth.

	Cluster Group															
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
No. of Trawls	5	4	41	4	206	11	256	3	1	3	296	1	1	5	6	63
Average Similarity (%)	27	25	37	34	35	41	39	38	*	24	37	*	*	40	38	41
Mean Species Richness	10	5	9	6	9	16	13	2	1	4	14	1	4	4	5	10
Mean Abundance	29	10	393	22	163	902	260	4	1	16	377	1	6	8	134	130
Depth (m)																
Min	8	16	7	25	7	43	20	50	200	132	50	414	424	152	420	258
Max	21	22	30	60	69	89	98	125	200	224	368	414	424	475	477	479
Mean	12	18	14	38	24	75	54	93	200	168	157	414	424	350	449	402
FRI Scores																
N/A	0	0	0	0	0	0	0	0	0	1	46	1	1	4	6	63
n≥45	3	0	15	0	22	0	0	0	0	1	4	—	—	0	—	—
%Non-Reference	60	0	37	0	11	0	0	0	0	50	2	—	—	0	—	—
%Trawls by Survey																
1994	0	25	2	0	16	0	14	0	0	33	14	0	0	0	0	0
1998	60	50	73	75	22	9	35	67	100	0	22	0	0	20	0	0
2003	40	0	12	0	18	27	21	0	0	0	22	0	100	40	0	24
2008	0	25	0	0	16	18	7	0	0	0	14	0	0	40	0	33
2013	0	0	2	25	17	9	13	33	0	0	16	100	0	0	83	22
2018	0	0	10	0	11	36	9	0	0	67	13	0	0	0	17	21

* Similarity only calculated for groups with >1 trawl



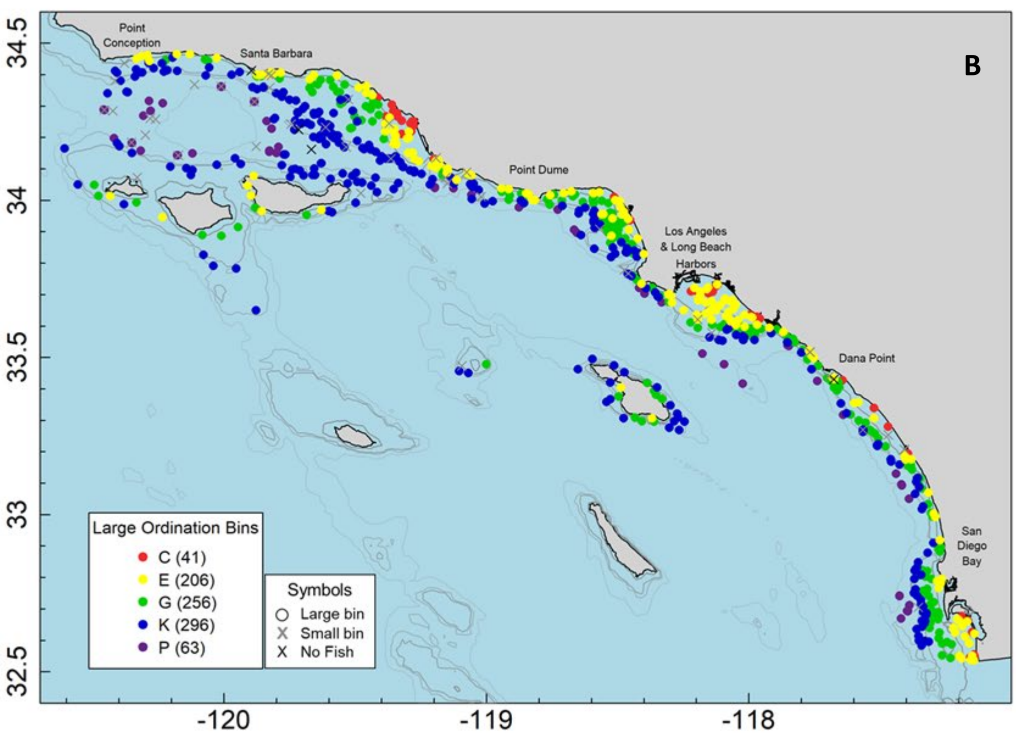


Figure 20. Distribution of (A) small "outlier" offshore fish cluster groups (n ≤ 11 trawls) and (B) large groups (n > 11 trawls). Excluded trawls with no fish are shown as "X". Number of trawls is in parentheses.

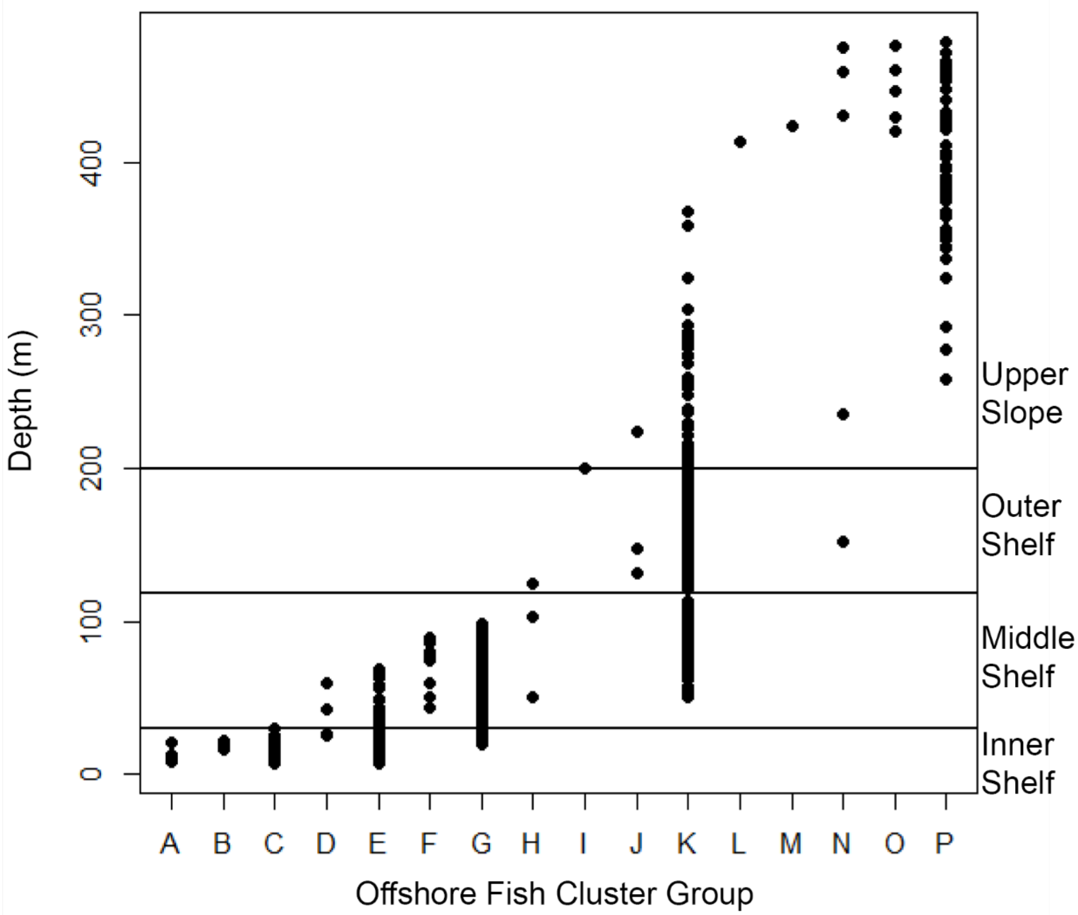


Figure 21. Depth distribution for each offshore fish cluster group described in Figure 19. Each data point represents a single trawl.

Trends in Demersal Fish Population Attributes

For each Bight survey, there was some variation in the most abundant fish, particularly in Bays & Harbors and on the Inner and Middle Shelf (Figure 22). White Croaker was the most abundant fish found in Bays & Harbors, with the highest abundance collected in Bight '98 (11,351 individuals). Although numbers of White Croaker decreased in subsequent Bight surveys, it remained the most abundant fish collected in Bays & Harbors during Bight '03 and Bight '08. California Lizardfish and Slough Anchovy were the most abundant fishes collected in Bays & Harbors during Bight'13 and Bight '18, respectively. Speckled Sanddab was the most abundant fish collected on the Inner Shelf during Bight '94, Bight '03, Bight '08 and Bight '13. White Croaker and Northern Anchovy were the most abundant fishes collected on the Inner Shelf during Bight '98 and Bight '18, respectively. Pacific Sanddab was the most abundant fish collected on the Middle Shelf during Bight '94, Bight '03 and Bight '08, with the highest abundance collected during Bight ’03 (13,547 individuals). California Lizardfish was the most abundant fish collected on the Middle Shelf during Bight ’98 and Bight ’13, while the Halfbanded Rockfish was the most abundant fish collected on the Middle Shelf during Bight ’18.

Pacific Sanddab was the most abundant fish collected on the Outer Shelf in every Bight survey, with abundances 4 to 9 times greater in Bight ’13 (12,908 individuals) compared to other surveys. Slender Sole was the most abundant fish collected on the Upper Slope, with abundances ranging from 2,020 individuals in Bight ’08 to 3,577 individuals in Bight ’13.

California Lizardfish experienced a dramatic increase in abundance in 2013 compared to previous Bight surveys; however, abundances decreased in 2018 and fell within historic ranges of the earlier Bight surveys. Northern Anchovy had record high abundances in Bays & Harbors and on the Inner Shelf during Bight ’18 compared to previous Bight surveys when abundances ranged from 18 individuals during Bight ’13 to 3,105 individuals during Bight ’98. Although Bight ’18 had over 3 times the number of Northern Anchovy compared to other Bight surveys, they were only encountered in 7 trawls during the Bight ’18 survey. This was similar to other Bight surveys when Northern Anchovies were encountered at 1 station during Bight ’13 to 35 stations during Bight ’98. Slough Anchovy had record high abundances during Bight ’18 (4,748 individuals) but were only encountered in Bays & Harbors. The numbers of Slough Anchovy were nearly 7 times greater than other Bight surveys, which ranged from 64 during Bight ’98 to 697 during Bight ’13. Similar to Northern Anchovy, Slough Anchovy was encountered at a few stations (5 stations during Bight ’08 to 8 stations during Bight ’98 and Bight ’18).

The Ecological Index (E.I.) rank of species uses three ecological variables (abundance, biomass and frequency of occurrence) to determine the ecological importance of species to energy flow (Allen et al. 2002b; Williams et al. 2015b). The top fish species by E.I. for each stratum were generally similar to the top ten by abundance, with a few exceptions and some differences in ranking (Figure 23). E.I. ranks varied throughout Bight surveys in Bays & Harbors. White Croaker ranked highest in Bight ’98 and Bight ’08 (E.I. 5,759 and 2,220, respectively), California Halibut ranked highest during Bight ’03 (E.I. 1,239), California Lizardfish ranked highest during Bight ’13 and Slough Anchovy ranked highest during Bight ’18. On the Inner Shelf, Speckled Sanddab ranked highest in Bight ’94 (E.I. 4,616), Bight ’03 (E.I. 7,443), Bight ’08 (E.I. 8114) and Bight ’18 (E.I. 4,048); however, White Croaker ranked highest during Bight ’98 and California Lizardfish ranked highest in Bight ’13 (E.I. 4,640 and 6,014, respectively). Pacific Sanddab ranked highest on the Middle Shelf during each Bight survey (E.I. range = 3,470 to 7,501), with the exception of Bight ’98 when California Lizardfish ranked highest (E.I. 2,369). Pacific Sanddab ranked highest on the Outer Shelf during each Bight survey and the E.I. score ranged from 3,635 during Bight ’94 to 9,888 during Bight ’13. Slender Sole ranked highest on the Upper Slope during each Bight survey and were remarkably similar between surveys with E.I. scores ranging from 5,544 during Bight ’08 to 6,406 during Bight ’13.

Trends in Demersal Fish Anomalies

The prevalence of total fish anomalies was less than 1.5% of individuals for all Bight surveys and has decreased from 1.47% during Bight ’98 to 0.21% during Bight ’18 (Figure 24). The most common anomaly among the six regional monitoring surveys was parasites. Fin erosion, lesions, and tumors are potentially indicative of exposure to environmental stressors (Allen 1977; Mearns 1973, 1975; Sindermann et al. 1982). The percent of fish with potential stress- or disease-associated anomalies for all Bight trawl surveys was low (< 0.20% of individuals; Figure 25) and ranged from 0.030% during Bight ’08 to 0.161% during Bight ’94. The prevalence of fish anomalies indicative of stress was similar during Bight ’13 and Bight ’18 (0.071% and 0.065%, respectively). Tumors made up the largest percentage of anomalies indicative of stress (over half of stress-associated anomalies) and ranged from 0.030% during Bight ’08 to 0.089% during Bight ’94.

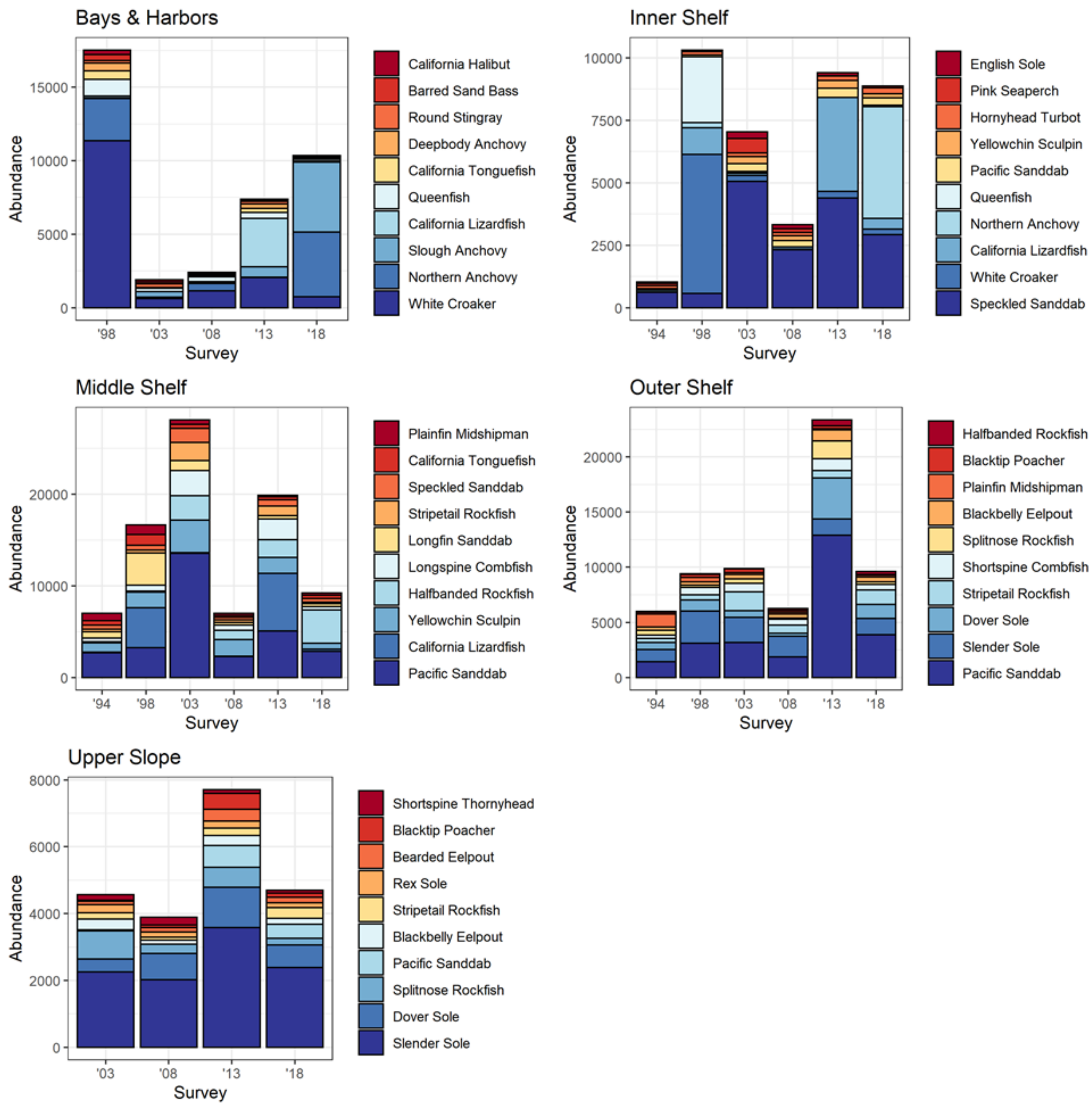


Figure 22. Top ten demersal fish species by abundance for each stratum collected for all Bight trawl surveys. The fish species are sorted from most abundant (bottom) to least abundant (top) within a stratum for all years.

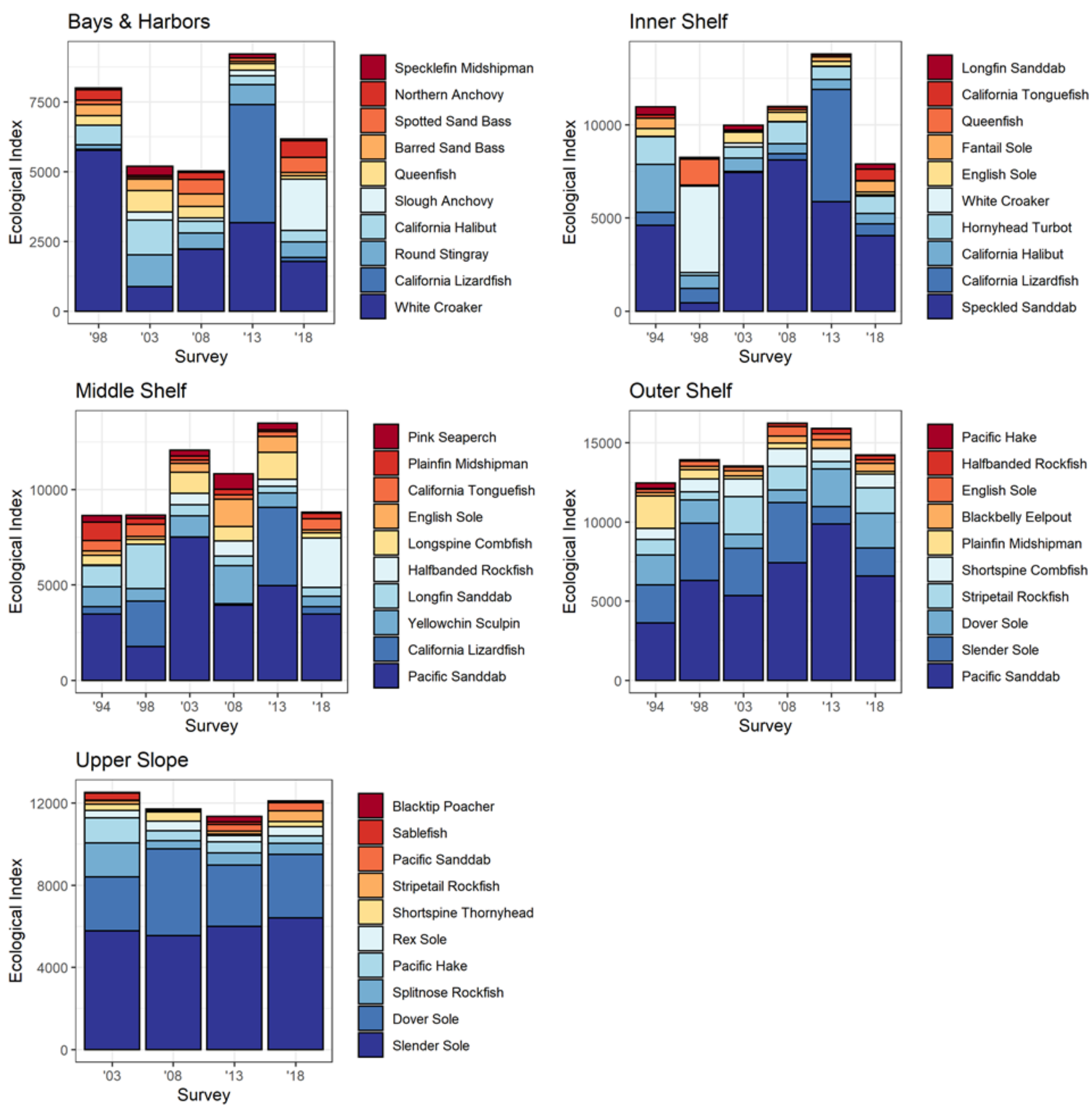


Figure 23. Top ten demersal fish species ranked by Ecological Index (E.I.) for each stratum collected for all Bight trawl surveys. The fish species are sorted from the highest E.I. (bottom) to lowest E.I. (top) within a stratum for all years.

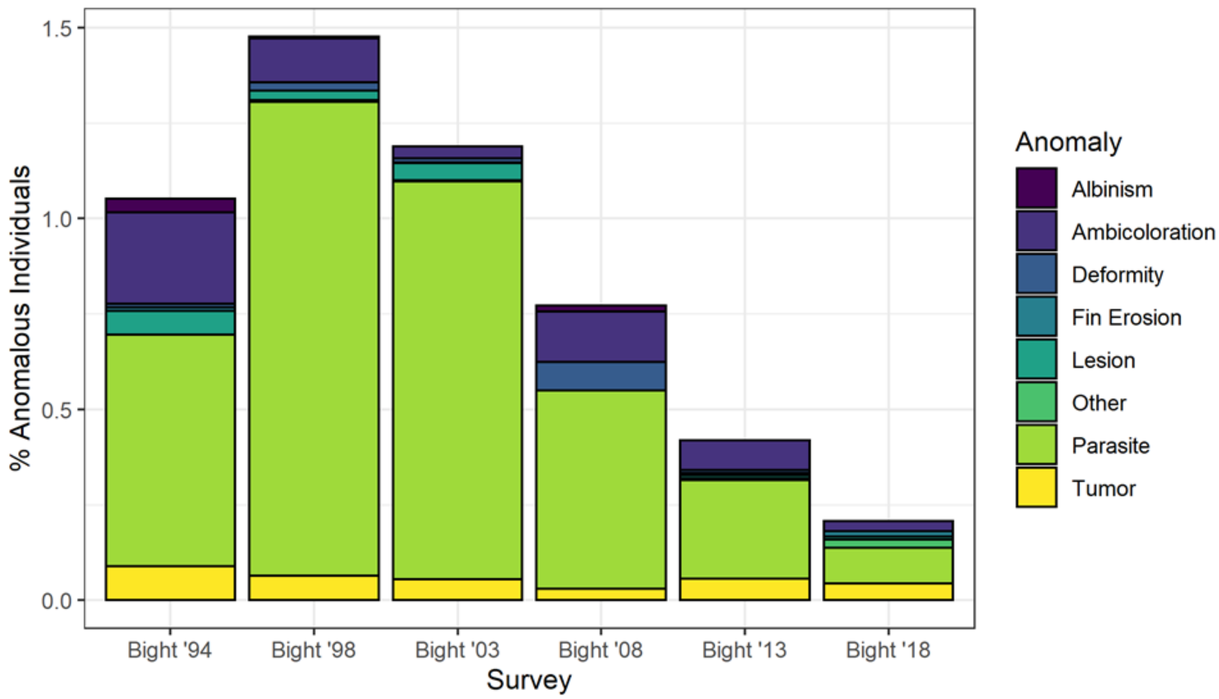


Figure 24. Percent of individual demersal fish with anomalies for all Bight trawl surveys.

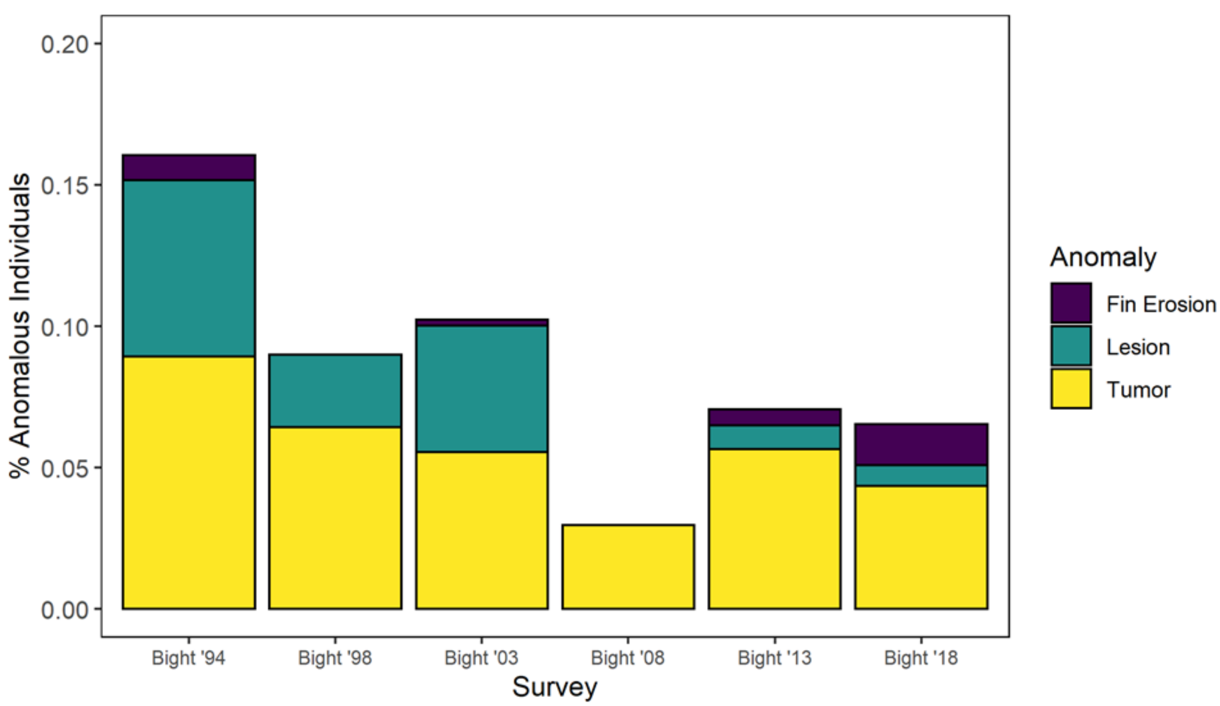


Figure 25. Percent of individual demersal fish with potential stress or disease associated anomalies for all Bight trawl surveys.

Trends in Megabenthic Invertebrate Community Attributes

Trends in megabenthic invertebrates across the SCB from 1994 to 2018 were evaluated using Shannon diversity (H') (Figure 26). H' diversity had no consistent pattern of increasing or decreasing trends across Bight surveys on all Shelf strata and Upper Slope. Median H' diversity ranged from 0.85 in Bight ’03 to 1.39 in Bight ’13 on the Inner Shelf, from 0.78 in Bight ’94 to 1.9 in Bight’08 on the Middle Shelf, from 0.97 in Bight ’94 to 1.45 in Bight ’08 on the Outer Shelf, and from 0.78 in Bight ’18 to 0.96 in Bight ’03 on the Upper Slope (Table E59). The only stratum where a trend was evident was in the Bays & Harbors, which showed a small, but consistent, decrease from Bight ’98 to Bight ’18, with median values decreasing from 1.62 in Bight ’98 to 0.9 in Bight ’18. Abundance, biomass and taxonomic richness have shown little variability over the different Bight cycles for all strata, including Bays & Harbors (Figure E41, Figure E42, Figure E43).

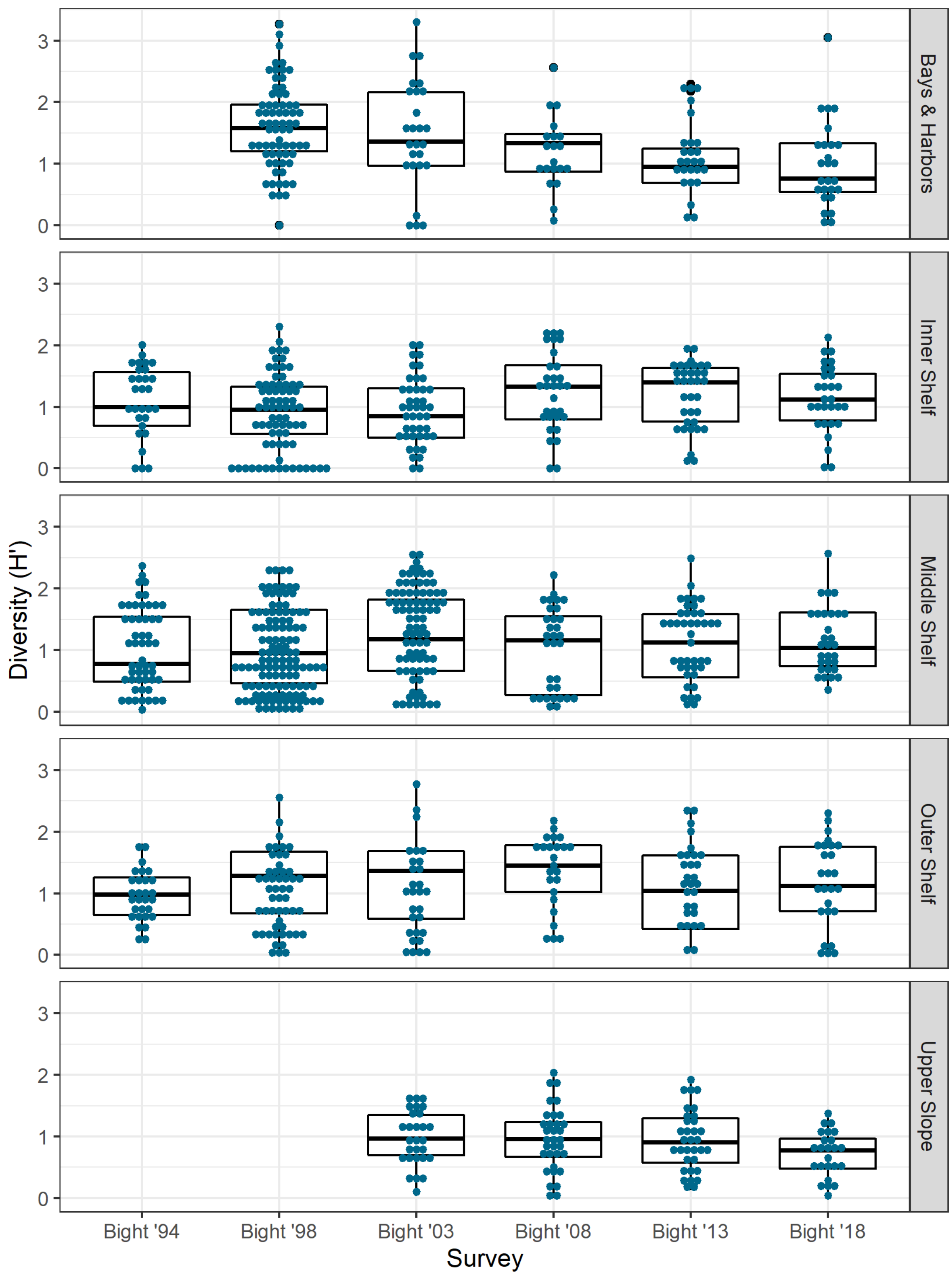


Figure 26. Demersal invertebrate Shannon diversity (H') in the SCB by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

Site Revisit Temporal Trends of Megabenthic Invertebrates

Shannon diversity (H') and taxonomic richness also showed similarly stable trends in the SCB. Trends in Shannon diversity (H') were considered “stable” in 95.4% of SCB area, ranging from 78.6% of the Inner Shelf to 100% of the Outer Shelf area (Figure E45, Table E60, Table E61). Diversity was increasing in 14.3% of the Inner Shelf area and 7.7% of both the Middle Shelf and Upper Slope area. Diversity was decreasing in less than 8% of the area on the Inner Shelf and Upper Slope. Trends in taxonomic richness were considered “stable” in 95.4% of SCB area, ranging from 75% of the Outer Shelf to 100% of Bays & Harbors and Inner and Middle Shelf areas (Figure E46, Table E62, Table E63). Richness was increasing in 12.5% of the Outer Shelf area and was decreasing in 12.5% of the Outer Shelf and 7.7% of the Upper Slope area.

Multivariate Analyses of Megabenthic Invertebrate Assemblages

Multivariate analyses were used to discriminate between megabenthic invertebrate assemblages from a total of 1,070 trawls conducted during Bight Surveys (Bight ’94 – Bight ’18). Fourteen sites were excluded from these analyses because no megabenthic invertebrates were collected in these trawls. Invertebrate assemblages located within Bays & Harbors were found to be significantly different than those located on the coastal shelf and slope of the SCB (one-way ANOSIM, $\rho = 0.49$, $p \leq 0.001$, number of permutations = 999). Based on SIMPER analysis, the two regions had an average dissimilarity of 97%. Based on these results, subsequent multivariate analyses were performed separately on data from each region.

Bays and Harbors

Multivariate analyses of megabenthic invertebrate communities in Bays & Harbors included a total of 139 trawls conducted during Bight Surveys (Bight ’98 – Bight ’18). Invertebrate assemblages were found to be significantly different from one another (one-way ANOSIM, $\rho = 0.544$, $p = 0.001$, number of permutations = 999), with pairwise comparisons showing that POLA/POLB was significantly different from all other embayments. San Diego Bay (SDB) North and SDB – Central were significantly different from Mission Bay and each other, while SDB – South and SDB – Central as well as SDB – South and Mission Bay were not significantly different from one another. Survey years were also significantly different from one another (one-way ANOSIM, $\rho = 0.15$, $p = 0.001$, number of permutations = 999), with pairwise comparisons showing that all years were significantly different from one another except for 2013 and 2018, which were not significantly different from one another. Differences between years appear to be due to the establishment of dominant *Sicyonia penicillata* communities in POLA/POLB beginning in 2013. This change is highlighted by the shift in E.I. values (discussed in more detail in Appendix F) and E.I. ranks compared to secondary invertebrate species. These analyses resulted in a total of nine SIMPROF-supported cluster groups, or types of trawl invertebrate assemblages (cluster groups A-I; Table 13, Figure 27, Figure 28), which were overlaid on station maps to examine spatial distribution. These assemblages represented from 2 to 75 trawls each and ranged from 16 to 29% similarity (mean = 23%) for clusters with more than one trawl. A BEST/BVSTEP test ($\rho = 0.954$, $p = 0.0001$, number of permutations = 9999) implicated *Acanthoptilum* sp (Sea Pen), *Arcularia tiarula* (Western Mud Nassa), *Astropecten armatus* (Spiny Sand Star), *Bulla gouldiana* (California Bubble Snail), *Ciona robusta* (Sea Squirt), *Crangon nigromaculata*, *Farfantepenaeus californiensis* (Yellowleg Shrimp), *Musculista senhousia* (Asian Date Mussel), *Navanax inermis* (California Aglaja), *Philine auriformis* (New Zealand Bubble Snail), and *Pyromaia tuberculata* (Tuberculate Pear Crab) as being influential to the pattern (gradient) observed in Figure 27. SIMPROF groups largely reflected spatial differences between embayments (e.g., Group D primarily within POLA/POLB), as well as potential habitat types such as shallow eelgrass beds within Mission Bay and SDB – South. Group H was the most prevalent example with large degrees of overlap between the middle and inner portions of Mission Bay and SDB – Central and SDB – South where the communities were dominated by the *Musculista senhousia* and ascidians. There were no discernible patterns for megabenthic invertebrate assemblages associated with areas that may be more impacted (e.g., marinas, constricted channels) within the larger embayments.

Coastal Shelf and Slope Strata

Multivariate analyses of megabenthic invertebrate communities on the SCB shelf and slope included a total of 898 trawls conducted during Bight Surveys (Bight '94 – Bight '18). These analyses resulted in 13 main ecologically-relevant SIMPROF-supported groups, or types of megabenthic invertebrate assemblages (Table 14, Figure 29, Figure 30). These assemblages represented from 1 to 505 trawls each and ranged from 9 to 70% similarity (mean = 29%) for clusters with more than one trawl. A BEST/BVSTEP test ($\rho = 0.954$, $p \leq 0.001$, number of permutations = 999) implicated *Acanthoptilum* sp, *Apostichopus californicus* (California Sea Cucumber), *Astropecten californicus* (Sand Star), *Brissopsis pacifica* (Pacific Heart Urchin), *Crangon nigromaculata*, *Luidia foliolata* (Sand Star), *Lytechinus pictus*, *Myxoderma platyacanthum* (Sea Star), *Octopus rubescens* (Red Octopus), *Ophiura luetkenii* (Brokenspine Brittlestar), *Pleurobranchaea californica* (California Sea Slug), *Pyromaia tuberculata, Sicyonia ingentis,* and *Strongylocentrotus fragilis* as being influential to the overall pattern (gradient) of the cluster dendrogram. As with demersal fishes, there were no discernible patterns in the megabenthic invertebrate assemblages associated with survey year or proximity to known pollution sources (e.g., major POTW discharge sites). Instead, invertebrate assemblages also appeared to be influenced primarily by depth (Figure 30 Figure 31) and most likely unique characteristics of specific station locations (e.g., habitat differences), and/or the unique composition of invertebrate assemblages. Ten of the invertebrate cluster groups (groups A, B, C, D, F, G, H, I, J, L) were small "outlier" clusters with ≤ 5 trawls in each group. With the exception of cluster group F, these trawls had low species richness (≤ 7 species per haul), whereas mean abundance per trawl was highly variable (1 – 735 organisms per haul). Sixty-seven percent (67%) of these trawls were from sites located north of Point Dume (Figure 30A). The remaining clusters (groups E, K, M) each spanned the entire SCB (Figure 30B), representing the transition of common invertebrate assemblages from the Inner Shelf to the Upper Slope. The species composition and main descriptive characteristics of each cluster group are included in Appendix F, along with additional analyses of group E, K and M sub-groups.

Table 13. Description of Bays & Harbors invertebrate cluster groups A–I defined in Figure 27 and Figure 28.

	Cluster Group								
	A	B	C	D	E	F	G	H	I
Total No. Trawls	1	2	10	75	3	4	13	29	1
Average Similarity (%)	*	24	29	22	16	24	25	23	*
Mean Species Richness	2	5	5	6	4	7	5	4	3
Mean Abundance	4	17	157	112	16	664	42	97	10
Depth (m)									
Min	15	4	5	3	7	3	3	3	7
Max	15	13	18	25	27	12	10	13	7
Mean	15	8	12	14	15	6	5	6	7
%Trawls by Survey									
1998	0	100	10	43	33	0	8	45	0
2003	100	0	0	9	0	100	15	3	0
2008	0	0	30	9	0	0	62	0	100
2013	0	0	20	20	67	0	15	24	0
2018	0	0	40	19	0	0	0	28	0

* Similarity only calculated for groups with >1 trawl

Figure 27. Shade plot of Top 50 megabenthic invertebrate species by embayment. (Note that shading is the log-transformed abundance value normalized to the range of values for each species).

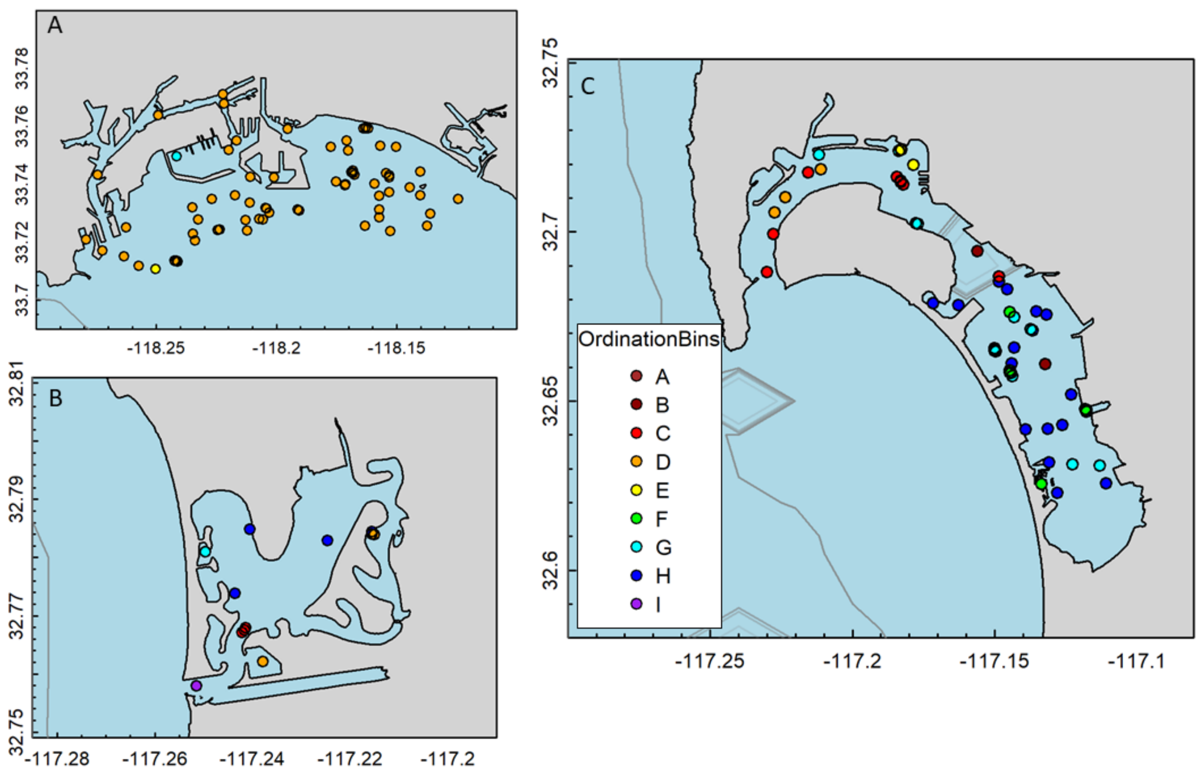


Figure 28. Demersal invertebrate SIMPROF groups within POLA/POLB (A), Mission Bay (B) and San Diego Bay (C).

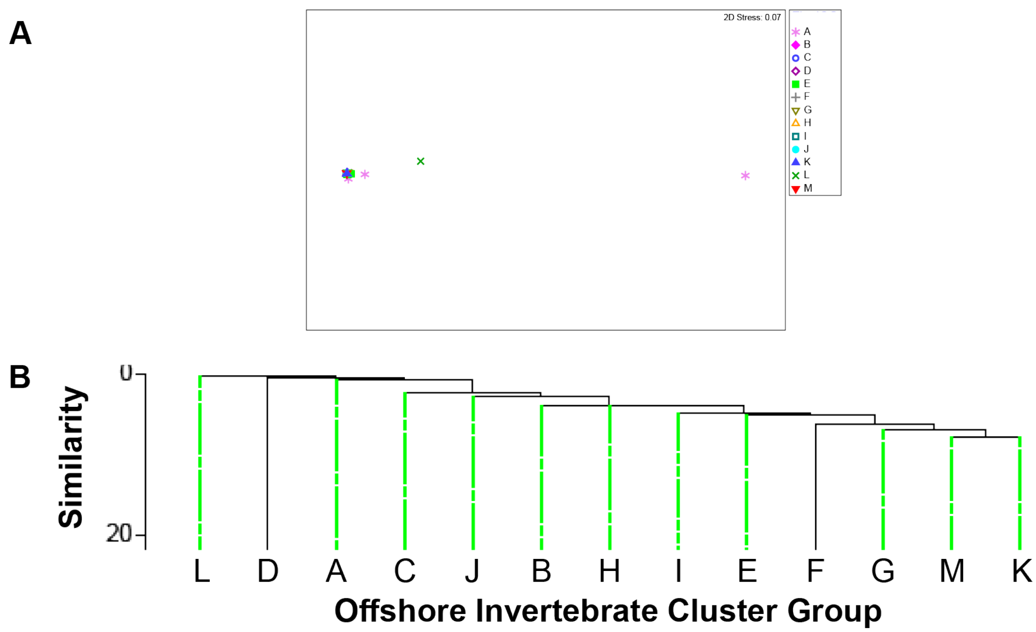


Figure 29. Results of ordination and cluster analysis of megabenthic invertebrate assemblages from Bight trawl stations sampled in 1994, 1998, 2003, 2008, 2013, 2018. Data are presented as (A) nMDS ordination and (B) a dendrogram of main cluster groups. Groups were named to increase with depth.

Table 14. Description of offshore invertebrate cluster groups A–M defined in Figure 29.

	Cluster Group												
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
No. of Trawls	4	4	1	1	117	1	3	4	2	5	505	2	249
Average Similarity (%)	18	20	*	*	19	*	31	30	46	9	22	70	24
Mean Species Richness	4	7	1	1	5	14	5	3	2	8	10	3	13
Mean Abundance	576	20	1	1	29	735	40	9	3	115	574	113	2569
Depth (m)													
Min	8	16	29	31	7	88	20	41	50	162	9	461	33
Max	18	28	29	31	36	88	148	195	200	200	227	477	479
Mean	13	21	29	31	17	88	99	91	125	175	61	469	252
%Trawls by Survey													
1994	0	0	0	0	9	0	33	0	0	0	15	0	9
1998	50	50	100	100	34	0	33	50	100	60	30	0	11
2003	0	50	0	0	20	0	0	0	0	20	21	0	20
2008	0	0	0	0	10	100	0	0	0	0	11	0	21
2013	0	0	0	0	14	0	0	0	0	0	13	50	22
2018	50	0	0	0	14	0	33	50	0	20	9	50	16

* Similarity only calculated for groups with >1 trawl

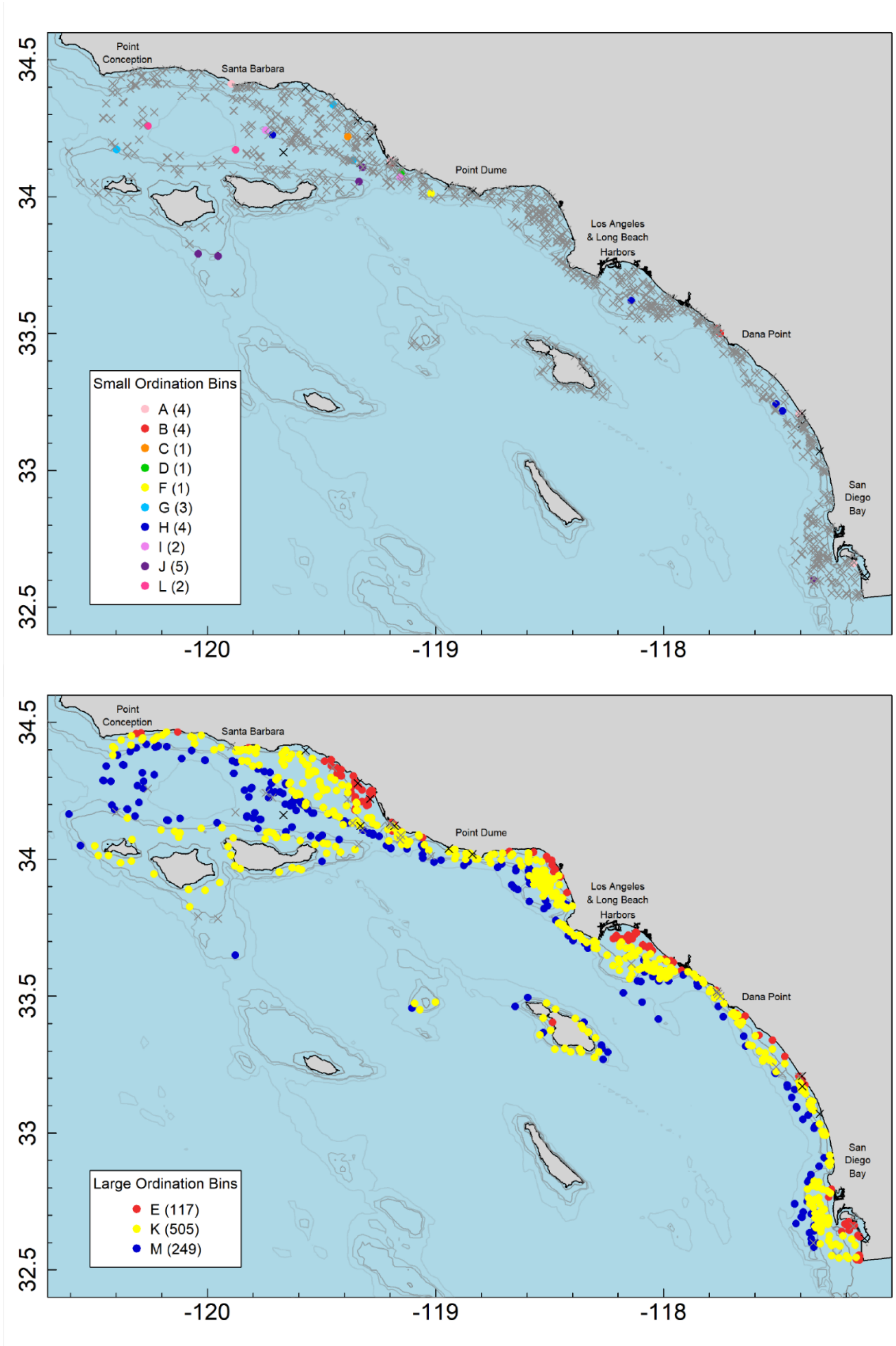


Figure 30. Distribution of (A) small "outlier" offshore invertebrate cluster groups (n ≤ 5 trawls) and (B) large groups (n > 5 trawls). Excluded trawls with no invertebrates are shown as "X".

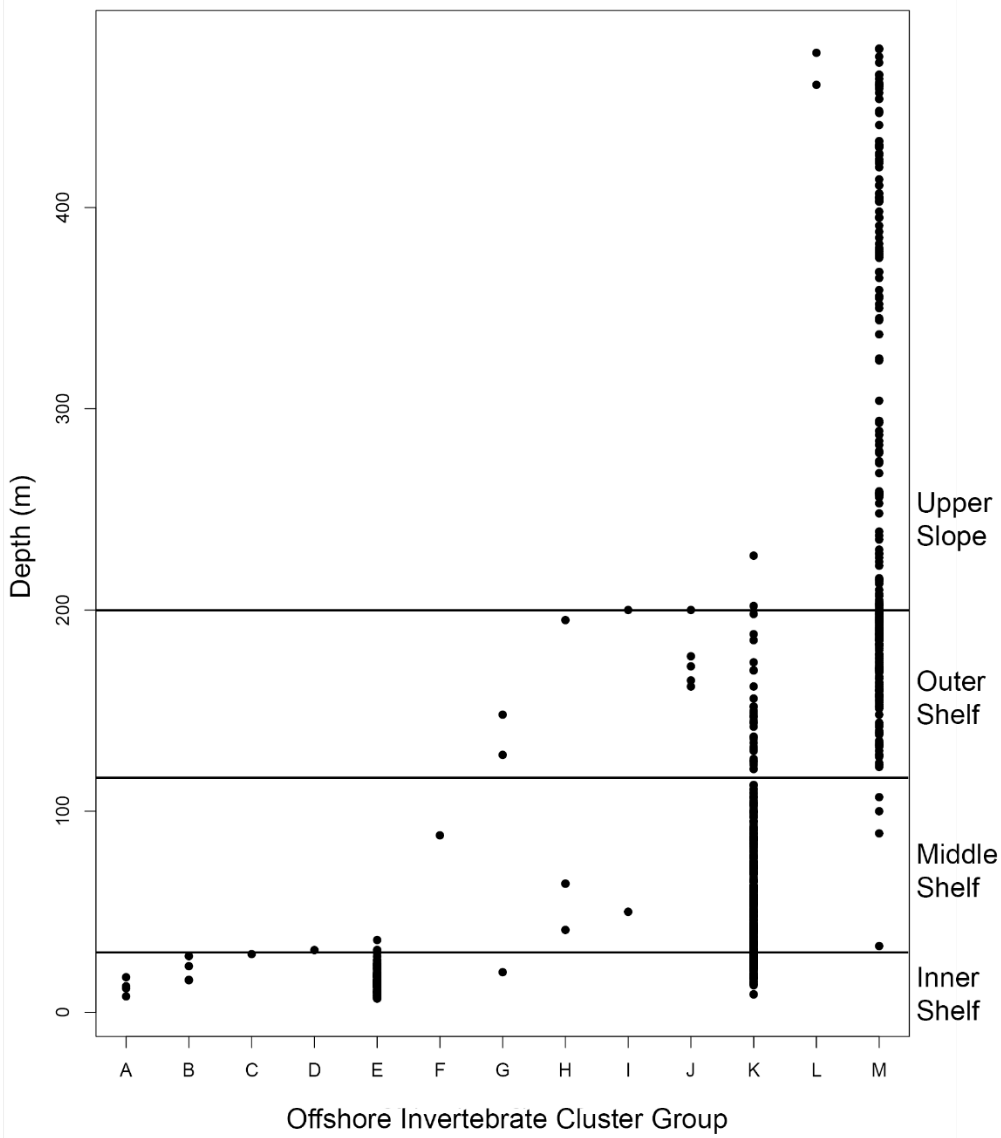


Figure 31. Depth distribution for each offshore invertebrate cluster group described in Figure 29. Each data point represents a single trawl.

Trends in Megabenthic Invertebrate Population Attributes

The relative dominance of the top ten megabenthic invertebrate species by abundance for each stratum collected for all Bight trawl surveys was variable across Bight surveys (Figure 32). *Pyromaia tuberculata*, *Crangon nigromaculata*, *Sicyonia penicillata*, and *Dendraster excentricus* were the most abundant invertebrates collected in Bays & Harbors during Bight '98, Bight '03, Bight '08, Bight '13 and Bight '18, respectively. *Astropecten californicus* was the most abundant invertebrate collected on the Inner Shelf during Bight '94, Bight '03, Bight '08, and Bight '13. *Dendraster excentricus* was the most abundant invertebrate collected on the Inner Shelf in Bight '18 and was encountered in record high numbers (2,117 individuals) however, it was only collected at two sites. *Lytechinus pictus* was the most abundant invertebrate on the Middle Shelf over every Bight survey, except Bight '13, when *Ophiura luetkenii* was most abundant. *Strongylocentrotus fragilis* was most abundant on the Outer Shelf in Bight '03, Bight '08 and Bight '13 surveys. *Lytechinus pictus* was most abundant on the Outer Shelf in Bight '94, *Sicyonia ingentis* was most abundant in Bight '98, and *Pleuroncodes planipes* was most abundant in Bight '18, with record high numbers collected (51,724 individuals). *Brisaster latifrons* (Northern Heart Urchin) was the most abundant species collected on the Upper Slope in Bight '03 and *Brisaster townsendi* (Heart Urchin) was most abundant in Bight '08 and Bight '13. Similar to the Outer Shelf, *Pleuroncodes planipes* was collected in record high numbers on the Upper Slope during Bight '18 (80,248 individuals).

The Ecological Index (E.I.) rank of species uses three ecological variables (abundance, biomass and frequency of occurrence) to determine the ecological importance of species. Similar to abundance, the ranking of top ten invertebrate species by E.I. for each stratum collected for all Bight trawl surveys was variable for all strata (Figure 33). The first ranking invertebrates in Bays & Harbors were *Pyromaia tuberculata* in Bight '98, *Porifera* sp SD 4 in Bight '03, *Suberites latus* in Bight '08, and *Sicyonia penicillata* in Bight '13 and Bight '18. *Astropecten californicus* ranked first on the Inner Shelf in Bight '94, Bight '03 Bight '08 and Bight '13. *Crangon nigromaculata* and *Dendraster excentricus* ranked first on the Inner Shelf in Bight '98 and Bight '18, respectively. *Lytechinus pictus* ranked first on the Middle Shelf in Bight '94, Bight '98, Bight '03 and Bight '08. *Ophiura luetkenii* and *Sicyonia ingentis* ranked highest on the Middle Shelf in Bight '13 and Bight '18, respectively. *Strongylocentrotus fragilis* ranked first on the Outer Shelf in Bight '94, Bight '03, Bight '08 and Bight '13. *Sicyonia ingentis* ranked first on the Outer Shelf in Bight '98 and *Pleuroncodes planipes* ranked first in Bight '18. *Brisaster latifrons* ranked first on the Upper Slope in Bight '03, while *Briaster townsendi* ranked first in Bight '08 and Bight '13. Similar to the Outer Shelf, *Pleuroncodes planipes* ranked first on the Upper Slope during Bight '18.

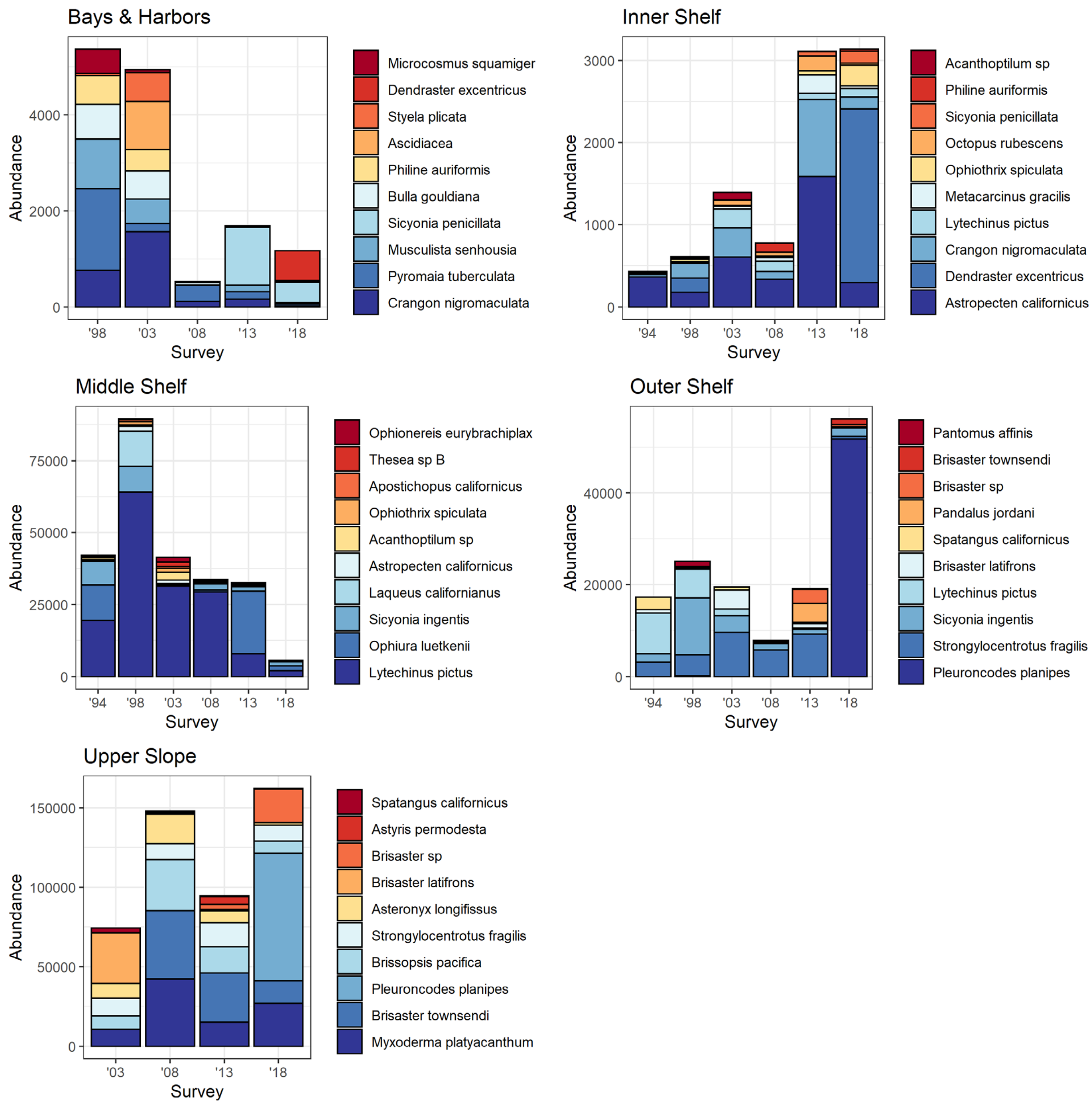


Figure 32. Top ten megabenthic invertebrate species by abundance for each stratum collected for all Bight trawl survey. The invertebrate species are sorted from most abundant (bottom) to least abundant (top) within a stratum for all years.

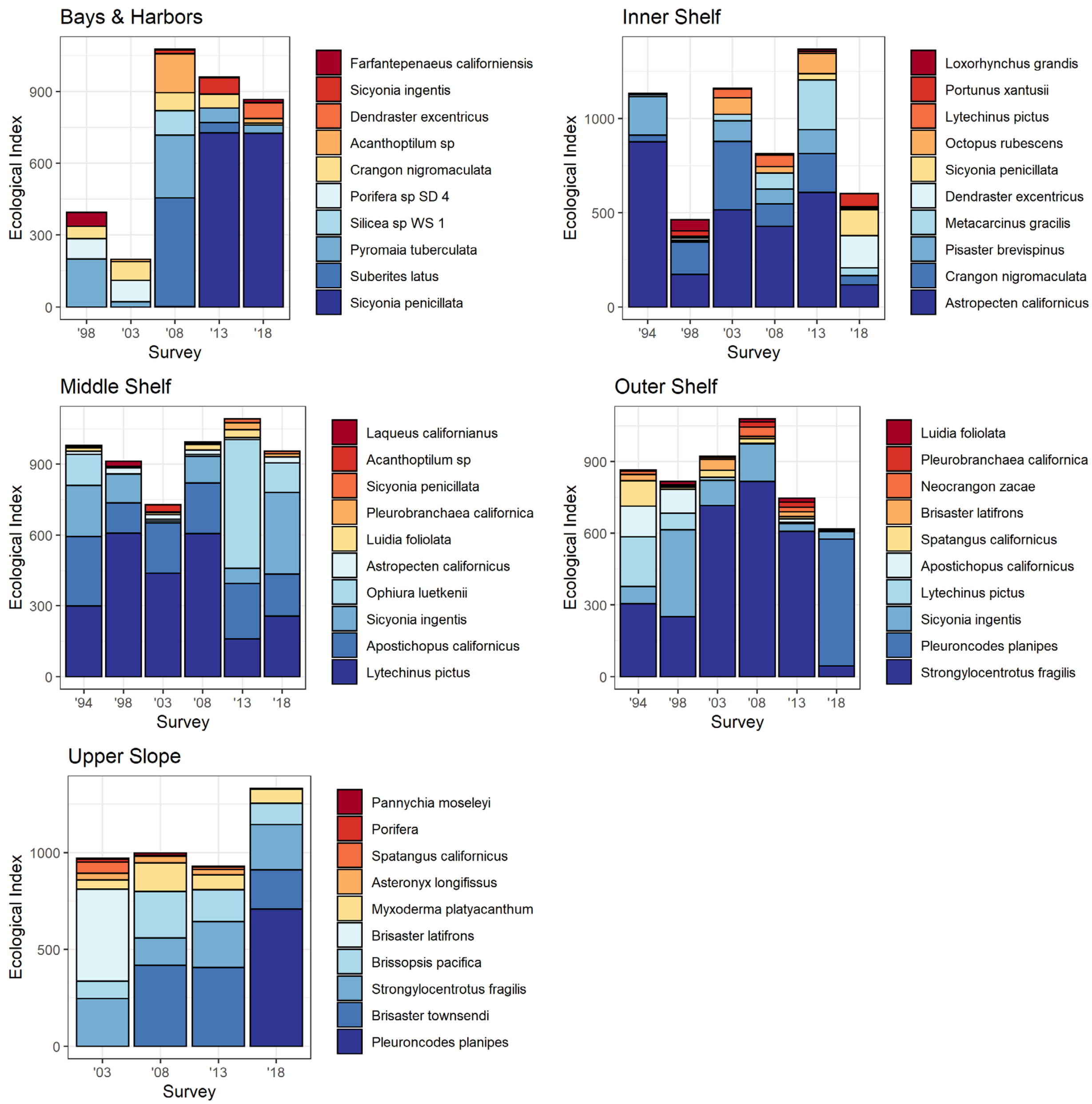


Figure 33. Top ten megabenthic invertebrate species ranked by Ecological Index (E.I.) for each stratum collected for all Bight trawl survey. The invertebrate species are sorted from the highest E.I. (bottom) to lowest E.I. (top) within a stratum for all years.

IV. Discussion

No evidence of contaminant exposure in SCB demersal fish populations

More than 46,000 fish were collected in the SCB during Bight ’18. Based on two primary lines of evidence (anomalies indicative of stress and Fish Response Index), the SCB fish populations appeared healthy in 2018, suggesting little evidence of contaminant exposure impacting demersal fish communities. Trends analysis of only revisit sites indicates that the majority of the SCB shelf is in “stable condition,” with no significant trend in either improving or declining condition over time. Furthermore, across all Bight surveys, FRI scores have been consistently in reference condition and stress-associated anomalies consistently low, suggesting SCB demersal fish populations have been generally healthy since the 1994 Bight survey and that there is no evidence of long-term trends in indicators of contaminant exposure in fish communities. Additionally, based on multivariate analyses, there were no discernible patterns in these demersal fish assemblages that could be associated with known pollution sources (e.g., proximity to major POTW discharge sites). Instead, communities appeared to be influenced primarily by depth, followed by habitat differences, and the occasional occurrence of unique assemblages.

Few anomalies indicative of stress (tumors, fin erosion and lesions) were observed during the Bight '18 survey and they were scattered throughout the SCB, with no clear association with any single region. In Bight '18, anomalies indicative of stress were found on 18 fish at 7 stations and affected 0.05% fish examined. This falls within the typical range for all Bight surveys, where anomalies indicative of stress were consistently low and ranged from 0.03% in Bight '08 to 0.16% in Bight '94. Tumors were the most common anomaly indicative of stress in all Bight surveys, followed by lesions and fin erosion. The rate of anomalies indicative of stress remains low when compared to surveys conducted in the 1970s when fin rot and tumors were observed in 31% and 3.3%, respectively, of Dover Sole collected between Pt. Conception and San Diego (Word et al. 1977).

Using the FRI to measure fish community response to pollution gradients on the continental shelf (Allen et al. 2001), we found that 98.8% of the Bight area and 97.6% of sites were in reference condition in Bight '18. Historically, over 90% of trawled fish in the SCB survey area has remained in reference condition based on these Bight surveys. Out of 784 Bight survey shelf stations, 45 had FRI scores associated with non-reference conditions (6% of stations). Eighty-seven percent (n=39) of these stations occurred on the Inner Shelf. Thirty-three of the non-reference stations were located in the northern Bight, occurring from Point Dume to Point Conception. However, non-reference stations did not consistently correspond to "outlier" cluster groups determined by multivariate analyses. Whereas 93% of the trawls that fell into one of these outlier groups occurred north of Point Dume, 90% of those from applicable depths were considered in reference condition. This suggests that the demersal fish assemblages in the northern Bight are different from the areas where the FRI was developed, and elevated FRI values in this region perhaps are not indicative of sediment contamination.

The FRI was developed for the Inner, Middle and Outer Shelf with a depth range of 9 to 215 m, therefore the index was not applied to the Bays & Harbors and Upper Slope. In addition, the index was not validated on the Inner Shelf and Outer Shelf due to the lack of appropriate validation models. Allen et al. (2001) acknowledged that their effort provides an important first step in demersal fish index development for the southern California shelf and recommended a continued examination of this index. A critical review of the FRI is recommended to determine whether the index is sensitive to pollution gradients throughout the SCB and if this index could be applied to Bays & Harbors. It may be necessary to update the FRI or develop a new index based on the outcome of a critical review.

Fish community composition shows significant variability across Bight Surveys

Northern Anchovy was the most abundant fish collected during the Bight '18 survey, followed by Pacific Sanddab and Slough Anchovy. Northern Anchovies were collected in numbers that were 3 times greater than the next highest abundance collected in Bight ’98. Slough Anchovies were collected in numbers that were 6 times higher than the next highest abundances in Bight ’13. The record high numbers of Northern and Slough Anchovies collected during the Bight ’18 survey were found at few stations and Slough Anchovies were only collected in Bays & Harbors in San Diego and Mission Bay, with 88% of Northern Anchovies collected at 2 sites and 66% of Slough Anchovies collected at 1 site. Yearly regional monitoring by California Cooperative Oceanic Fisheries Investigations (CalCOFI) has found consistently high densities of young of the year anchovy in the SCB starting in 2015, with a significant increase in the abundance of adult Northern Anchovy in 2018 and 2019 (Thompson et al. 2018, 2019), similar to the increase in these species observed in the Bight ’18 survey.

The Ecological Index (E.I.) was calculated for the first time in Bight trawl reports. The E.I. incorporates three ecological variables: % Number, % Weight, and % Frequency of Occurrence (E.I. = (%N + % Wt)* %FO; Allen et al. 2002; Williams et al. 2015b). By incorporating these three values into an index, it gives us information regarding the ecological importance of a species to the ecosystem energy flow (Allen et al. 2002; Williams et al. 2015). The E.I. was calculated for each stratum for all Bight surveys. In Bight ’18, Slough Anchovy ranked highest in the Bays & Harbors, followed by White Croaker. Northern Anchovy ranked third in Bays & Harbors and seventh on the Inner Shelf.

The E.I. was more variable across survey years in Bays & Harbors and Inner Shelf than Middle & Outer Shelf and Upper Slope for all Bight surveys. Four different species ranked highest in Bays & Harbors (White Croaker, California Halibut, California Lizardfish and Slough Anchovy) and three different species ranked highest on the Inner Shelf (Speckled Sanddab, White Croaker and California Lizardfish). Two species ranked first on the Middle Shelf (Pacific Sanddab and California Lizardfish) and one species ranked first on the Outer Shelf and Upper Slope (Pacific Sanddab and Slender Sole, respectively).

Despite variability in fish community composition, there was no discernable trend in fish abundance, biomass, taxonomic richness, or Shannon diversity over multiple surveys. Trends analysis of only revisit sites shows that the majority of the SCB (> 90% of area) is “stable,” with no significant trends in either H' diversity or taxonomic richness.

Megabenthic invertebrate’s community attributes have remained similar across Bight surveys

More than 237,000 invertebrates were collected in the SCB during Bight ’18. Currently, there are no reliable biointegrity assessment tools for trawl-caught invertebrates (Walther et al. 2017). However, invertebrate community attributes have shown little change across Bight cycles, suggesting no declines or improvement in biointegrity. The only noticeable pattern was a slight decrease in H' diversity in Bays & Harbors, which is likely due to the establishment and dominance of *Sicyonia penicillata* in 2013 and 2018. Furthermore, observed anomalies in invertebrates were infrequently encountered (0.01% of individuals). Trends analysis of only revisit sites shows that the majority of the SCB (> 90% of area) is “stable,” with no significant trends in either H' diversity or taxonomic richness. Finally, as with the fish, there were no discernible patterns in megabenthic invertebrate assemblages that could be associated with potential stressors (e.g., proximity to wastewater or stormwater discharge sites). Instead, communities appeared to be influenced primarily by depth, followed by habitat differences, and the occasional occurrence of unique assemblages.

Megabenthic invertebrate population composition shows significant variability across Bight Surveys

Pleuroncodes planipes was collected in record high numbers during Bight '18 (n=131,995), with the majority collected on the Outer Shelf and Upper Slope in the San Diego region. *Dendraster excentricus* was collected in historic high numbers in Bays & Harbors and on the Inner Shelf during Bight '18. The E.I. was calculated for each stratum for all Bight surveys. The E.I. ranks were variable throughout the Bight surveys with the exception of the Inner Shelf where *Astropecten californicus* scored highest during Bight '94 through Bight '13 and *Dendraster excentricus* ranked first in Bight '18. The occurrence of invertebrate anomalies was low during Bight '18 and occurred in 0.11% of invertebrates examined.

The Bight Program fills a need for regional monitoring of demersal fish and megabenthic invertebrate communities

The Bight Regional Monitoring Program is valuable because data are collected to examine temporal and spatial patterns. This allows managers to put local monitoring in context with the rest of the region. In addition, monitoring provides a unique mechanism to examine biological communities, habitats, changing oceanographic environment and identify shifts in baseline conditions (Schiff et al. 2016). The Bight '18 program has documented changes in community composition and ecological condition since 1994. These changes, while not obviously linked to contaminant exposure, might be linked to broad regional changes in temperature, dissolved oxygen, ocean currents, and ocean acidification. Changes in community composition related to El Niño temperature shifts have been documented in the Bight (Miller and Schiff 2012). Sato et al. (2017) documented habitat compression and expansion and shifts in populations of trawl-caught sea urchins in the SCB. The trends may have been linked to variability in environmental conditions such as oxygen and pH associated with El Niño, frontal weather patterns, upwelling intensity, and ocean warming. Climate change is expected to intensify ocean warming, hypoxia, and acidification, and decrease productivity in the SCB, which may result in habitat range shifts for fish and invertebrate species (Bograd et al. 2008; Bednaršek et al. 2014; Howard et al. 2020). Continued monitoring of demersal species in light of global changes in ocean habitats will continue to provide important contextual information for Southern California coastal managers.

V. Conclusions

The Bight '18 Program provided a regional assessment of trawled demersal fishes and megabenthic invertebrates in the SCB. Based on the results of this survey, the Demersal Fishes and Megabenthic Invertebrates Technical Committee concluded that:

- **Southern California Bight trawl-caught fish communities are in good condition.** Nearly 99% of the SCB had FRI values indicative of reference conditions at shelf sites. Although, we did not apply FRI to Bays & Harbors and Upper Slope because the tool was not calibrated for these habitats, overall fish anomalies, particularly those associated with stress, were low region-wide. There were no consistent patterns in fish anomalies or

Shannon diversity (H') in the Bight, and anomalies were typically limited to one individual in the catch.

- **Extent of SCB in reference condition has remained similarly high over the six Bight surveys spanning 24 years.** Percent of reference area based on the FRI has ranged from 93%, in Bight '03 to 99% in both Bight '94 and '18. Over the years, a few sites have presented with "non-reference" FRI, but there is generally no clustering of these sites, with the notable exception of the Santa Barbara Channel. Similarly, fish community metrics, abundance, biomass, and H' diversity have also remained comparable throughout the history of the Program.

- **Fish anomalies have decreased since Bight '98.** Though low in all surveys, fish anomalies have decreased from ~1.5% in Bight '98 to ~0.25% in Bight '18. The most significant reduction in stress-related anomalies occurred between the 1994 and 1998 surveys. Tumors were the most common anomaly.

- **Northern Anchovies Anchovy, Pacific Sanddab and Slough Anchovy had the highest abundance in Bight '18 (9,914; 7,438; 4,744 individuals, respectively).** Record-high numbers of both Northern and Slough Anchovies were collected during Bight '18 (next highest abundance was 3,105 (Bight '98) and 697 individuals (Bight '13), respectively). Pacific Sanddab had the second highest abundance in Bight '18; however, it fell within the range of other Bight surveys of 4,125 (Bight '94) to 19,004 individuals (Bight '13). The record high California Lizardfish abundance observed in Bight '13 (13,434 individuals) decreased to 796 individuals in Bight '18. Fish abundances and ecological indices were most highly variable in Bays & Harbors and on Inner Shelf and Middle Shelf strata, with Outer Shelf and Upper Slope strata remaining more consistent from survey to survey.

- ***Pleuroncodes planipes* had record high numbers in Bight '18 (n=131,995) and was most abundant on the Outer Shelf and Upper Slope (51,724 and 80,248 individuals, respectively).** *Dendraster excentricus* was encountered in record high numbers in Bight '18 (2,914 individuals) in Bays & Harbors on the Inner Shelf however, they were encountered at only 4 sites. The relative dominance of the top ten megabenthic invertebrate species by abundance and ecological indices for each stratum collected for all Bight trawl surveys was variable.

VI. Recommendations

Recommendations from 2018 Bight Program

Based on the efforts from Bight '18, the Sediment Quality Planning and Demersal Fish and Megabenthic Invertebrates Technical Committee agree on the following recommendations to follow up on current survey results or to improve the next regional survey implementation.

- **Critically review and, if needed, update the Fish Response Index (FRI).** As noted above, the FRI only applies to the shelf (9 – 215 m) and hasn't been updated since its development and was not calibrated to assess the Bays & Harbors and Upper Slope. No progress on the recommendation to review and update the FRI has been made since 2013.

It is recommended to review the FRI to determine if the current tool is applicable to Bays & Harbors and if we need a better tool for trawl fish assessments (e.g., Observed/Expected).

- **Use local environmental context data to characterize species distribution changes over time.** Trawl caught species have experienced distribution shifts over time. These changes may be related to local environmental changes in temperature, dissolved oxygen and pH. Regional Ocean Model coupled to Biogeochemical Elemental Cycling (ROMS-BEC) model runs through 2018 are currently being conducted and validated against observational data. These datasets will be available in 2021 and will allow for analysis of trawl-caught benthic communities with the context of changing temperature, dissolved oxygen, and acidification regimes. To further improve ROMS-BEC validation, agencies should consider installing DO sensor packages to otter trawls for future surveys. These sensors can both provide oceanographic context to biological measurements and can be used for validation of ROMS-BEC into the future. Other local empirical data may also be used to characterize these changes.

- **Continue to improve information management.** Information management has improved greatly over the course of the Bight program. However, there is still work to be done. Inconsistencies in field classification, changes in species to include/exclude in the data analysis and changes to species names will continue to affect the program. Information Management for the Trawl group must continue to stay on top of these changes as our knowledge grows. Before the next survey, three tasks should be completed to continue to improve IM. Firstly, the group should continue to engage in a synoptic data review of Bight historic datasets to integrate them into a unified dataset which includes the Bight '23 trawl survey data. A synoptic data review is needed to resolve changes in look-up lists and taxa included or excluded from analysis and metadata accompanying the datasets, including documentation of data changes amongst Bight surveys. The Trawl dataset should be considered a "living" dataset and metadata should be updated during every Bight cycle and posted online. Secondly, before the next Bight survey the field manual should be updated to clarify which fish/invertebrate species should be excluded in the final dataset to avoid post-hoc revisions to the final dataset. This should be done for both data submission checks and narrative sections of the manual. Finally, to increase transparency in the Program's data analysis, as well as in the interest of repeating analysis in future surveys, all R scripts used to generate the report should be posted online.

- **Continued support of regional taxonomic societies that improve the comparability and quality of species identifications amongst regional Bight survey participants.** As in the Bight '13 Program, the Trawl Technical committee continues to recommend support of regional scientific associations including The Southern California Association of Ichthyological Taxonomists and Ecologists (www.SCAITE.org) and the Southern California Association of Marine Invertebrate Taxonomists (www.SCAMIT.org), in order to maintain the high level of quality assurance and quality control of trawl-caught fish and invertebrate assemblages in the Bight Program.

Recommendations from 2013 Bight Program

To ensure the Bight program continues to improve over time, Bight '18 followed through on some of the recommendations from Bight' 13, while others remain unresolved:

1. **Critically review and update the Fish Response Index (FRI)**. The FRI is a useful tool for assessing whether fish communities are healthy based on the pollution tolerance weighted abundance of all species found in a trawl. Though it is known that certain species have variable sensitivities to pollution, some scientists suspect that the FRI may have sensitivity to certain species, and the index cannot be applied beyond shelf depth. The FRI needs to be evaluated and either modified to overcome these limitations or a more robust approach for assessing the biointegrity of fish needs to be developed. Since the 2013 survey, the Trawl Technical Subcommittee decided not to apply the FRI to embayment strata, citing concerns about the aforementioned robustness of the index.

2. **Improve information management.** This recommendation emerged from a desire to minimize errors which occurred during data submission and reporting. An improved information management system was expected to expedite the quality assurance and quality control of data, allowing the technical committee to have greater confidence in the quality of final datasets, which in turn would speed up the time to get to data analysis and interpretation. The Trawl Technical Committee worked directly with SCCWRP IT specialists to implement the suggestions from previous surveys into a series of automated data checkers for Bight '18. This online data checker evaluated the data inventory and quality control results expected from the participating agencies, which was an improvement to the data submission process relative to the previous surveys.

3. **Further investigate linkages between biological and oceanographic condition.** Long-running regional monitoring data provides a unique mechanism to examine biological communities and habitats within a changing oceanographic environment. A recommendation from the Bight '13 program was to examine regional trawl-caught community data within the context of broad, regional oceanographic regime changes. This analysis could include comparing observational datasets from regional and local fish and invertebrate trawls with environmental observations from Bight Partners (CalCOFI, SCCOOS, Regional POTWs), regional environmental indices such as the El Niño and NPGO indices, and modeled data outputs. Through these comparisons, we will be able to better understand the effects of broad oceanographic changes on epibenthic communities. Observational data are readily available for these comparisons, and the models are being run for years which overlap with Bight Program years, so work on this recommendation is ongoing.

4. **Continue to incorporate SCAITE and SCAMIT into pre-field surveys to further improve in-field identifications.** This recommendation stems from a continued desire to maintain the high levels of quality assurance and quality control of trawl-caught fish and invertebrate assemblages during Bight Programs. These improvements have been largely a function of increased emphasis of pre-field training activities on methods and species identifications. Bight '13 indicated that these activities should be continued in collaboration with local scientific societies with parallel missions: The Southern California Association of Ichthyological Taxonomists and Ecologists

(www.SCAITE.org) and the Southern California Association of Marine Invertebrate Taxonomists (www.SCAMIT.org). Bight ’18 Trawl committee continued this association and felt so strongly about the benefits of the collaborations, that it is once again a recommendation of the Bight ’18 Program.

5. **Evaluate additional indicators of contaminant impacts.** The measurements of abundance, H' diversity, biomass, age structure and external health anomalies have traditionally been used to assess the condition of demersal fishes and megabenthic invertebrates, and whether there have been effects of contaminant exposure on a community level. Additional indicators of organism response that are linked to sublethal effects of contaminant exposure, such as changes in tissue pathology and molecular markers (e.g., genes, hormones), should be evaluated for inclusion in future trawl surveys to the extent feasible, focusing on embayment strata where healthy fish communities were found less frequently. There was no progress on this recommendation in the Bight ’18 Program.

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APPENDIX A – SAMPLING LOCATIONS

Table A15. Bight '18 Trawl Sampling Locations.

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10000	Revisit	Yes	Bay	0.26923	CLA-EMD	33.75940	-118.16267	50	320.4	5	6	6	5.1	3.9	20.9
B18-10001	New Site	Yes	Bay	0.26923	CLA-EMD	33.75298	-118.15022	63	341.6	7	7.9	6	4.9	8.5	19.6
B18-10002	Revisit	Yes	Bay	0.26923	CLA-EMD	33.74422	-118.16873	84	340.8	10.4	11.6	6	5.1	11.1	19.8
B18-10003	New Site	Yes	Bay	0.26923	CLA-EMD	33.74379	-118.13986	63	401.4	7	7.8	7	6.5	12.5	19.8
B18-10004	Revisit	Yes	Bay	0.26923	CLA-EMD	33.74272	-118.15320	78	412	9.5	10.2	7	6.8	13.1	18.8
B18-10005	New Site	Yes	Bay	0.26923	CLA-EMD	33.74081	-118.17514	87	309	11	12	6	4.8	27.8	19
B18-10006	Revisit	Yes	Bay	0.26923	CLA-EMD	33.73980	-118.17132	87	348.3	11	12.2	7	8	7.8	18.7
B18-10007	New Site	Yes	Bay	0.26923	CLA-EMD	33.73370	-118.21135	128	354.4	19.3	20.2	6	4.8	17.2	16.7
B18-10008	Revisit	Yes	Bay	0.26923	CLA-EMD	33.73168	-118.20415	132	366.8	20	21.2	6	4.8	7.5	17
B18-10009	Revisit	No	Bay	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10010	New Site	No	Bay	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10011	Revisit	Yes	Bay	0.26923	CLA-EMD	33.72421	-118.22437	113	258.6	15	15.6	6	5	34.6	17.2
B18-10012	Revisit	Yes	Bay	0.26923	CLA-EMD	33.71345	-118.24131	148	330.6	23.8	24.6	6	4.8	23	15.1
B18-10016	New Site	Yes	Bay	0.26923	WOOD	32.78487	-117.24052	15	382	4	3.3	6	7	174.5	21.3
B18-10017	Revisit	Yes	Bay	0.26923	WOOD	32.78448	-117.21536	12	373.2	3.7	3.2	6	6.5	134.7	26.7
B18-10019	Revisit	Yes	Bay	0.26923	WOOD	32.76791	-117.24148	29	586.5	7.9	7.3	11	9.5	33.4	21.7

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10022	Revisit	Yes	Bay	0.26923	WOOD	32.72415	-117.18298	42	535.5	11.9	11.1	10	8.8	175.9	19.1
B18-10023	New Site	Yes	Bay	0.26923	WOOD	32.71746	-117.21593	60	564.6	15.7	15.8	9	10.3	32.9	16.6
B18-10024	Revisit	Yes	Bay	0.26923	WOOD	32.71496	-117.18291	42	591.9	11.7	11.5	10	10.3	10.2	19.5
B18-10030	New Site	Yes	Bay	0.26923	WOOD	32.68796	-117.23051	80	597.2	17.2	19	10	9.8	1.8	13.4
B18-10034	Revisit	Yes	Bay	0.26923	WOOD	32.66518	-117.14980	16	588.9	4.7	4.5	10	8.7	2.8	25.4
B18-10036	Revisit	Yes	Bay	0.26923	WOOD	32.65834	-117.14422	16	595.8	4.9	4.7	11	10.5	45.7	25.7
B18-10037	Revisit	Yes	Bay	0.26923	WOOD	32.64694	-117.11824	40	558.2	11	10.5	11	9.5	63	26.5
B18-10038	New Site	Yes	Bay	0.26923	WOOD	32.64280	-117.12623	20	614.1	4.8	4.7	10	10.3	14.1	25.9
B18-10039	New Site	Yes	Bay	0.26923	WOOD	32.64165	-117.13919	20	310.7	4.7	4.6	7	6.8	76.6	26.3
B18-10042	New Site	Yes	Bay	0.26923	WOOD	32.62581	-117.11154	18	615.7	3	3	10	10.8	51.4	26.2
B18-10204	New Site	No	Inner Shelf	NA	MBC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10205	Revisit	Yes	Inner Shelf	40.4304	ABC Laboratories	34.40395	-119.81211	-88	350.8	17.6	19.1	10	15.2	37.9	16.6
B18-10207	Revisit	Yes	Inner Shelf	40.4304	ABC Laboratories	34.39614	-119.66200	-88	348.4	24.8	24.5	10	13.8	38.9	14.9
B18-10208	New Site	Yes	Inner Shelf	40.4304	ABC Laboratories	34.33408	-119.43462	-88	384.5	19.4	19.8	10	14.3	0.4	16.3
B18-10210	New Site	Yes	Inner Shelf	40.4304	ABC Laboratories	34.24335	-119.38525	-88	420.9	26.2	26.6	10	14	30	14.3
B18-10211	New Site	Yes	Inner Shelf	40.4304	ABC Laboratories	34.22842	-119.35253	-88	376.7	23.5	23.8	10	12	79.1	14.5
B18-10212	New Site	Yes	Inner Shelf	40.4304	ABC Laboratories	34.19945	-119.29609	-88	402.4	18	18.4	10	11.7	49.3	16.7
B18-10213	Revisit	Yes	Inner Shelf	40.4304	ABC Laboratories	34.17863	-119.34714	-88	388.6	26.2	26.7	10	13.7	17.3	14.7
B18-10214	Revisit	Yes	Inner Shelf	40.4304	ABC Laboratories	34.12488	-119.19248	-88	482.5	14.7	14.8	10	14.8	31.4	16
B18-10215	Revisit	Yes	Inner Shelf	40.4304	ABC Laboratories	34.10102	-119.15105	-88	360.4	14.4	15	10	12.2	63.9	15.6

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10218	Revisit	Yes	Inner Shelf	40.4304	CLA-EMD	34.02330	-118.59348	146	628.3	22.3	23.3	11	10.1	12.1	15.4
B18-10219	Revisit	Yes	Inner Shelf	40.4304	CLA-EMD	33.96243	-118.47612	111	624.3	15.8	16.2	11	10	0.6	17.7
B18-10220	Revisit	Yes	Inner Shelf	40.4304	OCSD	33.73338	-118.12203	50	266.1	7	6.3	6	6.3	81.4	21.2
B18-10221	Revisit	Yes	Inner Shelf	40.4304	ABC Laboratories	34.08009	-119.05971	-88	302.2	16.9	17.7	10	12	45.7	15.6
B18-10222	New Site	Yes	Inner Shelf	40.4304	OCSD	33.71037	-118.22166	130	513.5	19	18.9	11	11.9	16.8	16.5
B18-10223	New Site	Yes	Inner Shelf	40.4304	OCSD	33.70516	-118.19199	140	605.3	22	21.8	10	12.2	19.4	15.4
B18-10224	Revisit	Yes	Inner Shelf	40.4304	LACSD	33.69520	-118.29600	143	514.5	27	29.1	11	9.6	8.3	14.4
B18-10225	Revisit	Yes	Inner Shelf	40.4304	OCSD	33.65960	-118.13100	176	491.5	29	28.7	11	9.9	8.5	16.3
B18-10226	Revisit	Yes	Inner Shelf	40.4304	OCSD	33.64340	-118.07874	170	570.4	29	28.2	11	11.7	3.4	14.9
B18-10227	Revisit	Yes	Inner Shelf	40.4304	OCSD	33.62780	-117.98752	105	505.8	15.5	15	11	10.4	12.1	16.3
B18-10228	New Site	Yes	Inner Shelf	40.4304	OCSD	33.61892	-118.04180	176	588.5	29.5	28.8	10	9.3	16.7	14.7
B18-10230	New Site	No	Inner Shelf	NA	OCSD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10231	New Site	Yes	Inner Shelf	40.4304	City of San Diego	33.30719	-117.52339	132	453.2	18.5	19	10	11	11	15.9
B18-10235	New Site	No	Inner Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10237	New Site	Yes	Inner Shelf	40.4304	City of San Diego	32.65983	-117.16843	100	474.9	11.5	11.5	10	10.3	2.9	14.8
B18-10241	New Site	Yes	Mid Shelf	67.3261	MBC	34.43592	-120.23676	350	680.7	75.5	74.8	10	9.7	NA	10.5
B18-10242	New Site	Yes	Mid Shelf	67.3261	MBC	34.42375	-120.05774	350	658.4	70.5	71	10	12.7	NA	11
B18-10243	Revisit	Yes	Mid Shelf	67.3261	ABC Laboratories	34.40098	-119.83279	-88	312.9	30.3	30.8	10	15.8	11.3	14.5
B18-10244	New Site	Yes	Mid Shelf	67.3261	ABC Laboratories	34.35909	-119.82502	-88	425.4	87.6	87.6	10	17.3	28.5	10.7
B18-10245	New Site	Yes	Mid Shelf	67.3261	ABC Laboratories	34.35756	-119.67377	-88	321.9	54.9	56	10	16.3	19.2	12.5

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10246	Revisit	Yes	Mid Shelf	67.3261	ABC Laboratories	34.34406	-119.56253	-88	387.1	44.2	45.2	10	14.3	4.1	13.7
B18-10247	New Site	Yes	Mid Shelf	67.3261	ABC Laboratories	34.31192	-119.54770	-88	361.3	66.9	67.9	10	15	17.1	12.1
B18-10248	New Site	Yes	Mid Shelf	67.3261	ABC Laboratories	34.22980	-119.51817	-88	235.8	87.6	89	10	17.5	5.5	11.3
B18-10249	New Site	Yes	Mid Shelf	67.3261	ABC Laboratories	34.19527	-119.39090	-88	384.8	35.2	36	10	12.3	9.8	12.5
B18-10250	New Site	Yes	Mid Shelf	67.3261	CLA-EMD	34.05265	-119.04910	372	575.4	85	83.8	11	8.9	82.2	11.6
B18-10251	New Site	Yes	Mid Shelf	67.3261	ABC Laboratories	34.01578	-118.91202	-88	282.1	60	60.7	10	16.2	76.7	12
B18-10252	New Site	No	Mid Shelf	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10253	Revisit	Yes	Mid Shelf	67.3261	CLA-EMD	33.94378	-118.51978	245	561.3	47.8	48.4	11	10	26.4	13.6
B18-10254	Revisit	Yes	Mid Shelf	67.3261	CLA-EMD	33.93486	-118.53976	276	496.4	57	57.2	11	11	20.7	13.1
B18-10255	New Site	Yes	Mid Shelf	67.3261	CLA-EMD	33.86611	-118.52809	319	653.5	69.3	69.4	11	9.7	0.1	12.6
B18-10256	Revisit	No	Mid Shelf	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10258	Revisit	Yes	Mid Shelf	67.3261	OCSD	33.64810	-118.14900	176	500.2	32	31.9	11	10.6	61.2	16
B18-10260	Revisit	Yes	Mid Shelf	67.3261	OCSD	33.60195	-118.05646	215	540.7	39	38.7	11	9.8	87.8	13.3
B18-10261	Revisit	No	Mid Shelf	NA	OCSD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10262	New Site	Yes	Mid Shelf	67.3261	OCSD	33.59497	-118.19450	252	644.3	51	52.3	11	9.5	91.2	13
B18-10263	New Site	No	Mid Shelf	NA	OCSD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10265	Revisit	Yes	Mid Shelf	67.3261	City of San Diego	33.26975	-117.56483	320	335.2	80	81.4	11	9.8	13.2	11.9
B18-10266	Revisit	Yes	Mid Shelf	67.3261	City of San Diego	33.26558	-117.53345	320	509	63	64.1	11	10.5	34.3	12.3
B18-10267	New Site	Yes	Mid Shelf	67.3261	City of San Diego	33.21759	-117.48051	320	537.4	61.5	64.4	11	10	14.2	12.2
B18-10268	Revisit	No	Mid Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10269	Revisit	Yes	Mid Shelf	67.3261	City of San Diego	33.08764	-117.35097	325	548.6	73	71.9	12	12.3	43.6	11.8
B18-10274	New Site	No	Mid Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10277	Revisit	Yes	Mid Shelf	67.3261	City of San Diego	32.58969	-117.26429	286	492.7	57.5	57	11	10.5	3.7	12.2
B18-10278	Revisit	Yes	Mid Shelf	67.3261	City of San Diego	32.55148	-117.19950	195	544.9	35	35	11	10.8	16.7	12.8
B18-10279	New Site	No	Outer Shelf	NA	MBC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10280	New Site	No	Outer Shelf	NA	SCCWRP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10283	Revisit	Yes	Outer Shelf	23.28776	LACSD	34.27783	-119.71844	791	518.2	199	200.2	11	14.9	13.1	9.6
B18-10284	New Site	Yes	Outer Shelf	23.28776	LACSD	34.27242	-119.65734	588	492.1	131.5	134.4	11	18.3	9.6	10
B18-10286	New Site	Yes	Outer Shelf	23.28776	LACSD	34.24396	-119.70577	751	571.8	174	176.1	12	14.4	42.4	9.7
B18-10290	Revisit	Yes	Outer Shelf	23.28776	LACSD	34.20677	-119.56748	594	508.2	136	136.1	11	23.1	50.8	9.8
B18-10291	New Site	Yes	Outer Shelf	23.28776	LACSD	34.19693	-119.57133	657	511.7	147.5	148.2	11	14	5.9	9.6
B18-10292	New Site	Yes	Upper Slope	125.22493	LACSD	34.19563	-119.63733	874	482.6	213.5	215.5	11	15.9	2.5	9.2
B18-10294	Revisit	Yes	Outer Shelf	23.28776	LACSD	34.13290	-119.37902	802	494.6	187	189.5	11	17.4	15.1	9.6
B18-10295	New Site	Yes	Outer Shelf	23.28776	ABC Laboratories	34.13275	-119.36336	-88	436.1	147.5	144.3	10	20	17.5	10.3
B18-10296	Revisit	Yes	Outer Shelf	23.28776	LACSD	34.13268	-119.36990	765	558	173	173.9	11	16.4	38.4	9.6
B18-10297	Revisit	Yes	Outer Shelf	23.28776	LACSD	34.12281	-119.33129	598	537.1	128	131.2	11	14.4	21.8	9.9
B18-10299	Revisit	Yes	Outer Shelf	23.28776	ABC Laboratories	34.10717	-119.31902	-88	283.6	192.5	186.8	10	19.8	0	9.4
B18-10300	New Site	Yes	Outer Shelf	23.28776	ABC Laboratories	34.08884	-119.27476	-88	374.3	184	199.7	10	19.8	49.7	9.4
B18-10302	Revisit	No	Outer Shelf	NA	ABC Laboratories	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10303	Revisit	Yes	Outer Shelf	23.28776	CLA-EMD	34.04413	-119.05558	651	491.9	194	201.9	11	8.4	37.3	9.5

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10304	New Site	Yes	Outer Shelf	23.28776	CLA-EMD	34.03355	-119.03001	596	706.3	168	168.3	13	11.3	0.8	9.6
B18-10305	Revisit	No	Outer Shelf	NA	LACSD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10306	New Site	No	Outer Shelf	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10307	Revisit	Yes	Outer Shelf	23.28776	LACSD	33.95711	-118.59303	684	512	154	157.1	11	12.9	2.1	10.1
B18-10308	New Site	Yes	Outer Shelf	23.28776	CLA-EMD	33.91234	-118.58857	598	775.3	171.5	173.5	13	8.1	4.2	9.4
B18-10309	New Site	Yes	Outer Shelf	23.28776	CLA-EMD	33.81915	-118.52555	588	541.2	164.5	164.8	11	12.9	17.3	9.6
B18-10310	Revisit	Yes	Mid Shelf	67.3261	LACSD	33.76745	-118.45903	457	494.8	87.5	91.4	11	11.8	14.1	11.3
B18-10311	Revisit	Yes	Outer Shelf	23.28776	CLA-EMD	33.76710	-118.46000	499	450.7	135.5	143.1	11	11.1	61.6	10.1
B18-10312	New Site	No	Outer Shelf	NA	OCSD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10313	New Site	Yes	Outer Shelf	23.28776	OCSD	33.56828	-118.02428	480	523.1	123.5	126	11	10	9.6	10.3
B18-10314	Revisit	Yes	Upper Slope	125.22493	OCSD	33.54790	-117.85292	691	537.5	210	207.1	10	11.5	87.4	9.5
B18-10316	New Site	No	Outer Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10317	Revisit	No	Outer Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10320	Revisit	Yes	Outer Shelf	23.28776	City of San Diego	32.58574	-117.34070	620	447.4	183.5	211.2	11	5.2	61.5	9.5
B18-10321	Revisit	No	Upper Slope	NA	MBC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10322	Revisit	Yes	Upper Slope	125.22493	MBC	34.34418	-120.36868	900	619.8	289	289.6	10	17.3	NA	8.4
B18-10325	New Site	Yes	Upper Slope	125.22493	LACSD	34.26184	-119.80543	994	567.7	268.5	267.3	11	12.9	6.3	8.8
B18-10327	New Site	Yes	Upper Slope	125.22493	SCCWRP	34.25798	-120.26148	1365	1390.4	473.5	478.7	31	10.3	23.9	6.9
B18-10328	New Site	Yes	Upper Slope	125.22493	LACSD	34.25208	-119.83735	1021	549.4	392.5	391	11	6.1	44.6	7.6
B18-10329	New Site	No	Upper Slope	NA	SCCWRP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10330	New Site	No	Upper Slope	NA	SCCWRP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10331	Revisit	No	Upper Slope	NA	SCCWRP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10332	New Site	Yes	Upper Slope	125.22493	LACSD	34.17080	-119.79363	1051	640.8	394	396.9	13	7.3	12.5	7.7
B18-10333	Revisit	Yes	Upper Slope	125.22493	LACSD	34.15835	-119.82779	1081	582.6	405	407.7	13	11.1	6.7	7.5
B18-10334	New Site	Yes	Upper Slope	125.22493	SCCWRP	34.14987	-120.12131	1440	1454.4	482.1	474.3	30	13.3	70.9	6.7
B18-10335	Revisit	Yes	Upper Slope	125.22493	LACSD	34.14567	-119.76996	NR	NR	NR	NR	NR	NR	NR	NR
B18-10336	Revisit	No	Upper Slope	NA	SCCWRP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10337	New Site	No	Upper Slope	NA	LACSD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10338	Revisit	Yes	Upper Slope	125.22493	LACSD	34.11828	-119.62890	980	461.3	257.5	260.7	11	21.1	0.2	8.8
B18-10339	Revisit	Yes	Upper Slope	125.22493	LACSD	34.04160	-119.19757	1096	517.5	395	377	13	12.6	11.1	8
B18-10340	New Site	Yes	Upper Slope	125.22493	LACSD	34.03853	-119.12564	1015	506	281	345.4	11	12.8	18.7	8.4
B18-10341	New Site	Yes	Upper Slope	125.22493	CLA-EMD	33.95821	-118.64883	730	948.5	223	226.8	15	12.6	111.2	9.3
B18-10342	New Site	Yes	Upper Slope	125.22493	LACSD	33.90606	-118.66638	1125	579.6	437	441.5	15	16.1	52.1	7.3
B18-10343	Revisit	Yes	Upper Slope	125.22493	LACSD	33.69420	-118.34700	945	466	281	287.1	11	15.9	17.4	8.8
B18-10344	Revisit	Yes	Upper Slope	125.22493	OCSD	33.55610	-118.02196	730	614.6	228	227	11	14.8	58.6	9.1
B18-10345	New Site	Yes	Upper Slope	125.22493	OCSD	33.55556	-118.11478	800	657.3	256	256	11	11.5	30.9	8.9
B18-10346	Revisit	Yes	Upper Slope	125.22493	OCSD	33.53682	-117.84771	980	606.1	354.5	349.6	11	8.2	16.8	8
B18-10347	New Site	No	Upper Slope	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10348	Revisit	Yes	Upper Slope	125.22493	City of San Diego	33.09383	-117.41715	1300	941.4	424	404.6	17	18.8	NA	7.7
B18-10349	New Site	Yes	Upper Slope	125.22493	City of San Diego	33.05043	-117.38955	1350	564.8	380.5	383.7	11	4.5	56	7.9

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10350	New Site	Yes	Upper Slope	125.22493	City of San Diego	32.70484	-117.35372	740	614	226.5	218.2	11	8.8	NA	9.3
B18-10351	Revisit	Yes	Upper Slope	125.22493	City of San Diego	32.69303	-117.39480		685.7	NR	NR	11	NR	44	NR
B18-10402	Overdraw	No	Bay	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10411	Overdraw	Yes	Bay	0.26923	CLA-EMD	33.73616	-118.21703	92	321.6	12.5	13.2	6	5	3.4	19.6
B18-10417	Overdraw	Yes	Bay	0.26923	CLA-EMD	33.73105	-118.15729	103	332.3	13	14.2	6	5.2	39.5	18.7
B18-10838	New Site	Yes	Inner Shelf	40.4304	MBC	34.41259	-119.89582	150	1210.5	17.2	16.8	10	12.7	NA	16.2
B18-10842	New Site	Yes	Inner Shelf	40.4304	ABC Laboratories	34.32716	-119.41379	-88	324.4	14	14.7	10	15.5	13.3	17.2
B18-10848	New Site	Yes	Inner Shelf	40.4304	ABC Laboratories	34.10921	-119.20953	-88	337.5	28.3	29.4	10	16	30.3	15.5
B18-10862	Overdraw	Yes	Inner Shelf	40.4304	OCSD	33.68923	-118.19188	150	588.8	25	24.2	10	11.9	NA	15.2
B18-10867	New Site	Yes	Inner Shelf	40.4304	OCSD	33.65989	-118.05484	110	535	19	18.2	10	9.7	4.9	18
B18-10873	Overdraw	No	Inner Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10875	Overdraw	Yes	Inner Shelf	40.4304	City of San Diego	33.17528	-117.40351	160	552.6	22	23.1	11	11.8	NA	15.2
B18-10879	Overdraw	Yes	Inner Shelf	40.4304	City of San Diego	32.66829	-117.20604	81	612.4	9.5	10	11	10.5	NA	15.7
B18-10880	New Site	No	Inner Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10881	Overdraw	No	Inner Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10905	Overdraw	Yes	Mid Shelf	67.3261	CLA-EMD	33.99112	-118.53566	180	632.7	32.3	32.8	11	9.6	89.3	15
B18-10906	New Site	No	Mid Shelf	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10908	Overdraw	No	Mid Shelf	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10909	Overdraw	No	Mid Shelf	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10911	Overdraw	Yes	Mid Shelf	67.3261	CLA-EMD	33.77770	-118.47388	381	609.3	92.5	103.3	11	10.4	NA	11

Station ID	Station Type	Success	Stratum	Area Weight	Sampling Organization	Target Latitude	Target Longitude	Boat Wire Out (m)	Trawl Length (m)	Boat Avg Dep (m)	Net Avg Depth (m)	Boat Trawl Time (min)	Net Bot Time (Min)	Boat Distance to Target (m)	Net Avg Temp (°C)
B18-10913	Overdraw	Yes	Mid Shelf	67.3261	OCSD	33.63544	-118.19986	180	360.2	34.5	33.7	8	12.1	NA	15.1
B18-10914	New Site	Yes	Mid Shelf	67.3261	OCSD	33.61116	-118.22246	252	537.6	51	49.7	11	10.7	16.6	13.7
B18-10915	Overdraw	Yes	Outer Shelf	23.28776	OCSD	33.60098	-118.07190	470	611.2	123	119.3	11	9.2	NA	10.8
B18-10925	Overdraw	Yes	Mid Shelf	67.3261	City of San Diego	33.24229	-117.50775	300	587.6	62.5	65.5	11	9.8	43.8	12.5
B18-10930	Overdraw	Yes	Mid Shelf	67.3261	City of San Diego	32.70738	-117.33664	410	464	101.5	102.1	10	8.7	9.5	11.3
B18-10949	Overdraw	Yes	Outer Shelf	23.28776	LACSD	34.24707	-119.68237	801	471.8	199	201.6	10	14.6	NA	9.3
B18-10953	Overdraw	Yes	Outer Shelf	23.28776	ABC Laboratories	34.16293	-119.46724	-88	193.5	176.5	178	10	11.2	5.7	9.5
B18-10964	Overdraw	No	Outer Shelf	NA	CLA-EMD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10968	Overdraw	Yes	Outer Shelf	23.28776	CLA-EMD	33.92348	-118.56771	596	793.3	167.5	169.2	13	9.7	67	9.6
B18-10973	Overdraw	Yes	Outer Shelf	23.28776	OCSD	33.59186	-118.07965	600	571	161	172.5	11	10	NA	9.8
B18-10983	Overdraw	No	Outer Shelf	NA	City of San Diego	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18-10989	Overdraw	Yes	Outer Shelf	23.28776	City of San Diego	32.74190	-117.35936	570	599.8	145	149.2	11	13.2	NA	10.3
B18-10992	Overdraw	Yes	Outer Shelf	23.28776	City of San Diego	32.59969	-117.34349	620	445.3	172	170.9	11	14	48.1	9.8
B18-11000	Overdraw	Yes	Upper Slope	125.22493	LACSD	34.22873	-119.81928	1022	630.9	377.5	378.4	11	9.7	32	7.8
B18-11032	Overdraw	Yes	Upper Slope	125.22493	City of San Diego	33.13008	-117.43958	1200	553.7	344	352.3	11	9.3	NA	8.3
B18-10000	Revisit	Yes	Bay	0.26923	CLA-EMD	33.75940	-118.16267	50	320.4	5	6	6	5.1	3.9	20.9
B18-10001	New Site	Yes	Bay	0.26923	CLA-EMD	33.75298	-118.15022	63	341.6	7	7.9	6	4.9	8.5	19.6

APPENDIX B – QUALITY ASSURANCE/QUALITY CONTROL

Introduction

The quality assurance program for the Bight '18 trawl program targeted two specific categories to ensure data comparably among the eight participating organizations. The first was quality assurance (QA), followed by quality control (QC). QA components were done prior to the start of the regional survey through design, planning, and management activities so that appropriate data were collected in a standard way. QA activities included method manuals, planned in-survey QC activities, proficiency examinations, plus verbal briefings with Boat Captains and Chief Field Scientists. The goals of QA were to ensure that: 1) field collection, processing, and laboratory analytical techniques were applied consistently and correctly; 2) the number of lost, damaged, and uncollected samples were minimized; 3) the integrity of the data were maintained and documented from sample collection to entry into the data record; 4) all data were comparable; and 5) results should be reproducible.

QC activities were implemented during the data collection phase of the study to evaluate the effectiveness of the QA activities. QC activities ensure that measurement error and bias were identified, quantified, and accounted for, or eliminated, if practical. QC activities include both internal and external checks. Typical internal QC checks include repeated measurements and use of independent methods to verify findings. Typical external QC checks include independent field (performance) audits, independent species voucher verification, and post-survey data review.

The following section describes results of the QA/QC activities conducted during the study. The methods can be found in four planning documents: Sediment Quality Assessment Workplan (Bight '18 2018a), Sediment Quality Assurance Workplan (Bight '18 2018b), Sediment Quality Assessment Field Operations Manual (Bight '18 2018c) and an Information Management Plan (Bight '18 2018d). The results of QC audits were evaluated to give the reader a sense of basic measurement errors when reviewing the survey's results. In addition, a post-survey performance review was included to facilitate improvement in data quality among organizations for future surveys.

Quality Control

Completeness

Overall, the survey met the design goal with a 90% success rate (Table B16). The optimal design was 30 planned sites per strata, but resource issues, funding, and restrictions caused a reduction in the success rate for outer shelf and upper slope sites. The stratum "Other" reflects extra trawls appearing in the database but were not part of the initial survey design. These two sites were given a zero weighting for the analysis. All sites attempted came from randomly selected primary draw or overdraw station lists. Most site failures were due to a variety of obstructions (Table B17) or untrawlable conditions. Five sites were visited multiple times before being abandoned or trawled. Twenty sites were re-trawled at least twice, usually because of improper bottom time, outside the 100 m radius, or no contact with the bottom. Four sites were re-trawled 3 times. One site was successful on the 6th attempt.

Table B16. Station sampling success during the Bight ’18 Regional Monitoring Survey. Associated depths with each stratum can be found in the methods section of this report. Asterisk (*) means that 2 successful sites where not part of the survey design (extra trawls).

Stratum	Planned	Attempted	Success Total	Abandoned	Design Success
Bays/Harbors	30	30	26	2	87%
Inner Shelf	30	35	29	6	97%
Middle Shelf	30	38	30	8	100%
Outer Shelf	30	36	26	10	87%
Upper Slope	30	32	24	7	80%
Other/Marina	0	2*	2*	2*	0%
Totals	**150**	**173**	**137**	**35**	**90%**

Table B17. Reasons given why a trawl station was unsuccessful during the Bight ’18 Regional Monitoring Survey. High-density abundance represents a full trawl with either pelagic red crabs or heart urchins (too heavy for winch to lift). The non-representative site was within a historical outfall sludge zone.

Failure Reason	Number of Stations	Percent of stations
Manmade obstruction-Ship/traps	7	4.1%
Natural obstruction-Rocks/Reef	5	2.8%
Unsuitable for trawling	4	2.3%
Pre-abandoned before survey	4	2.3%
Not in target stratum depth	3	1.8%
Torn or hung net	2	1.2%
Authority denies access	2	1.2%
Logistics/mechanical	2	1.2%
High-density abundance	2	1.2%
Not representative	1	0.6%
Overdraw plotted on land	1	0.6%
Total	**33**	**19.3%**

Comparability

Field audits showed field crews from their respected organization followed the field manual. All organizations used similar equipment and trawled the same way. Animal community assessment data was collected similarly by sorting, identifying, enumerating, and weighing. Auditor observed crews doing internal QA/QC checks as specified in the field manual. Random checks showed correct counts and good agreement with wet weights, less than or equal to 0.1 kg. Species were identified correctly during field audits, or appropriately returned for laboratory identification as FIDs. Nearly all organizations retained voucher specimens for post-survey species validation by independent QA/QC taxonomists. All observed anomalies were identified correctly. Some noted items to work on in future surveys include clearer definitions for fouling animals, excluded species from index determination, anomaly guide, and better procedures to quantify anomalies present while using the “aliquot method” for enumeration.

Representativeness

Distance to target. For trawl paths, 96% came within 100 m of their assigned sampling station coordinates. Only five sites missed the criteria. Three were within bays (4 – 30 m depth) and the other two were either on the outer shelf (121 – 200 m depth) or upper slope (201 – 500 m depth). No field crew missed the criteria by more than 30 m. The trawl committee did not reject any site.

10% depth criteria. Of the trawls, 96% met the criteria of being within ± 10% the expected depth range. Examination was based on both the start-end trawl depth and pressure-temperature sensor information, when compared to site occupation data. The sites were either on the mid shelf (31 – 120 m depth), outer shelf, or upper slope. Generally, sites missing the depth criteria were close enough where the biology was not expected to be influenced by the depth changes. The trawl committee did not reject any site.

Accuracy and Precision

Counts, Weights, Lengths. The survey established MQOs for counts, weights, and lengths on accuracy and completeness. The reporting limits for weights and length are 0.1 kg and 1 cm, respectively. To aid with length, the field committee used a “Tweener” datasheet during internal audits to address individual perception issues when measuring fish near a centimeter mark (+/- 2 mm). It gave field crews flexibility in meeting acceptable Bight ’18 QA/QC levels given this historical problem area. Table B18 summarizes the data submitted by sampling organizations.

Internal audits showed field crew met the 90% MQO for accuracy and completeness. Counts were typically off by +/- 1. The frequency of occurrence for count errors were 9% for fish and 7% for invertebrates. Weights were usually within +/- 0.1 kg. Many organizations weighed animals in grams (1 or 10 g units) which resulted in higher error rates. The frequency of occurrence for weight errors were 52% for fish and 27% for invertebrates due to moisture loss and boat movement. Lengths were only measured in fish and usually off by +/- 1 cm. The frequency of occurrence for length errors were 54%. Errors usually occur on fish straddling the centimeter mark. “Tweener” QA/QC datasheets indicated 39% of the species counts had lengths straddling a centimeter mark and occurred in 85% of the submitted internal audit forms. Field crews seldom missed lengths greater than 2 cm. These errors typically are the result of transcription errors related to processing rather than the physical measurement of a fish, but both could happen.

Table B18. Summary of field organizations internal audits on fish and invertebrate groupings during the Bight '18 regional trawl survey. "Tweeners" are lengths that straddle a centimeter mark by ±2 mm.

	Overall Averages for Participating Organizations			
MQO	Criteria	Error Rate Accuracy	Repeatability Precision	Completeness
Fish (33 forms submitted)				
Identification	Species level	0%	100%	100%
Counts	Each	< 1%	91%	99%
Weights	0.1 kg	3%	85%	99%
Lengths	1 cm	4%	53%	99%
Anomalies	Identification	0%	NA	100%
Avg. % Tweeners	+/- 2 mm at cm	NA	39%	NA
Retraining occurred	Yes	NA	25%	100%
Invertebrates (29 forms submitted)				
Identification	Species level	< 1%	99%	99%
Counts	Each	< 1%	93%	100%
Weights	0.1 kg	< 1%	72%	100%

Taxonomy

Pre-Survey Fauna Knowledge - Verification. All field organizations passed the bucket practicum with correct identifications for fishes and invertebrates. One organization needed to re-take a second bucket of invertebrates before passing. Only a limited number of animals were categorized as needing further identification (FID) by experienced taxonomists but many were correctly identified. Organizations were warned that too many FIDs indicate some lack of knowledge regarding common trawl fishes and invertebrates in Southern California. No organization was excluded from the survey or required to carry qualified taxonomists (recognized by the trawl committee) onboard their boats. No single fish species stood out as difficult to identify. For invertebrates, *Pentamera pseudocalcigera* and *Apostichopus californicus* stood out and may have been the result of being older preserved specimens.

Post-Survey Voucher Checks – Fishes and Invertebrates. A different approach was used by both referee organizations: Southern California Association of Ichthyological Taxonomists and Ecologists (SCAITE) and Southern California Association of Marine Invertebrate Taxonomists (SCAMIT). A group consensus approach reduced the number of meetings required to validate vouchers with disagreements being sent to specialists. While the approach sped up identification, documentation of specific errors was limiting.

SCAITE needed 4 meetings to resolve 429 vouchers, FIDs, and anomalies. About 4% of the vouchers were corrected. Less than 1% were backed off to genus level. Sampling organizations were required to make changes to any trawl data before or after submission to the regional survey's database. Some photo vouchers continue to be problematic because key characteristics are missing in the photos. One organization ignored the field manual request for jarred specimens and only submitted photo vouchers.

SCAMIT needed 4 meetings to resolve approximately 440 vouchers, FIDs, and anomalies. Roughly 1% of the vouchers were corrected. Less than 1% were backed off to genus or family level. Sampling organizations were required to make changes to any trawl data before or after submission to the regional survey's database. Some photo vouchers continue to be problematic because key characteristics are missing in the photos.

Bias

Temperature/Pressure sensors. Organizations submitted 100% of the trawl sensor data. In confined shallow bay/harbor areas (18 sites), 5-minute boat trawls averaged 5.7 minutes (±1.0 SD) of net bottom time and depth ranged from 3.2 – 26.7 m (Figure 33). Field organizations were asked to adjust their standard 10-minute boat trawls so net bottom times fall within an 8–15-minute window. Sixty-eight percent fell within the window. If the bottom time falls between 15-20 minutes, crews were asked to adjust subsequent deployment durations. Fourteen percent fell within that window and occurred in all offshore strata. The field manual asks crews to re-trawl if sensor indicated less than 8-minute or greater than 20-minute bottom time. Seven sites met this criterion: 2 on the outer shelf and 3 on the upper slope. These sites were located at the extreme edge of the sampling organizations travel zone and they had limited resources to re-trawl.

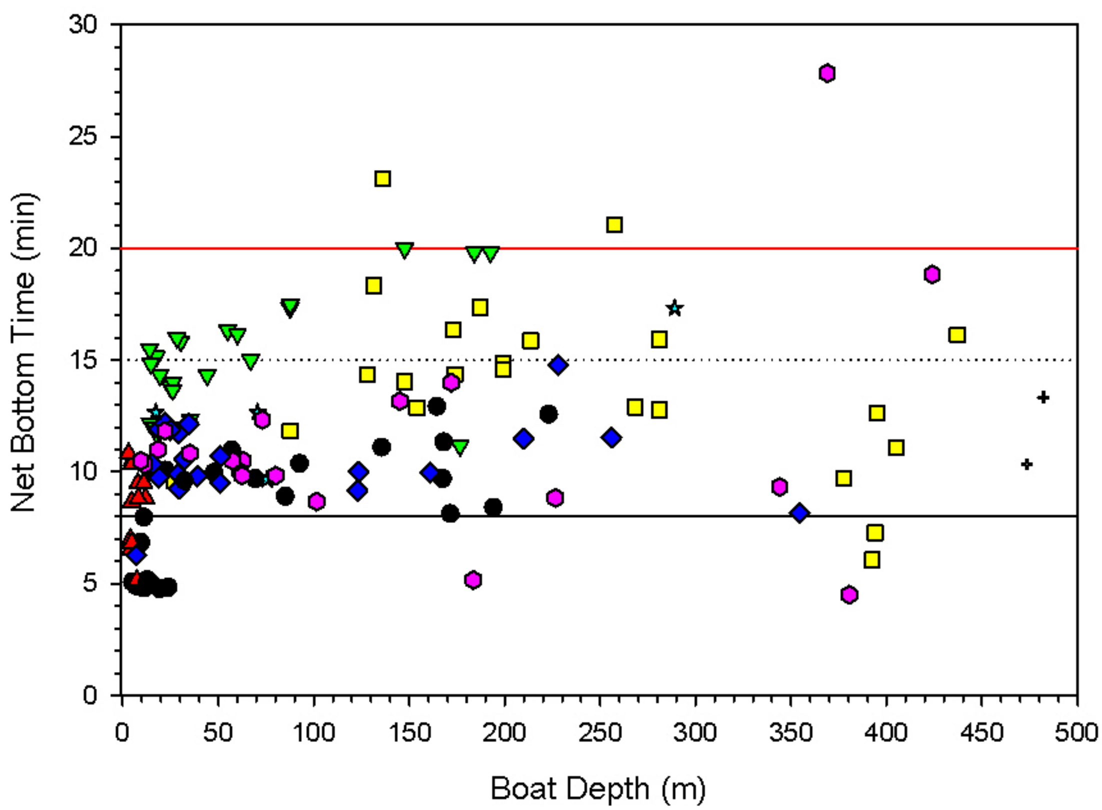

Figure B34. Net bottom times recorded by pressure/temperature sensors mounted on trawl doors during the Bight '18 regional survey. Five-minute trawls were recommended for confined areas in bays. Target bottom times were between 8 – 15 minutes. Times between 15 – 20 minutes were reserved for crews to readjust subsequent trawls with wire scope and boat deck times. Organizations were requested to re-trawl deeper water sites if times were less than 8 minutes and greater than 20 minutes. The eight symbols represent the field organizations participating in the survey.

Discussion

MQOs

Overall, participating organizations met the measurement quality objectives planned by the steering committee. The taxonomic identification error continues to be low with the implementation of voucher checks with experts from SCAITE and SCAMIT. The trend to photo voucher animals without visible meristic characteristics should be categorized as catch documentation, not taxonomic validation. External field audits continue to provide an independent check on an organization's methodology and validate their use of protocols established for the survey. It also validated that organizations are watching for anomalies. Internal audits continue to show high accuracy for counts (less than 1%), biomass (+/- 0.1 kg), length (+/- 1 cm), and noting external anomaly information. The precision estimates continue to show the difficulty crews had to reproduce results for weight and length measurements because of boat motion, moisture loss, and individual perception issues. Internal and external QC activities continue to be unpopular with organizations because of additional time and supplies needed to complete the task (hard to budget). But without them, accuracy and precision estimates could not be made. The trawl committee concluded that the data produced during the regional survey was comparable among organizations.

Anomalies can represent categories from physical ailments (e.g., skeletal deformities, growths) to parasites. Managers associate anomalies with habitat stress. For Bight 2018, field crews were asked to note the presence of traditional isopods often seen in fish gills and identify additional parasites. Field committee resisted counting isopods because of their frequent occurrence and ability to move under stress and shelter (hide) inside any fish gill cavity. Crews did a good job looking for the new parasite categories. A guide may be needed to help crews visually find these parasites and other anomalies. Anomalies usually have a low frequency of occurrence in the Southern California Bight Regional Surveys (Allen et. al. 2007, 2011, Walther et. al. 2017), regardless of perceived habitat (impacted or pristine). Evolutionarily, parasites are common and tend to target specific groups of organisms or species. Managers interested in habitat stress may need to look inside gill covers or internally to enumerate parasites. The cost would be high (time and labor). Note that recent drought conditions have caused many dischargers to increasing water reclamation thereby increasing solids discharge from their outfall pipes. Traditional anomaly observations can indicate adverse effects of high organic matter near discharge points.

Temperature/Pressure Sensors

The sensors continue to show their usefulness in helping field crews identify net bottom times. Short and long trawls were the result of resource issues rather than mistakes. Deep water trawls continue to challenge field crews from a resource perspective. Crews usually only can do 2, maybe 3, sites per day because of travel distance and the hours of net deployment/retrieval to find out if a trawl was within acceptability range. Choices to sample additional sites rather than re-trawl an existing site were made in the field. Data submitted was left to the trawl committee for acceptability and develop QA flags.

The field technical committee wanted to give field crews the ability (15-20 minutes zone) to adjust subsequent trawls near the depth zone without penalizing them from a resource perspective. There were mixed results with either using it as an acceptability zone without changes or an adjustment zone with changes. Oceanographic conditions and wind conditions at a site made some adjustments inconsequential as it relates to net bottom time. This illustrates the difficulty in reducing bottom time variability and resource expenditures for trawl surveys.

Data Submittal

In general, field crews were happy with the updated information management data checker and submittal process. The added QC checks with warnings helped correct many inconsistencies with the data. The change request form still needs some adjustments when organizations are making numerous changes to their submitted data. With minor adjustments such as technical committee reporting consistencies, additional QC checks, automated spreadsheet style change forms, and sampling calendar update, the next survey should progress smoothly.

Managers understand that once the data is submitted, a group QC process occurs, an analysis period exists with further QC processing, a draft report writing period happens with review, then the report gets submitted to the steering committee for review. Timelines are always requested during steering committee meetings. One organization requested SCCWRP to do data entry and submittal on their behalf. The result was pressure to continue a similar timeline. The report presents basic information.

Future Field Related Topics

There has been a concern regarding the “Aliquot Method” to estimate abundance and the reporting of anomalies. The method was designed to speed up the trawl processing procedure. The method was used infrequently but occurred during large hauls with greater than 500 individuals (e.g., heart urchins, red crabs, anchovies). These hauls already take hours to process while using the aliquot method. The manual requested field crews to look for anomalies. Field audits show they are looking for anomalies. There is always a chance that some anomalies could slip by during the process. Should we subset aliquot buckets for additional QC, specifically looking for anomalies? Additional time for more QC drives up an organization’s cost to complete their allotted survey sites. The current trawl processing procedures in the manual are a balance between operational costs, speed, and accuracy.

Reporting limits for weights has traditionally been 0.1 kg. In the past, groups of species weighing less than 0.1 kg were grouped together as a composite species to get estimate of the total trawl biomass. The trawl committee wanted to eliminate composite species, keep these species with a less than 0.1 kg weight, and estimate the weight using math. Many organizations already use smaller spring scales to weigh these species. Why not lower the reporting limit to 0.01 kg to minimize “< 0.1 kg” to fewer species? Historical information of length-weight curves for trawl caught species are limited. These curves could change depending on El Niño or La Niña oceanographic conditions. Lowering the reporting limit will also increase the precision error rate on reproducible weights as seen in the accuracy results.

Fish straddling the centimeter mark have historically been problematic because people’s perception change during quick processing of hundreds of fish and even after QC reprocessing. Over the last few regional surveys, the accuracy rate has been +/- 1 cm. The precision estimates depend on the number of “Tweener” fish (+/- 2 mm at cm mark). The higher the number of

“Tweener” fish, the larger the reproducibility error. Unless management wants a change to the reporting limit, the accuracy rate continues to be +/- 1 cm.

The trend of field organizations to replace jarred vouchers with photos is troubling. Many of these photographers disregard important meristic characteristics and concentrate on documentation rather than taxonomy. The field manual is very clear regarding when to use a photo voucher for taxonomy. Further discussions by the field committee, SCAITE, and SCAMIT will need to occur for clarification.

The field committee was asked to eliminate animals from identification in trawls and determine if a species should be excluded from Shannon diversity (H') index calculation. There was confusion among field groups as to the definition of a pelagic, colonial, epibenthic, or fouling animals, and which species are considered part of the definition. The criteria to exclude a family (incomplete identification) from index determination was at the discretion of the field taxonomist. The problem is that some pelagic species move within the water column and can be found occupying the near bottom habitat. Not all colonial invertebrates were eliminated. Discussions as to whether the trawl committee should eliminate animals during post-analysis rather than the field crews during in-survey enumeration occurred. The concern was unequal application among sampling organizations. Specific definitions and species lists need to be developed to help field crews consistently apply exclusions across all organizations.

Conclusions

- Stations were sampled adequately to meet the design plan established by the steering committee.
- QA/QC protocols were followed by participating field sampling organizations.
- MQOs established by the steering committee were met.
- Field crews are improving the bias associated with 10-minute boat trawls.
- The data were deemed comparable among organizations by the trawl subcommittee.

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APPENDIX C – TAXONOMIC LISTINGS

Table C19. Taxonomic listing of demersal fish species collected during the Bight ’18 trawl survey. Data are fish abundance (n), mean, standard deviation (Std Dev), and minimum (Min) and maximum (Max) standard length (cm). Taxonomic classification and scientific names area of Eschmeyer and Herold (1988) and Page et al. (2013).

Class	Order	Family	Species	Common Name	n	Mean	StdDev	Min	Max
MYXINI									
	MYXINIFORMES								
		Myxinidae	*Eptatretus stoutii*	Pacific Hagfish	15	30	11	9	45
CHONDRICHTHYES									
	CHIMAERIFORMES								
		Chimaeridae	*Hydrolagus colliei*	Spotted Ratfish	9	33	12	12	49
	HETERODONTIFORMES								
		Heterodontidae	*Heterodontus francisci*	Horn Shark	1	23	-	23	23
	CARCHARHINIFORMES								
		Scyliorhinidae	*Apristurus brunneus*	Brown Cat Shark	2	30	2	28	31
			Cephaloscyllium ventriosum	Swell Shark	1	15	-	15	15
			Parmaturus xaniurus	Filetail Cat Shark	63	19	3	14	30
	SQUALIFORMES								
		Squalidae	*Squalus suckleyi*	Pacific Spiny Dogfish	1	97	-	97	97
	SQUATINIFORMES								
		Squatinidae	*Squatina californica*	Pacific Angel Shark	1	41	-	41	41
	RAJIFORMES								
		Rhinobatidae	*Rhinobatos productus*	Shovelnose Guitarfish	1	65	-	65	65
		Rajidae	*Bathyraja interrupta*	Sandpaper Skate	1	46	-	46	46
			Raja inornata	California Skate	28	29	14	13	57
			Raja rhina	Longnose Skate	33	36	18	17	77
	MYLIOBATIFORMES								
		Platyrhynidae	*Platyrhinoidis triseriata*	Thornback	8	27	8	17	39
		Urotrygonidae	*Urobatis halleri*	Round Stingray	91	25	5	14	38
		Myliobatidae	*Myliobatis californica*	Bat Ray	8	72	6	61	83

Table C19. Continued.

Class	Order	Family	Species	Common Name	n	Mean	StdDev	Min	Max
ACTINOPTERYGII									
	ANGUILLIFORMES								
		Nemichthyidae	*Nemichthys scolopaceus*	Slender Snipe Eel	1	49	-	49	49
		Nettastomatidae	*Facciolella equatorialis*	Dogface Witch Eel	228	33	4	20	46
	CLUPEIFORMES								
		Engraulidae	*Anchoa compressa*	Deepbody Anchovy	2	11	0	11	11
			Anchoa delicatissima	Slough Anchovy	4,744	4	1	2	7
			Engraulis mordax	Northern Anchovy	9,914	6	1	3	9
	STOMIIFORMES								
		Phosichthyidae	*Tactostoma macropus*	Longfin Dragonfish	1	17	-	17	17
	AULOPIFORMES								
		Synodontidae	*Synodus lucioceps*	California Lizardfish	749	12	5	9	37
	MYCTOPHIFORMES								
		Myctophidae	*Triphoturus mexicanus*	Mexican Lampfish	1	8	-	8	8
	GADIFORMES								
		Macrouridae	*Nezumia stelgidolepis*	California Grenadier	67	17	4	10	31
		Moridae	*Physiculus rastrelliger*	Hundred-fathom Codling	13	15	6	7	20
		Merlucciidae	*Merluccius productus*	Pacific Hake	135	20	9	5	41
	OPHIDIIFORMES								
		Ophidiidae	*Chilara taylori*	Spotted Cusk-eel	67	17	3	12	26
			Ophidion scrippsae	Basketweave Cusk-eel	2	18	4	15	21
		Bythitidae	*Brosmophycis marginata*	Red Brotula	1	23	-	23	23
			Cataetyx rubrirostris	Rubynose Brotula	9	7	3	5	11
	BATRACHOIDIFORMES								
		Batrachoididae	*Porichthys myriaster*	Specklefin Midshipman	59	16	5	2	32
			Porichthys notatus	Plainfin Midshipman	421	12	5	3	27
	ATHERINIFORMES								
		Atherinopsidae	*Atherinops affinis*	Topsmelt	1	10	-	10	10

Table C19. Continued.

Class	Order	Family	Species	Common Name	n	Mean	StdDev	Min	Max
	GASTEROSTEIFORMES								
		Syngnathidae	*Hippocampus ingens*	Pacific Seahorse	3	16	9	6	22
			Syngnathus sp	unidentified pipefish	1	44	-	44	44
			Syngnathus auliscus	Barred Pipefish	1	15	-	15	15
			Syngnathus californiensis	Kelp Pipefish	2	17	0	17	17
			Syngnathus exilis	Barcheek Pipefish	66	21	3	14	26
	SCORPAENIFORMES								
		Scorpaenidae	*Scorpaena guttata*	California Scorpionfish	50	17	3	13	31
			Sebastes auriculatus	Brown Rockfish	3	13	6	7	19
			Sebastes aurora	Aurora Rockfish	1	8	-	8	8
			Sebastes caurinus	Copper Rockfish	1	12	-	12	12
			Sebastes chlorostictus	Greenspotted Rockfish	12	11	2	6	14
			Sebastes dallii	Calico Rockfish	34	7	3	3	13
			Sebastes diploproa	Splitnose Rockfish	454	10	3	5	18
			Sebastes elongatus	Greenstriped Rockfish	81	13	8	3	28
			Sebastes eos	Pink Rockfish	6	16	8	7	29
			Sebastes goodei	Chilipepper	2	16	0	16	16
			Sebastes helvomaculatus	Rosethorn Rockfish	4	9	0	9	9
			Sebastes hopkinsi	Squarespot Rockfish	27	10	3	6	18
			Sebastes jordani	Shortbelly Rockfish	120	15	1	8	18
			Sebastes lentiginosus	Freckled Rockfish	1	9	-	9	9
			Sebastes levis	Cowcod	3	15	1	14	16
			Sebastes macdonaldi	Mexican Rockfish	11	13	12	8	47
			Sebastes melanostomus	Blackgill Rockfish	1	8	-	8	8
			Sebastes miniatus	Vermilion Rockfish	58	19	4	13	31
			Sebastes paucispinis	Bocaccio	26	25	8	3	32
			Sebastes rosaceus	Rosy Rockfish	1	10	-	10	10
			Sebastes rosenblatti	Greenblotched Rockfish	12	16	8	8	32

Table C19. Continued.

Class	Order	Family	Species	Common Name	n	Mean	StdDev	Min	Max
			Sebastes rubrivinctus	Flag Rockfish	9	11	2	8	13
			Sebastes saxicola	Stripetail Rockfish	1,805	10	2	4	18
			Sebastes semicinctus	Halfbanded Rockfish	3,891	8	3	4	17
			Sebastes umbrosus	Honeycomb Rockfish	1	18	-	18	18
			Sebastolobus alascanus	Shortspine Thornyhead	85	12	4	5	26
			Sebastolobus altivelis	Longspine Thornyhead	7	13	2	9	15
		Triglidae	*Prionotus stephanophrys*	Lumptail Searobin	1	22	-	22	22
		Anoplopomatidae	*Anoplopoma fimbria*	Sablefish	4	39	4	33	43
		Hexagrammidae	*Ophiodon elongatus*	Lingcod	14	17	6	7	28
			Zaniolepis frenata	Shortspine Combfish	627	14	3	7	20
			Zaniolepis latipinnis	Longspine Combfish	386	8	3	3	16
		Cottidae	*Chitonotus pugetensis*	Roughback Sculpin	181	6	1	4	15
			Icelinus quadriseriatus	Yellowchin Sculpin	876	6	1	2	8
			Icelinus tenuis	Spotfin Sculpin	3	8	1	8	9
			Leptocottus armatus	Pacific Staghorn Sculpin	5	14	1	13	16
		Agonidae	*Agonopsis sterletus*	Southern Spearnose Poacher	15	10	3	6	15
			Bathyagonus pentacanthus	Bigeye Poacher	3	15	1	15	16
			Odontopyxis trispinosa	Pygmy Poacher	50	7	1	4	10
			Xeneretmus latifrons	Blacktip Poacher	215	13	2	5	18
			Xeneretmus ritteri	Stripefin Poacher	36	13	2	8	16
			Xeneretmus triacanthus	Bluespotted Poacher	43	14	1	11	16
		Liparidae	*Careproctus melanurus*	Blacktail Snailfish	8	14	4	7	18
			Paraliparis deani	Prickly Snailfish	2	5	0	5	5
	PERCIFORMES								
		Polyprionidae	*Stereolepis gigas*	Giant Sea Bass	1	27	-	27	27
		Serranidae	*Paralabrax clathratus*	Kelp Bass	10	10	1	9	13
			Paralabrax maculatofasciatus	Spotted Sand Bass	127	18	4	9	31
			Paralabrax nebulifer	Barred Sand Bass	63	15	4	9	29

Table C19. Continued.

Class	Order	Family	Species	Common Name	n	Mean	StdDev	Min	Max
		Malacanthidae	*Caulolatilus princeps*	Ocean Whitefish	2	17	6	13	21
		Carangidae	*Trachurus symmetricus*	Jack Mackerel	1	19	-	19	19
		Haemulidae	*Haemulon californiensis*	Salema	2	11	1	10	12
		Sciaenidae	*Atractoscion nobilis*	White Seabass	1	9	-	9	9
			Cheilotrema saturnum	Black Croaker	6	19	2	16	21
			Genyonemus lineatus	White Croaker	958	14	3	2	21
			Menticirrhus undulatus	California Corbina	1	30	-	30	30
			Seriphus politus	Queenfish	170	14	4	2	21
			Umbrina roncador	Yellowfin Croaker	2	34	12	25	42
		Embiotocidae	*Cymatogaster aggregata*	Shiner Perch	28	7	1	6	8
			Embiotoca jacksoni	Black Perch	1	8	-	8	8
			Zalembius rosaceus	Pink Seaperch	83	10	2	6	13
		Labridae	*Halichoeres semicinctus*	Rock Wrasse	4	20	4	15	23
		Bathymasteridae	*Rathbunella hypoplecta*	Bluebanded Ronquil	2	14	5	10	17
		Zoarcidae	*Lycodapus mandibularis*	Pallid Eelpout	12	8	4	4	14
			Lycodes cortezianus	Bigfin Eelpout	39	23	6	13	34
			Lycodes diapterus	Black Eelpout	74	22	5	6	27
			Lycodes pacificus	Blackbelly Eelpout	621	18	5	4	32
			Lyconema barbatum	Bearded Eelpout	178	13	3	6	18
		Stichaeidae	*Plectobranchus evides*	Bluebarred Prickleback	14	11	1	9	13
		Uranoscopidae	*Kathetostoma averruncus*	Smooth Stargazer	2	13	0	13	13
		Clinidae	*Heterostichus rostratus*	Giant Kelpfish	8	9	3	6	14
		Gobiidae	*Lepidogobius lepidus*	Bay Goby	250	4	1	3	7
			Rhinogobiops nicholsii	Blackeye Goby	3	7	0	7	7
		Stromateidae	*Peprilus simillimus*	Pacific Pompano	26	9	1	7	10
	PLEURONECTIFORMES								
		Paralichthyidae	*Citharichthys fragilis*	Gulf Sanddab	8	14	2	10	16
			Citharichthys sordidus	Pacific Sanddab	7,438	9	4	3	25

Table C19. Continued.

Class	Order	Family	Species	Common Name	n	Mean	StdDev	Min	Max
			Citharichthys stigmaeus	Speckled Sanddab	3,377	8	2	3	13
			Citharichthys xanthostigma	Longfin Sanddab	455	12	3	5	23
			Hippoglossina stomata	Bigmouth Sole	53	15	6	8	29
			Paralichthys californicus	California Halibut	108	21	11	5	57
			Xystreurys liolepis	Fantail Sole	127	17	5	9	30
		Pleuronectidae	*Eopsetta jordani*	Petrale Sole	5	37	7	29	46
			Glyptocephalus zachirus	Rex Sole	212	18	5	9	30
			Lyopsetta exilis	Slender Sole	3,982	13	3	2	22
			Microstomus pacificus	Dover Sole	2,435	13	5	4	27
			Parophrys vetulus	English Sole	218	18	6	7	34
			Pleuronichthys decurrens	Curlfin Sole	30	14	3	8	19
			Pleuronichthys guttulatus	Diamond Turbot	3	22	2	21	24
			Pleuronichthys ritteri	Spotted Turbot	56	14	4	6	20
			Pleuronichthys verticalis	Hornyhead Turbot	333	11	5	4	26
		Cynoglossidae	*Symphurus atricaudus*	California Tonguefish	694	13	2	5	17
			Symphurus oligomerus	Whitetail Tonguefish	1	17	-	17	17

Table C20. Summary of demersal fish species collected in Harbors & Bays during the Bight '18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

		Bays & Harbors			
Species Name	**Common Name**	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Anchoa delicatissima	Slough Anchovy	44.95	2.69	38.46	1832.10
Genyonemus lineatus	White Croaker	3.89	31.81	50.00	1784.79
Engraulis mordax	Northern Anchovy	46.82	4.40	11.54	590.99
Urobatis halleri	Round Stingray	0.48	13.92	38.46	553.91
Paralabrax maculatofasciatus	Spotted Sand Bass	0.67	12.15	42.31	542.46
Paralichthys californicus	California Halibut	0.31	6.35	61.54	409.96
Synodus lucioceps	California Lizardfish	0.47	2.26	53.85	146.73
Seriphus politus	Queenfish	0.63	4.70	23.08	122.91
Paralabrax nebulifer	Barred Sand Bass	0.26	2.08	50.00	117.03
Xystreurys liolepis	Fantail Sole	0.13	2.38	34.62	87.00
Porichthys myriaster	Specklefin Midshipman	0.15	1.47	46.15	74.47
Symphurus atricaudus	California Tonguefish	0.30	1.16	50.00	72.83
Myliobatis californica	Bat Ray	0.03	6.84	3.85	26.42
Raja inornata	California Skate	0.02	1.53	11.54	17.79
Citharichthys stigmaeus	Speckled Sanddab	0.25	0.49	23.08	17.02
Pleuronichthys ritteri	Spotted Turbot	0.05	0.49	30.77	16.66
Scorpaena guttata	California Scorpionfish	0.04	1.22	11.54	14.52
Cheilotrema saturnum	Black Croaker	0.03	0.61	19.23	12.35
Pleuronichthys verticalis	Hornyhead Turbot	0.04	0.31	15.38	5.27
Peprilus simillimus	Pacific Pompano	0.13	0.24	11.54	4.35
Rhinobatos productus	Shovelnose Guitarfish	0.01	0.73	3.85	2.84
Umbrina roncador	Yellowfin Croaker	0.01	0.24	7.69	1.96
Halichoeres semicinctus	Rock Wrasse	0.02	0.37	3.85	1.49
Hippocampus ingens	Pacific Seahorse	0.02	0.12	7.69	1.06
Cymatogaster aggregata	Shiner Perch	0.15	0.12	3.85	1.04
Menticirrhus undulatus	California Corbina	0.01	0.24	3.85	0.96
Pleuronichthys guttulatus	Diamond Turbot	0.01	0.18	3.85	0.72
Paralabrax clathratus	Kelp Bass	0.05	0.12	3.85	0.67
Citharichthys xanthostigma	Longfin Sanddab	0.02	0.12	3.85	0.53
Anchoa compressa	Deepbody Anchovy	0.01	0.06	3.85	0.28
Haemulon californiensis	Salema	0.01	0.06	3.85	0.28
Atherinops affinis	Topsmelt	0.01	0.06	3.85	0.26
Atractoscion nobilis	White Seabass	0.01	0.06	3.85	0.26
Heterodontus francisci	Horn Shark	0.01	0.06	3.85	0.26
Ophidion scrippsae	Basketweave Cusk-eel	0.01	0.06	3.85	0.26
Sebastes caurinus	Copper Rockfish	0.01	0.06	3.85	0.26
Syngnathus sp	unidentified pipefish	0.01	0.06	3.85	0.26
Trachurus symmetricus	Jack Mackerel	0.01	0.06	3.85	0.26
Zaniolepis frenata	Shortspine Combfish	0.01	0.06	3.85	0.26
Zaniolepis latipinnis	Longspine Combfish	0.01	0.06	3.85	0.26

Table C21. Summary of demersal fish species collected on the Inner Shelf during the Bight '18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

		Inner Shelf			
Species Name	Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
Citharichthys stigmaeus	Speckled Sanddab	30.02	18.89	82.76	4047.98
Pleuronichthys verticalis	Hornyhead Turbot	2.39	8.20	89.66	948.80
Synodus lucioceps	California Lizardfish	4.39	4.92	68.97	642.05
Symphurus atricaudus	California Tonguefish	2.97	4.53	82.76	620.69
Xystreurys liolepis	Fantail Sole	0.85	7.18	72.41	581.88
Paralichthys californicus	California Halibut	0.46	13.97	37.93	547.58
Engraulis mordax	Northern Anchovy	46.10	5.93	6.90	358.83
Citharichthys xanthostigma	Longfin Sanddab	1.38	4.53	48.28	285.11
Citharichthys sordidus	Pacific Sanddab	3.08	5.54	27.59	237.73
Parophrys vetulus	English Sole	0.80	2.58	44.83	151.44
Pleuronichthys ritteri	Spotted Turbot	0.43	2.58	34.48	103.73
Genyonemus lineatus	White Croaker	2.29	2.73	13.79	69.32
Porichthys myriaster	Specklefin Midshipman	0.31	1.33	41.38	67.68
Icelinus quadriseriatus	Yellowchin Sculpin	1.70	0.94	17.24	45.41
Pleuronichthys decurrens	Curlfin Sole	0.23	1.48	24.14	41.26
Platyrhinoidis triseriata	Thornback	0.08	2.42	13.79	34.51
Paralabrax nebulifer	Barred Sand Bass	0.11	1.09	24.14	29.11
Raja inornata	California Skate	0.11	1.48	17.24	27.52
Syngnathus exilis	Barcheek Pipefish	0.68	0.47	20.69	23.73
Seriphus politus	Queenfish	0.53	1.25	10.34	18.45
Squalus suckleyi	Pacific Spiny Dogfish	0.01	3.43	3.45	11.88
Heterostichus rostratus	Giant Kelpfish	0.08	0.39	17.24	8.15
Porichthys notatus	Plainfin Midshipman	0.21	0.31	13.79	7.14
Myliobatis californica	Bat Ray	0.02	1.80	3.45	6.26
Leptocottus armatus	Pacific Staghorn Sculpin	0.05	0.31	13.79	5.02
Pleuronichthys guttulatus	Diamond Turbot	0.02	0.39	6.90	2.83
Odontopyxis trispinosa	Pygmy Poacher	0.25	0.16	6.90	2.78
Raja rhina	Longnose Skate	0.02	0.39	3.45	1.42
Hippoglossina stomata	Bigmouth Sole	0.02	0.16	6.90	1.22
Lepidogobius lepidus	Bay Goby	0.15	0.08	3.45	0.80
Chitonotus pugetensis	Roughback Sculpin	0.14	0.08	3.45	0.77
Zaniolepis latipinnis	Longspine Combfish	0.05	0.08	3.45	0.45
Embiotoca jacksoni	Black Perch	0.01	0.08	3.45	0.30
Ophidion scrippsae	Basketweave Cusk-eel	0.01	0.08	3.45	0.30
Sebastes dallii	Calico Rockfish	0.01	0.08	3.45	0.30
Syngnathus auliscus	Barred Pipefish	0.01	0.08	3.45	0.30
Syngnathus californiensis	Kelp Pipefish	0.01	0.08	3.45	0.30

Table C22. Summary of demersal fish species collected on the Middle Shelf during the Bight ’18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

		Middle Shelf			
Species Name	Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
Citharichthys sordidus	Pacific Sanddab	24.29	17.49	83.33	3481.68
Sebastes semicinctus	Halfbanded Rockfish	30.84	21.08	50.00	2596.18
Symphurus atricaudus	California Tonguefish	2.97	4.08	83.33	587.63
Icelinus quadriseriatus	Yellowchin Sculpin	5.56	1.99	70.00	528.36
Microstomus pacificus	Dover Sole	4.07	6.35	50.00	520.99
Citharichthys xanthostigma	Longfin Sanddab	2.69	6.24	53.33	475.91
Synodus lucioceps	California Lizardfish	1.86	3.97	66.67	389.05
Porichthys notatus	Plainfin Midshipman	2.03	2.81	60.00	290.81
Zaniolepis latipinnis	Longspine Combfish	3.04	1.55	60.00	275.37
Pleuronichthys verticalis	Hornyhead Turbot	0.69	2.98	66.67	244.59
Scorpaena guttata	California Scorpionfish	0.34	4.47	40.00	192.41
Parophrys vetulus	English Sole	0.36	2.70	46.67	142.86
Citharichthys stigmaeus	Speckled Sanddab	3.49	1.32	26.67	128.52
Sebastes saxicola	Stripetail Rockfish	1.56	1.05	36.67	95.51
Hippoglossina stomata	Bigmouth Sole	0.32	1.38	43.33	73.79
Raja inornata	California Skate	0.10	2.26	30.00	70.94
Engraulis mordax	Northern Anchovy	8.56	1.32	6.67	65.92
Xystreurys liolepis	Fantail Sole	0.16	1.77	33.33	64.25
Chitonotus pugetensis	Roughback Sculpin	1.34	0.66	30.00	59.92
Zalembius rosaceus	Pink Seaperch	0.44	0.72	40.00	46.38
Sebastes dallii	Calico Rockfish	0.28	0.72	40.00	39.92
Zaniolepis frenata	Shortspine Combfish	0.35	0.72	30.00	31.98
Lepidogobius lepidus	Bay Goby	2.00	0.22	13.33	29.59
Sebastes miniatus	Vermilion Rockfish	0.44	3.75	6.67	27.97
Odontopyxis trispinosa	Pygmy Poacher	0.20	0.50	30.00	21.02
Paralichthys californicus	California Halibut	0.03	1.71	10.00	17.45
Lyopsetta exilis	Slender Sole	0.97	0.55	10.00	15.21
Ophiodon elongatus	Lingcod	0.11	0.66	16.67	12.88
Chilara taylori	Spotted Cusk-eel	0.07	0.39	23.33	10.60
Pleuronichthys decurrens	Curlfin Sole	0.06	0.44	20.00	10.02
Lycodes pacificus	Blackbelly Eelpout	0.11	0.50	13.33	8.10
Sebastes rubrivinctus	Flag Rockfish	0.07	0.22	13.33	3.85
Agonopsis sterletus	Southern Spearnose Poacher	0.04	0.22	13.33	3.51
Paralabrax nebulifer	Barred Sand Bass	0.02	0.39	6.67	2.69
Sebastes chlorostictus	Greenspotted Rockfish	0.08	0.17	10.00	2.42
Sebastes hopkinsi	Squarespot Rockfish	0.14	0.22	6.67	2.38
Sebastes elongatus	Greenstriped Rockfish	0.07	0.17	10.00	2.34
Pleuronichthys ritteri	Spotted Turbot	0.03	0.22	6.67	1.70
Stereolepis gigas	Giant Sea Bass	0.01	0.39	3.33	1.32
Squatina californica	Pacific Angel Shark	0.01	0.33	3.33	1.13
Lyconema barbatum	Bearded Eelpout	0.03	0.11	6.67	0.91
Rhinogobiops nicholsii	Blackeye Goby	0.03	0.11	6.67	0.91
Caulolatilus princeps	Ocean Whitefish	0.02	0.11	6.67	0.85
Sebastes auriculatus	Brown Rockfish	0.02	0.17	3.33	0.61
Porichthys myriaster	Specklefin Midshipman	0.01	0.17	3.33	0.58
Prionotus stephanophrys	Lumptail Searobin	0.01	0.17	3.33	0.58
Rathbunella hypoplecta	Bluebanded Ronquil	0.02	0.06	3.33	0.24
Sebastes jordani	Shortbelly Rockfish	0.02	0.06	3.33	0.24
Cephaloscyllium ventriosum	Swell Shark	0.01	0.06	3.33	0.21
Genyonemus lineatus	White Croaker	0.01	0.06	3.33	0.21
Raja rhina	Longnose Skate	0.01	0.06	3.33	0.21
Sebastes lentiginosus	Freckled Rockfish	0.01	0.06	3.33	0.21
Sebastes rosaceus	Rosy Rockfish	0.01	0.06	3.33	0.21
Sebastes rosenblatti	Greenblotched Rockfish	0.01	0.06	3.33	0.21
Sebastes umbrosus	Honeycomb Rockfish	0.01	0.06	3.33	0.21

Table C23. Summary of demersal fish species collected on the Outer Shelf during the Bight '18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

		Outer Shelf			
Species Name	Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
Citharichthys sordidus	Pacific Sanddab	37.32	31.15	96.15	6583.69
Microstomus pacificus	Dover Sole	12.34	12.43	88.46	2191.22
Lyopsetta exilis	Slender Sole	14.27	8.93	76.92	1784.29
Sebastes saxicola	Stripetail Rockfish	12.53	7.34	80.77	1605.56
Zaniolepis frenata	Shortspine Combfish	4.74	4.90	88.46	852.77
Lycodes pacificus	Blackbelly Eelpout	4.14	2.86	73.08	511.44
Sebastes semicinctus	Halfbanded Rockfish	2.39	2.49	53.85	262.60
Parophrys vetulus	English Sole	0.76	3.84	50.00	230.17
Porichthys notatus	Plainfin Midshipman	1.56	3.20	38.46	183.21
Sebastes elongatus	Greenstriped Rockfish	0.68	2.79	42.31	146.88
Sebastes diploproa	Splitnose Rockfish	2.44	1.05	23.08	80.63
Xeneretmus latifrons	Blacktip Poacher	0.85	0.64	53.85	80.16
Chilara taylori	Spotted Cusk-eel	0.42	0.60	50.00	51.34
Sebastes jordani	Shortbelly Rockfish	1.11	2.03	15.38	48.35
Glyptocephalus zachirus	Rex Sole	0.62	0.64	30.77	38.69
Merluccius productus	Pacific Hake	0.52	0.68	30.77	36.88
Sebastes paucispinis	Bocaccio	0.24	2.67	7.69	22.42
Citharichthys xanthostigma	Longfin Sanddab	0.02	2.79	7.69	21.59
Synodus lucioceps	California Lizardfish	0.13	0.60	26.92	19.86
Pleuronichthys verticalis	Hornyhead Turbot	0.13	0.68	19.23	15.45
Hippoglossina stomata	Bigmouth Sole	0.13	0.72	15.38	12.94
Eopsetta jordani	Petrale Sole	0.04	1.21	7.69	9.57
Xeneretmus triacanthus	Bluespotted Poacher	0.41	0.19	15.38	9.28
Raja rhina	Longnose Skate	0.06	2.34	3.85	9.20
Zaniolepis latipinnis	Longspine Combfish	0.20	0.26	19.23	8.96
Zalembius rosaceus	Pink Seaperch	0.30	0.23	15.38	8.07
Lyconema barbatum	Bearded Eelpout	0.13	0.15	15.38	4.25
Plectobranchus evides	Bluebarred Prickleback	0.07	0.15	15.38	3.36
Sebastes miniatus	Vermilion Rockfish	0.06	0.68	3.85	2.83
Sebastes rosenblatti	Greenblotched Rockfish	0.05	0.19	11.54	2.73
Sebastes hopkinsi	Squarespot Rockfish	0.10	0.11	11.54	2.42
Icelinus quadriseriatus	Yellowchin Sculpin	0.55	0.08	3.85	2.40
Hydrolagus colliei	Spotted Ratfish	0.04	0.23	7.69	2.04
Sebastes eos	Pink Rockfish	0.03	0.11	11.54	1.64
Sebastes macdonaldi	Mexican Rockfish	0.09	0.08	7.69	1.25
Lycodes cortezianus	Bigfin Eelpout	0.05	0.08	7.69	0.95
Agonopsis sterletus	Southern Spearnose Poacher	0.03	0.08	7.69	0.80
Scorpaena guttata	California Scorpionfish	0.03	0.08	7.69	0.80
Sebastes levis	Cowcod	0.03	0.08	7.69	0.80
Citharichthys fragilis	Gulf Sanddab	0.08	0.11	3.85	0.73
Chitonotus pugetensis	Roughback Sculpin	0.10	0.04	3.85	0.52
Sebastes helvomaculatus	Rosethorn Rockfish	0.04	0.04	3.85	0.29
Icelinus tenuis	Spotfin Sculpin	0.03	0.04	3.85	0.26
Sebastes chlorostictus	Greenspotted Rockfish	0.03	0.04	3.85	0.26
Kathetostoma averruncus	Smooth Stargazer	0.02	0.04	3.85	0.22
Odontopyxis trispinosa	Pygmy Poacher	0.02	0.04	3.85	0.22
Sebastes goodei	Chilipepper	0.02	0.04	3.85	0.22
Eptatretus stoutii	Pacific Hagfish	0.01	0.04	3.85	0.18
Nemichthys scolopaceus	Slender Snipe Eel	0.01	0.04	3.85	0.18
Ophiodon elongatus	Lingcod	0.01	0.04	3.85	0.18
Peprilus simillimus	Pacific Pompano	0.01	0.04	3.85	0.18
Pleuronichthys decurrens	Curlfin Sole	0.01	0.04	3.85	0.18
Raja inornata	California Skate	0.01	0.04	3.85	0.18
Sebastes auriculatus	Brown Rockfish	0.01	0.04	3.85	0.18
Sebastes rubrivinctus	Flag Rockfish	0.01	0.04	3.85	0.18

Table C24. Summary of demersal fish species collected on the Upper Slope during the Bight ’18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

		Upper Slope			
Species Name	Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
Lyopsetta exilis	Slender Sole	42.77	24.07	95.83	6405.86
Microstomus pacificus	Dover Sole	12.11	23.33	87.50	3100.65
Sebastes diploproa	Splitnose Rockfish	3.60	3.92	70.83	532.85
Sebastes saxicola	Stripetail Rockfish	5.77	4.75	50.00	525.78
Glyptocephalus zachirus	Rex Sole	2.65	4.46	62.50	444.38
Citharichthys sordidus	Pacific Sanddab	7.38	6.03	29.17	391.06
Merluccius productus	Pacific Hake	1.45	5.37	54.17	369.32
Lycodes pacificus	Blackbelly Eelpout	3.21	2.68	45.83	269.95
Sebastolobus alascanus	Shortspine Thornyhead	1.52	2.44	62.50	247.41
Facciolella equatorialis	Dogface Witch Eel	4.08	1.24	37.50	199.59
Raja rhina	Longnose Skate	0.43	4.34	41.67	198.55
Lyconema barbatum	Bearded Eelpout	2.90	0.70	54.17	195.19
Xeneretmus latifrons	Blacktip Poacher	2.27	0.62	29.17	84.41
Parmaturus xaniurus	Filetail Cat Shark	1.13	0.83	37.50	73.28
Zaniolepis frenata	Shortspine Combfish	1.67	1.24	25.00	72.61
Parophrys vetulus	English Sole	0.34	2.81	20.83	65.58
Lycodes cortezianus	Bigfin Eelpout	0.61	1.16	33.33	58.84
Lycodes diapterus	Black Eelpout	1.33	1.11	16.67	40.67
Nezumia stelgidolepis	California Grenadier	1.20	0.45	20.83	34.46
Eptatretus stoutii	Pacific Hagfish	0.25	0.74	33.33	33.13
Xeneretmus ritteri	Stripefin Poacher	0.64	0.29	20.83	19.45
Anoplopoma fimbria	Sablefish	0.07	1.16	12.50	15.35
Sebastes rosenblatti	Greenblotched Rockfish	0.11	0.87	12.50	12.18
Sebastes semicinctus	Halfbanded Rockfish	0.29	0.25	20.83	11.13
Chilara taylori	Spotted Cusk-eel	0.27	0.25	20.83	10.76
Hydrolagus colliei	Spotted Ratfish	0.09	0.45	16.67	9.06
Sebastes macdonaldi	Mexican Rockfish	0.04	0.95	8.33	8.21
Sebastes eos	Pink Rockfish	0.05	0.41	12.50	5.83
Cataetyx rubrirostris	Rubynose Brotula	0.16	0.17	16.67	5.44
Careproctus melanurus	Blacktail Snailfish	0.14	0.17	16.67	5.14
Physiculus rastrelliger	Hundred-fathom Codling	0.23	0.17	12.50	4.98
Lycodapus mandibularis	Pallid Eelpout	0.21	0.12	12.50	4.24
Plectobranchus evides	Bluebarred Prickleback	0.13	0.12	12.50	3.12
Eopsetta jordani	Petrale Sole	0.02	0.70	4.17	3.00
Sebastolobus altivelis	Longspine Thornyhead	0.13	0.17	8.33	2.42
Bathyagonus pentacanthus	Bigeye Poacher	0.05	0.12	12.50	2.22
Sebastes jordani	Shortbelly Rockfish	0.05	0.08	8.33	1.14
Bathyraja interrupta	Sandpaper Skate	0.02	0.25	4.17	1.11
Sebastes elongatus	Greenstriped Rockfish	0.04	0.21	4.17	1.01
Engraulis mordax	Northern Anchovy	0.18	0.04	4.17	0.92
Sebastes paucispinis	Bocaccio	0.02	0.17	4.17	0.76
Agonopsis sterletus	Southern Spearnose Poacher	0.13	0.04	4.17	0.69
Raja inornata	California Skate	0.02	0.08	4.17	0.42
Apristurus brunneus	Brown Cat Shark	0.04	0.04	4.17	0.32
Paraliparis deani	Prickly Snailfish	0.04	0.04	4.17	0.32
Brosmophycis marginata	Red Brotula	0.02	0.04	4.17	0.25
Sebastes aurora	Aurora Rockfish	0.02	0.04	4.17	0.25
Sebastes hopkinsi	Squarespot Rockfish	0.02	0.04	4.17	0.25
Sebastes melanostomus	Blackgill Rockfish	0.02	0.04	4.17	0.25
Symphurus oligomerus	Whitetail Tonguefish	0.02	0.04	4.17	0.25
Syngnathus californiensis	Kelp Pipefish	0.02	0.04	4.17	0.25
Synodus lucioceps	California Lizardfish	0.02	0.04	4.17	0.25
Tactostoma macropus	Longfin Dragonfish	0.02	0.04	4.17	0.25
Triphoturus mexicanus	Mexican Lampfish	0.02	0.04	4.17	0.25
Zaniolepis latipinnis	Longspine Combfish	0.02	0.04	4.17	0.25

Table C25. Taxonomic listing of megabenthic invertebrate species collected during the Bight '18 trawl survey. Data are total abundance; taxonomic hierarchies from SCAMIT ed. 12. SCB= Southern California Bight, B/H = Bays & Harbors, IS = Inner Shelf, MS = Middle Shelf, OS = Outer Shelf, US = Upper Slope.

					Abundance					
Phylum	**Class**	**Order**	**Family**	**Species**	**SCB**	**B/H**	**IS**	**MS**	**OS**	**US**
SILICEA										
	Demospongiae									
		Hadromerida								
			Suberitidae	*Suberites latus*	623	-	-	2	3	618
CALCAREA										
	Calcerea									
		Scycettida								
			Amphoriscidae	*Leucilla nuttingi*	8	-	-	8	-	-
CNIDARIA										
	Hydrozoa									
		Siphonophora								
			Rhodaliidae	*Dromalia alexandri*	28	-	-	-	5	23
	Anthozoa									
		Alcyonacea								
			Gorgoniidae	*Adelogorgia phyllosclera*	45	-	-	45	-	-
				Eugorgia rubens	6	-	-	6	-	-
				Heterogorgia tortuosa	2	-	1	1	-	-
			Plexauridae	*Thesea* sp B	1,227	-	12	140	1,075	-
		Pennatulacea								
			Renillidae	*Renilla koellikeri*	3	-	3	-	-	-
			Virgulariidae	*Acanthoptilum sp*	245	88	-	11	146	-
				Stylatula elongata	4	-	4	-	-	-
				Stylatula sp A	2	2	-	-	-	-
				Virgularia agassizii	4	-	-	1	2	1
				Virgularia californica	1	-	-	-	1	-

Table C25. Continued.

Phylum	Class	Order	Family	Species	Abundance					
					SCB	B/H	IS	MS	OS	US
			Pennatulidae	*Pennatula phosphorea*	42	-	-	-	1	41
				Ptilosarcus gurneyi	2	-	-	-	2	-
		Scleractinia								
			Caryophylliidae	*Desmophyllum dianthus*	69	-	-	-	69	-
		Actiniaria								
			Actiniidae	*Epiactis prolifera*	2	2	-	-	-	-
			Hormathiidae	*Hormathia digitata*	6	-	-	-	-	6
			Metridiidae	*Metridium farcimen*	70	-	-	-	59	11
		Zoanthidea								
			Parazoanthidae	*Savalia lucifica*	24	-	-	24	-	-
MOLLUSCA										
	Gastropoda									
		Tryblidiida								
			Lottiidae	*Lottia depicta*	4	4	-	-	-	-
			Calliostomatidae	*Calliostoma annulatum*	1	-	-	1	-	-
				Calliostoma platinum	1	-	-	-	-	1
				Calliostoma tricolor	3	-	3	-	-	-
				Calliostoma variegatum	1	-	-	-	1	-
			Turbinidae	*Chlorostoma aureotincta*	1	-	1	-	-	-
		Hypsogastropoda								
			Calyptraeidae	*Crepidula fornicata*	2	2	-	-	-	-
			Ovulidae	*Simnia barbarensis*	1	-	-	1	-	-
			Naticidae	*Calinaticina oldroydii*	5	-	-	-	3	2
			Bursidae	*Crossata ventricosa*	1	-	1	-	-	-
			Velutinidae	*Lamellaria diegoensis*	3	2	1	-	-	-
			Buccinidae	*Kelletia kelletii*	7	-	6	1	-	-
			Columbellidae	*Astyris permodesta*	83	-	-	-	-	83

Table C25. Continued.

Phylum	Class	Order	Family	Species	Abundance SCB	B/H	IS	MS	OS	US
			Muricidae	*Pteropurpura festiva*	20	20	-	-	-	-
				Pteropurpura vokesae	4	-	-	4	-	-
			Pseudomelatomidae	*Antiplanes thalea*	5	-	-	-	-	5
				Megasurcula carpenteriana	3	-	-	1	-	2
			Cancellariidae	*Cancellaria crawfordiana*	2	-	-	-	2	-
		Opisthobranchia								
			Bullidae	*Bulla gouldiana*	19	18	1	-	-	-
			Philinidae	*Philine auriformis*	108	48	21	39	-	-
			Aglajidae	*Aglaja ocelligera*	1	-	1	-	-	-
				Melanochlamys diomedea	1	-	1	-	-	-
				Navanax inermis	60	60	-	-	-	-
			Pleurobranchidae	*Pleurobranchaea californica*	142	-	5	40	63	34
			Chromodorididae	*Cadlina luteomarginata*	1	-	-	1	-	-
			Discodorididae	*Thordisa bimaculata*	1	-	-	1	-	-
			Onchidorididae	*Acanthodoris brunnea*	5	-	2	1	2	-
				Acanthodoris rhodoceras	4	2	-	2	-	-
			Polyceridae	*Polycera atra*	4	4	-	-	-	-
				Triopha maculata	6	6	-	-	-	-
			Arminidae	*Armina californica*	8	-	4	4	-	-
			Tritoniidae	*Tochuina gigantea*	5	-	2	2	1	-
				Tritonia festiva	2	-	-	2	-	-
				Tritonia tetraquetra	5	2	-	2	1	-
			Dendronotidae	*Dendronotus iris*	2	-	2	-	-	-
				Dendronotus venustus	8	2	5	1	-	-
			Dironidae	*Dirona picta*	1	-	1	-	-	-
	Bivalvia									
		Mytilida								
			Mytilidae	Musculista senhousia	56	56	-	-	-	-

Table C25. Continued.

Phylum	Class	Order	Family	Species	Abundance SCB	B/H	IS	MS	OS	US
		Ostreida								
			Ostreidae	*Crassostrea gigas*	2	2	-	-	-	-
			Pectinidae	*Leptopecten latiauratus*	6	6	-	-	-	-
	Cephalopoda									
		Sepioidea								
			Sepiolidae	*Rossia pacifica*	67	-	-	4	60	3
		Octopoda								
			Opisthoteuthidae	*Opisthoteuthis* sp A	3	-	-	-	-	3
			Octopodidae	*Octopus bimaculoides*	2	2	-	-	-	-
				Octopus californicus	99	-	-	-	9	90
				Octopus rubescens	161	-	26	77	50	8
				Octopus veligero	2	-	-	-	2	-
ANNELIDA										
	Polychaeta									
		Phyllodocida								
			Aphroditidae	*Aphrodita castanea*	2	-	-	-	2	-
				Aphrodita refulgida	1	-	-	-	1	-
ARTHROPODA										
	Pycnogonida									
		Pegmata								
			Nymphonidae	*Nymphon heterodenticulatum*	32	-	-	-	32	-
				Nymphon pixellae	1	-	-	-	1	-
	Malacostraca									
		Stomatopoda								
			Hemisquillidae	*Hemisquilla californiensis*	1	-	1	-	-	-
		Decapoda								
			Solenoceridae	*Solenocera mutator*	18	-	-	1	10	7

Table C25. Continued.

Phylum	Class	Order	Family	Species	Abundance					
					SCB	B/H	IS	MS	OS	US
			Penaeidae	*Farfantepenaeus californiensis*	32	28	4	-	-	-
			Sicyoniidae	*Sicyonia ingentis*	3,382	16	-	1,377	1,832	157
				Sicyonia penicillata	1,076	856	148	72	-	-
			Palaemonidae	*Palaemon macrodactylus*	14	14	-	-	-	-
			Hippolytidae	*Heptacarpus taylori*	3	-	3	-	-	-
				Spirontocaris sp	765	-	-	-	228	537
				Spirontocaris holmesi	861	-	-	-	393	468
				Spirontocaris prionota	1	-	-	1	-	-
				Spirontocaris sica	430	-	-	-	98	332
			Pandalidae	*Pandalus jordani*	2	-	-	-	2	-
				Pandalus platyceros	255	-	-	-	40	215
			Crangonidae	*Crangon alaskensis*	84	-	-	84	-	-
				Crangon nigromaculata	190	42	145	3	-	-
				Metacrangon spinosissima	20	-	-	1	19	-
				Neocrangon sp	3	-	-	-	2	1
				Neocrangon resima	79	-	-	-	60	19
				Neocrangon zacae	556	-	-	-	405	151
			Palinuridae	*Panulirus interruptus*	7	6	1	-	-	-
			Diogenidae	*Paguristes bakeri*	3	-	2	1	-	-
				Paguristes turgidus	14	-	-	1	12	1
				Paguristes ulreyi	13	-	-	13	-	-
			Paguridae	*Orthopagurus minimus*	6	-	-	6	-	-
				Pagurus armatus	6	6	-	-	-	-
				Pagurus hartae	1	-	-	1	-	-
				Pagurus spilocarpus	3	2	1	-	-	-
				Parapagurodes laurentae	1	-	-	1	-	-
				Phimochirus californiensis	2	-	-	2	-	-

Table C25. Continued.

Phylum	Class	Order	Family	Species	Abundance					
					SCB	B/H	IS	MS	OS	US
			Galatheidae	*Janetogalathea californiensis*	4	-	-	-	4	-
			Munididae	*Munida hispida*	76	-	-	-	1	75
				Pleuroncodes planipes	131,995	-	-	23	51,724	80,248
			Lithodidae	*Glyptolithodes cristatipes*	17	-	-	-	-	17
				Lopholithodes foraminatus	16	-	-	-	13	3
				Paralithodes californiensis	8	-	-	-	-	8
				Paralithodes rathbuni	3	-	-	-	2	1
			Calappidae	*Platymera gaudichaudii*	38	-	-	4	34	-
			Leucosiidae	*Randallia ornata*	3	-	3	-	-	-
			Epialtidae	*Pugettia dalli*	3	-	-	3	-	-
				Chorilia longipes	2	-	-	1	-	1
				Loxorhynchus sp	1	-	-	1	-	-
				Loxorhynchus crispatus	3	2	1	-	-	-
				Loxorhynchus grandis	2	-	-	2	-	-
			Inachidae	*Ericerodes hemphillii*	12	-	3	9	-	-
			Inachoididae	*Pyromaia tuberculata*	98	74	14	10	-	-
			Parthenopidae	*Latulambrus occidentalis*	3	-	2	1	-	-
			Cancridae	Cancridae	3	-	3	-	-	-
				Metacarcinus anthonyi	3	-	2	1	-	-
				Metacarcinus gracilis	33	-	32	1	-	-
				Romaleon antennarium	6	2	3	1	-	-
			Portunidae	*Portunus xantusii*	81	32	49	-	-	-
			Panopeidae	*Lophopanopeus bellus*	36	36	-	-	-	-
			Pinnotheridae	*Pinnixa occidentalis Cmplx*	1	-	-	1	-	-
ECHINODERMATA										
	Crinoidea									
		Comatulida								

Table C25. Continued.

Phylum	Class	Order	Family	Species	Abundance					
					SCB	B/H	IS	MS	OS	US
			Antedonidae	*Florometra serratissima*	4	-	-	-	4	-
	Asteroidea			Asteroidea	2	-	-	1	-	1
		Paxillosida								
			Luidiidae	*Luidia* sp	2	-	1	1	-	-
				Luidia armata	25	-	6	18	1	-
				Luidia asthenosoma	11	-	-	7	4	-
				Luidia foliolata	92	-	3	31	54	4
			Astropectinidae	*Astropecten* sp	93	-	21	72	-	-
				Astropecten armatus	18	10	6	2	-	-
				Astropecten californicus	492	-	293	171	26	2
				Astropecten ornatissimus	26	-	-	-	26	-
		Valvatida								
			Odontasteridae	*Odontaster crassus*	1	-	-	1	-	-
			Goniasteridae	*Mediaster aequalis*	1	-	-	-	1	-
				Pseudarchaster pusillus	176	-	-	-	-	176
			Asterinidae	*Patiria miniata*	12	12	-	-	-	-
		Spinulosida								
			Poraniidae	*Poraniopsis inflata*	1	-	-	-	1	-
			Echinasteridae	*Henricia* sp	3	-	-	1	2	-
		Forcipulatida								
			Asteriidae	*Sclerasterias heteropaes*	3	-	-	3	-	-
				Stylasterias forreri	13	-	-	-	4	9
		Zorocallida								
			Zoroasteridae	*Myxoderma platyacanthum*	26,833	-	-	-	-	26,833
	Ophiuroidea									
		Euryalida								
			Asteronychidae	*Asteronyx longifissus*	1,580	-	-	-	-	1,580

Table C25. Continued.

Phylum	Class	Order	Family	Species	Abundance SCB	B/H	IS	MS	OS	US
			Gorgonocephalidae	*Gorgonocephalus eucnemis*	21	-	-	-	21	-
		Ophiurida								
			Ophiacanthidae	*Ophiacantha diplasia*	1	-	-	-	1	-
			Ophiuridae	*Ophiura luetkenii*	2,167	-	-	1,709	458	-
			Amphiuridae	*Amphichondrius granulatus*	60	-	-	42	18	-
				Amphipholis pugetana	1	-	-	-	1	-
				Amphipholis squamata	1	-	-	1	-	-
			Ophiotricidae	*Ophiothrix spiculata*	394	14	249	106	23	2
			Ophiactidae	*Ophiopholis bakeri*	28	-	-	1	22	5
	Echinoidea									
		Camarodonta								
			Toxopneustidae	*Lytechinus pictus*	2,210	14	104	2,012	76	4
			Strongylocentrotidae	*Strongylocentrotus fragilis*	10,758	-	-	26	618	10,114
				Strongylocentrotus purpuratus	16	16	-	-	-	-
		Clypeasteroida								
			Dendrasteridae	*Dendraster excentricus*	3,353	1,236	2,117	-	-	-
				Dendraster terminalis	2	-	2	-	-	-
		Spatangoida								
			Schizasteridae	*Brisaster* sp	21,684	-	-	-	506	21,178
				Brisaster latifrons	147	-	-	-	120	27
				Brisaster townsendi	15,386	-	-	-	1,208	14,178
			Brissidae	*Brissopsis pacifica*	7,773	-	-	-	74	7,699
				Brissopsis sp LA1	72	-	-	-	-	72
			Spatangidae	*Spatangus californicus*	96	-	-	-	28	68
	Holothuroidea									
		Elasipodida								
			Laetmogonidae	*Pannychia moseleyi*	35	-	-	-	-	35

Table C25. Continued.

Phylum	Class	Order	Family	Species	Abundance SCB	B/H	IS	MS	OS	US
CHORDATA										
	Ascidiacea									
		Stolidobranchiata								
			Styelidae	*Styela clava*	2	2	-	-	-	-
				Styela gibbsii	1	-	-	1	-	-
				Styela plicata	2	2	-	-	-	-
			Pyuridae	*Bathypera feminalba*	1	-	-	1	-	-

Table C26. Summary of megabenthic invertebrate species collected in Bays & Harbors during the Bight '18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

	Bays & Harbors			
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Sicyonia penicillata	29.18	39.07	46.15	3149.88
Dendraster excentricus	42.13	31.22	3.85	282.11
Pyromaia tuberculata	2.52	1.34	38.46	148.47
Acanthoptilum sp	3.00	0.80	23.08	87.74
Portunus xantusii	1.09	1.69	26.92	75.00
Panulirus interruptus	0.20	8.92	7.69	70.19
Navanax inermis	2.04	0.80	23.08	65.72
Musculista senhousia	1.91	0.80	23.08	62.57
Farfantepenaeus californiensis	0.95	1.74	19.23	51.80
Philine auriformis	1.64	0.54	15.38	33.40
Crangon nigromaculata	1.43	0.54	15.38	30.26
Lophopanopeus bellus	1.23	0.54	15.38	27.11
Pyuridae	4.64	1.34	3.85	22.97
Bulla gouldiana	0.61	0.54	15.38	17.67
Apostichopus parvimensis	0.41	3.57	3.85	15.30
Astropecten armatus	0.34	0.71	11.54	12.17
Sicyonia ingentis	0.55	0.27	7.69	6.25
Ophiothrix spiculata	0.48	0.27	7.69	5.73
Patiria miniata	0.41	0.27	7.69	5.20
Ciona robusta	0.34	0.27	7.69	4.68
Octopus bimaculoides	0.07	0.89	3.85	3.69
Leptopecten latiauratus	0.20	0.27	7.69	3.63
Pteropurpura festiva	0.68	0.13	3.85	3.14
Nassarius tiarula	0.14	0.27	7.69	3.11
Strongylocentrotus purpuratus	0.55	0.13	3.85	2.61
Lytechinus pictus	0.48	0.13	3.85	2.35
Palaemon macrodactylus	0.48	0.13	3.85	2.35
Californiconus californicus	0.34	0.13	3.85	1.83
Mesocentrotus franciscanus	0.27	0.13	3.85	1.56
Pagurus armatus	0.20	0.13	3.85	1.30
Triopha maculata	0.20	0.13	3.85	1.30
Lottia depicta	0.14	0.13	3.85	1.04
Polycera atra	0.14	0.13	3.85	1.04
Acanthodoris rhodoceras	0.07	0.13	3.85	0.78
Apostichopus californicus	0.07	0.13	3.85	0.78
Crassostrea gigas	0.07	0.13	3.85	0.78

Table C26. Continued.

Bays & Harbors				
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Crepidula fornicata	0.07	0.13	3.85	0.78
Dendronotus venustus	0.07	0.13	3.85	0.78
Epiactis prolifera	0.07	0.13	3.85	0.78
Lamellaria diegoensis	0.07	0.13	3.85	0.78
Loxorhynchus crispatus	0.07	0.13	3.85	0.78
Pagurus spilocarpus	0.07	0.13	3.85	0.78
Romaleon antennarium	0.07	0.13	3.85	0.78
Styela clava	0.07	0.13	3.85	0.78
Styela plicata	0.07	0.13	3.85	0.78
Stylatula sp A	0.07	0.13	3.85	0.78
Tritonia tetraquetra	0.07	0.13	3.85	0.78
Virgularia sp	0.07	0.13	3.85	0.78

Table C27. Summary of megabenthic invertebrate species collected on the Inner Shelf during the Bight '18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

Inner Shelf				
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Dendraster excentricus	77.61	20.56	10.34	1015.59
Sicyonia penicillata	2.71	14.13	48.28	813.27
Astropecten californicus	5.37	4.80	68.97	701.25
Portunus xantusii	0.90	14.23	27.59	417.47
Crangon nigromaculata	2.66	2.45	55.17	281.80
Metacarcinus gracilis	0.59	10.00	24.14	255.54
Ophiothrix spiculata	4.57	2.96	24.14	181.63
Octopus rubescens	0.48	2.14	20.69	54.20
Lytechinus pictus	1.91	0.77	17.24	46.07
Kelletia kelletii	0.11	5.10	6.90	35.95
Pyromaia tuberculata	0.26	1.07	24.14	32.06
Metacarcinus anthonyi	0.04	4.08	6.90	28.40
Astropecten sp	0.39	0.77	17.24	19.83
Philine auriformis	0.39	0.77	17.24	19.83
Astropecten armatus	0.11	0.77	17.24	15.09
Flabellinopsis iodinea	0.13	0.61	13.79	10.22
Armina californica	0.07	0.61	13.79	9.46
Stylatula elongata	0.07	0.61	13.79	9.46
Farfantepenaeus californiensis	0.07	0.82	10.34	9.20
Crossata ventricosa	0.02	2.55	3.45	8.86
Thesea sp B	0.22	0.46	10.34	7.03
Luidia armata	0.11	0.46	10.34	5.89
Pleurobranchaea californica	0.09	0.46	10.34	5.70
Loxorhynchus crispatus	0.02	1.53	3.45	5.34
Ericerodes hemphillii	0.06	0.46	10.34	5.32
Randallia ornata	0.06	0.46	10.34	5.32
Dendronotus venustus	0.09	0.31	6.90	2.74
Calliostoma tricolor	0.06	0.31	6.90	2.49
Luidia foliolata	0.06	0.31	6.90	2.49
Acanthodoris brunnea	0.04	0.31	6.90	2.36
Dendraster terminalis	0.04	0.31	6.90	2.36
Latulambrus occidentalis	0.04	0.31	6.90	2.36
Nudibranchia	0.04	0.31	6.90	2.36
Tochuina gigantea	0.04	0.31	6.90	2.36
Hemisquilla californiensis	0.02	0.51	3.45	1.82
Panulirus interruptus	0.02	0.51	3.45	1.82

Table C27. Continued.

Inner Shelf				
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Californiconus californicus	0.06	0.15	3.45	0.72
Cancridae	0.06	0.15	3.45	0.72
Heptacarpus taylori	0.06	0.15	3.45	0.72
Renilla koellikeri	0.06	0.15	3.45	0.72
Romaleon antennarium	0.06	0.15	3.45	0.72
Apatia pricei	0.04	0.15	3.45	0.65
Dendronotus iris	0.04	0.15	3.45	0.65
Paguristes bakeri	0.04	0.15	3.45	0.65
Acanthodoris sp	0.02	0.15	3.45	0.59
Aglaja ocelligera	0.02	0.15	3.45	0.59
Bulla gouldiana	0.02	0.15	3.45	0.59
Chlorostoma aureotincta	0.02	0.15	3.45	0.59
Dirona picta	0.02	0.15	3.45	0.59
Hermissenda opalescens	0.02	0.15	3.45	0.59
Heterogorgia tortuosa	0.02	0.15	3.45	0.59
Lamellaria diegoensis	0.02	0.15	3.45	0.59
Luidia sp	0.02	0.15	3.45	0.59
Melanochlamys diomedea	0.02	0.15	3.45	0.59
Pagurus spilocarpus	0.02	0.15	3.45	0.59

Table C28. Summary of megabenthic invertebrate species collected on the Middle Shelf during the Bight '18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

	Middle Shelf			
Species Name	% Abundance	% Biomass	% Frequency	Ecological Index
Sicyonia ingentis	27.71	27.30	56.67	3117.41
Lytechinus pictus	28.80	7.59	63.33	2304.71
Apostichopus californicus	1.53	42.12	36.67	1600.50
Ophiura luetkenii	24.46	3.61	40.00	1123.09
Astropecten californicus	2.45	1.03	63.33	220.17
Pleurobranchaea californica	0.57	2.47	40.00	121.87
Ophiothrix spiculata	1.52	0.63	50.00	107.14
Octopus rubescens	1.10	1.15	46.67	105.28
Thesea sp B	2.00	0.50	40.00	100.18
Sicyonia penicillata	1.03	1.78	33.33	93.66
Astropecten sp	1.03	0.25	20.00	25.62
Crangon alaskensis	1.20	0.17	13.33	18.26
Philine auriformis	0.56	0.21	16.67	12.78
Luidia foliolata	0.44	0.31	16.67	12.49
Acanthoptilum sp	0.16	0.29	23.33	10.49
Platymera gaudichaudii	0.06	0.97	10.00	10.30
Loxorhynchus grandis	0.03	3.06	3.33	10.29
Luidia armata	0.26	0.25	20.00	10.16
Luidia asthenosoma	0.10	0.21	16.67	5.15
Strongylocentrotus fragilis	0.37	0.13	10.00	4.97
Amphichondrius granulatus	0.60	0.08	6.67	4.56
Ericerodes hemphillii	0.13	0.17	13.33	3.94
Metacarcinus anthonyi	0.01	1.11	3.33	3.75
Orthopagurus minimus	0.09	0.17	13.33	3.37
Adelogorgia phyllosclera	0.64	0.28	3.33	3.07
Pyromaia tuberculata	0.14	0.13	10.00	2.68
Pleuroncodes planipes	0.33	0.42	3.33	2.49
Coryrhynchus lobifrons	0.09	0.13	10.00	2.11
Telesto sp	0.23	0.08	6.67	2.08
Armina californica	0.06	0.13	10.00	1.82
Pteropurpura vokesae	0.06	0.13	10.00	1.82
Paguristes ulreyi	0.19	0.08	6.67	1.80
Crangon nigromaculata	0.04	0.13	10.00	1.68
Lissodendoryx sp	0.36	0.04	3.33	1.33
Savalia lucifica	0.34	0.04	3.33	1.28
Eugorgia rubens	0.09	0.08	6.67	1.13

Table C28. Continued.

Middle Shelf				
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Metacarcinus gracilis	0.01	0.28	3.33	0.97
Rossia pacifica	0.06	0.08	6.67	0.94
Sclerasterias heteropaes	0.04	0.08	6.67	0.84
Tritonia tetraquetra	0.03	0.08	6.67	0.75
Leucilla nuttingi	0.11	0.04	3.33	0.52
Styela sp	0.11	0.04	3.33	0.52
Romaleon antennarium	0.01	0.14	3.33	0.51
Pugettia dalli	0.04	0.04	3.33	0.28
Acanthodoris rhodoceras	0.03	0.04	3.33	0.23
Astropecten armatus	0.03	0.04	3.33	0.23
Flabellinopsis iodinea	0.03	0.04	3.33	0.23
Phimochirus californiensis	0.03	0.04	3.33	0.23
Suberites latus	0.03	0.04	3.33	0.23
Tochuina gigantea	0.03	0.04	3.33	0.23
Tritonia festiva	0.03	0.04	3.33	0.23
Acanthodoris brunnea	0.01	0.04	3.33	0.19
Acarnus sp	0.01	0.04	3.33	0.19
Amphipholis squamata	0.01	0.04	3.33	0.19
Apatia pricei	0.01	0.04	3.33	0.19
Apostichopus parvimensis	0.01	0.04	3.33	0.19
Araiofusus araios	0.01	0.04	3.33	0.19
Araiofusus eueides	0.01	0.04	3.33	0.19
Asteroidea	0.01	0.04	3.33	0.19
Bathypera feminalba	0.01	0.04	3.33	0.19
Cadlina luteomarginata	0.01	0.04	3.33	0.19
Californiconus californicus	0.01	0.04	3.33	0.19
Calliostoma annulatum	0.01	0.04	3.33	0.19
Chorilia longipes	0.01	0.04	3.33	0.19
Dallinella occidentalis	0.01	0.04	3.33	0.19
Dendronotus venustus	0.01	0.04	3.33	0.19
Halichondria sp	0.01	0.04	3.33	0.19
Henricia sp	0.01	0.04	3.33	0.19
Heterogorgia tortuosa	0.01	0.04	3.33	0.19
Kelletia kelletii	0.01	0.04	3.33	0.19
Latulambrus occidentalis	0.01	0.04	3.33	0.19
Loxorhynchus sp	0.01	0.04	3.33	0.19
Luidia sp	0.01	0.04	3.33	0.19
Megasurcula carpenteriana	0.01	0.04	3.33	0.19

Table C28. Continued.

Middle Shelf				
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Metacrangon spinosissima	0.01	0.04	3.33	0.19
Nudibranchia	0.01	0.04	3.33	0.19
Odontaster crassus	0.01	0.04	3.33	0.19
Ophiopholis bakeri	0.01	0.04	3.33	0.19
Paguristes bakeri	0.01	0.04	3.33	0.19
Paguristes turgidus	0.01	0.04	3.33	0.19
Pagurus hartae	0.01	0.04	3.33	0.19
Parapagurodes laurentae	0.01	0.04	3.33	0.19
Pennatulacea sp HYP1	0.01	0.04	3.33	0.19
Philinorbis albus	0.01	0.04	3.33	0.19
Pinnixa occidentalis Cmplx	0.01	0.04	3.33	0.19
Poecilosclerida	0.01	0.04	3.33	0.19
Simnia barbarensis	0.01	0.04	3.33	0.19
Solenocera mutator	0.01	0.04	3.33	0.19
Spirontocaris prionota	0.01	0.04	3.33	0.19
Styela gibbsii	0.01	0.04	3.33	0.19
Thordisa bimaculata	0.01	0.04	3.33	0.19
Virgularia agassizii	0.01	0.04	3.33	0.19

Table C29. Summary of megabenthic invertebrate species collected on the Outer Shelf during the Bight '18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

	Outer Shelf			
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Pleuroncodes planipes	91.16	74.81	38.46	6383.23
Strongylocentrotus fragilis	0.54	6.02	80.77	529.92
Sicyonia ingentis	1.61	3.23	76.92	373.05
Metridium farcimen	0.05	4.92	30.77	153.01
Brisaster townsendi	1.98	3.28	19.23	101.27
Pleurobranchaea californica	0.06	1.31	53.85	73.26
Thesea sp B	1.77	0.08	19.23	35.59
Neocrangon zacae	0.36	0.09	61.54	27.41
Brisaster sp	0.45	0.47	23.08	21.25
Ophiura luetkenii	0.40	0.05	42.31	19.07
Apostichopus californicus	0.01	0.55	30.77	17.13
Platymera gaudichaudii	0.03	0.86	15.38	13.63
Octopus rubescens	0.04	0.14	65.38	11.83
Pandalus platyceros	0.04	0.37	26.92	10.89
Gorgonocephalus eucnemis	0.02	0.54	19.23	10.78
Lopholithodes foraminatus	0.01	0.90	11.54	10.55
Brissopsis pacifica	0.07	0.30	26.92	9.78
Spirontocaris holmesi	0.35	0.05	23.08	9.15
Luidia foliolata	0.05	0.21	34.62	8.81
Octopus californicus	0.01	0.32	23.08	7.52
Brisaster latifrons	0.11	0.25	19.23	6.75
Spirontocaris sp	0.20	0.03	19.23	4.47
Rossia pacifica	0.05	0.05	38.46	4.06
Acanthoptilum sp	0.13	0.04	23.08	3.79
Neocrangon resima	0.05	0.04	34.62	3.16
Spatangus californicus	0.02	0.33	7.69	2.75
Astropecten ornatissimus	0.02	0.04	30.77	2.07
Desmophyllum dianthus	0.06	0.16	7.69	1.71
Astropecten californicus	0.02	0.03	26.92	1.42
Lytechinus pictus	0.07	0.02	15.38	1.29
Metacrangon spinosissima	0.02	0.03	26.92	1.26
Solenocera mutator	0.01	0.03	26.92	1.04
Calinaticina oldroydii	0.00	0.09	7.69	0.68
Ophiopholis bakeri	0.02	0.02	15.38	0.56
Amphichondrius granulatus	0.02	0.02	15.38	0.51
Stylasterias forreri	0.00	0.03	11.54	0.42

Table C29. Continued.

	Outer Shelf			
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Spirontocaris sica	0.09	0.01	3.85	0.39
Ophiothrix spiculata	0.02	0.01	11.54	0.38
Florometra serratissima	0.00	0.02	15.38	0.32
Suberites latus	0.00	0.02	11.54	0.29
Dromalia alexandri	0.00	0.03	7.69	0.29
Luidia asthenosoma	0.00	0.01	11.54	0.19
Tochuina gigantea	0.00	0.04	3.85	0.17
Paguristes turgidus	0.01	0.01	7.69	0.15
Nymphon heterodenticulatum	0.03	0.00	3.85	0.12
Aphrodita castanea	0.00	0.01	7.69	0.08
Octopus veligero	0.00	0.01	7.69	0.08
Paralithodes rathbuni	0.00	0.01	7.69	0.08
Ptilosarcus gurneyi	0.00	0.01	7.69	0.08
Janetogalathea californiensis	0.00	0.00	3.85	0.03
Acanthodoris brunnea	0.00	0.00	3.85	0.02
Actiniaria	0.00	0.00	3.85	0.02
Cancellaria crawfordiana	0.00	0.00	3.85	0.02
Henricia sp	0.00	0.00	3.85	0.02
Neocrangon sp	0.00	0.00	3.85	0.02
Pandalus jordani	0.00	0.00	3.85	0.02
Virgularia agassizii	0.00	0.00	3.85	0.02
Amphipholis pugetana	0.00	0.00	3.85	0.02
Aphrodita refulgida	0.00	0.00	3.85	0.02
Asteriidae	0.00	0.00	3.85	0.02
Calliostoma variegatum	0.00	0.00	3.85	0.02
Dallinella occidentalis	0.00	0.00	3.85	0.02
Gorgoniidae	0.00	0.00	3.85	0.02
Halocynthia igaboja	0.00	0.00	3.85	0.02
Luidia armata	0.00	0.00	3.85	0.02
Mediaster aequalis	0.00	0.00	3.85	0.02
Munida hispida	0.00	0.00	3.85	0.02
Nymphon pixellae	0.00	0.00	3.85	0.02
Ophiacantha diplasia	0.00	0.00	3.85	0.02
Pennatula phosphorea	0.00	0.00	3.85	0.02
Philinorbis albus	0.00	0.00	3.85	0.02
Poraniopsis inflata	0.00	0.00	3.85	0.02
Tritonia tetraquetra	0.00	0.00	3.85	0.02
Virgularia californica	0.00	0.00	3.85	0.02

Table C30. Summary of megabenthic invertebrate species collected on the Upper Slope during the Bight '18 trawl survey. Data are % abundance, % biomass, frequency of occurrence and Ecological Index.

	Upper Slope			
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Pleuroncodes planipes	48.23	39.49	72.00	6315.39
Strongylocentrotus fragilis	5.56	16.31	104.00	2274.92
Brisaster townsendi	8.66	15.69	84.00	2045.70
Brisaster sp	13.63	15.11	40.00	1149.32
Brissopsis pacifica	4.49	6.10	96.00	1016.53
Myxoderma platyacanthum	17.36	2.05	40.00	776.56
Suberites latus	0.36	0.98	28.00	37.44
Pandalus platyceros	0.07	0.58	36.00	23.53
Asteronyx longifissus	0.85	0.21	20.00	21.22
Apostichopus sp A	0.03	1.02	20.00	20.93
Octopus californicus	0.03	0.27	68.00	20.36
Spatangus californicus	0.02	0.41	40.00	17.10
Spirontocaris sp	0.16	0.03	44.00	8.53
Pleurobranchaea californica	0.01	0.16	44.00	7.55
Paralithodes californiensis	0.00	0.33	20.00	6.63
Spirontocaris holmesi	0.15	0.03	36.00	6.51
Metridium farcimen	0.00	0.31	16.00	5.06
Spirontocaris sica	0.09	0.02	40.00	4.60
Sicyonia ingentis	0.05	0.14	24.00	4.57
Glyptolithodes cristatipes	0.01	0.17	24.00	4.27
Neocrangon zacae	0.05	0.02	52.00	3.64
Pseudarchaster pusillus	0.04	0.01	20.00	1.02
Munida hispida	0.02	0.10	8.00	0.97
Pannychia moseleyi	0.01	0.03	16.00	0.72
Hormathia digitata	0.00	0.06	8.00	0.49
Stylasterias forreri	0.00	0.05	8.00	0.45
Brisaster latifrons	0.01	0.02	16.00	0.39
Brissopsis sp LA1	0.02	0.07	4.00	0.37
Lopholithodes foraminatus	0.00	0.08	4.00	0.33
Pennatula phosphorea	0.01	0.01	16.00	0.32
Dromalia alexandri	0.01	0.03	8.00	0.29
Neocrangon resima	0.01	0.01	20.00	0.28
Opisthoteuthis sp A	0.00	0.03	8.00	0.24
Octopus rubescens	0.00	0.01	20.00	0.21
Astyris permodesta	0.03	0.00	4.00	0.11
Solenocera mutator	0.00	0.00	12.00	0.08

Table C30. Continued.

Upper Slope				
Species Name	**% Abundance**	**% Biomass**	**% Frequency**	**Ecological Index**
Rossia pacifica	0.00	0.00	12.00	0.07
Calinaticina oldroydii	0.00	0.01	8.00	0.06
Antiplanes thalea	0.00	0.00	8.00	0.04
Luidia foliolata	0.00	0.00	8.00	0.04
Tritia insculpta	0.00	0.00	8.00	0.03
Lissodendoryx sp	0.00	0.01	4.00	0.03
Megasurcula carpenteriana	0.00	0.01	4.00	0.02
Ophiopholis bakeri	0.00	0.00	4.00	0.01
Lytechinus pictus	0.00	0.00	4.00	0.01
Brissopsis sp	0.00	0.00	4.00	0.01
Ophiothrix spiculata	0.00	0.00	4.00	0.01
Asteroidea	0.00	0.00	4.00	0.01
Astropecten californicus	0.00	0.00	4.00	0.01
Calliostoma platinum	0.00	0.00	4.00	0.01
Chorilia longipes	0.00	0.00	4.00	0.01
Gastropoda	0.00	0.00	4.00	0.01
Neocrangon sp	0.00	0.00	4.00	0.01
Paguristes turgidus	0.00	0.00	4.00	0.01
Paguroidea	0.00	0.00	4.00	0.01
Paralithodes rathbuni	0.00	0.00	4.00	0.01
Virgularia agassizii	0.00	0.00	4.00	0.01

Appendix D – Anomalies

Table D31. Demersal fish anomalies by type, species and stratum during the Bight '18 trawl survey.

Anomaly Code	Common Name	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope	All Strata	Total Observed	Percent Anomaly
Ambicoloration	Curlfin Sole	-	1	1	-	-	2	30	6.7
	Dover Sole	-	-	-	1	-	1	2,435	< 0.1
	Hornyhead Turbot	-	-	2	-	-	2	333	0.6
	Pacific Sanddab	-	-	-	1	-	1	7,438	< 0.1
	Slender Sole	-	-	-	1	-	1	3,982	< 0.1
	All Species	-	1	3	3	-	7	35,741	< 0.1
Eye Parasite	Pacific Sanddab	-	1	7	9	-	17	7,438	0.2
	All Species	-	1	7	9	-	17	35,741	< 0.1
Fin Erosion	Dover Sole	-	-	3	1	-	4	2,435	0.2
	All Species	-	-	3	1	-	4	35,741	< 0.1
Leeches	Bigmouth Sole	-	-	1	-	-	1	53	1.9
	Curlfin Sole	-	1	-	-	-	1	30	3.3
	Hornyhead Turbot	-	2	1	-	-	3	333	0.9
	All Species	-	3	2	-	-	5	35,741	< 0.1
Lesion	English Sole	-	-	-	2	-	2	218	0.9
	All Species	-	-	-	2	-	2	35,741	< 0.1
Monogeneans	California Halibut	1	1	-	-	-	2	108	1.9
	All Species	1	1	-	-	-	2	35,741	< 0.1
Other	Dover Sole	-	-	-	1	2	3	2,435	0.1
	Pacific Sanddab	-	-	-	2	-	2	7,438	< 0.1
	Splitnose Rockfish	-	-	-	-	1	1	454	0.2
	All Species	-	-	-	3	3	6	35,741	< 0.1
Parasite	Black Eelpout	-	-	-	-	1	1	74	1.4
	Speckled Sanddab	-	1	-	-	-	1	3,377	< 0.1
	All Species	-	1	-	-	1	2	35,741	< 0.1
Tumor	Dover Sole	-	-	6	2	-	8	2,435	0.3
	Splitnose Rockfish	-	-	-	-	3	3	454	0.7
	Spotted Sand Bass	1	-	-	-	-	1	127	0.8
	All Species	1	-	6	2	3	12	35,741	< 0.1

Table D32. Total area (km²) of the SCB with demersal fish anomalies indicative of stress or disease, including fin erosion, tumors, or lesions by stratum during the Bight '18 trawl survey.

Stratum	Fin Erosion	Lesion	Tumor	Total Anomalies	Affected Area
Bays & Harbors	-	-	3.6	3.6	0.3
Inner Shelf	-	-	-	-	-
Middle Shelf	3.3	-	6.7	6.7	135.3
Outer Shelf	3.8	3.8	7.7	15.4	93.2
Upper Slope	-	-	4	4	125.2
All Strata	1.4	0.7	4.3	5.8	402.3

Table D33. Demersal fish anomalies by type and survey year.

Survey	Anomaly	Anomaly Abundance	Total Fish	Percent Anomaly
Bight '94	Albinism	4	11212	0.036
Bight '98	Albinism	1	23360	0.004
Bight '08	Albinism	1	6737	0.015
Bight '13	Albinism	1	70792	0.001
Bight '94	Ambicoloration	27	11212	0.241
Bight '98	Ambicoloration	27	23360	0.116
Bight '03	Ambicoloration	15	46914	0.032
Bight '08	Ambicoloration	9	6737	0.134
Bight '13	Ambicoloration	55	70792	0.078
Bight '18	Ambicoloration	7	27563	0.025
Bight '94	Deformity	1	11212	0.009
Bight '98	Deformity	5	23360	0.021
Bight '03	Deformity	5	46914	0.011
Bight '08	Deformity	5	6737	0.074
Bight '13	Deformity	5	70792	0.007
Bight '94	Fin Erosion	1	11212	0.009
Bight '03	Fin Erosion	1	46914	0.002
Bight '13	Fin Erosion	4	70792	0.006
Bight '18	Fin Erosion	4	27563	0.015
Bight '94	Lesion	7	11212	0.062
Bight '98	Lesion	6	23360	0.026
Bight '03	Lesion	21	46914	0.045
Bight '13	Lesion	6	70792	0.008
Bight '18	Lesion	2	27563	0.007

Table D33. Continued.

Survey	Anomaly	Anomaly Abundance	Total Fish	Percent Anomaly
Bight '98	Other	1	23360	0.004
Bight '03	Other	1	46914	0.002
Bight '13	Other	3	70792	0.004
Bight '18	Other	6	27563	0.022
Bight '94	Parasite	68	11212	0.606
Bight '98	Parasite	290	23360	1.241
Bight '03	Parasite	489	46914	1.042
Bight '08	Parasite	35	6737	0.520
Bight '13	Parasite	183	70792	0.259
Bight '18	Parasite	26	27563	0.094
Bight '94	Tumor	10	11212	0.089
Bight '98	Tumor	15	23360	0.064
Bight '03	Tumor	26	46914	0.055
Bight '08	Tumor	2	6737	0.030
Bight '13	Tumor	40	70792	0.057
Bight '18	Tumor	12	27563	0.044

APPENDIX E – ANCILLARY DATA

Table E34. Demersal fish abundance by stratum during the Bight '18 trawl survey.

Stratum	No. of Stations	Total	Min	Max	Area Weighted Values: Median	Mean	SD	95 % CL	% Above Bight Median
Bays & Harbors	26	10,722	4	4,563	78	412	1,022	393	-64.2
Inner Shelf	29	9,723	0	4,699	146	335	840	306	-33.3
Middle Shelf	30	11,760	33	3,196	221	392	616	221	0.9
Outer Shelf	26	10,372	2	2,286	322	399	451	173	47
Upper Slope	24	5,583	22	590	225	233	158	63	2.7
Total (all stations)	135	48,160	0	4,699	219	313	519	91	

Table E35. Demersal fish biomass (kg) by stratum during the Bight '18 trawl survey.

Stratum	No. of Stations	Total	Min	Max	Area Weighted Values: Median	Mean	SD	95 % CL	% Above Bight Median
Bays & Harbors	26	164	0.3	25	4.4	6.3	6	2.3	-27.5
Inner Shelf	29	128	0	19	3.6	4.4	3.8	1.4	-40
Middle Shelf	30	181	1.3	33	3.6	6	6.7	2.4	-39.2
Outer Shelf	26	266	0.1	40	8.1	10.2	9.1	3.5	35
Upper Slope	24	242	0.7	23.9	9.1	10.1	6.6	2.6	51.7
Total (all stations)	135	981	0	40	6	7.9	6.9	1.5	

Table E36. Demersal fish Shannon diversity (H') by stratum during the Bight '18 trawl survey.

Stratum	No. of Stations	Min	Max	Area Weighted Values: Median	Mean	SD	CL	% Above Bight Median
Bays & Harbors	26	0.02	2	1.2	1.18	1	0.28	-16.9
Inner Shelf	29	0.00	2	1.31	1.21	0.51	0.19	-9.2
Middle Shelf	30	0.54	2	1.47	1.48	0.37	0.13	1.9
Outer Shelf	26	0.00	2	1.5	1.44	0.47	0.18	4.6
Upper Slope	24	0.18	2.11	1.44	1.43	0.44	0.17	-0.1
Total (all stations)	135	0.00	2	1.44	1.41	0.45	0.09	

Table E37. Demersal fish taxonomic richness by stratum during the Bight '18 trawl survey.

Stratum	No. of Stations	Total	Min	Max	Area Weighted Values: Median	Mean	SD	95 % CL	% Above Bight Median
Bays & Harbors	26	40	2	11	7	7	3	1	-36.4
Inner Shelf	29	38	1	14	9	8.9	2.8	1	-18.2
Middle Shelf	30	55	6	27	14	13.2	4.9	1.8	22.7
Outer Shelf	26	55	1	22	12	12.1	5.5	2.1	4.5
Upper Slope	24	55	2	20	12	12.1	4.4	1.8	9.1
Total (all stations)	135	130	1	27	11	11.9	4.7	1	

Table E38. Fish Response Index (FRI) by stratum during the Bight '18 trawl survey. FRI scores higher than 45 (in red) are associated with non-reference fish community.

Stratum	# Stations	Min	Max	Area Weighted Values: Median	Mean	SD	95 % CL	% Above Bight Median	% Reference Sites	% Reference Area
Inner Shelf	28	17	44	23.6	25.2	6.5	2.4	2	100	100
Middle Shelf	30	11.7	33.5	23	21.9	5.3	1.9	-0.7	100	100
Outer Shelf	26	5.8	49.2	23.4	25.4	9.6	3.7	1.3	92.3	92.3
Total (all stations)	84	5.8	49.2	23.1	23.5	6.7	1.4		97.6	98.8

Table E39. Biomass (kg) of demersal fish species collected during the Bight '18 trawl survey by stratum.

Common Name	Family	Biomass (Kg)					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Dover Sole	Pleuronectidae	101	-	-	12	33	56.5
Slender Sole	Pleuronectidae	83	-	-	1	24	58.3
White Croaker	Sciaenidae	56	52	3.5	0.1	-	-
Halfbanded Rockfish	Scorpaenidae	45	-	-	38.2	7	1
Stripetail Rockfish	Scorpaenidae	33	-	-	2	19.5	11.5
California Halibut	Paralichthyidae	31	10.4	18	3.1	-	-
Speckled Sanddab	Paralichthyidae	28	0.8	24.3	2.4	-	-
English Sole	Pleuronectidae	25	-	3.3	4.9	10	6.8
Longfin Sanddab	Paralichthyidae	24.7	0.2	5.8	11.3	7.4	-
Round Stingray	Urotrygonidae	22.8	22.8	-	-	-	-
Spotted Sand Bass	Serranidae	19.9	19.9	-	-	-	-
California Lizardfish	Synodontidae	18.9	3.7	6.3	7.2	1.6	0.1
Hornyhead Turbot	Pleuronectidae	18.2	0.5	10.5	5.4	1.8	-
Shortspine Combfish	Hexagrammidae	17.4	0.1	-	1.3	13	3
Northern Anchovy	Engraulidae	17.3	7.2	7.6	2.4	-	0.1
Longnose Skate	Rajidae	17.3	-	0.5	0.1	6.2	10.5
Fantail Sole	Paralichthyidae	16.3	3.9	9.2	3.2	-	-
California Tonguefish	Cynoglossidae	15.1	1.9	5.8	7.4	-	-
Blackbelly Eelpout	Zoarcidae	15	-	-	0.9	7.6	6.5
Pacific Hake	Merlucciidae	14.8	-	-	-	1.8	13
Plainfin Midshipman	Batrachoididae	14	-	0.4	5.1	8.5	-
Bat Ray	Myliobatidae	13.5	11.2	2.3	-	-	-
Rex Sole	Pleuronectidae	12.5	-	-	-	1.7	10.8
Splitnose Rockfish	Scorpaenidae	12.3	-	-	-	2.8	9.5
California Scorpionfish	Scorpaenidae	10.3	2	-	8.1	0.2	-
Queenfish	Sciaenidae	9.3	7.7	1.6	-	-	-
California Skate	Rajidae	8.8	2.5	1.9	4.1	0.1	0.2
Vermilion Rockfish	Scorpaenidae	8.6	-	-	6.8	1.8	-
Greenstriped Rockfish	Scorpaenidae	8.2	-	-	0.3	7.4	0.5
Bocaccio	Scorpaenidae	7.5	-	-	-	7.1	0.4
Shortspine Thornyhead	Scorpaenidae	5.9	-	-	-	-	5.9
Shortbelly Rockfish	Scorpaenidae	5.7	-	-	0.1	5.4	0.2
Barred Sand Bass	Serranidae	5.5	3.4	1.4	0.7	-	-
Yellowchin Sculpin	Cottidae	5	-	1.2	3.6	0.2	-
Petrale Sole	Pleuronectidae	4.9	-	-	-	3.2	1.7
Bigmouth Sole	Paralichthyidae	4.6	-	0.2	2.5	1.9	-
Spotted Turbot	Pleuronectidae	4.5	0.8	3.3	0.4	-	-
Slough Anchovy	Engraulidae	4.4	4.4	-	-	-	-
Specklefin Midshipman	Batrachoididae	4.4	2.4	1.7	0.3	-	-
Pacific Spiny Dogfish	Squalidae	4.4	-	4.4	-	-	-
Longspine Combfish	Hexagrammidae	3.8	0.1	0.1	2.8	0.7	0.1
Blacktip Poacher	Agonidae	3.2	-	-	-	1.7	1.5
Thornback	Platyrhynidae	3.1	-	3.1	-	-	-
Dogface Witch Eel	Nettastomatidae	3	-	-	-	-	3
Bigfin Eelpout	Zoarcidae	3	-	-	-	0.2	2.8
Spotted Cusk-eel	Ophidiidae	2.9	-	-	0.7	1.6	0.6
Curlfin Sole	Pleuronectidae	2.8	-	1.9	0.8	0.1	-
Sablefish	Anoplopomatidae	2.8	-	-	-	-	2.8
Black Eelpout	Zoarcidae	2.7	-	-	-	-	2.7
Greenblotched Rockfish	Scorpaenidae	2.7	-	-	0.1	0.5	2.1
Mexican Rockfish	Scorpaenidae	2.5	-	-	-	0.2	2.3

Table E39. Continued.

Common Name	Family	Biomass (Kg) SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Bearded Eelpout	Zoarcidae	2.3	-	-	0.2	0.4	1.7
Filetail Cat Shark	Scyliorhinidae	2	-	-	-	-	2
Pacific Hagfish	Myxinidae	1.9	-	-	-	0.1	1.8
Pink Seaperch	Embiotocidae	1.9	-	-	1.3	0.6	-
Spotted Ratfish	Chimaeridae	1.7	-	-	-	0.6	1.1
Roughback Sculpin	Cottidae	1.4	-	0.1	1.2	0.1	-
Calico Rockfish	Scorpaenidae	1.4	-	0.1	1.3	-	-
Lingcod	Hexagrammidae	1.3	-	-	1.2	0.1	-
Pink Rockfish	Scorpaenidae	1.3	-	-	-	0.3	1
Pygmy Poacher	Agonidae	1.2	-	0.2	0.9	0.1	-
Shovelnose Guitarfish	Rhinobatidae	1.2	1.2	-	-	-	-
California Grenadier	Macrouridae	1.1	-	-	-	-	1.1
Black Croaker	Sciaenidae	1	1	-	-	-	-
Diamond Turbot	Pleuronectidae	0.8	0.3	0.5	-	-	-
Squarespot Rockfish	Scorpaenidae	0.8	-	-	0.4	0.3	0.1
Southern Spearnose Poacher	Agonidae	0.7	-	-	0.4	0.2	0.1
Bluebarred Prickleback	Stichaeidae	0.7	-	-	-	0.4	0.3
Giant Sea Bass	Polyprionidae	0.7	-	-	0.7	-	-
Stripefin Poacher	Agonidae	0.7	-	-	-	-	0.7
Barcheek Pipefish	Syngnathidae	0.6	-	0.6	-	-	-
Sandpaper Skate	Rajidae	0.6	-	-	-	-	0.6
Rock Wrasse	Labridae	0.6	0.6	-	-	-	-
Pacific Angel Shark	Squatinidae	0.6	-	-	0.6	-	-
Giant Kelpfish	Clinidae	0.5	-	0.5	-	-	-
Bay Goby	Gobiidae	0.5	-	0.1	0.4	-	-
Pacific Pompano	Stromateidae	0.5	0.4	-	-	0.1	-
Flag Rockfish	Scorpaenidae	0.5	-	-	0.4	0.1	-
Bluespotted Poacher	Agonidae	0.5	-	-	-	0.5	-
Blacktail Snailfish	Liparidae	0.4	-	-	-	-	0.4
Rubynose Brotula	Bythitidae	0.4	-	-	-	-	0.4
Pacific Staghorn Sculpin	Cottidae	0.4	-	0.4	-	-	-
California Corbina	Sciaenidae	0.4	0.4	-	-	-	-
Hundred-fathom Codling	Moridae	0.4	-	-	-	-	0.4
Brown Rockfish	Scorpaenidae	0.4	-	-	0.3	0.1	-
Greenspotted Rockfish	Scorpaenidae	0.4	-	-	0.3	0.1	-
Longspine Thornyhead	Scorpaenidae	0.4	-	-	-	-	0.4
Yellowfin Croaker	Sciaenidae	0.4	0.4	-	-	-	-
Bigeye Poacher	Agonidae	0.3	-	-	-	-	0.3
Pallid Eelpout	Zoarcidae	0.3	-	-	-	-	0.3
Gulf Sanddab	Paralichthyidae	0.3	-	-	-	0.3	-
Lumptail Searobin	Triglidae	0.3	-	-	0.3	-	-
Ocean Whitefish	Malacanthidae	0.2	-	-	0.2	-	-
Shiner Perch	Embiotocidae	0.2	0.2	-	-	-	-
Pacific Seahorse	Syngnathidae	0.2	0.2	-	-	-	-
Basketweave Cusk-eel	Ophidiidae	0.2	0.1	0.1	-	-	-
Kelp Bass	Serranidae	0.2	0.2	-	-	-	-
Blackeye Goby	Gobiidae	0.2	-	-	0.2	-	-
Cowcod	Scorpaenidae	0.2	-	-	-	0.2	-
Kelp Pipefish	Syngnathidae	0.2	-	0.1	-	-	0.1
Deepbody Anchovy	Engraulidae	0.1	0.1	-	-	-	-
Brown Cat Shark	Scyliorhinidae	0.1	-	-	-	-	0.1
Topsmelt	Atherinopsidae	0.1	0.1	-	-	-	-
White Seabass	Sciaenidae	0.1	0.1	-	-	-	-

Table E39. Continued.

Common Name	Family	Biomass (Kg)					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Red Brotula	Bythitidae	0.1	-	-	-	-	0.1
Swell Shark	Scyliorhinidae	0.1	-	-	0.1	-	-
Black Perch	Embiotocidae	0.1	-	0.1	-	-	-
Salema	Haemulidae	0.1	0.1	-	-	-	-
Horn Shark	Heterodontidae	0.1	0.1	-	-	-	-
Spotfin Sculpin	Cottidae	0.1	-	-	-	0.1	-
Smooth Stargazer	Uranoscopidae	0.1	-	-	-	0.1	-
Slender Snipe Eel	Nemichthyidae	0.1	-	-	-	0.1	-
Prickly Snailfish	Liparidae	0.1	-	-	-	-	0.1
Bluebanded Ronquil	Bathymasteridae	0.1	-	-	0.1	-	-
Aurora Rockfish	Scorpaenidae	0.1	-	-	-	-	0.1
Copper Rockfish	Scorpaenidae	0.1	0.1	-	-	-	-
Chilipepper	Scorpaenidae	0.1	-	-	-	0.1	-
Rosethorn Rockfish	Scorpaenidae	0.1	-	-	-	0.1	-
Freckled Rockfish	Scorpaenidae	0.1	-	-	0.1	-	-
Blackgill Rockfish	Scorpaenidae	0.1	-	-	-	-	0.1
Rosy Rockfish	Scorpaenidae	0.1	-	-	0.1	-	-
Honeycomb Rockfish	Scorpaenidae	0.1	-	-	0.1	-	-
Whitetail Tonguefish	Cynoglossidae	0.1	-	-	-	-	0.1
Barred Pipefish	Syngnathidae	0.1	-	0.1	-	-	-
unidentified pipefish	Syngnathidae	0.1	0.1	-	-	-	-
Longfin Dragonfish	Phosichthyidae	0.1	-	-	-	-	0.1
Jack Mackerel	Carangidae	0.1	0.1	-	-	-	-
Mexican Lampfish	Myctophidae	0.1	-	-	-	-	0.1

Table E40. Frequency of occurrence (%) of demersal fish species collected during the Bight '18 trawl survey by stratum.

Common Name	Family	Frequency					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Dover Sole	Pleuronectidae	60	-	-	50	89	84
Slender Sole	Pleuronectidae	51	-	-	10	77	92
Pacific Sanddab	Paralichthyidae	50	-	28	83	96	28
Stripetail Rockfish	Scorpaenidae	39	-	-	37	81	48
California Tonguefish	Cynoglossidae	38	50	83	83	-	-
Hornyhead Turbot	Pleuronectidae	36	15	90	67	19	-
California Lizardfish	Synodontidae	35	54	69	67	27	4
English Sole	Pleuronectidae	35	-	45	47	50	20
Splitnose Rockfish	Scorpaenidae	33	-	-	-	23	68
Blackbelly Eelpout	Zoarcidae	30	-	-	13	73	44
Rex Sole	Pleuronectidae	30	-	-	-	31	60
Halfbanded Rockfish	Scorpaenidae	28	-	-	50	54	20
Shortspine Combfish	Hexagrammidae	27	4	-	30	89	24
Shortspine Thornyhead	Scorpaenidae	27	-	-	-	-	60
Bearded Eelpout	Zoarcidae	27	-	-	7	15	52
Pacific Hake	Merlucciidae	26	-	-	-	31	52
Longfin Sanddab	Paralichthyidae	24	4	48	53	8	-
Yellowchin Sculpin	Cottidae	24	-	17	70	4	-
Plainfin Midshipman	Batrachoididae	23	-	14	60	39	-
Fantail Sole	Paralichthyidae	22	35	72	33	-	-
Speckled Sanddab	Paralichthyidae	22	23	83	27	-	-
Longspine Combfish	Hexagrammidae	22	4	3	60	19	4
Spotted Cusk-eel	Ophidiidae	20	-	-	23	50	20
Longnose Skate	Rajidae	20	-	3	3	4	40
Blacktip Poacher	Agonidae	17	-	-	-	54	28
Dogface Witch Eel	Nettastomatidae	16	-	-	-	-	36
Filetail Cat Shark	Scyliorhinidae	16	-	-	-	-	36
Bigmouth Sole	Paralichthyidae	15	-	7	43	15	-
Bigfin Eelpout	Zoarcidae	15	-	-	-	8	32
Pacific Hagfish	Myxinidae	15	-	-	-	4	32
California Skate	Rajidae	14	12	17	30	4	4
Pink Seaperch	Embiotocidae	13	-	-	40	15	-
California Scorpionfish	Scorpaenidae	12	12	-	40	8	-
Calico Rockfish	Scorpaenidae	12	-	3	40	-	-
Curlfin Sole	Pleuronectidae	10	-	24	20	4	-
Pygmy Poacher	Agonidae	10	-	7	30	4	-
Roughback Sculpin	Cottidae	10	-	3	30	4	-
California Halibut	Paralichthyidae	9	62	38	10	-	-
California Grenadier	Macrouridae	9	-	-	-	-	20
Stripefin Poacher	Agonidae	9	-	-	-	-	20
Greenstriped Rockfish	Scorpaenidae	8	-	-	10	42	4
Specklefin Midshipman	Batrachoididae	8	46	41	3	-	-
Spotted Ratfish	Chimaeridae	8	-	-	-	8	16
Spotted Turbot	Pleuronectidae	8	31	35	7	-	-
Greenblotched Rockfish	Scorpaenidae	7	-	-	3	12	12
Blacktail Snailfish	Liparidae	7	-	-	-	-	16
Rubynose Brotula	Bythitidae	7	-	-	-	-	16
Black Eelpout	Zoarcidae	7	-	-	-	-	16
Bluebarred Prickleback	Stichaeidae	7	-	-	-	15	12
Pink Rockfish	Scorpaenidae	6	-	-	-	12	12
Southern Spearnose Poacher	Agonidae	6	-	-	13	8	4
Barred Sand Bass	Serranidae	6	50	24	7	-	-

Table E40. Continued.

Common Name	Family	Frequency					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Shortbelly Rockfish	Scorpaenidae	6	-	-	3	15	8
Sablefish	Anoplopomatidae	5	-	-	-	-	12
Bigeye Poacher	Agonidae	5	-	-	-	-	12
Pallid Eelpout	Zoarcidae	5	-	-	-	-	12
Hundred-fathom Codling	Moridae	5	-	-	-	-	12
Lingcod	Hexagrammidae	5	-	-	17	4	-
Northern Anchovy	Engraulidae	5	8	7	7	-	4
Squarespot Rockfish	Scorpaenidae	5	-	-	7	12	4
Bay Goby	Gobiidae	5	-	3	13	-	-
Mexican Rockfish	Scorpaenidae	4	-	-	-	8	8
Flag Rockfish	Scorpaenidae	4	-	-	13	4	-
Longspine Thornyhead	Scorpaenidae	4	-	-	-	-	8
Barcheek Pipefish	Syngnathidae	4	-	21	-	-	-
White Croaker	Sciaenidae	3	50	14	3	-	-
Greenspotted Rockfish	Scorpaenidae	3	-	-	10	4	-
Giant Kelpfish	Clinidae	3	-	17	-	-	-
Petrale Sole	Pleuronectidae	3	-	-	-	8	4
Bocaccio	Scorpaenidae	3	-	-	-	8	4
Kelp Pipefish	Syngnathidae	2	-	3	-	-	4
Pacific Staghorn Sculpin	Cottidae	2	-	14	-	-	-
Thornback	Platyrhynidae	2	-	14	-	-	-
Vermilion Rockfish	Scorpaenidae	2	-	-	7	4	-
Ocean Whitefish	Malacanthidae	2	-	-	7	-	-
Blackeye Goby	Gobiidae	2	-	-	7	-	-
Brown Cat Shark	Scyliorhinidae	2	-	-	-	-	4
Sandpaper Skate	Rajidae	2	-	-	-	-	4
Red Brotula	Bythitidae	2	-	-	-	-	4
Prickly Snailfish	Liparidae	2	-	-	-	-	4
Aurora Rockfish	Scorpaenidae	2	-	-	-	-	4
Blackgill Rockfish	Scorpaenidae	2	-	-	-	-	4
Whitetail Tonguefish	Cynoglossidae	2	-	-	-	-	4
Longfin Dragonfish	Phosichthyidae	2	-	-	-	-	4
Mexican Lampfish	Myctophidae	2	-	-	-	-	4
Queenfish	Sciaenidae	2	23	10	-	-	-
Bluespotted Poacher	Agonidae	1	-	-	-	15	-
Brown Rockfish	Scorpaenidae	1	-	-	3	4	-
Diamond Turbot	Pleuronectidae	1	4	7	-	-	-
Swell Shark	Scyliorhinidae	1	-	-	3	-	-
Lumptail Searobin	Triglidae	1	-	-	3	-	-
Bluebanded Ronquil	Bathymasteridae	1	-	-	3	-	-
Freckled Rockfish	Scorpaenidae	1	-	-	3	-	-
Rosy Rockfish	Scorpaenidae	1	-	-	3	-	-
Honeycomb Rockfish	Scorpaenidae	1	-	-	3	-	-
Pacific Angel Shark	Squatinidae	1	-	-	3	-	-
Giant Sea Bass	Polyprionidae	1	-	-	3	-	-
Cowcod	Scorpaenidae	1	-	-	-	8	-
Bat Ray	Myliobatidae	1	4	3	-	-	-
Basketweave Cusk-eel	Ophidiidae	1	4	3	-	-	-
Black Perch	Embiotocidae	1	-	3	-	-	-
Pacific Spiny Dogfish	Squalidae	1	-	3	-	-	-
Barred Pipefish	Syngnathidae	1	-	3	-	-	-
Pacific Pompano	Stromateidae	0	12	-	-	4	-
Gulf Sanddab	Paralichthyidae	0	-	-	-	4	-

Table E40. Continued.

Common Name	Family	Frequency					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Spotfin Sculpin	Cottidae	0	-	-	-	4	-
Smooth Stargazer	Uranoscopidae	0	-	-	-	4	-
Slender Snipe Eel	Nemichthyidae	0	-	-	-	4	-
Chilipepper	Scorpaenidae	0	-	-	-	4	-
Rosethorn Rockfish	Scorpaenidae	0	-	-	-	4	-
Spotted Sand Bass	Serranidae	< 0.1	42	-	-	-	-
Round Stingray	Urotrygonidae	< 0.1	39	-	-	-	-
Slough Anchovy	Engraulidae	< 0.1	31	-	-	-	-
Black Croaker	Sciaenidae	< 0.1	19	-	-	-	-
Pacific Seahorse	Syngnathidae	< 0.1	8	-	-	-	-
Yellowfin Croaker	Sciaenidae	< 0.1	8	-	-	-	-
Deepbody Anchovy	Engraulidae	< 0.1	4	-	-	-	-
Topsmelt	Atherinopsidae	< 0.1	4	-	-	-	-
White Seabass	Sciaenidae	< 0.1	4	-	-	-	-
Shiner Perch	Embiotocidae	< 0.1	4	-	-	-	-
Salema	Haemulidae	< 0.1	4	-	-	-	-
Rock Wrasse	Labridae	< 0.1	4	-	-	-	-
Horn Shark	Heterodontidae	< 0.1	4	-	-	-	-
California Corbina	Sciaenidae	< 0.1	4	-	-	-	-
Kelp Bass	Serranidae	< 0.1	4	-	-	-	-
Shovelnose Guitarfish	Rhinobatidae	< 0.1	4	-	-	-	-
Copper Rockfish	Scorpaenidae	< 0.1	4	-	-	-	-
unidentified pipefish	Syngnathidae	< 0.1	4	-	-	-	-
Jack Mackerel	Carangidae	< 0.1	4	-	-	-	-

Table E41. Megabenthic invertebrate abundance by stratum during the Bight '18 trawl survey.

Stratum	No. of Stations	Total	Min	Max	Area Weighted Values				% Above Bight Median
					Median	Mean	SD	95 % CL	
Bays & Harbors	26	26	2,934	6	1,284	61	113	241	93
Inner Shelf	29	29	3,338	1	2,128	21	115	387	141
Middle Shelf	30	30	6,427	4	1,069	81	214	285	102
Outer Shelf	26	26	59,788	17	27,475	152	2,300	6,865	2,639
Upper Slope	24	24	165,255	41	51,182	2,841	6,886	11,280	4,513
Total (all stations)	135	135	237,742	1	51,182	330	3,327	8,410	2,137

Table E42. Megabenthic invertebrate biomass (Kg) by stratum during the Bight '18 trawl survey.

Stratum	No. of Stations	Total	Min	Max	Area Weighted Values Median	Mean	SD	95 % CL	% Above Bight Median
Bays & Harbors	26	72.36	0.12	15.3	1.7	2.8	3.6	1.4	-51.5
Inner Shelf	29	20.02	0.03	4.8	0.3	0.7	0.9	0.3	-91.6
Middle Shelf	30	72.54	0.09	24.8	1.1	2.4	4.6	1.7	-70.5
Outer Shelf	26	701.68	0.06	268.6	4.4	27	70	26.9	21.7
Upper Slope	23	1,855.22	0.09	480.2	44.4	80.7	108.1	44.2	1,135.40
Total (all stations)	134	2,721.82	0.03	480.2	3.6	38.1	83.1	21.1	

Table E43. Megabenthic invertebrate Shannon diversity (H') by stratum during the Bight '18 trawl survey.

Stratum	No. of Stations	Min	Max	Area Weighted Values Median	Mean	SD	95 % CL	% Above Bight Median
Bays & Harbors	26	0	3.04	0.87	0.98	0.68	0.26	-3.2
Inner Shelf	29	0	2.12	1.12	1.14	0.53	0.19	24.5
Middle Shelf	30	0.35	2.57	1.05	1.16	0.53	0.19	16.8
Outer Shelf	26	0	2.3	1.21	1.17	0.69	0.26	34.5
Upper Slope	24	0.04	1.37	0.78	0.72	0.36	0.14	-13.1
Total (all stations)	135	0	3.04	0.9	0.96	0.53	0.11	

Table E44. Megabenthic invertebrate taxonomic richness by stratum during the Bight '18 trawl survey.

Stratum	No. of Stations	Total	Min	Max	Area Weighted Values Median	Mean	SD	95 % CL	% Above Bight Median
Bays & Harbors	26	53	2	17	5	5.1	3.2	1.2	-44.4
Inner Shelf	29	53	1	16	6	6.4	3.1	1.1	-33.3
Middle Shelf	30	90	3	21	9	9.7	4.7	1.7	0
Outer Shelf	26	73	1	25	13	12.7	6.7	2.6	44.4
Upper Slope	24	54	2	21	12	11.1	4.3	1.7	27.8
Total (all stations)	135	200	1	25	9	10	4.8	1	

Table E45. Biomass (Kg) of megabenthic invertebrate species collected during the Bight '18 trawl survey by stratum.

		Biomass (Kg)					
Species	Phylum:Family	SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Pleuroncodes planipes	Arthropoda:Munididae	1,257	-	-	0.3	524.5	733
Strongylocentrotus fragilis	Echinodermata:Strongylocentrotidae	345	-	-	0.1	42.2	303
Brisaster townsendi	Echinodermata:Schizasteridae	314	-	-	-	23	291
Brisaster sp	Echinodermata:Schizasteridae	284	-	-	-	3.3	280
Brissopsis pacifica	Echinodermata:Brissidae	115	-	-	-	2.1	113
Sicyonia ingentis	Arthropoda:Sicyoniidae	45	0.1	-	20	23	2.6
Metridium farcimen	Cnidaria:Metridiidae	40	-	-	-	34.5	5.8
Myxoderma platyacanthum	Echinodermata:Zoroasteridae	38	-	-	-	-	38.1
Apostichopus californicus	Echinodermata:Stichopodidae	34	0.1	-	30	3.8	-
Sicyonia penicillata	Arthropoda:Sicyoniidae	22	17.5	2.8	1.3	-	-
Tetilla sp	Silicea:Tetillidae	20	20.1	-	-	-	-
Apostichopus sp A	Echinodermata:Stichopodidae	19	-	-	-	-	18.9
Suberites latus	Silicea:Suberitidae	18.3	-	-	< 0.1	0.2	18.1
Dendraster excentricus	Echinodermata:Dendrasteridae	18	14	4	-	-	-
Pleurobranchaea californica	Mollusca:Pleurobranchidae	14	-	0.1	1.8	9.2	3
Pandalus platyceros	Arthropoda:Pandalidae	13.4	-	-	-	2.6	10.8
Spatangus californicus	Echinodermata:Spatangidae	9.8	-	-	-	2.3	7.5
Lopholithodes foraminatus	Arthropoda:Lithodidae	7.8	-	-	-	6.3	1.5
Octopus californicus	Mollusca:Octopodidae	7.3	-	-	-	2.2	5
Platymera gaudichaudii	Arthropoda:Calappidae	6.7	-	-	0.7	6	-
Paralithodes californiensis	Arthropoda:Lithodidae	6.1	-	-	-	-	6.1
Lytechinus pictus	Echinodermata:Toxopneustidae	5.8	0.1	0.2	5.5	0.1	< 0.1
Suberites sp	Silicea:Suberitidae	5.6	5.6	-	-	-	-
Panulirus interruptus	Arthropoda:Palinuridae	4.1	4	0.1	-	-	-
Asteronyx longifissus	Echinodermata:Asteronychidae	4	-	-	-	-	4
Gorgonocephalus eucnemis	Echinodermata:Gorgonocephalidae	3.8	-	-	-	3.8	-
Portunus xantusii	Arthropoda:Portunidae	3.5	0.8	2.8	-	-	-
Glyptolithodes cristatipes	Arthropoda:Lithodidae	3.2	-	-	-	-	3.2
Ophiura luetkenii	Echinodermata:Ophiuridae	2.9	-	-	2.6	0.3	-
Octopus rubescens	Mollusca:Octopodidae	2.4	-	0.4	0.8	1	0.2
Loxorhynchus grandis	Arthropoda:Epialtidae	2.2	-	-	2.2	-	-
Metacarcinus gracilis	Arthropoda:Cancridae	2.2	-	2	0.2	-	-
Cymothoidae	Arthropoda:Cymothoidae	2	0.4	0.4	0.6	0.5	0.1
Brisaster latifrons	Echinodermata:Schizasteridae	2	-	-	-	1.7	0.3
Astropecten californicus	Echinodermata:Astropectinidae	1.9	-	0.9	0.7	0.2	< 0.1
Munida hispida	Arthropoda:Munididae	1.8	-	-	-	< 0.1	1.8
Luidia foliolata	Echinodermata:Luidiidae	1.8	-	0.1	0.2	1.4	0.1
Apostichopus parvimensis	Echinodermata:Stichopodidae	1.6	1.6	-	< 0.1	-	-
Metacarcinus anthonyi	Arthropoda:Cancridae	1.6	-	0.8	0.8	-	-
Brissopsis sp LA1	Echinodermata:Brissidae	1.3	-	-	-	-	1.3
Ophiothrix spiculata	Echinodermata:Ophiotricidae	1.3	0.1	0.6	0.4	0.1	< 0.1
Halichondridae	Poriferia:Halichondridae	1.3	1.3	-	-	-	-
Stylasterias forreri	Echinodermata:Asteriidae	1.2	-	-	-	0.2	1
Desmophyllum dianthus	Cnidaria:Caryophylliidae	1.1	-	-	-	1.1	-
Hormathia digitata	Cnidaria:Hormathiidae	1.1	-	-	-	-	1.1
Thesea sp B	Cnidaria:Plexauridae	1	-	0.1	0.4	0.6	-
Kelletia kelletii	Mollusca:Buccinidae	1	-	1	< 0.1	-	-
Neocrangon zacae	Arthropoda:Crangonidae	1	-	-	-	0.6	0.4
Farfantepenaeus californiensis	Arthropoda:Penaeidae	0.9	0.8	0.2	-	-	-
Pyromaia tuberculata	Arthropoda:Inachoididae	0.9	0.6	0.2	0.1	-	-
Spirontocaris holmesi	Arthropoda:Hippolytidae	0.9	-	-	-	0.4	0.5
Acanthoptilum sp	Cnidaria:Virgulariidae	0.8	0.4	-	0.2	0.2	-
Spirontocaris sp	Arthropoda:Hippolytidae	0.8	-	-	-	0.2	0.6
Crangon nigromaculata	Arthropoda:Crangonidae	0.8	0.2	0.5	0.1	-	-
Dromalia alexandri	Cnidaria:Rhodaliidae	0.8	-	-	-	0.2	0.5
Calinaticina oldroydii	Mollusca:Naticidae	0.7	-	-	-	0.6	0.1
Pannychia moseleyi	Echinodermata:Laetmogonidae	0.6	-	-	-	-	0.6
Pyuridae	Chordata:Pyuridae	0.6	0.6	-	-	-	-

Table E45. Continued.

Species	Phylum:Family	Biomass (Kg)					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Philine auriformis	Mollusca:Philinidae	0.5	0.2	0.2	0.2	-	-
Opisthoteuthis sp A	Mollusca:Opisthoteuthidae	0.5	-	-	-	-	0.5
Rossia pacifica	Mollusca:Sepiolidae	0.5	-	-	0.1	0.4	0.1
Astropecten armatus	Echinodermata:Astropectinidae	0.5	0.3	0.2	< 0.1	-	-
Crossata ventricosa	Mollusca:Bursidae	0.5	-	0.5	-	-	-
Spirontocaris sica	Arthropoda:Hippolytidae	0.5	-	-	-	0.1	0.4
Neocrangon resima	Arthropoda:Crangonidae	0.4	-	-	-	0.3	0.2
Octopus bimaculoides	Mollusca:Octopodidae	0.4	0.4	-	-	-	-
Tochuina gigantea	Mollusca:Tritoniidae	0.4	-	0.1	< 0.1	0.3	-
Loxorhynchus crispatus	Arthropoda:Epialtidae	0.4	0.1	0.3	-	-	-
Musculista senhousia	Mollusca:Mytilidae	0.4	0.4	-	-	-	-
Navanax inermis	Mollusca:Aglajidae	0.4	0.4	-	-	-	-
Astropecten sp	Echinodermata:Astropectinidae	0.3	-	0.2	0.2	-	-
Solenocera mutator	Arthropoda:Solenoceridae	0.3	-	-	< 0.1	0.2	0.1
Astropecten ornatissimus	Echinodermata:Astropectinidae	0.3	-	-	-	0.3	-
Luidia armata	Echinodermata:Luidiidae	0.3	-	0.1	0.2	< 0.1	-
Bulla gouldiana	Mollusca:Bullidae	0.3	0.2	< 0.1	-	-	-
Lophopanopeus bellus	Arthropoda:Panopeidae	0.2	0.2	-	-	-	-
Luidia asthenosoma	Echinodermata:Luidiidae	0.2	-	-	0.2	0.1	-
Metacrangon spinosissima	Arthropoda:Crangonidae	0.2	-	-	< 0.1	0.2	-
Pseudarchaster pusillus	Echinodermata:Goniasteridae	0.2	-	-	-	-	0.2
Armina californica	Mollusca:Arminidae	0.2	-	0.1	0.1	-	-
Ericerodes hemphillii	Arthropoda:Inachidae	0.2	-	0.1	0.1	-	-
Adelogorgia phyllosclera	Cnidaria:Gorgoniidae	0.2	-	-	0.2	-	-
Romaleon antennarium	Arthropoda:Cancridae	0.2	0.1	< 0.1	0.1	-	-
Amphichondrius granulatus	Echinodermata:Amphiuridae	0.2	-	-	0.1	0.1	-
Ophiopholis bakeri	Echinodermata:Ophiactidae	0.2	-	-	< 0.1	0.1	< 0.1
Dendronotus venustus	Mollusca:Dendronotidae	0.2	0.1	0.1	< 0.1	-	-
Flabellinopsis iodinea	Mollusca:Flabellinopsidae	0.2	-	0.1	< 0.1	-	-
Pennatula phosphorea	Cnidaria:Pennatulidae	0.2	-	-	-	< 0.1	0.1
Tritonia tetraquetra	Mollusca:Tritoniidae	0.2	0.1	-	0.1	< 0.1	-
Lissodendoryx sp	Silicea:Coelosphaeridae	0.1	-	-	< 0.1	-	0.1
Megasurcula carpenteriana	Mollusca:Pseudomelatomidae	0.1	-	-	< 0.1	-	0.1
Acanthodoris brunnea	Mollusca:Onchidorididae	0.1	-	0.1	< 0.1	< 0.1	-
Californiconus californicus	Mollusca:Conidae	0.1	0.1	< 0.1	< 0.1	-	-
Ciona robusta	Chordata:Cionidae	0.1	0.1	-	-	-	-
Crangon alaskensis	Arthropoda:Crangonidae	0.1	-	-	0.1	-	-
Florometra serratissima	Echinodermata:Antedonidae	0.1	-	-	-	0.1	-
Leptopecten latiauratus	Mollusca:Pectinidae	0.1	0.1	-	-	-	-
Nassarius tiarula	Mollusca:Nassariidae	0.1	0.1	-	-	-	-
Orthopagurus minimus	Arthropoda:Paguridae	0.1	-	-	0.1	-	-
Paguristes turgidus	Arthropoda:Diogenidae	0.1	-	-	< 0.1	0.1	< 0.1
Patiria miniata	Echinodermata:Asterinidae	0.1	0.1	-	-	-	-
Stylatula elongata	Cnidaria:Virgulariidae	0.1	-	0.1	-	-	-
Hemisquilla californiensis	Arthropoda:Hemisquillidae	0.1	-	0.1	-	-	-
Acanthodoris rhodoceras	Mollusca:Onchidorididae	0.1	0.1	-	< 0.1	-	-
Coryrhynchus lobifrons	Arthropoda:Inachidae	0.1	-	-	0.1	-	-
Lamellaria diegoensis	Mollusca:Velutinidae	0.1	0.1	< 0.1	-	-	-
Latulambrus occidentalis	Arthropoda:Parthenopidae	0.1	-	0.1	< 0.1	-	-
Nudibranchia	Mollusca:NA	0.1	-	0.1	< 0.1	-	-
Pagurus spilocarpus	Arthropoda:Paguridae	0.1	0.1	< 0.1	-	-	-
Paralithodes rathbuni	Arthropoda:Lithodidae	0.1	-	-	-	0.1	< 0.1
Pteropurpura vokesae	Mollusca:Muricidae	0.1	-	-	0.1	-	-
Randallia ornata	Arthropoda:Leucosiidae	0.1	-	0.1	-	-	-
Virgularia agassizii	Cnidaria:Virgulariidae	0.1	-	-	< 0.1	< 0.1	< 0.1
Antiplanes thalea	Mollusca:Pseudomelatomidae	0.1	-	-	-	-	0.1
Apatia pricei	Mollusca:Apatidae	0.1	-	< 0.1	< 0.1	-	-
Aphrodita castanea	Annelida:Aphroditidae	0.1	-	-	-	0.1	-
Asteroidea	Echinodermata:uncertain	0.1	-	-	< 0.1	-	< 0.1
Calliostoma tricolor	Mollusca:Calliostomatidae	0.1	-	0.1	-	-	-

Table E45. Continued.

Species	Phylum:Family	Biomass (Kg) SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Chalinidae	Silicea:Chalinidae	0.1	0.1	-	-	-	-
Chorilia longipes	Arthropoda:Epialtidae	0.1	-	-	< 0.1	-	< 0.1
Crassostrea gigas	Mollusca:Ostreidae	0.1	0.1	-	-	-	-
Crepidula fornicata	Mollusca:Calyptraeidae	0.1	0.1	-	-	-	-
Dallinella occidentalis	Brachiopoda:Terebrataliidae	0.1	-	-	< 0.1	< 0.1	-
Dendraster terminalis	Echinodermata:Dendrasteridae	0.1	-	0.1	-	-	-
Epiactis prolifera	Cnidaria:Actiniidae	0.1	0.1	-	-	-	-
Eugorgia rubens	Cnidaria:Gorgoniidae	0.1	-	-	0.1	-	-
Henricia sp	Echinodermata:Echinasteridae	0.1	-	-	< 0.1	< 0.1	-
Heterogorgia tortuosa	Cnidaria:Gorgoniidae	0.1	-	< 0.1	< 0.1	-	-
Lottia depicta	Mollusca:Lottiidae	0.1	0.1	-	-	-	-
Luidia sp	Echinodermata:Luidiidae	0.1	-	< 0.1	< 0.1	-	-
Mesocentrotus franciscanus	Echinodermata:Strongylocentrotidae	0.1	0.1	-	-	-	-
Muricea fruticosa	Cnidaria:Plexauridae	0.1	0.1	-	-	-	-
Neocrangon sp	Arthropoda:Crangonidae	0.1	-	-	-	< 0.1	< 0.1
Octopus veligero	Mollusca:Octopodidae	0.1	-	-	-	0.1	-
Paguristes bakeri	Arthropoda:Diogenidae	0.1	-	< 0.1	< 0.1	-	-
Paguristes ulreyi	Arthropoda:Diogenidae	0.1	-	-	0.1	-	-
Pagurus armatus	Arthropoda:Paguridae	0.1	0.1	-	-	-	-
Palaemon macrodactylus	Arthropoda:Palaemonidae	0.1	0.1	-	-	-	-
Philinorbis albus	Mollusca:Philinorbidae	0.1	-	-	< 0.1	< 0.1	-
Polycera atra	Mollusca:Polyceridae	0.1	0.1	-	-	-	-
Pteropurpura festiva	Mollusca:Muricidae	0.1	0.1	-	-	-	-
Ptilosarcus gurneyi	Cnidaria:Pennatulidae	0.1	-	-	-	0.1	-
Sclerasterias heteropaes	Echinodermata:Asteriidae	0.1	-	-	0.1	-	-
Strongylocentrotus purpuratus	Echinodermata:Strongylocentrotidae	0.1	0.1	-	-	-	-
Styela clava	Chordata:Styelidae	0.1	0.1	-	-	-	-
Styela plicata	Chordata:Styelidae	0.1	0.1	-	-	-	-
Stylatula sp A	Cnidaria:Virgulariidae	0.1	0.1	-	-	-	-
Telesto sp	Cnidaria:Clavulariidae	0.1	-	-	0.1	-	-
Triopha maculata	Mollusca:Polyceridae	0.1	0.1	-	-	-	-
Tritia insculpta	Mollusca:Nassariidae	0.1	-	-	-	-	0.1
Virgularia sp	Cnidaria:Virgulariidae	0.1	0.1	-	-	-	-
Acanthodoris sp	Mollusca:Onchidorididae	< 0.1	-	< 0.1	-	-	-
Acarnus sp	Silicea:Acarnidae	< 0.1	-	-	< 0.1	-	-
Actiniaria	Cnidaria:NA	< 0.1	-	-	-	< 0.1	-
Aglaja ocelligera	Mollusca:Aglajidae	< 0.1	-	< 0.1	-	-	-
Amphipholis pugetana	Echinodermata:Amphiuridae	< 0.1	-	-	-	< 0.1	-
Amphipholis squamata	Echinodermata:Amphiuridae	< 0.1	-	-	< 0.1	-	-
Aphrodita refulgida	Annelida:Aphroditidae	< 0.1	-	-	-	< 0.1	-
Araiofusus araios	Mollusca:Fasciolariidae	< 0.1	-	-	< 0.1	-	-
Araiofusus eueides	Mollusca:Fasciolariidae	< 0.1	-	-	< 0.1	-	-
Asteriidae	Echinodermata:Asteriidae	< 0.1	-	-	-	< 0.1	-
Astyris permodesta	Mollusca:Columbellidae	< 0.1	-	-	-	-	< 0.1
Bathypera feminalba	Chordata:Pyuridae	< 0.1	-	-	< 0.1	-	-
Brissopsis sp	Echinodermata:Brissidae	< 0.1	-	-	-	-	< 0.1
Cadlina luteomarginata	Mollusca:Chromodorididae	< 0.1	-	-	< 0.1	-	-
Calliostoma annulatum	Mollusca:Calliostomatidae	< 0.1	-	-	< 0.1	-	-
Calliostoma platinum	Mollusca:Calliostomatidae	< 0.1	-	-	-	-	< 0.1
Calliostoma variegatum	Mollusca:Calliostomatidae	< 0.1	-	-	-	< 0.1	-
Cancellaria crawfordiana	Mollusca:Cancellariidae	< 0.1	-	-	-	< 0.1	-
Cancridae	Arthropoda:Cancridae	< 0.1	-	< 0.1	-	-	-
Chlorostoma aureotincta	Mollusca:Turbinidae	< 0.1	-	< 0.1	-	-	-
Dendronotus iris	Mollusca:Dendronotidae	< 0.1	-	< 0.1	-	-	-
Dirona picta	Mollusca:Dironidae	< 0.1	-	< 0.1	-	-	-
Epizoanthus induratum	Cnidaria:Epizoanthidae	< 0.1	-	-	-	< 0.1	-
Gastropoda	Mollusca:NA	< 0.1	-	-	-	-	< 0.1
Gorgoniidae	Gorgoniidae	< 0.1	-	-	-	< 0.1	-
Halichondria sp	Silicea:Halichondriidae	< 0.1	-	-	< 0.1	-	-
Haliclona sp	Silicea:Chalinidae	< 0.1	-	-	< 0.1	-	-

Table E45. Continued.

Species	Phylum:Family	Biomass (Kg)					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Halocynthia igaboja	Chordata:Pyuridae	< 0.1	-	-	-	< 0.1	-
Heptacarpus taylori	Arthropoda:Hippolytidae	< 0.1	-	< 0.1	-	-	-
Hermissenda opalescens	Mollusca:Facelinidae	< 0.1	-	< 0.1	-	-	-
Janetogalathea californiensis	Arthropoda:Galatheidae	< 0.1	-	-	-	< 0.1	-
Leucilla nuttingi	Calcarea:Amphoriscidae	< 0.1	-	-	< 0.1	-	-
Loxorhynchus sp	Arthropoda:Epialtidae	< 0.1	-	-	< 0.1	-	-
Mediaster aequalis	Echinodermata:Goniasteridae	< 0.1	-	-	-	< 0.1	-
Melanochlamys diomedea	Mollusca:Aglajidae	< 0.1	-	< 0.1	-	-	-
Nymphon heterodenticulatum	Arthropoda:Nymphonidae	< 0.1	-	-	-	< 0.1	-
Nymphon pixellae	Arthropoda:Nymphonidae	< 0.1	-	-	-	< 0.1	-
Odontaster crassus	Echinodermata:Odontasteridae	< 0.1	-	-	< 0.1	-	-
Ophiacantha diplasia	Echinodermata:Ophiacanthidae	< 0.1	-	-	-	< 0.1	-
Paguroidea	Arthropoda:NA	< 0.1	-	-	-	-	< 0.1
Pagurus hartae	Arthropoda:Paguridae	< 0.1	-	-	< 0.1	-	-
Pandalus jordani	Arthropoda:Pandalidae	< 0.1	-	-	-	< 0.1	-
Parapagurodes laurentae	Arthropoda:Paguridae	< 0.1	-	-	< 0.1	-	-
Pennatulacea sp HYP1	Anthozoa:NA	< 0.1	-	-	< 0.1	-	-
Phimochirus californiensis	Arthropoda:Paguridae	< 0.1	-	-	< 0.1	-	-
Pinnixa occidentalis Cmplx	Arthropoda:Pinnotheridae	< 0.1	-	-	< 0.1	-	-
Poecilosclerida	Silicea:NA	< 0.1	-	-	< 0.1	-	-
Poraniopsis inflata	Echinodermata:Poraniidae	< 0.1	-	-	-	< 0.1	-
Pugettia dalli	Arthropoda:Epialtidae	< 0.1	-	-	< 0.1	-	-
Renilla koellikeri	Cnidaria:Renillidae	< 0.1	-	< 0.1	-	-	-
Savalia lucifica	Cnidaria:Parazoanthidae	< 0.1	-	-	< 0.1	-	-
Simnia barbarensis	Mollusca:Ovulidae	< 0.1	-	-	< 0.1	-	-
Spirontocaris prionota	Arthropoda:Hippolytidae	< 0.1	-	-	< 0.1	-	-
Styela gibbsii	Chordata:Styelidae	< 0.1	-	-	< 0.1	-	-
Styela sp	Chordata:Styelidae	< 0.1	-	-	< 0.1	-	-
Thordisa bimaculata	Mollusca:Discodorididae	< 0.1	-	-	< 0.1	-	-
Tritonia festiva	Mollusca:Tritoniidae	< 0.1	-	-	< 0.1	-	-
Virgularia californica	Cnidaria:Virgulariidae	< 0.1	-	-	-	< 0.1	-

Table E46. Frequency of occurrence (%) of megabenthic invertebrate species collected during the Bight '18 trawl survey by stratum.

		Frequency					
Species	**Phylum:Family**	**SCB**	**Bays & Harbors**	**Inner Shelf**	**Middle Shelf**	**Outer Shelf**	**Upper Slope**
Strongylocentrotus fragilis	Echinodermata:Strongylocentrotidae	43	-	-	10	80.8	72
Cymothoidae	Arthropoda:Cymothoidae	38	26.9	48.3	63.3	69.2	12
Pleurobranchaea californica	Mollusca:Pleurobranchidae	38	-	10.3	40	54	44
Brissopsis pacifica	Echinodermata:Brissidae	37	-	-	-	26.9	76
Astropecten californicus	Echinodermata:Astropectinidae	36	-	69	63.3	26.9	8
Octopus californicus	Mollusca:Octopodidae	35	-	-	-	23	72
Sicyonia ingentis	Arthropoda:Sicyoniidae	33	8	-	53.3	76.9	24
Brisaster townsendi	Echinodermata:Schizasteridae	32	-	-	-	15.4	68
Octopus rubescens	Mollusca:Octopodidae	32	-	20.7	47	65.4	20
Pleuroncodes planipes	Arthropoda:Munididae	29	-	-	3.3	30.8	56
Neocrangon zacae	Arthropoda:Crangonidae	29	-	-	-	62	52
Lytechinus pictus	Echinodermata:Toxopneustidae	25	3.8	17.2	63.3	15.4	4
Spirontocaris sp	Arthropoda:Hippolytidae	23.3	-	-	-	19.2	48
Ophiothrix spiculata	Echinodermata:Ophiotricidae	21.5	7.7	24.1	50	11.5	4
Spirontocaris sica	Arthropoda:Hippolytidae	20.2	-	-	-	3.8	44
Brisaster sp	Echinodermata:Schizasteridae	20.1	-	-	-	23.1	40
Spatangus californicus	Echinodermata:Spatangidae	18.7	-	-	-	7.7	40
Pandalus platyceros	Arthropoda:Pandalidae	18.6	-	-	-	26.9	36
Spirontocaris holmesi	Arthropoda:Hippolytidae	18.3	-	-	-	23.1	36
Sicyonia penicillata	Arthropoda:Sicyoniidae	17.9	46.2	48.3	33.3	-	-
Ophiura luetkenii	Echinodermata:Ophiuridae	15.3	-	-	40	42.3	-
Thesea sp B	Cnidaria:Plexauridae	14.7	-	10.3	40	15.4	-
Suberites latus	Silicea:Suberitidae	14.6	-	-	3.3	11.5	28
Apostichopus californicus	Echinodermata:Stichopodidae	13.4	3.8	-	36.7	30.8	-
Luidia foliolata	Echinodermata:Luidiidae	12.7	-	6.9	16.7	34.6	8
Crangon nigromaculata	Arthropoda:Crangonidae	12.3	15.4	55.2	10	-	-
Neocrangon resima	Arthropoda:Crangonidae	12.1	-	-	-	34.6	20
Glyptolithodes cristatipes	Arthropoda:Lithodidae	10.8	-	-	-	-	24
Myxoderma platyacanthum	Echinodermata:Zoroasteridae	10.8	-	-	-	-	24
Pseudarchaster pusillus	Echinodermata:Goniasteridae	10.8	-	-	-	-	24
Rossia pacifica	Mollusca:Sepiolidae	10.7	-	-	6.7	38.5	12
Solenocera mutator	Arthropoda:Solenoceridae	10.5	-	-	3.3	26.9	16
Metridium farcimen	Cnidaria:Metridiidae	9.9	-	-	-	30.8	16
Apostichopus sp A	Echinodermata:Stichopodidae	9	-	-	-	-	20
Paralithodes californiensis	Arthropoda:Lithodidae	9	-	-	-	-	20
Brisaster latifrons	Echinodermata:Schizasteridae	8.9	-	-	-	19.2	16
Acanthoptilum sp	Cnidaria:Virgulariidae	8.8	23.1	-	23.3	23.1	-
Astropecten sp	Echinodermata:Astropectinidae	8.7	-	17.2	20	-	-
Luidia armata	Echinodermata:Luidiidae	7.9	-	10.3	20	3.8	-
Philine auriformis	Mollusca:Philinidae	7.8	15.4	17.2	16.7	-	-
Pennatula phosphorea	Cnidaria:Pennatulidae	7.6	-	-	-	3.8	16
Asteronyx longifissus	Echinodermata:Asteronychidae	7.2	-	-	-	-	16
Pannychia moseleyi	Echinodermata:Laetmogonidae	7.2	-	-	-	-	16
Pyromaia tuberculata	Arthropoda:Inachoididae	7	38.5	24.1	10	-	-
Luidia asthenosoma	Echinodermata:Luidiidae	5.9	-	-	16.7	11.5	-
Ericerodes hemphillii	Arthropoda:Inachidae	5.6	-	10.3	13.3	-	-
Tritia insculpta	Mollusca:Nassariidae	5.4	-	-	-	-	12
Armina californica	Mollusca:Arminidae	5.2	-	13.8	10	-	-
Metacarcinus gracilis	Arthropoda:Cancridae	5.1	-	24.1	3.3	-	-
Portunus xantusii	Arthropoda:Portunidae	4.7	26.9	27.6	-	-	-
Stylasterias forreri	Echinodermata:Asteriidae	4.6	-	-	-	11.5	8
Calinaticina oldroydii	Mollusca:Naticidae	4.3	-	-	-	7.7	8
Dromalia alexandri	Cnidaria:Rhodaliidae	4.3	-	-	-	7.7	8
Platymera gaudichaudii	Arthropoda:Calappidae	4.3	-	-	10	15.4	-
Ophiopholis bakeri	Echinodermata:Ophiactidae	4.1	-	-	3.3	15.4	4
Munida hispida	Arthropoda:Munididae	3.9	-	-	-	3.8	8
Astropecten armatus	Echinodermata:Astropectinidae	3.9	11.5	17.2	3.3	-	-
Crangon alaskensis	Arthropoda:Crangonidae	3.9	-	-	13.3	-	-

Table E46. Continued.

Species	Phylum:Family	Frequency					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Orthopagurus minimus	Arthropoda:Paguridae	3.9	-	-	13.3	-	-
Antiplanes thalea	Mollusca:Pseudomelatomidae	3.6	-	-	-	-	8
Hormathia digitata	Cnidaria:Hormathiidae	3.6	-	-	-	-	8
Opisthoteuthis sp A	Mollusca:Opisthoteuthidae	3.6	-	-	-	-	8
Paguristes turgidus	Arthropoda:Diogenidae	3.4	-	-	3.3	7.7	4
Metacrangon spinosissima	Arthropoda:Crangonidae	3.3	-	-	3.3	26.9	-
Flabellinopsis iodinea	Mollusca:Flabellinopsidae	3.3	-	13.8	3.3	-	-
Amphichondrius granulatus	Echinodermata:Amphiuridae	3.3	-	-	6.7	15.4	-
Virgularia agassizii	Cnidaria:Virgulariidae	3.1	-	-	3.3	3.8	4
Coryrhynchus lobifrons	Arthropoda:Inachidae	2.9	-	-	10	-	-
Pteropurpura vokesae	Mollusca:Muricidae	2.9	-	-	10	-	-
Lopholithodes foraminatus	Arthropoda:Lithodidae	2.8	-	-	-	11.5	4
Asteroidea	Echinodermata:uncertain	2.8	-	-	3.3	-	4
Chorilia longipes	Arthropoda:Epialtidae	2.8	-	-	3.3	-	4
Lissodendoryx sp	Silicea:Coelosphaeridae	2.8	-	-	3.3	-	4
Megasurcula carpenteriana	Mollusca:Pseudomelatomidae	2.8	-	-	3.3	-	4
Astropecten ornatissimus	Echinodermata:Astropectinidae	2.7	-	-	-	30.8	-
Paralithodes rathbuni	Arthropoda:Lithodidae	2.5	-	-	-	7.7	4
Acanthodoris brunnea	Mollusca:Onchidorididae	2.5	-	6.9	3.3	3.8	-
Tochuina gigantea	Mollusca:Tritoniidae	2.5	-	6.9	3.3	3.8	-
Stylatula elongata	Cnidaria:Virgulariidae	2.3	-	13.8	-	-	-
Tritonia tetraquetra	Mollusca:Tritoniidae	2.3	3.8	-	6.7	3.8	-
Neocrangon sp	Arthropoda:Crangonidae	2.1	-	-	-	3.8	4
Dendronotus venustus	Mollusca:Dendronotidae	2.1	3.8	6.9	3.3	-	-
Kelletia kelletii	Mollusca:Buccinidae	2.1	-	6.9	3.3	-	-
Latulambrus occidentalis	Arthropoda:Parthenopidae	2.1	-	6.9	3.3	-	-
Metacarcinus anthonyi	Arthropoda:Cancridae	2.1	-	6.9	3.3	-	-
Nudibranchia	Mollusca:NA	2.1	-	6.9	3.3	-	-
Eugorgia rubens	Cnidaria:Gorgoniidae	1.9	-	-	6.7	-	-
Paguristes ulreyi	Arthropoda:Diogenidae	1.9	-	-	6.7	-	-
Sclerasterias heteropaes	Echinodermata:Asteriidae	1.9	-	-	6.7	-	-
Telesto sp	Cnidaria:Clavulariidae	1.9	-	-	6.7	-	-
Astyris permodesta	Mollusca:Columbellidae	1.8	-	-	-	-	4
Brissopsis sp	Echinodermata:Brissidae	1.8	-	-	-	-	4
Brissopsis sp LA1	Echinodermata:Brissidae	1.8	-	-	-	-	4
Calliostoma platinum	Mollusca:Calliostomatidae	1.8	-	-	-	-	4
Gastropoda	Mollusca:NA	1.8	-	-	-	-	4
Paguroidea	Arthropoda:NA	1.8	-	-	-	-	4
Farfantepenaeus californiensis	Arthropoda:Penaeidae	1.8	19.2	10.3	-	-	-
Randallia ornata	Arthropoda:Leucosiidae	1.7	-	10.3	-	-	-
Gorgonocephalus eucnemis	Echinodermata:Gorgonocephalidae	1.7	-	-	-	19.2	-
Californiconus californicus	Mollusca:Conidae	1.6	3.8	3.4	3.3	-	-
Romaleon antennarium	Arthropoda:Cancridae	1.6	3.8	3.4	3.3	-	-
Apatia pricei	Mollusca:Apatidae	1.6	-	3.4	3.3	-	-
Heterogorgia tortuosa	Cnidaria:Gorgoniidae	1.6	-	3.4	3.3	-	-
Luidia sp	Echinodermata:Luidiidae	1.6	-	3.4	3.3	-	-
Paguristes bakeri	Arthropoda:Diogenidae	1.6	-	3.4	3.3	-	-
Florometra serratissima	Echinodermata:Antedonidae	1.3	-	-	-	15.4	-
Dallinella occidentalis	Brachiopoda:Terebrataliidae	1.3	-	-	3.3	3.8	-
Henricia sp	Echinodermata:Echinasteridae	1.3	-	-	3.3	3.8	-
Philinorbis albus	Mollusca:Philinorbidae	1.3	-	-	3.3	3.8	-
Dendraster excentricus	Echinodermata:Dendrasteridae	1.2	3.8	6.9	-	-	-
Calliostoma tricolor	Mollusca:Calliostomatidae	1.2	-	6.9	-	-	-
Dendraster terminalis	Echinodermata:Dendrasteridae	1.2	-	6.9	-	-	-
Acanthodoris rhodoceras	Mollusca:Onchidorididae	1	3.8	-	3.3	-	-
Apostichopus parvimensis	Echinodermata:Stichopodidae	1	3.8	-	3.3	-	-
Acarnus sp	Silicea:Acarnidae	1	-	-	3.3	-	-
Adelogorgia phyllosclera	Cnidaria:Gorgoniidae	1	-	-	3.3	-	-
Amphipholis squamata	Echinodermata:Amphiuridae	1	-	-	3.3	-	-
Araiofusus araios	Mollusca:Fasciolariidae	1	-	-	3.3	-	-

Table E46. Continued.

Species	Phylum:Family	Frequency					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Araiofusus eueides	Mollusca:Fasciolariidae	1	-	-	3.3	-	-
Bathypera feminalba	Chordata:Pyuridae	1	-	-	3.3	-	-
Cadlina luteomarginata	Mollusca:Chromodorididae	1	-	-	3.3	-	-
Calliostoma annulatum	Mollusca:Calliostomatidae	1	-	-	3.3	-	-
Halichondria sp	Silicea:Halichondriidae	1	-	-	3.3	-	-
Haliclona sp	Silicea:Chalinidae	1	-	-	3.3	-	-
Leucilla nuttingi	Calcarea:Amphoriscidae	1	-	-	3.3	-	-
Loxorhynchus grandis	Arthropoda:Epialtidae	1	-	-	3.3	-	-
Loxorhynchus sp	Arthropoda:Epialtidae	1	-	-	3.3	-	-
Odontaster crassus	Echinodermata:Odontasteridae	1	-	-	3.3	-	-
Pagurus hartae	Arthropoda:Paguridae	1	-	-	3.3	-	-
Parapagurodes laurentae	Arthropoda:Paguridae	1	-	-	3.3	-	-
Pennatulacea sp HYP1	Anthozoa:NA	1	-	-	3.3	-	-
Phimochirus californiensis	Arthropoda:Paguridae	1	-	-	3.3	-	-
Pinnixa occidentalis Cmplx	Arthropoda:Pinnotheridae	1	-	-	3.3	-	-
Poecilosclerida	Silicea:NA	1	-	-	3.3	-	-
Pugettia dalli	Arthropoda:Epialtidae	1	-	-	3.3	-	-
Savalia lucifica	Cnidaria:Parazoanthidae	1	-	-	3.3	-	-
Simnia barbarensis	Mollusca:Ovulidae	1	-	-	3.3	-	-
Spirontocaris prionota	Arthropoda:Hippolytidae	1	-	-	3.3	-	-
Styela gibbsii	Chordata:Styelidae	1	-	-	3.3	-	-
Styela sp	Chordata:Styelidae	1	-	-	3.3	-	-
Thordisa bimaculata	Mollusca:Discodorididae	1	-	-	3.3	-	-
Tritonia festiva	Mollusca:Tritoniidae	1	-	-	3.3	-	-
Aphrodita castanea	Annelida:Aphroditidae	0.7	-	-	-	7.7	-
Desmophyllum dianthus	Cnidaria:Caryophylliidae	0.7	-	-	-	7.7	-
Octopus veligero	Mollusca:Octopodidae	0.7	-	-	-	7.7	-
Ptilosarcus gurneyi	Cnidaria:Pennatulidae	0.7	-	-	-	7.7	-
Bulla gouldiana	Mollusca:Bullidae	0.6	15.4	3.4	-	-	-
Panulirus interruptus	Arthropoda:Palinuridae	0.6	7.7	3.4	-	-	-
Lamellaria diegoensis	Mollusca:Velutinidae	0.6	3.8	3.4	-	-	-
Loxorhynchus crispatus	Arthropoda:Epialtidae	0.6	3.8	3.4	-	-	-
Pagurus spilocarpus	Arthropoda:Paguridae	0.6	3.8	3.4	-	-	-
Acanthodoris sp	Mollusca:Onchidorididae	0.6	-	3.4	-	-	-
Aglaja ocelligera	Mollusca:Aglajidae	0.6	-	3.4	-	-	-
Cancridae	Arthropoda:Cancridae	0.6	-	3.4	-	-	-
Chlorostoma aureotincta	Mollusca:Turbinidae	0.6	-	3.4	-	-	-
Crossata ventricosa	Mollusca:Bursidae	0.6	-	3.4	-	-	-
Dendronotus iris	Mollusca:Dendronotidae	0.6	-	3.4	-	-	-
Dirona picta	Mollusca:Dironidae	0.6	-	3.4	-	-	-
Hemisquilla californiensis	Arthropoda:Hemisquillidae	0.6	-	3.4	-	-	-
Heptacarpus taylori	Arthropoda:Hippolytidae	0.6	-	3.4	-	-	-
Hermissenda opalescens	Mollusca:Facelinidae	0.6	-	3.4	-	-	-
Melanochlamys diomedea	Mollusca:Aglajidae	0.6	-	3.4	-	-	-
Renilla koellikeri	Cnidaria:Renillidae	0.6	-	3.4	-	-	-
Actiniaria	Cnidaria:NA	0.3	-	-	-	3.8	-
Amphipholis pugetana	Echinodermata:Amphiuridae	0.3	-	-	-	3.8	-
Aphrodita refulgida	Annelida:Aphroditidae	0.3	-	-	-	3.8	-
Asteriidae	Echinodermata:Asteriidae	0.3	-	-	-	3.8	-
Calliostoma variegatum	Mollusca:Calliostomatidae	0.3	-	-	-	3.8	-
Cancellaria crawfordiana	Mollusca:Cancellariidae	0.3	-	-	-	3.8	-
Epizoanthus induratum	Cnidaria:Epizoanthidae	0.3	-	-	-	3.8	-
Gorgoniidae	Cnidaria:NA	0.3	-	-	-	3.8	-
Halocynthia igaboja	Chordata:Pyuridae	0.3	-	-	-	3.8	-
Janetogalathea californiensis	Arthropoda:Galatheidae	0.3	-	-	-	3.8	-
Mediaster aequalis	Echinodermata:Goniasteridae	0.3	-	-	-	3.8	-
Nymphon heterodenticulatum	Arthropoda:Nymphonidae	0.3	-	-	-	3.8	-
Nymphon pixellae	Arthropoda:Nymphonidae	0.3	-	-	-	3.8	-
Ophiacantha diplasia	Echinodermata:Ophiacanthidae	0.3	-	-	-	3.8	-
Pandalus jordani	Arthropoda:Pandalidae	0.3	-	-	-	3.8	-

Table E46. Continued.

Species	Phylum:Family	Frequency					
		SCB	Bays & Harbors	Inner Shelf	Middle Shelf	Outer Shelf	Upper Slope
Poraniopsis inflata	Echinodermata:Poraniidae	0.3	-	-	-	3.8	-
Virgularia californica	Cnidaria:Virgulariidae	0.3	-	-	-	3.8	-
Musculista senhousia	Mollusca:Mytilidae	< 0.1	23.1	-	-	-	-
Navanax inermis	Mollusca:Aglajidae	< 0.1	23.1	-	-	-	-
Tetilla sp	Silicea:Tetillidae	< 0.1	19.2	-	-	-	-
Lophopanopeus bellus	Arthropoda:Panopeidae	< 0.1	15.4	-	-	-	-
Halichondridae	Poriferia:Halichondridae	< 0.1	11.5	-	-	-	-
Ciona robusta	Chordata:Cionidae	< 0.1	7.7	-	-	-	-
Leptopecten latiauratus	Mollusca:Pectinidae	< 0.1	7.7	-	-	-	-
Nassarius tiarula	Mollusca:Nassariidae	< 0.1	7.7	-	-	-	-
Patiria miniata	Echinodermata:Asterinidae	< 0.1	7.7	-	-	-	-
Suberites sp	Silicea:Suberitidae	< 0.1	7.7	-	-	-	-
Chalinidae	Silicea:Chalinidae	< 0.1	3.8	-	-	-	-
Crassostrea gigas	Mollusca:Ostreidae	< 0.1	3.8	-	-	-	-
Crepidula fornicata	Mollusca:Calyptraeidae	< 0.1	3.8	-	-	-	-
Epiactis prolifera	Cnidaria:Actiniidae	< 0.1	3.8	-	-	-	-
Lottia depicta	Mollusca:Lottiidae	< 0.1	3.8	-	-	-	-
Mesocentrotus franciscanus	Echinodermata:Strongylocentrotidae	< 0.1	3.8	-	-	-	-
Muricea fruticosa	Cnidaria:Plexauridae	< 0.1	3.8	-	-	-	-
Octopus bimaculoides	Mollusca:Octopodidae	< 0.1	3.8	-	-	-	-
Pagurus armatus	Arthropoda:Paguridae	< 0.1	3.8	-	-	-	-
Palaemon macrodactylus	Arthropoda:Palaemonidae	< 0.1	3.8	-	-	-	-
Polycera atra	Mollusca:Polyceridae	< 0.1	3.8	-	-	-	-
Pteropurpura festiva	Mollusca:Muricidae	< 0.1	3.8	-	-	-	-
Pyuridae	Chordata:Pyuridae	< 0.1	3.8	-	-	-	-
Strongylocentrotus purpuratus	Echinodermata:Strongylocentrotidae	< 0.1	3.8	-	-	-	-
Styela clava	Chordata:Styelidae	< 0.1	3.8	-	-	-	-
Styela plicata	Chordata:Styelidae	< 0.1	3.8	-	-	-	-
Stylatula sp A	Cnidaria:Virgulariidae	< 0.1	3.8	-	-	-	-
Triopha maculata	Mollusca:Polyceridae	< 0.1	3.8	-	-	-	-
Virgularia sp	Cnidaria:Virgulariidae	< 0.1	3.8	-	-	-	-

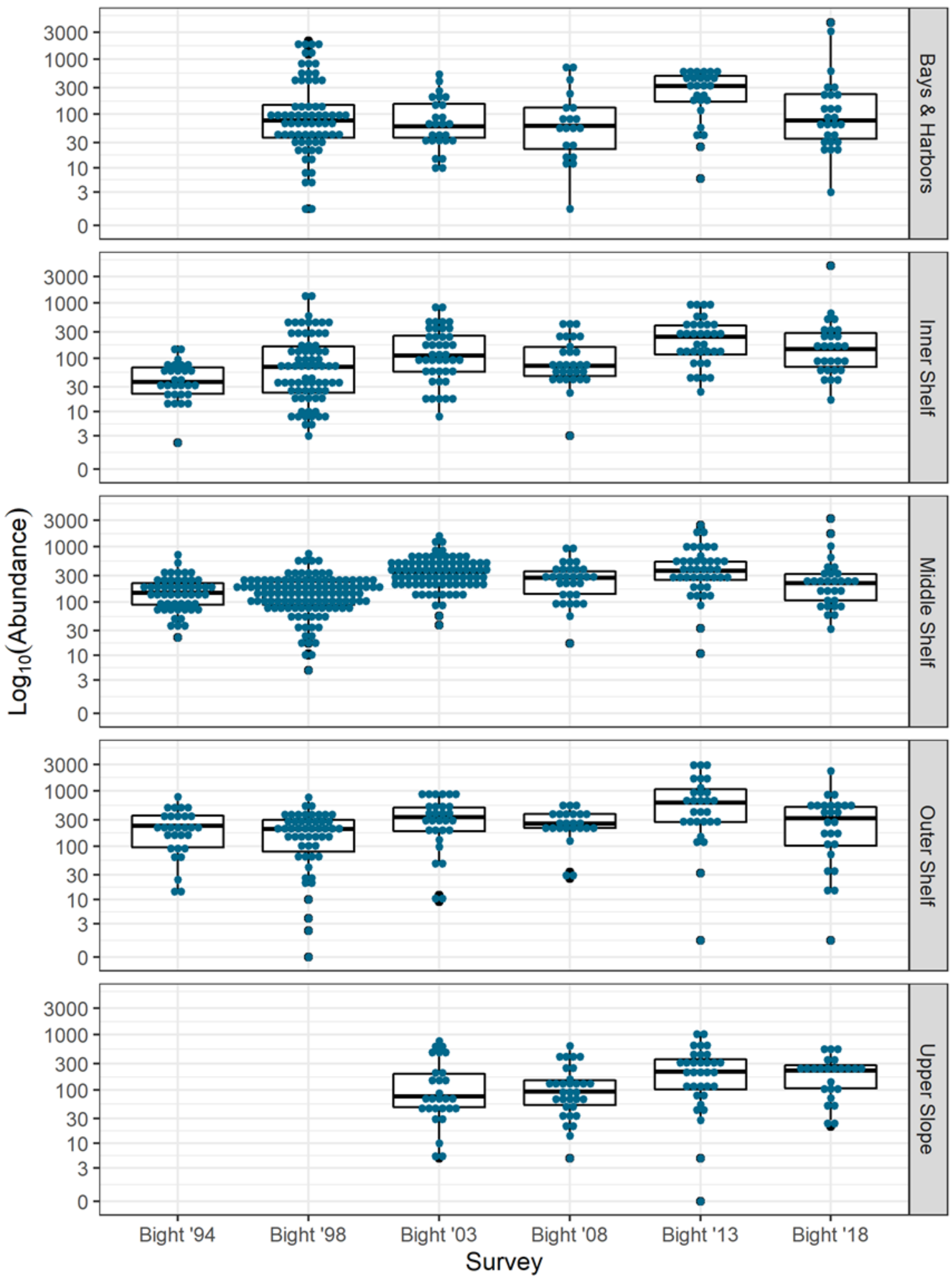

Figure E35. Demersal fish log abundance by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

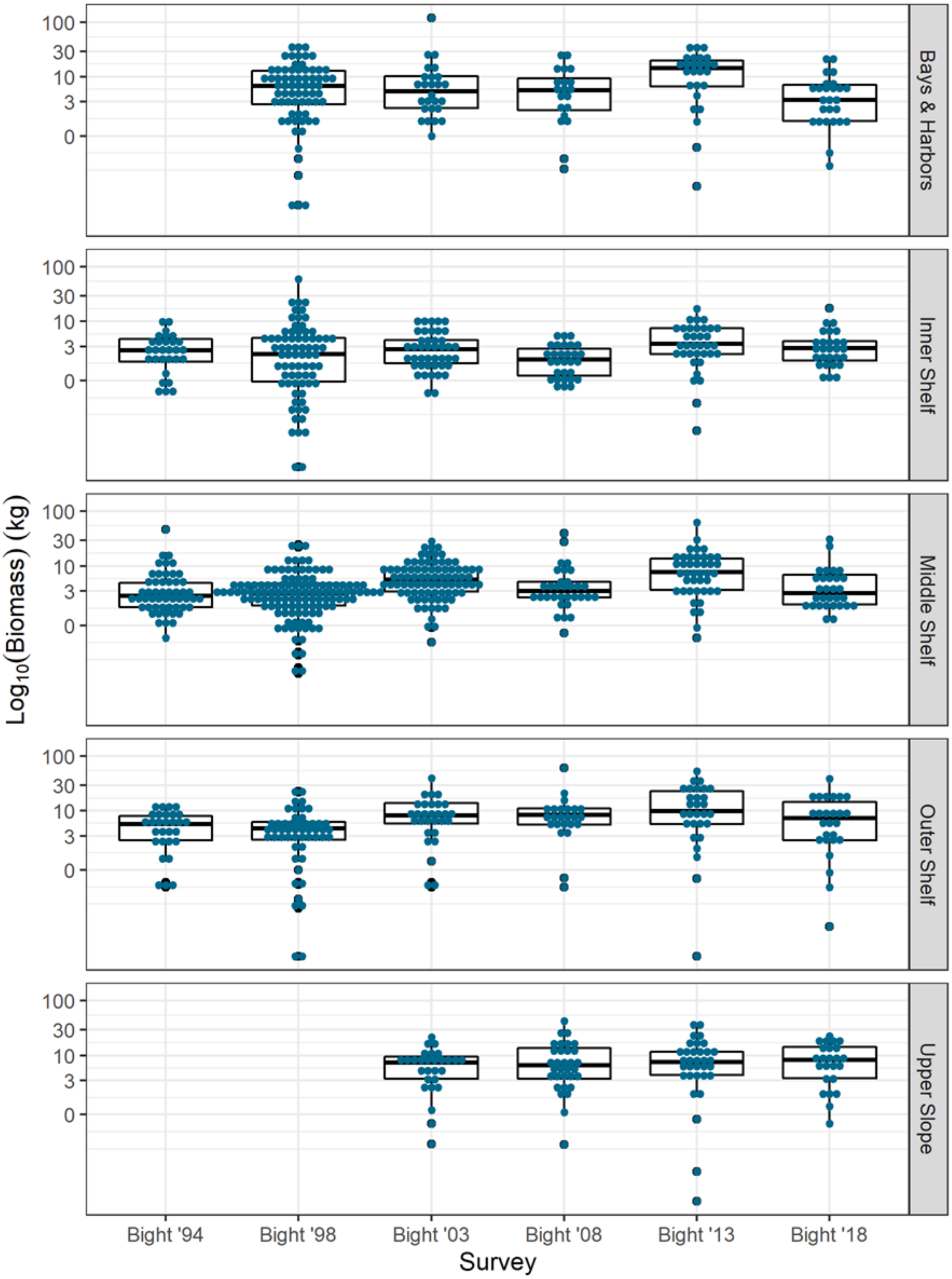

Figure E36. Demersal fish log biomass by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

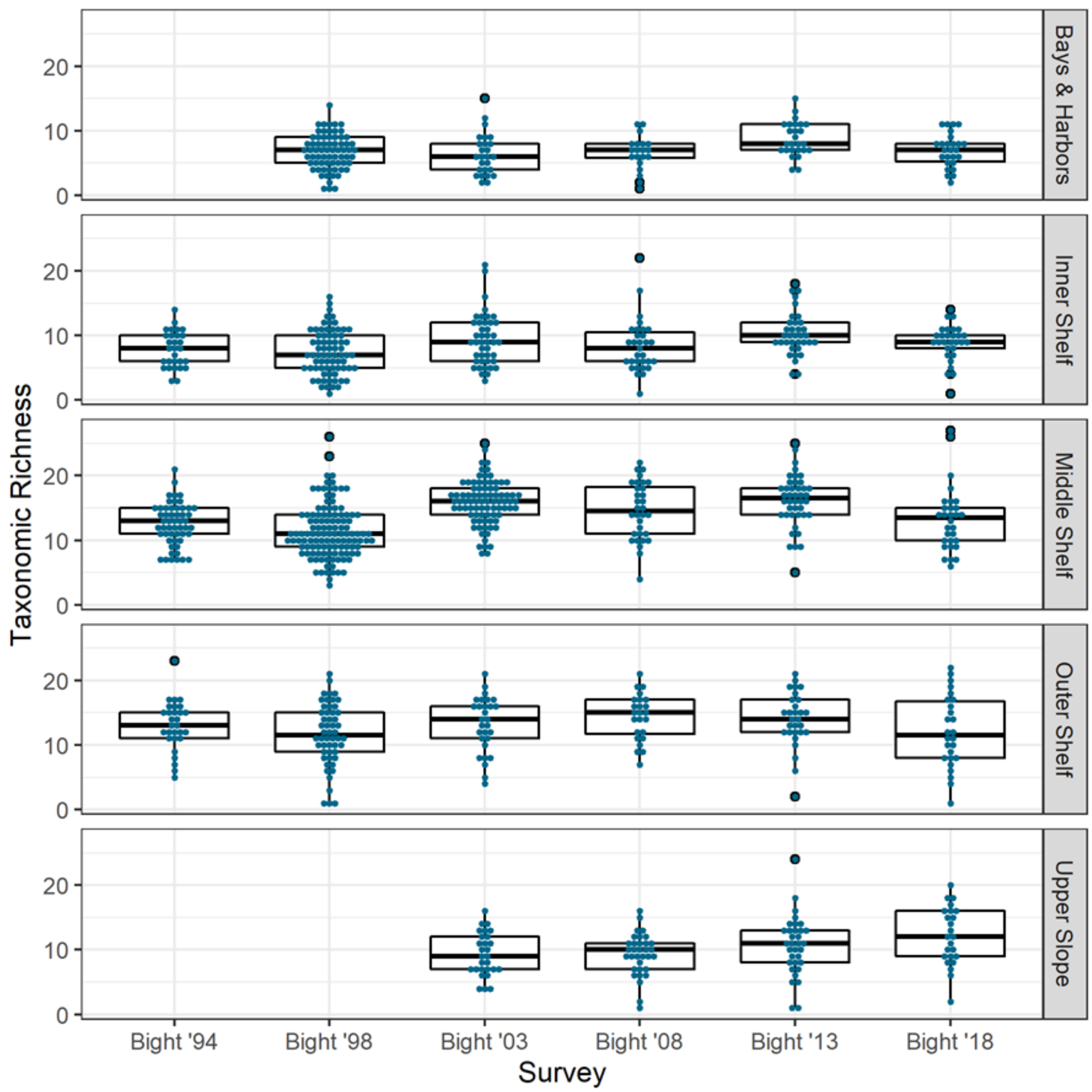

Figure E37. Demersal fish taxonomic richness by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

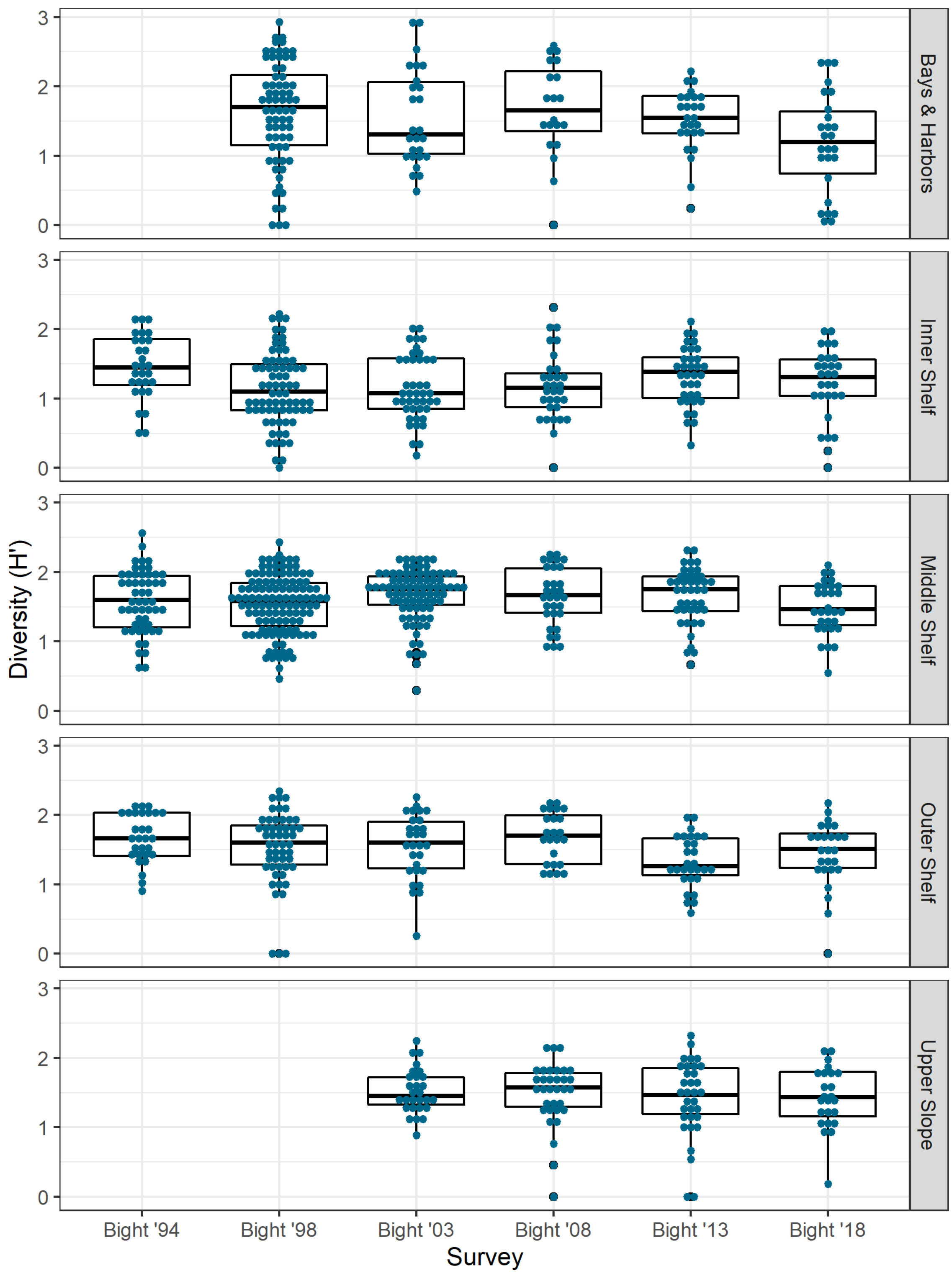

Figure E38. Demersal fish Shannon diversity (H') by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

Table E47. Summary of area weighted demersal fish abundance by stratum and survey.

		Abundance				
Survey	Stratum	Mean	Standard Deviation	Minimum	Maximum	Median
Bight '94	Inner Shelf	48.76	37.01	3	170	38
Bight '94	Middle Shelf	158.31	127.47	23	726	134
Bight '94	Outer Shelf	247.29	183.40	15	779	235
Bight '98	Bays & Harbors	346.81	469.19	2	2102	94
Bight '98	Inner Shelf	111.17	249.48	4	1491	73
Bight '98	Middle Shelf	169.93	127.53	6	757	149
Bight '98	Outer Shelf	186.43	160.23	0	763	142
Bight '03	Bays & Harbors	112.23	126.32	10	526	61
Bight '03	Inner Shelf	180.77	199.54	9	852	120
Bight '03	Middle Shelf	408.82	261.04	39	1569	363
Bight '03	Outer Shelf	424.54	289.01	10	942	352
Bight '03	Upper Slope	136.16	222.17	6	765	74
Bight '08	Bays & Harbors	209.72	216.58	2	738	90
Bight '08	Inner Shelf	123.87	125.35	0	467	73
Bight '08	Middle Shelf	301.16	223.68	18	1005	278.5
Bight '08	Outer Shelf	275.54	143.14	26	621	252
Bight '08	Upper Slope	145.48	151.38	0	629	88
Bight '13	Bays & Harbors	292.37	200.74	7	652	294
Bight '13	Inner Shelf	322.66	277.42	25	1013	245
Bight '13	Middle Shelf	513.44	516.15	12	2450	359
Bight '13	Outer Shelf	789.10	843.97	2	3087	703
Bight '13	Upper Slope	266.71	267.96	1	1071	201
Bight '18	Bays & Harbors	412.38	1041.81	4	4563	78.5
Bight '18	Inner Shelf	335.28	855.05	0	4699	146
Bight '18	Middle Shelf	392.00	626.95	33	3196	221
Bight '18	Outer Shelf	398.92	460.22	2	2286	322
Bight '18	Upper Slope	232.63	160.92	22	590	225

Table E48. Summary of area weighted demersal fish biomass (kg) by stratum and survey.

		Biomass (kg)				
Survey	**Stratum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**
Bight '94	Inner Shelf	3.89	2.70	0.60	11.13	3.40
Bight '94	Middle Shelf	4.42	7.11	0.60	48.30	3.10
Bight '94	Outer Shelf	6.23	3.90	0.50	13.93	6.40
Bight '98	Bays & Harbors	9.87	9.09	0.06	40.28	8.20
Bight '98	Inner Shelf	3.56	8.58	0.03	60.40	2.93
Bight '98	Middle Shelf	4.44	4.42	0.14	26.33	3.67
Bight '98	Outer Shelf	6.27	5.28	0.00	24.57	5.50
Bight '03	Bays & Harbors	12.25	22.77	1.00	118.46	6.23
Bight '03	Inner Shelf	4.02	3.06	0.60	12.20	3.63
Bight '03	Middle Shelf	7.63	5.69	0.50	29.80	6.30
Bight '03	Outer Shelf	11.22	8.22	0.50	40.90	9.30
Bight '03	Upper Slope	7.81	5.28	0.30	22.90	8.13
Bight '08	Bays & Harbors	10.16	7.90	0.26	30.10	6.46
Bight '08	Inner Shelf	2.56	1.68	0.00	6.50	2.30
Bight '08	Middle Shelf	6.67	8.25	0.73	41.67	4.00
Bight '08	Outer Shelf	10.67	11.74	0.50	61.70	8.90
Bight '08	Upper Slope	10.05	9.52	0.00	44.43	7.02
Bight '13	Bays & Harbors	14.08	10.77	0.13	40.20	13.86
Bight '13	Inner Shelf	5.35	4.00	0.13	18.50	4.20
Bight '13	Middle Shelf	11.46	10.85	0.60	63.80	8.80
Bight '13	Outer Shelf	18.23	13.10	0.03	54.20	15.90
Bight '13	Upper Slope	10.55	9.35	0.03	39.70	7.90
Bight '18	Bays & Harbors	6.30	6.05	0.30	24.50	4.35
Bight '18	Inner Shelf	4.42	3.83	0.00	18.90	3.60
Bight '18	Middle Shelf	6.04	6.80	1.30	32.90	3.65
Bight '18	Outer Shelf	10.21	9.28	0.10	40.10	8.10
Bight '18	Upper Slope	10.09	6.74	0.70	23.90	9.10

Table E49. Summary of area weighted demersal fish Shannon diversity (H') by stratum and survey.

		Shannon Diversity (H')				
Survey	**Stratum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**
Bight '94	Inner Shelf	1.46	0.47	0.50	2.18	1.45
Bight '94	Middle Shelf	1.60	0.44	0.58	2.56	1.59
Bight '94	Outer Shelf	1.67	0.35	0.91	2.16	1.66
Bight '98	Bays & Harbors	1.53	0.74	0.00	2.93	1.57
Bight '98	Inner Shelf	1.23	0.53	0.00	2.22	1.17
Bight '98	Middle Shelf	1.59	0.42	0.46	2.43	1.62
Bight '98	Outer Shelf	1.49	0.53	0.00	2.35	1.60
Bight '03	Bays & Harbors	1.55	0.70	0.49	2.92	1.31
Bight '03	Inner Shelf	1.12	0.47	0.18	2.04	1.00
Bight '03	Middle Shelf	1.62	0.38	0.30	2.22	1.73
Bight '03	Outer Shelf	1.58	0.47	0.26	2.26	1.68
Bight '03	Upper Slope	1.55	0.32	0.89	2.25	1.55
Bight '08	Bays & Harbors	1.79	0.68	0.00	2.59	1.51
Bight '08	Inner Shelf	1.17	0.50	0.00	2.31	1.16
Bight '08	Middle Shelf	1.65	0.42	0.88	2.26	1.67
Bight '08	Outer Shelf	1.68	0.36	1.12	2.18	1.69
Bight '08	Upper Slope	1.49	0.46	0.00	2.16	1.57
Bight '13	Bays & Harbors	1.43	0.46	0.24	2.22	1.47
Bight '13	Inner Shelf	1.31	0.42	0.33	2.11	1.39
Bight '13	Middle Shelf	1.65	0.40	0.67	2.35	1.76
Bight '13	Outer Shelf	1.35	0.37	0.59	2.01	1.43
Bight '13	Upper Slope	1.38	0.55	0.00	2.32	1.47
Bight '18	Bays & Harbors	1.18	0.73	0.02	2.39	1.20
Bight '18	Inner Shelf	1.21	0.52	0.00	1.98	1.31
Bight '18	Middle Shelf	1.48	0.38	0.54	2.10	1.47
Bight '18	Outer Shelf	1.44	0.48	0.00	2.17	1.50
Bight '18	Upper Slope	1.43	0.45	0.18	2.11	1.44

Table E50. Summary of area weighted demersal fish taxonomic richness by stratum and survey.

		Taxonomic Richness				
Survey	Stratum	Mean	Standard Deviation	Minimum	Maximum	Median
Bight '94	Inner Shelf	7.81	2.82	3	14	8
Bight '94	Middle Shelf	12.29	3.27	7	21	13
Bight '94	Outer Shelf	12.81	3.80	5	23	13
Bight '98	Bays & Harbors	6.80	2.73	1	14	7
Bight '98	Inner Shelf	7.81	3.45	1	16	8
Bight '98	Middle Shelf	11.78	4.11	3	26	11
Bight '98	Outer Shelf	11.05	4.77	1	21	10
Bight '03	Bays & Harbors	6.35	3.24	2	15	6
Bight '03	Inner Shelf	9.49	4.01	3	21	9
Bight '03	Middle Shelf	15.98	3.38	8	25	16
Bight '03	Outer Shelf	13.96	4.29	4	21	16
Bight '03	Upper Slope	9.01	3.31	4	16	8
Bight '08	Bays & Harbors	7.48	2.67	1	11	7
Bight '08	Inner Shelf	8.39	4.10	1	22	8
Bight '08	Middle Shelf	14.59	4.41	4	22	14.5
Bight '08	Outer Shelf	14.05	3.58	7	21	15
Bight '08	Upper Slope	9.30	3.24	1	16	10
Bight '13	Bays & Harbors	9.02	2.67	4	15	8
Bight '13	Inner Shelf	10.12	3.36	4	18	10
Bight '13	Middle Shelf	15.49	4.04	5	25	16
Bight '13	Outer Shelf	14.25	4.20	2	21	15
Bight '13	Upper Slope	10.24	4.58	1	24	10
Bight '18	Bays & Harbors	7.00	2.61	2	11	7
Bight '18	Inner Shelf	8.86	2.85	1	14	9
Bight '18	Middle Shelf	13.23	4.99	6	27	13.5
Bight '18	Outer Shelf	12.12	5.57	1	22	11.5
Bight '18	Upper Slope	12.13	4.48	2	20	12

Table E51. Slope, P-values, and trend designations for FRI scores at revisited sites with three or more occupations. Shaded areas indicate P-values ≤ 0.05.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2382	4	Inner Shelf	0.3	0.04	Declining
2320	4	Inner Shelf	-0.43	0.04	Improving
2325	4	Inner Shelf	-0.77	0.01	Improving
2304	3	Inner Shelf	0.72	0.58	Stable
2307	4	Inner Shelf	0.49	0.57	Stable
2359	3	Inner Shelf	0.97	0.21	Stable
2376	4	Inner Shelf	0.05	0.92	Stable
4003	4	Inner Shelf	-2.83	0.31	Stable
4042	4	Inner Shelf	0.07	0.93	Stable
4047	4	Inner Shelf	-2.45	0.13	Stable
4055	4	Inner Shelf	-1.94	0.09	Stable
4058	4	Inner Shelf	-0.41	0.34	Stable
4061	4	Inner Shelf	-0.78	0.49	Stable
4090	4	Inner Shelf	-0.32	0.56	Stable
4048	4	Middle Shelf	1.05	0.05	Declining
2192	4	Middle Shelf	0.76	0.18	Stable
2208	4	Middle Shelf	0.15	0.44	Stable
2301	4	Middle Shelf	-1.19	0.12	Stable
2365	4	Middle Shelf	0.03	0.97	Stable
2396	4	Middle Shelf	0.01	0.96	Stable
2408	3	Middle Shelf	1.11	0.06	Stable
2419	4	Middle Shelf	0.54	0.17	Stable
4000	4	Middle Shelf	-0.08	0.78	Stable
4006	3	Middle Shelf	0.67	0.40	Stable
4045	4	Middle Shelf	0.32	0.64	Stable
4080	4	Middle Shelf	0.22	0.12	Stable
4096	4	Middle Shelf	0.93	0.12	Stable
4038	7	Outer Shelf	0.33	0.13	Stable
4068	4	Outer Shelf	0.27	0.79	Stable
4133	4	Outer Shelf	-0.63	0.08	Stable
4144	3	Outer Shelf	2.26	0.80	Stable
4227	3	Outer Shelf	1.35	0.10	Stable
4269	4	Outer Shelf	-1.56	0.19	Stable
4285	4	Outer Shelf	0.46	0.26	Stable
4419	4	Outer Shelf	0.48	0.31	Stable
7603	3	Outer Shelf	0.99	0.62	Stable

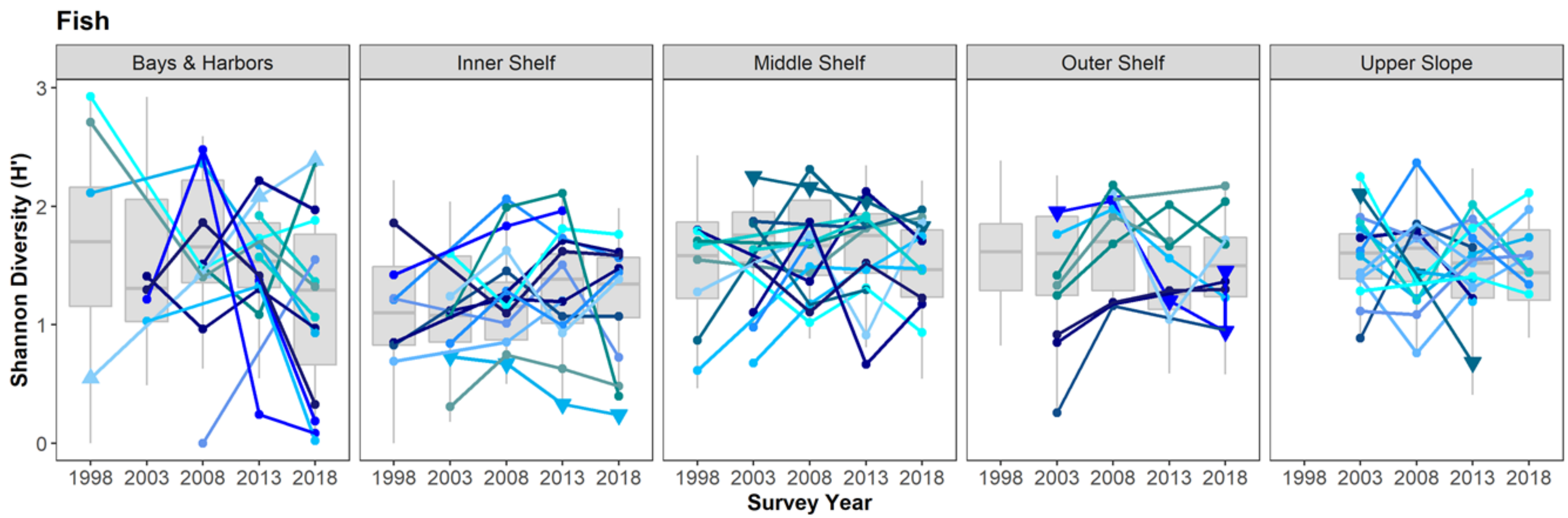

Figure E39. Trends in individual revisited sites across surveys. Grey box plots represent all Bight data collected during each survey. Blue lines are individual revisited sites, where circles represent "stable" condition, upward triangles indicate "increasing diversity" (positive slope, p-value ≤ 0.05), and downward triangles indicate "decreasing diversity" (negative slope, p-value ≤ 0.05).

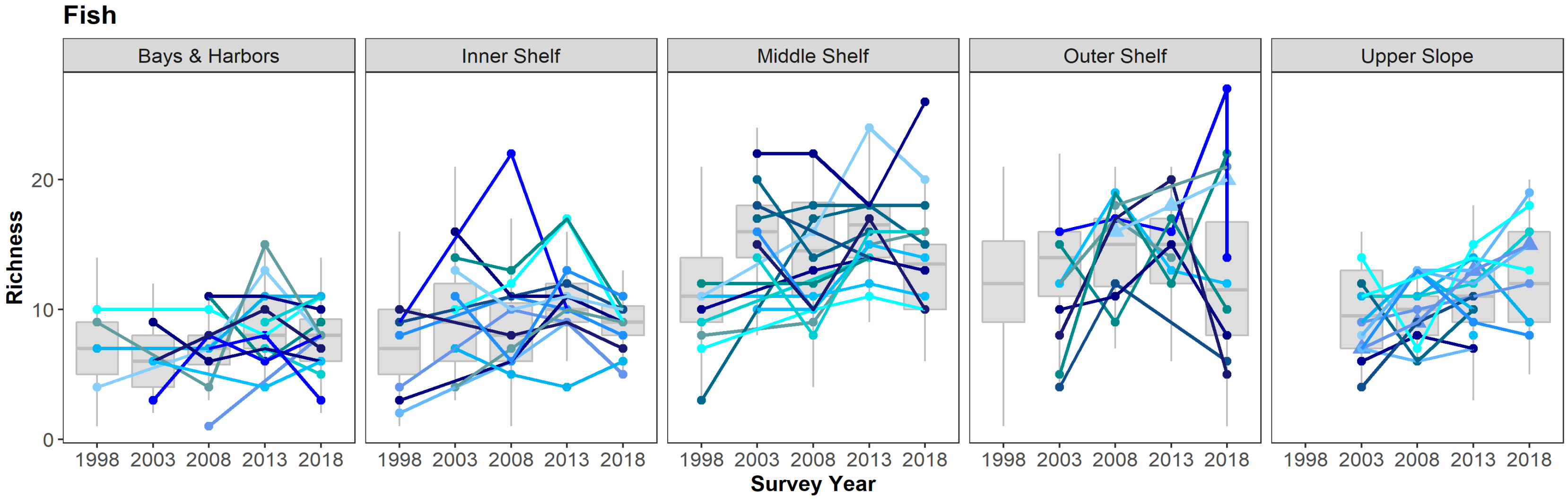

Figure E40. Trends in individual revisited sites across surveys. Grey box plots represent all Bight data collected during each survey. Blue lines are individual revisited sites, where circles represent “stable” condition, upward triangles indicate “increasing taxonomic richness” (positive slope, p-value ≤ 0.05), and downward triangles indicate “decreasing taxonomic richness” (negative slope, p-value ≤ 0.05).

Table E52. Percent of area characterized as having increasing, stable or decreasing demersal fish Shannon diversity (H’) based on the trend in values between 1998/2003 and 2018 for each stratum and for the entire SCB.

Stratum	Number of Sites	Increasing	Stable	Decreasing
Bays & Harbors	11	9.1	90.9	0
Inner Shelf	14	0	92.9	7.1
Middle Shelf	13	0	92.3	7.7
Outer Shelf	10	0	90	10
Upper Slope	14	0	92.9	7.1
All Strata	61	0.01	92.4	7.5

Table E53. Slope, P-values, and trend designations for demersal fish Shannon diversity (H’) at revisited sites with three or more occupations. Shaded areas indicate P-values ≤ 0.05.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2162	4	Bays & Harbors	0.09	0	Increasing
2152	4	Bays & Harbors	-0.05	0.28	Stable
2157	3	Bays & Harbors	0.09	0.53	Stable
2242	4	Bays & Harbors	-0.06	0.23	Stable
2436	4	Bays & Harbors	-0.07	0.13	Stable
4092	4	Bays & Harbors	-0.08	0.42	Stable
4098	4	Bays & Harbors	-0.02	0.45	Stable
4116	4	Bays & Harbors	-0.07	0.33	Stable
4148	3	Bays & Harbors	-0.05	0.6	Stable
4228	3	Bays & Harbors	-0.23	0.29	Stable
4242	3	Bays & Harbors	0.05	0.56	Stable
4003	4	Inner Shelf	-0.04	0.04	Decreasing
2304	3	Inner Shelf	0.03	0.25	Stable
2307	4	Inner Shelf	-0.01	0.64	Stable
2320	4	Inner Shelf	0.02	0.56	Stable
2325	4	Inner Shelf	0.01	0.66	Stable
2359	3	Inner Shelf	0.04	0.07	Stable
2376	4	Inner Shelf	0.04	0.06	Stable
2382	4	Inner Shelf	-0.01	0.71	Stable
4042	4	Inner Shelf	0.02	0.13	Stable
4047	4	Inner Shelf	0.02	0.51	Stable
4055	4	Inner Shelf	-0.04	0.69	Stable
4058	4	Inner Shelf	-0.01	0.88	Stable
4061	4	Inner Shelf	0.01	0.73	Stable
4090	4	Inner Shelf	0.03	0.29	Stable
4080	4	Middle Shelf	-0.03	0.02	Decreasing
2192	4	Middle Shelf	0.02	0.24	Stable

Table E53. Continued.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2208	4	Middle Shelf	0.05	0.05	Stable
2301	4	Middle Shelf	0.05	0.28	Stable
2365	4	Middle Shelf	0	0.88	Stable
2396	4	Middle Shelf	-0.04	0.16	Stable
2408	3	Middle Shelf	0.01	0.57	Stable
2419	4	Middle Shelf	0.01	0.72	Stable
4000	4	Middle Shelf	0.05	0.08	Stable
4006	3	Middle Shelf	-0.06	0.45	Stable
4045	4	Middle Shelf	-0.01	0.71	Stable
4048	4	Middle Shelf	-0.01	0.77	Stable
4096	4	Middle Shelf	-0.02	0.74	Stable
4038	7	Outer Shelf	-0.06	0.02	Decreasing
4068	4	Outer Shelf	-0.04	0.18	Stable
4133	4	Outer Shelf	0.03	0.33	Stable
4144	3	Outer Shelf	0.04	0.57	Stable
4227	3	Outer Shelf	0.04	0.59	Stable
4269	4	Outer Shelf	0.03	0.05	Stable
4279	4	Outer Shelf	0.01	0.65	Stable
4285	4	Outer Shelf	0.02	0.09	Stable
4419	4	Outer Shelf	0.03	0.5	Stable
7603	3	Outer Shelf	-0.04	0.75	Stable
4199	3	Upper Slope	-0.14	0.02	Decreasing
4007	3	Upper Slope	-0.01	0.93	Stable
4039	3	Upper Slope	-0.05	0.4	Stable
4071	4	Upper Slope	0.02	0.49	Stable
4083	4	Upper Slope	0	0.89	Stable
4088	4	Upper Slope	-0.02	0.26	Stable
4091	3	Upper Slope	0.08	0.46	Stable
4125	4	Upper Slope	0	0.98	Stable
4132	4	Upper Slope	-0.01	0.84	Stable
4179	3	Upper Slope	-0.04	0.25	Stable
4201	4	Upper Slope	0.03	0.36	Stable
4202	4	Upper Slope	0.04	0.1	Stable
4211	4	Upper Slope	-0.03	0.56	Stable
4329	3	Upper Slope	0	0.97	Stable

Table E54. Percent of area characterized as having increasing, stable or decreasing demersal fish taxonomic richness based on the trend in values between 1998/2003 and 2018 for each stratum and for the entire SCB.

Stratum	Number of Sites	Increasing	Stable	Decreasing
Bays & Harbors	11	0	100	0
Inner Shelf	14	0	100	0
Middle Shelf	13	0	100	0
Outer Shelf	10	10	90	0
Upper Slope	13	7.7	92.3	0
All Strata	61	4.3	95.7	0

Table E55. Slope, P-values, and trend designations for demersal fish taxonomic richness at revisited sites with three or more occupations. Shaded areas indicate P-values ≤ 0.05.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2152	4	Bays & Harbors	0.01	0.96	Stable
2157	3	Bays & Harbors	-0.2	0.74	Stable
2162	4	Bays & Harbors	0.3	0.32	Stable
2242	4	Bays & Harbors	0.23	0.15	Stable
2436	4	Bays & Harbors	0.09	0.83	Stable
4092	4	Bays & Harbors	0.26	0.29	Stable
4098	4	Bays & Harbors	-0.16	0.27	Stable
4116	4	Bays & Harbors	0.1	0.62	Stable
4148	3	Bays & Harbors	-0.03	0.88	Stable
4228	3	Bays & Harbors	-0.4	0.45	Stable
4242	3	Bays & Harbors	-0.1	0.33	Stable
2304	3	Inner Shelf	0.46	0.07	Stable
2307	4	Inner Shelf	0.09	0.73	Stable
2320	4	Inner Shelf	0.02	0.90	Stable
2325	4	Inner Shelf	0.08	0.47	Stable
2359	3	Inner Shelf	0.24	0.83	Stable
2376	4	Inner Shelf	0.36	0.12	Stable
2382	4	Inner Shelf	-0.13	0.17	Stable
4003	4	Inner Shelf	-0.08	0.60	Stable
4042	4	Inner Shelf	-0.36	0.14	Stable
4047	4	Inner Shelf	0.04	0.93	Stable
4055	4	Inner Shelf	-0.16	0.64	Stable
4058	4	Inner Shelf	-0.16	0.27	Stable
4061	4	Inner Shelf	0.36	0.12	Stable
4090	4	Inner Shelf	0.14	0.70	Stable
2192	4	Middle Shelf	0.43	0.09	Stable
2208	4	Middle Shelf	0.02	0.71	Stable

Table E55. Continued.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2301	4	Middle Shelf	0.66	0.19	Stable
2365	4	Middle Shelf	0.17	0.15	Stable
2396	4	Middle Shelf	0.17	0.15	Stable
2408	3	Middle Shelf	0.11	0.45	Stable
2419	4	Middle Shelf	0.55	0.15	Stable
4000	4	Middle Shelf	0.34	0.17	Stable
4006	3	Middle Shelf	-0.4	0.55	Stable
4045	4	Middle Shelf	-0.16	0.71	Stable
4048	4	Middle Shelf	0.28	0.52	Stable
4080	4	Middle Shelf	0.06	0.23	Stable
4096	4	Middle Shelf	0.16	0.68	Stable
7603	3	Outer Shelf	0.4	0.00	Increasing
4038	7	Outer Shelf	0.27	0.36	Stable
4068	4	Outer Shelf	-0.12	0.77	Stable
4133	4	Outer Shelf	-0.14	0.77	Stable
4144	3	Outer Shelf	0.2	0.74	Stable
4227	3	Outer Shelf	0.03	0.97	Stable
4269	4	Outer Shelf	-0.04	0.91	Stable
4279	4	Outer Shelf	0.34	0.40	Stable
4285	4	Outer Shelf	-0.12	0.89	Stable
4419	4	Outer Shelf	0.88	0.25	Stable
4202	4	Upper Slope	0.56	0.01	Increasing
4007	3	Upper Slope	0	1.00	Stable
4039	3	Upper Slope	0.1	0.67	Stable
4071	4	Upper Slope	-0.06	0.81	Stable
4083	4	Upper Slope	0.72	0.05	Stable
4091	3	Upper Slope	0.7	0.15	Stable
4125	4	Upper Slope	0.4	0.45	Stable
4132	4	Upper Slope	0.32	0.13	Stable
4179	3	Upper Slope	0.1	0.85	Stable
4199	3	Upper Slope	-0.2	0.79	Stable
4201	4	Upper Slope	0.4	0.12	Stable
4211	4	Upper Slope	-0.02	0.95	Stable
4329	3	Upper Slope	0.16	0.42	Stable

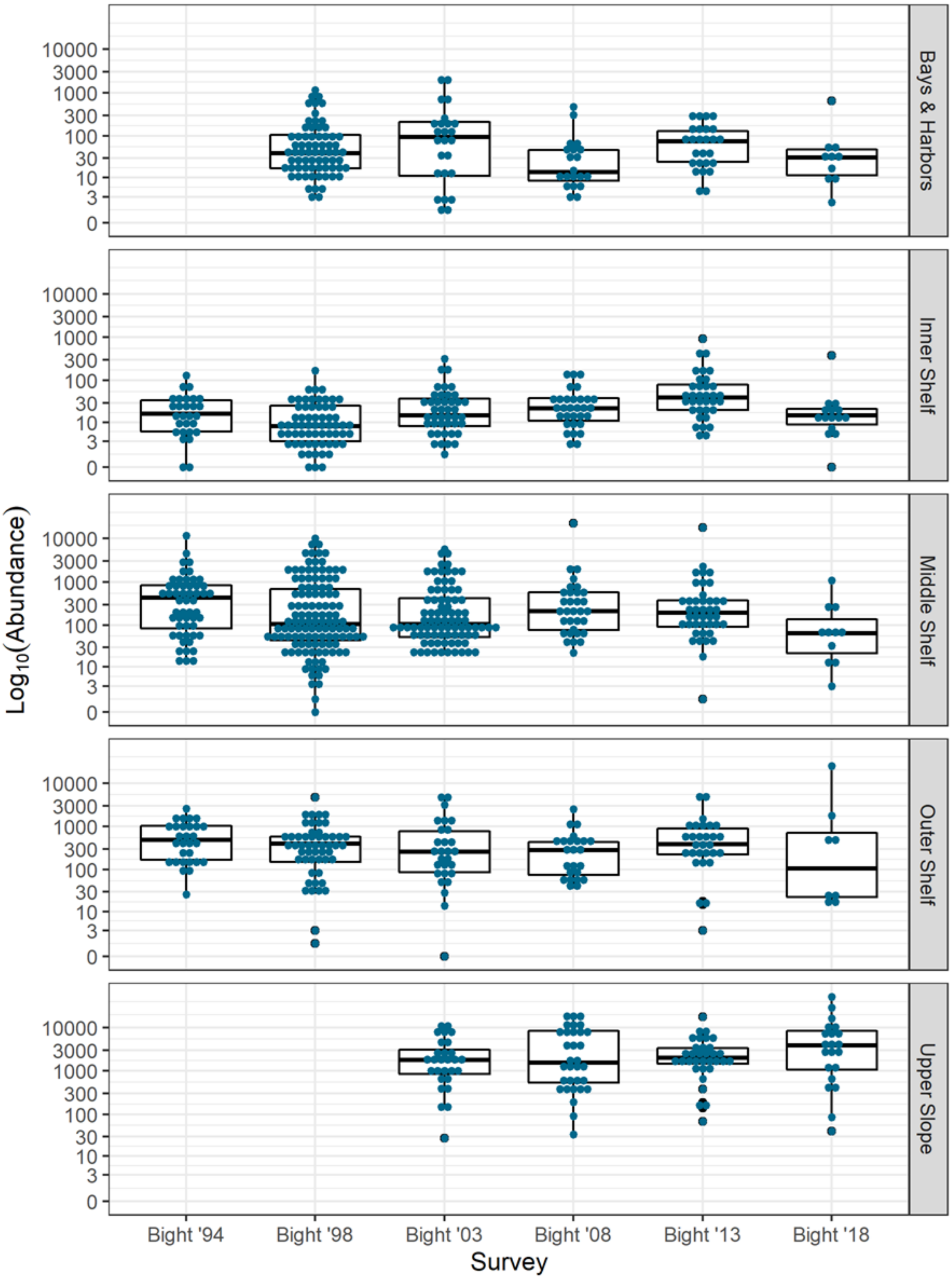

Figure E41. Megabenthic invertebrate log abundance by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

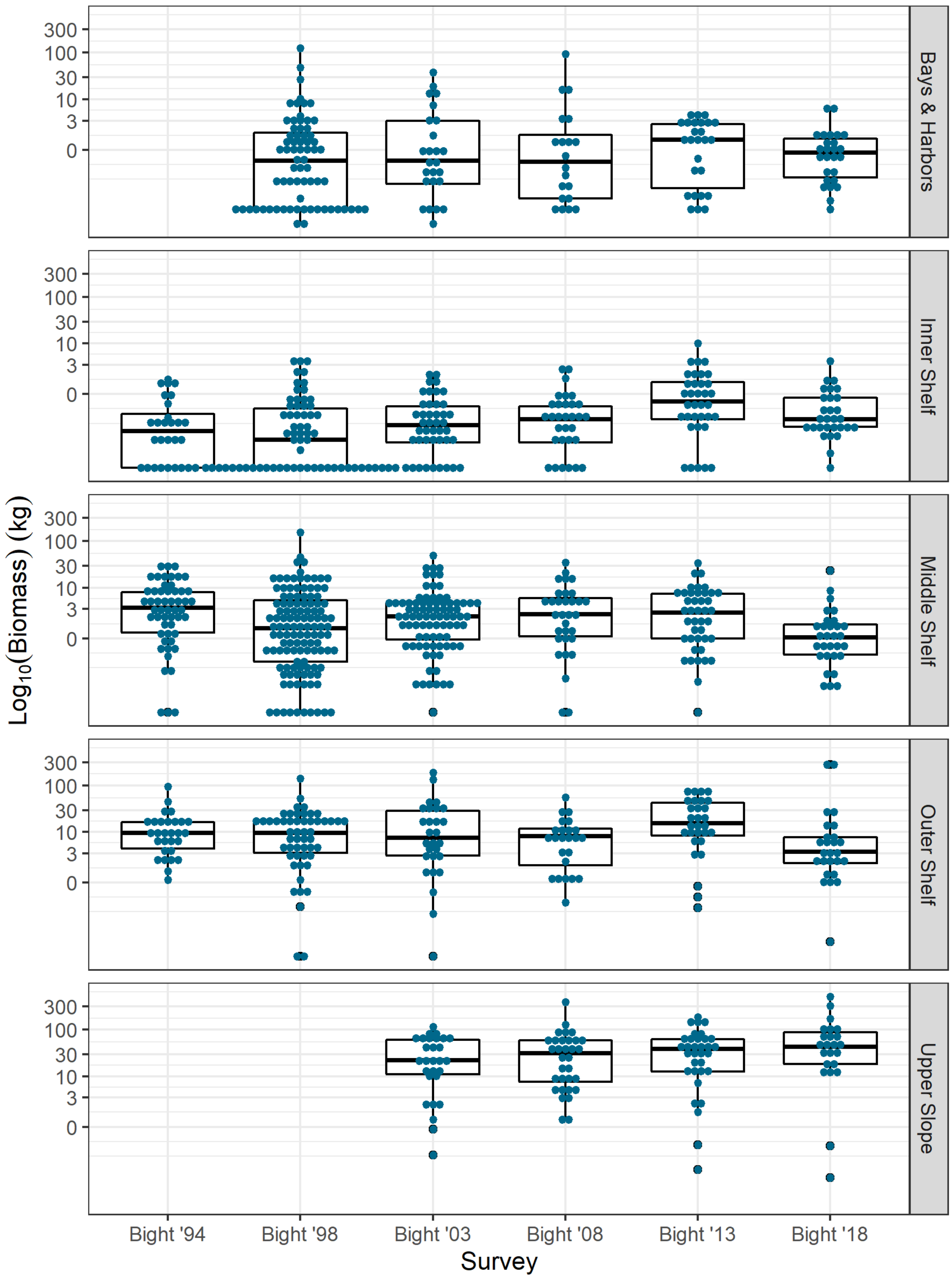

Figure E42. Megabenthic invertebrate log biomass by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

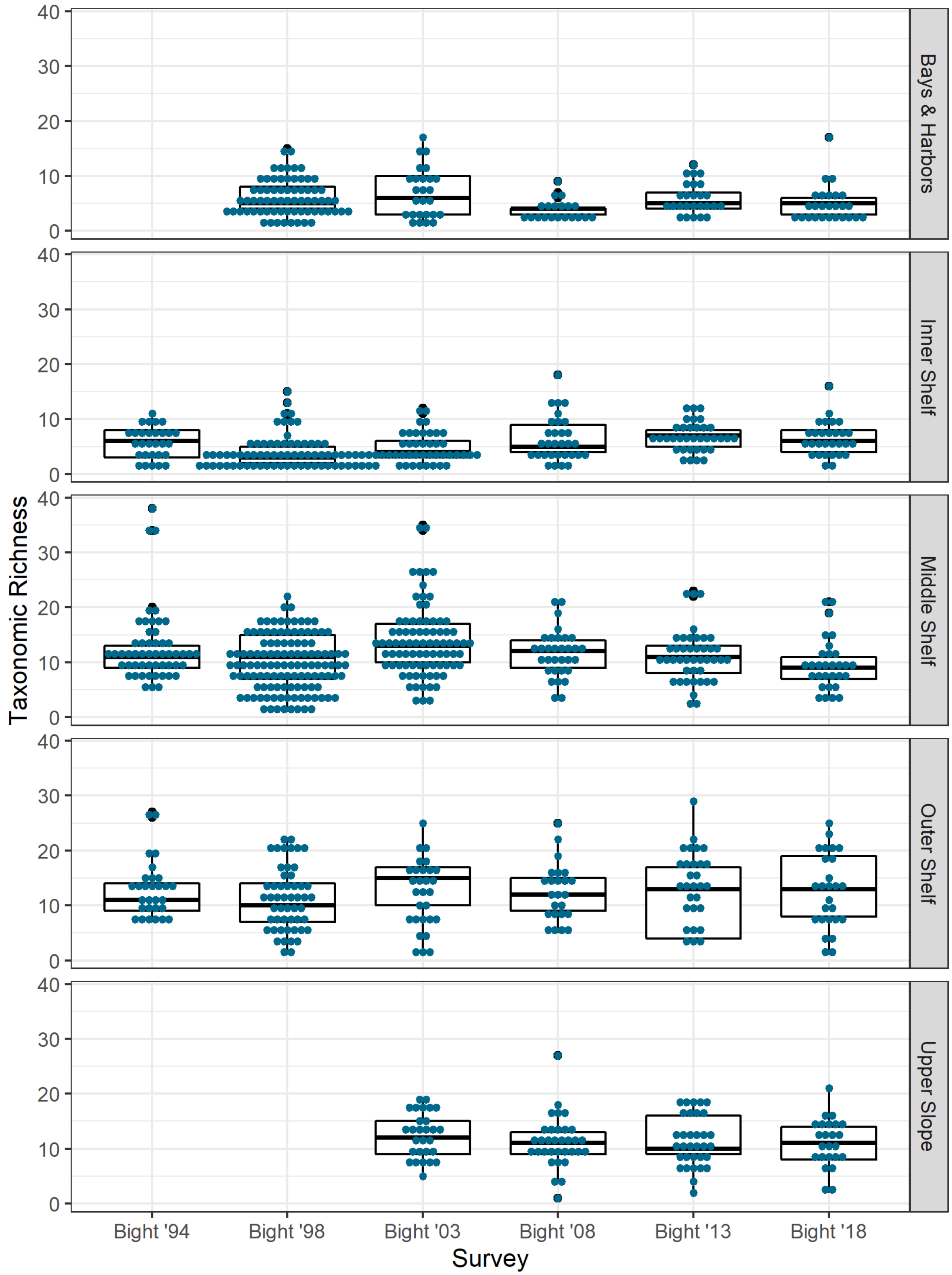

Figure E43. Megabenthic invertebrate taxonomic richness in the SCB by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

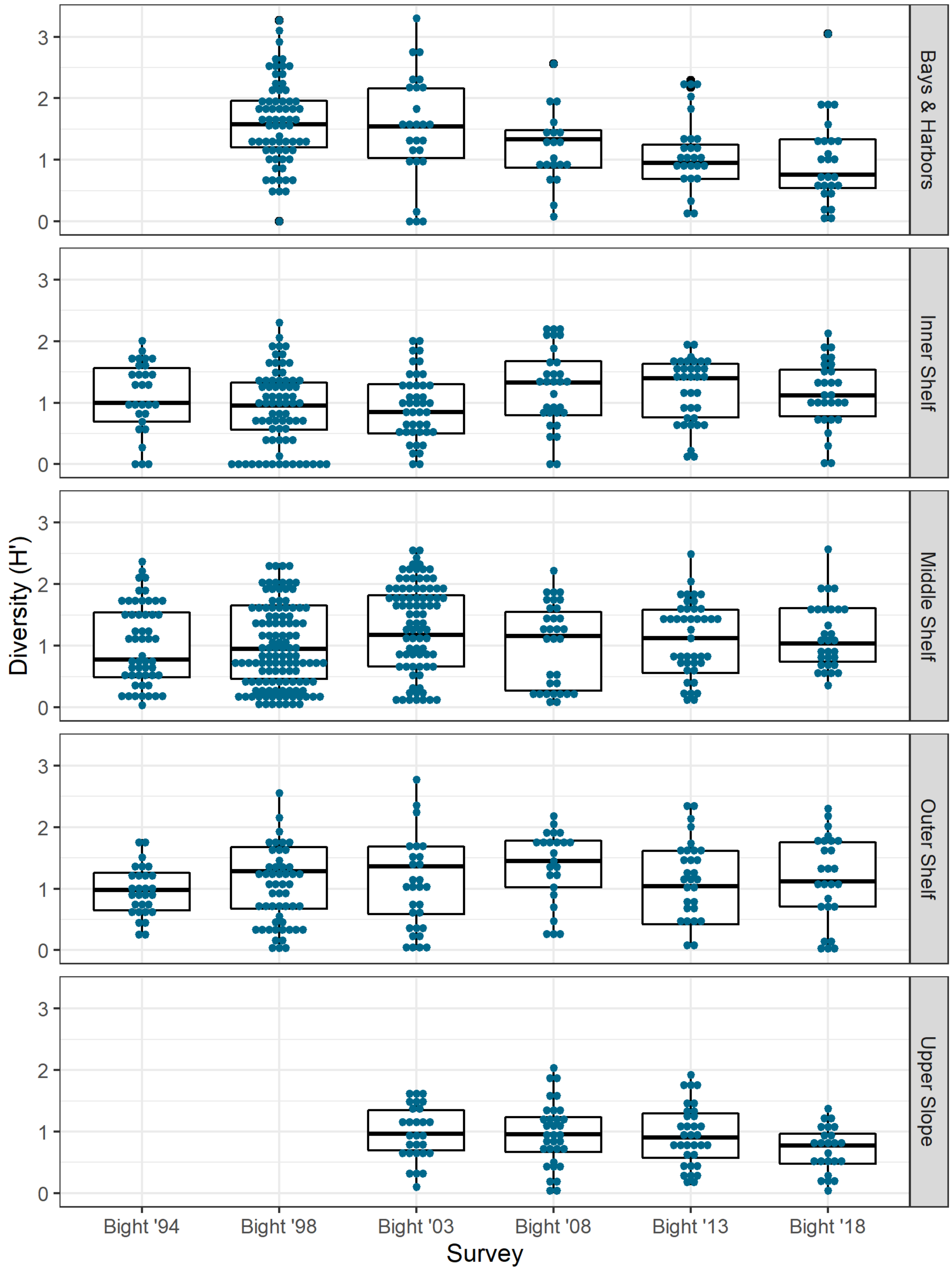

Figure E44. Megabenthic invertebrate Shannon diversity (H') by stratum and survey. Data are median, upper and lower quartiles, and results (represented by blue dots).

Table E56. Summary of area weighted megabenthic invertebrate abundance by stratum and survey.

		Abundance				
Survey	**Stratum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**
Bight '94	Inner Shelf	25.31	28.02	0	131	17
Bight '94	Middle Shelf	853.52	1730.37	14	11617	435
Bight '94	Outer Shelf	650.49	637.06	27	2569	459
Bight '98	Bays & Harbors	122.13	215.48	4	1134	36
Bight '98	Inner Shelf	15.50	24.25	0	172	8
Bight '98	Middle Shelf	639.27	1582.75	1	10005	145
Bight '98	Outer Shelf	400.07	767.92	2	4709	175
Bight '03	Bays & Harbors	274.42	527.44	0	1952	94
Bight '03	Inner Shelf	32.36	59.07	2	323	15
Bight '03	Middle Shelf	667.80	1038.64	21	5618	163
Bight '03	Outer Shelf	611.20	1282.74	0	4712	170
Bight '03	Upper Slope	3024.59	3208.91	28	10986	1835
Bight '08	Bays & Harbors	53.95	116.57	4	466	16
Bight '08	Inner Shelf	35.13	38.02	3	160	23
Bight '08	Middle Shelf	1085.25	3881.98	23	22179	214.5
Bight '08	Outer Shelf	393.57	548.50	37	2534	255
Bight '08	Upper Slope	4681.58	5772.72	0	20038	1472
Bight '13	Bays & Harbors	80.27	97.74	5	316	37
Bight '13	Inner Shelf	89.17	175.08	5	921	39
Bight '13	Middle Shelf	1052.52	2765.15	2	17973	187
Bight '13	Outer Shelf	797.60	1196.03	4	5160	570
Bight '13	Upper Slope	3345.28	3369.89	68	17600	2240
Bight '18	Bays & Harbors	114.00	194.98	6	1,284.00	32
Bight '18	Inner Shelf	115.00	94.20	1	2,128.50	16
Bight '18	Middle Shelf	215.00	310.67	4	1,069.00	65
Bight '18	Outer Shelf	2300.00	8548.86	17	27,475.50	239
Bight '18	Upper Slope	6886.00	12388.51	41	51,182.00	3,858

Table E57. Summary of area weighted megabenthic invertebrate biomass by stratum and survey.

		Biomass (kg)				
Survey	Stratum	Mean	Standard Deviation	Minimum	Maximum	Median
Bight '94	Inner Shelf	0.41	0.59	0	2.03	0.13
Bight '94	Middle Shelf	6.34	8.01	0.03	31.83	4
Bight '94	Outer Shelf	14.73	18.37	1.13	95.43	10.43
Bight '98	Bays & Harbors	3.44	16.36	0.03	125.4	0.26
Bight '98	Inner Shelf	0.58	1.07	0	5.31	0.03
Bight '98	Middle Shelf	4.71	15.59	0.03	151.53	1.94
Bight '98	Outer Shelf	11.34	20.73	0.03	138.23	5.73
Bight '03	Bays & Harbors	4.39	8.93	0	39	0.55
Bight '03	Inner Shelf	0.41	0.65	0.03	2.6	0.2
Bight '03	Middle Shelf	6.50	8.11	0.03	50.2	3.5
Bight '03	Outer Shelf	19.00	40.79	0	186.7	6.7
Bight '03	Upper Slope	34.08	32.05	0.26	113.9	22.4
Bight '08	Bays & Harbors	5.33	20.98	0.06	93.46	0.3
Bight '08	Inner Shelf	0.58	0.83	0.03	3.5	0.3
Bight '08	Middle Shelf	6.25	8.07	0.03	36.68	3.15
Bight '08	Outer Shelf	10.71	12.70	0.39	57.53	8.4
Bight '08	Upper Slope	45.25	66.43	0	367.08	30.3
Bight '13	Bays & Harbors	1.78	1.78	0.06	5.86	1.43
Bight '13	Inner Shelf	1.70	2.17	0.03	11.23	1.03
Bight '13	Middle Shelf	4.78	7.09	0.03	35.8	3.2
Bight '13	Outer Shelf	29.72	24.42	0.3	82.83	23.9
Bight '13	Upper Slope	51.09	45.72	0.13	181.93	40.2
Bight '18	Bays & Harbors	2.80	2.28	0.12	15.3	0.87
Bight '18	Inner Shelf	0.70	0.57	0.03	4.8	0.3
Bight '18	Middle Shelf	2.40	1.07	0.09	24.8	1.06
Bight '18	Outer Shelf	27.00	91.85	0.06	268.6	4.37
Bight '18	Upper Slope	80.50	116.18	0.09	480.2	48.5

Table E58. Summary of area weighted megabenthic invertebrate taxonomic richness by stratum and survey.

		Taxonomic Richness				
Survey	**Stratum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**
Bight '94	Inner Shelf	5.62	2.84	1	11	6
Bight '94	Middle Shelf	11.96	6.66	5	38	11
Bight '94	Outer Shelf	12.68	5.12	7	27	11
Bight '98	Bays & Harbors	5.93	3.16	1	15	5
Bight '98	Inner Shelf	4.10	2.99	1	15	3
Bight '98	Middle Shelf	11.29	4.96	1	22	11
Bight '98	Outer Shelf	11.10	5.77	1	22	10
Bight '03	Bays & Harbors	6.92	4.65	1	17	6.5
Bight '03	Inner Shelf	4.50	2.64	1	12	4
Bight '03	Middle Shelf	14.56	6.29	3	35	13
Bight '03	Outer Shelf	13.67	6.19	1	25	15
Bight '03	Upper Slope	12.25	4.22	5	19	12
Bight '08	Bays & Harbors	3.93	1.83	2	9	4
Bight '08	Inner Shelf	6.42	4.06	1	18	5
Bight '08	Middle Shelf	11.56	4.17	3	21	12
Bight '08	Outer Shelf	12.20	5.20	5	25	12
Bight '08	Upper Slope	11.15	4.62	1	27	11
Bight '13	Bays & Harbors	5.67	2.81	2	12	5
Bight '13	Inner Shelf	6.91	2.58	2	12	7
Bight '13	Middle Shelf	11.32	4.60	2	23	11
Bight '13	Outer Shelf	12.28	6.31	3	29	13
Bight '13	Upper Slope	11.17	4.68	2	19	10
Bight '18	Bays & Harbors	5.10	1.48	2	17	5
Bight '18	Inner Shelf	6.40	2.27	1	16	6
Bight '18	Middle Shelf	9.70	4.90	3	21	9
Bight '18	Outer Shelf	12.70	9.46	1	25	13
Bight '18	Upper Slope	11.10	4.40	2	21	11.5

Table E59. Summary of area weighted megabenthic invertebrate Shannon diversity (H') by stratum and survey.

		Shannon Diversity (H')				
Survey	**Stratum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**
Bight '94	Inner Shelf	1.09	0.58	0.00	2.01	0.99
Bight '94	Middle Shelf	0.99	0.65	0.03	2.37	0.78
Bight '94	Outer Shelf	0.96	0.40	0.24	1.80	0.97
Bight '98	Bays & Harbors	1.57	0.68	0.00	3.27	1.58
Bight '98	Inner Shelf	0.92	0.63	0.00	2.30	0.95
Bight '98	Middle Shelf	1.09	0.65	0.00	2.34	0.95
Bight '98	Outer Shelf	1.14	0.60	0.00	2.56	1.28
Bight '03	Bays & Harbors	1.48	0.88	0.00	3.30	1.54
Bight '03	Inner Shelf	0.92	0.54	0.00	2.02	0.85
Bight '03	Middle Shelf	1.23	0.71	0.07	2.56	1.17
Bight '03	Outer Shelf	1.24	0.74	0.00	2.77	1.36
Bight '03	Upper Slope	0.98	0.44	0.10	1.66	0.96
Bight '08	Bays & Harbors	1.24	0.58	0.08	2.56	1.33
Bight '08	Inner Shelf	1.25	0.63	0.00	2.22	1.33
Bight '08	Middle Shelf	1.02	0.67	0.04	2.22	1.19
Bight '08	Outer Shelf	1.34	0.60	0.23	2.18	1.45
Bight '08	Upper Slope	0.96	0.52	0.00	2.03	0.95
Bight '13	Bays & Harbors	1.08	0.58	0.12	2.29	0.95
Bight '13	Inner Shelf	1.23	0.52	0.11	1.98	1.39
Bight '13	Middle Shelf	1.09	0.59	0.09	2.49	1.13
Bight '13	Outer Shelf	1.00	0.63	0.07	2.37	1.04
Bight '13	Upper Slope	0.93	0.49	0.13	1.93	0.91
Bight '18	Bays & Harbors	0.72	0.51	0.19	1.85	0.87
Bight '18	Inner Shelf	1.09	0.47	0.00	1.90	1.12
Bight '18	Middle Shelf	1.29	0.45	0.67	1.93	1.05
Bight '18	Outer Shelf	0.93	0.80	0.00	2.18	1.21
Bight '18	Upper Slope	0.74	0.40	0.04	1.37	0.78

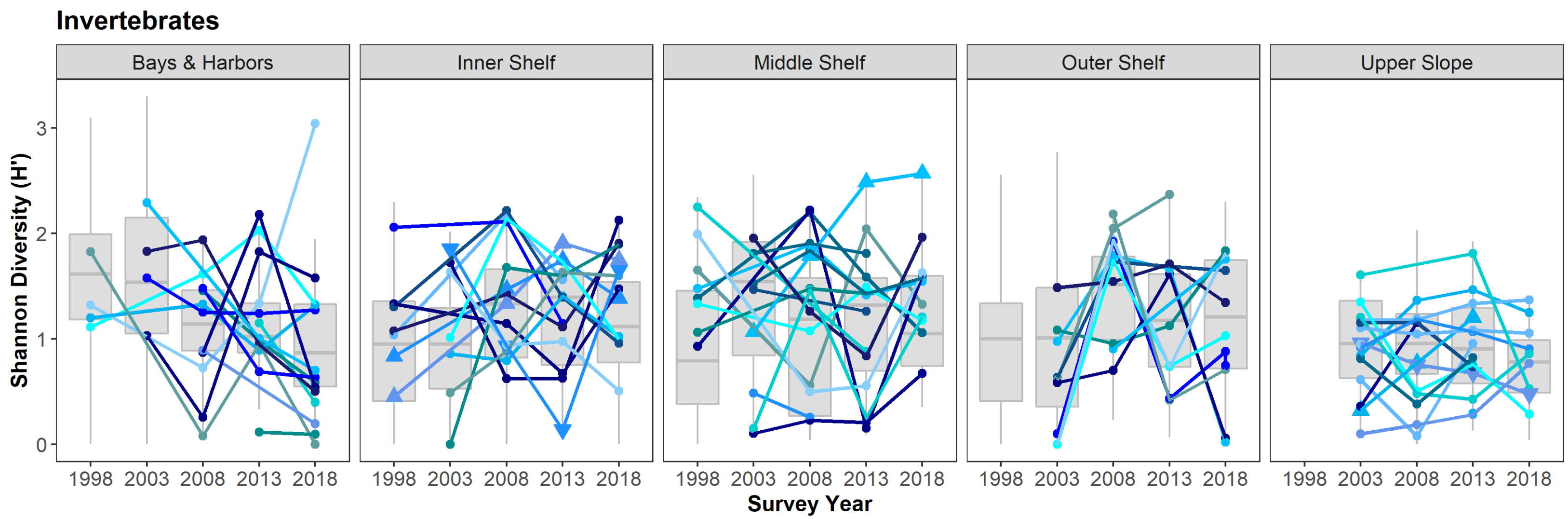

Figure E45. Megabenthic invertebrate Shannon diversity (H') trends in individual revisited sites across surveys. Grey box plots represent all Bight data collected during each survey. Blue lines are individual revisited sites, where circles represent "stable" condition, upward triangles indicate "increasing taxonomic richness" (positive slope, p-value ≤ 0.05), and downward triangles indicate "decreasing taxonomic richness" (negative slope, p-value ≤ 0.05).

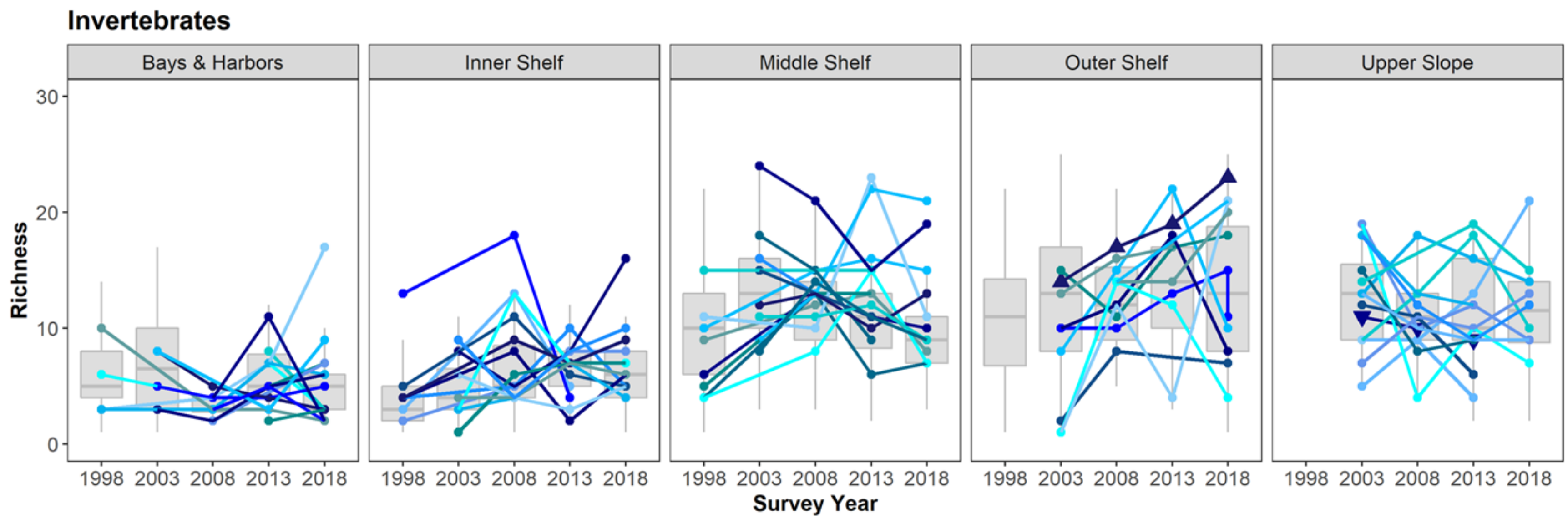

Figure E46. Megabenthic invertebrate taxonomic richness trends in individual revisited sites across surveys. Grey box plots represent all Bight data collected during each survey. Blue lines are individual revisited sites, where circles represent "stable" condition, upward triangles indicate "increasing diversity" (positive slope, p-value ≤ 0.05), and downward triangles indicate "decreasing diversity" (negative slope, p-value ≤ 0.05).

Table E60. Percent of area characterized as having increasing, stable or decreasing megabenthic invertebrate Shannon diversity (H') based on the trend in values between 1998/2003 and 2018 for each stratum and for the entire SCB.

Stratum	Number of Sites	Increasing	Stable	Decreasing
Bays & Harbors	9	0	100	0
Inner Shelf	14	14.3	78.6	7.1
Middle Shelf	13	7.7	92.3	0
Outer Shelf	8	0	100	0
Upper Slope	13	7.7	84.6	7.7
All Strata	57	1.09	95.4	3.5

Table E61. Slope, P-values, and trend designations for invertebrate Shannon diversity (H') at revisited sites with three or more occupations. Shaded areas indicate P-values ≤ 0.05.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2152	4	Bays & Harbors	0.02	0.53	Stable
2162	3	Bays & Harbors	-0.01	0.89	Stable
2242	3	Bays & Harbors	-0.02	0.64	Stable
2436	3	Bays & Harbors	-0.07	0.55	Stable
4092	3	Bays & Harbors	-0.03	0.31	Stable
4098	3	Bays & Harbors	0.08	0.66	Stable
4116	3	Bays & Harbors	-0.09	0.40	Stable
4228	3	Bays & Harbors	-0.08	0.30	Stable
4242	3	Bays & Harbors	-0.03	0.88	Stable
4090	3	Inner Shelf	-0.17	0.03	Decreasing
2307	3	Inner Shelf	0.1	0.04	Increasing
2320	3	Inner Shelf	0.06	0.02	Increasing
2304	3	Inner Shelf	0.05	0.58	Stable
2325	4	Inner Shelf	-0.02	0.72	Stable
2359	3	Inner Shelf	-0.05	0.49	Stable
2376	4	Inner Shelf	0	0.89	Stable
2382	3	Inner Shelf	0.01	0.81	Stable
4003	4	Inner Shelf	0.02	0.49	Stable
4042	3	Inner Shelf	-0.11	0.34	Stable
4047	4	Inner Shelf	-0.01	0.89	Stable
4055	4	Inner Shelf	0.11	0.17	Stable
4058	3	Inner Shelf	-0.07	0.36	Stable
4061	4	Inner Shelf	0.08	0.06	Stable
4000	3	Middle Shelf	0.14	0.01	Increasing
2192	3	Middle Shelf	0.01	0.96	Stable
2208	4	Middle Shelf	0	0.97	Stable

Table E61. Continued.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2301	4	Middle Shelf	-0.01	0.74	Stable
2365	4	Middle Shelf	0.01	0.94	Stable
2396	3	Middle Shelf	0.01	0.88	Stable
2408	3	Middle Shelf	0.03	0.28	Stable
2419	3	Middle Shelf	-0.1	0.24	Stable
4006	3	Middle Shelf	0	0.99	Stable
4045	3	Middle Shelf	-0.11	0.09	Stable
4048	3	Middle Shelf	0.01	0.96	Stable
4080	3	Middle Shelf	-0.01	0.85	Stable
4096	4	Middle Shelf	0.03	0.14	Stable
4038	5	Outer Shelf	0.08	0.55	Stable
4068	4	Outer Shelf	-0.06	0.52	Stable
4133	3	Outer Shelf	0	0.85	Stable
4144	3	Outer Shelf	0.18	0.22	Stable
4269	3	Outer Shelf	0.1	0.27	Stable
4279	4	Outer Shelf	-0.01	0.78	Stable
4285	4	Outer Shelf	0.04	0.63	Stable
4419	3	Outer Shelf	0.07	0.76	Stable
4088	4	Upper Slope	-0.03	0.01	Decreasing
4179	3	Upper Slope	0.09	0.01	Increasing
4007	3	Upper Slope	0.03	0.75	Stable
4039	3	Upper Slope	0.04	0.69	Stable
4071	4	Upper Slope	0.03	0.37	Stable
4083	4	Upper Slope	0.01	0.07	Stable
4091	3	Upper Slope	-0.04	0.34	Stable
4125	4	Upper Slope	-0.06	0.17	Stable
4132	4	Upper Slope	-0.02	0.62	Stable
4199	3	Upper Slope	0	0.99	Stable
4201	4	Upper Slope	0	0.48	Stable
4202	4	Upper Slope	0.04	0.09	Stable
4211	4	Upper Slope	0	0.85	Stable

Table E62. Percent of Area Characterized as having increasing, stable or decreasing invertebrate taxonomic richness based on the trend in values between 1998/2003 and 2018 for each stratum and for the entire SCB.

Stratum	Number of Sites	Increasing	Stable	Decreasing
Bays & Harbors	9	0	100	0
Inner Shelf	14	0	100	0
Middle Shelf	13	0	100	0
Outer Shelf	8	12.5	75	12.5
Upper Slope	13	0	92.3	7.7
All Strata	57	1.09	95.4	3.5

Table E63. Slope, P-values, and trend designations for megabenthic invertebrate taxonomic richness at revisited sites with three or more occupations. Shaded areas indicate P-values ≤ 0.05.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2152	4	Bays & Harbors	-0.09	0.57	Stable
2162	3	Bays & Harbors	0.24	0.30	Stable
2242	3	Bays & Harbors	0.23	0.45	Stable
2436	3	Bays & Harbors	-0.5	0.21	Stable
4092	3	Bays & Harbors	-0.1	0.33	Stable
4098	3	Bays & Harbors	0.2	0.55	Stable
4116	3	Bays & Harbors	-0.4	0.18	Stable
4228	3	Bays & Harbors	-0.1	0.79	Stable
4242	3	Bays & Harbors	-0.2	0.86	Stable
2304	3	Inner Shelf	0.26	0.76	Stable
2307	3	Inner Shelf	0.39	0.12	Stable
2320	3	Inner Shelf	0.36	0.35	Stable
2325	4	Inner Shelf	-0.02	0.95	Stable
2359	3	Inner Shelf	-0.44	0.68	Stable
2376	4	Inner Shelf	0.02	0.92	Stable
2382	3	Inner Shelf	0.24	0.47	Stable
4003	4	Inner Shelf	0.12	0.55	Stable
4042	3	Inner Shelf	0	1.00	Stable
4047	4	Inner Shelf	0.12	0.81	Stable
4055	4	Inner Shelf	0.38	0.15	Stable
4058	3	Inner Shelf	-0.3	0.12	Stable
4061	4	Inner Shelf	0.18	0.23	Stable
4090	3	Inner Shelf	-0.1	0.88	Stable
2192	3	Middle Shelf	0.27	0.06	Stable
2208	4	Middle Shelf	0.27	0.14	Stable
2301	4	Middle Shelf	0.1	0.77	Stable

Table E63. Continued.

Original Station ID	Number of Sites	Stratum	Slope	P-value	Trend
2365	4	Middle Shelf	0.21	0.40	Stable
2396	3	Middle Shelf	0.69	0.22	Stable
2408	3	Middle Shelf	0.57	0.21	Stable
2419	3	Middle Shelf	0.67	0.50	Stable
4000	3	Middle Shelf	1.3	0.14	Stable
4006	3	Middle Shelf	-0.9	0.12	Stable
4045	3	Middle Shelf	-0.2	0.55	Stable
4048	3	Middle Shelf	0.1	0.33	Stable
4080	3	Middle Shelf	0.3	0.67	Stable
4096	4	Middle Shelf	-0.42	0.28	Stable
4279	4	Outer Shelf	0.58	0.01	Increasing
4038	5	Outer Shelf	0.26	0.10	Stable
4068	4	Outer Shelf	0.26	0.73	Stable
4133	3	Outer Shelf	0.2	0.79	Stable
4144	3	Outer Shelf	0.4	0.18	Stable
4269	3	Outer Shelf	0.8	0.18	Stable
4285	4	Outer Shelf	0.14	0.86	Stable
4419	3	Outer Shelf	0.3	0.83	Stable
4039	3	Upper Slope	-0.2	0.00	Decreasing
4007	3	Upper Slope	-0.1	0.88	Stable
4071	4	Upper Slope	0.02	0.94	Stable
4083	4	Upper Slope	0.8	0.09	Stable
4088	4	Upper Slope	-0.56	0.20	Stable
4091	3	Upper Slope	-0.6	0.23	Stable
4125	4	Upper Slope	-0.6	0.40	Stable
4132	4	Upper Slope	0.16	0.74	Stable
4179	3	Upper Slope	-0.6	0.23	Stable
4199	3	Upper Slope	-0.6	0.42	Stable
4201	4	Upper Slope	-0.26	0.11	Stable
4202	4	Upper Slope	0.34	0.12	Stable
4211	4	Upper Slope	-0.42	0.28	Stable

APPENDIX F – SUPPLEMENTAL MULTIVARIATE ANALYSIS

The following section describes supplemental results of multivariate analyses performed on demersal fish and megabenthic invertebrate trawls conducted during Bight ’94 - ’18. As stated in Section II under Data Analyses/Multivariate Analyses, analyses included ordination (non-metric multidimensional scaling; nMDS), as well as hierarchical agglomerative clustering (cluster analysis) with group-average linking, and additional one-way ANOSIM tests to look for significant differences between groups. The Bray-Curtis measure of similarity was used as the basis for the ordination and cluster analysis, and abundance data were transformed to lessen the influence of the most abundant species and increase the importance of rare species. Similarity profile analysis (SIMPROF) was used to confirm the non-random structure of the resultant cluster dendrogram (Clarke et al. 2008), with major ecologically-relevant clusters receiving SIMPROF support retained as cluster groups. A BEST test using the BVSTEP procedure was conducted to determine which subset of species best described patterns within the resulting cluster dendrograms. Similarity percentages analysis (SIMPER) was used to determine which species were responsible for > 70% of the contributions to within-group similarity (i.e., characteristic species) by location (to support ANOSIM tests) and by cluster group (to support cluster group selection).

For each dataset, trawls with no fish or invertebrates present were removed from ordination and cluster analysis to better resolve community groups. These included four trawls with no demersal fishes (B08-7620, B08-7194, B98-2106, and B18-10838) and 14 trawls with no megabenthic invertebrates (B94-1684, B98-2273, B98-2276, B98-2279, B98-2286, B98-2328, B98-2338, B98-2361, B98-2377, B98-2379, B03-4180, B03-4419, B08-6295, and B08-7620). Multivariate analysis of fish and megabenthic invertebrates only included sites categorized as bays and harbors, limited to the Ports of Los Angeles/Long Beach (POLA/POLB), Mission Bay and San Diego Bay (SDB). Temporal trends exclude numerous small marinas and bays sites sampled during previous Bight surveys since most have not been revisited on a regular basis and generally do not have enough stations for robust historical analysis. Given the low replication of sampling, it was determined that these stations should be removed from analysis. Recognizing that there are different ecoregions within San Diego Bay (Williams et al. 2019; Amec Foster Wheeler 2016), analysis split San Diego Bay into North, Central and South ecoregions.

Multivariate Analyses of Demersal Fish Assemblages

Fish in Bays and Harbors

Multivariate analysis of fish abundance data assessed community patterns across bays and harbors in the SCB. Abundance data was visualized using an nMDS ordination plot and one-way ANOSIM tests were run to look for significant differences between years and embayments. This analysis revealed the following observations:

- 1998 was significantly different from all years, and 2013 was significantly different from all years except 2018.
- All bays/ecoregions were significantly different from one another.

Differences between years may in part be driven by the distribution and number of stations within each bay. Table F64 shows the number of trawls in POLA/POLB, SDB and Mission Bay across years. Surveys in 1998, 2013, and 2018 more heavily sampled POLA/POLB compared to SDB and Mission Bay. Additionally, surveys in 1998 sampled areas of POLA/POLB (main shipping channels, basins, slips and marinas) that were not revisited in subsequent surveys. Based on similar long-term monitoring studies within the Port Complex (MBC 2016; Wood E&IS in prep), it has been shown that these areas have distinct fish communities compared to the outer harbor areas near the breakwater and east San Pedro Bay which may account for the statistical difference between 1998 and all other survey years. The 2013 survey appears to have statistically separated from other surveys due to the prevalence of California Lizardfish (*Synodus lucioceps*), which was the top species by Ecological Index (E.I.) in 2013 but ranked seventh in the 2018 survey (Table F65).

Using similarity percentages (SIMPER) analysis shows the species that best represent the spatial community differences across bays and ecoregions (Table F66). The analysis identifies the relative contribution of each species within the group, as well as the cumulative contribution of the top species that make up at least 70% of the community composition within that group. It is notable that each group has a different species that contributes most to the community. White Croaker (*Genyonemus lineatus*) in POLA/POLB was the most dominant member of any group, contributing 39% of the community composition. The species that compose the largest share of the POLA/POLB group are also not present within any other bay/ecoregion group, while there is considerable overlap between Mission Bay and SDB ecoregion groups. This distinct spatial community difference between POLA/POLB and the southern bays can also help explain some of the patterns observed in EI over time (Table F65), whereby years with heavy POLA/POLB influence have those species more highly ranked than years where SDB and Mission Bay were more equally represented.

Table F64. Trawls in ports of LA/LB, San Diego Bay and Mission Bay across survey years.

Year	POLA/POLB	SD Bay	Mission Bay
1998	30 Trawls	17 Trawls	2 Trawls
2003	7 Trawls	8 Trawls	1 Trawl
2008	6 Trawls	9 Trawls	3 Trawls
2013	15 Trawls	13 Trawls	3 Trawls
2018	16 Trawls	10 Trawls	4 Trawls

These analyses resulted in 16 ecologically-relevant SIMPROF- supported cluster groups, or fish assemblages (cluster groups A-P; Table 10 in main report; Figure 16 in main report; Figure F47 through Figure F51, which were overlaid on station maps to examine spatial distribution. These assemblages represented from 1 to 53 trawls ranging from 29% to 62% similarity (mean = 48%) for cluster with n>1. A BEST/BVSTEP test ($\rho = 0.952$, $p = 0.001$, number of permutations = 999) implicated California Lizardfish, California Tonguefish, California Halibut, White Croaker, Round Stingray, Spotted Sand Bass, Barred Sand Bass and Slough Anchovy as being influential to the overall pattern (gradient) seen in Figure 16 in main report. Results of SIMPER analysis for each SIMPROF group is shown in Table F67. Five of the cluster groups (groups A, B, D, G, N) were small "outlier" clusters (n = 1-2 trawls) that were composed of stations from only one survey year, with 1998 having three of these outlier cluster groups. The largest cluster group was Group I, which was located in the outer areas of POLA/POLB and east San Pedro Bay and were distinguished by White Croaker, Queenfish, and California Tonguefish. Groups C, D and F were located in more restricted portions of POLA/POLB and the LA River estuary and were distinguished by, northern anchovy and California lizardfish, while group E was primarily near the breakwater and had higher proportions of Speckled Sanddab and California Tonguefish.

SDB – South was composed primarily of Group L, which was characterized by the high proportion of Slough Anchovy, Deepbody Anchovy, and Round Stingray, while much of SDB – Central was within Group P, which had a core community of Spotted Sand Bass, Barred Sand Bass, California Halibut and Round Stingray. SDB – North was represented by Groups N, O and C, which have higher proportions of California Lizardfish, California Tonguefish and Spotted Sand Bass. Mission Bay was primarily made up of Group J near the mouth, which was predominantly Shiner Perch and Kelp Bass. The inner reaches of Mission Bay largely fell into Group L, which is similar to SDB – South in having shallow mudflat habitat with eelgrass beds and supports similar fish communities.

Table F65. Historical fish Ecological Index values for fish captured in Ports of LA/LB, Mission Bay and San Diego Bay.

2018				
Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
Slough Anchovy	44.9	2.69	38.5	1832
White Croaker	3.89	31.8	50.0	1785
Northern Anchovy	46.8	4.40	11.5	591
Round Stingray	0.48	13.9	38.5	554
Spotted Sand Bass	0.67	12.1	42.3	542
California Halibut	0.31	6.35	61.5	410
California Lizardfish	0.47	2.26	53.8	147
Queenfish	0.63	4.70	23.1	123
Barred Sand Bass	0.26	2.08	50.0	117
Fantail Sole	0.13	2.38	34.6	87.00

2013				
Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
California Lizardfish	39.9	21.4	69.2	4241
White Croaker	24.8	38.4	50.0	3163
Round Stingray	2.13	16.4	38.5	715
California Halibut	0.92	3.88	65.4	314
California Tonguefish	3.29	0.83	73.1	301
Queenfish	4.95	1.78	34.6	233
Speckled Sanddab	4.00	0.54	50.0	227
Slough Anchovy	8.45	0.10	23.1	198
Specklefin Midshipman	1.48	1.41	50.0	145
Spotted Sand Bass	0.70	2.66	34.6	117

2008				
Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
White Croaker	38.8	35.2	30.0	2220
Round Stingray	2.63	13.7	35.0	571
Spotted Sand Bass	2.09	9.44	45.0	519
Barred Sand Bass	3.57	3.86	60.0	446
California Halibut	1.75	4.76	65.0	423
Queenfish	11.3	5.49	25.0	419
Yellowfin Croaker	3.51	7.12	30.0	319
Northern Anchovy	16.5	0.44	15.0	253
Black Croaker	1.42	4.84	25.0	156
Slough Anchovy	4.18	0.19	25.0	109

2003				
Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
California Halibut	4.90	10.4	80.8	1239
Round Stingray	8.64	20.9	38.5	1135
White Croaker	21.4	7.03	30.8	874
Queenfish	7.57	25.9	23.1	771
Barred Sand Bass	4.08	4.82	46.2	411
Specklefin Midshipman	5.35	2.36	42.3	326
Slough Anchovy	12.4	0.21	23.1	291
Speckled Sanddab	6.48	0.51	23.1	161
White Seaperch	3.67	2.97	15.4	102
Diamond Turbot	0.89	1.86	34.6	95.2

1998				
Common Name	% Abundance	% Biomass	% Frequency	Ecological Index
White Croaker	59.7	37.3	59.4	5759
California Halibut	1.61	8.69	68.1	702
Barred Sand Bass	2.05	4.05	63.8	389
Northern Anchovy	15.1	0.93	23.2	372
Queenfish	5.92	2.99	39.1	349
California Tonguefish	3.04	0.97	42.0	169
Spotted Sand Bass	0.70	5.61	26.1	165
Round Stingray	1.03	7.41	18.8	159
White Seaperch	0.96	2.18	27.5	86.5
Specklefin Midshipman	0.66	1.51	30.4	65.9

Note: Shading indicates that the species was in the top ten species by EI in at least four of five survey years

Table F66. Historical fish Ecological Index values for fish captured in Ports of LA/LB, Mission Bay and San Diego Bay.

Group POLA/POLB		
Species	Community Contribution (%)	Cumulative Contribution (%)
White Croaker	39.1	39.1
California Tonguefish	16.4	55.5
California Lizardfish	10.5	66.0
Queenfish	8.48	74.5

Group San Diego Bay - North		
Species	Community Contribution (%)	Cumulative Contribution (%)
Barred Sand Bass	20.8	20.8
Spotted Sand Bass	19.9	40.6
California Halibut	16.2	56.9
Round Stingray	10.6	67.4
Spotted Turbot	8.75	76.2

Group Mission Bay		
Species	Community Contribution (%)	Cumulative Contribution (%)
California Halibut	28.0	28.0
Shiner Perch	17.9	45.9
Slough Anchovy	13.9	59.7
Spotted Sand Bass	11.3	71.1

Group San Diego Bay - Central		
Species	Community Contribution (%)	Cumulative Contribution (%)
Round Stingray	32.3	32.3
Spotted Sand Bass	24.4	56.8
Barred Sand Bass	16.7	73.5

Group San Diego Bay - South		
Species	Community Contribution (%)	Cumulative Contribution (%)
Slough Anchovy	35.5	35.5
Spotted Sand Bass	21.0	56.5
Barred Sand Bass	16.8	73.3

Table F67. Composition of bays and harbors fish cluster groups A–P. For groups with n>1, highlighted values indicate the most characteristic species according to SIMPER analysis and the cumulative percent contribution (C%C) is included at the bottom. For groups with n=1, highlighted values are top five most abundant species, and N/A (not applicable) is included for C%C.

	Cluster Group															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Number of Trawls	1	1	6	2	3	5	1	3	54	4	2	19	6	2	5	25
Species	**Mean Abundance**															
Spotted Sand Bass	0	0	0	0	0	0	0	0	0	4	0	3	2	1	20	5
Diamond Turbot	0	0	0	0	0	0	0	<1	<1	<1	0	<1	<1	3	<1	<1
Round Stingray	0	0	0	0	0	0	0	0	<1	1	0	11	0	1	14	8
Slough Anchovy	0	0	0	0	0	1	0	0	0	0	0	304	<1	8	<1	0
California Halibut	0	0	2	3	0	1	1	6	3	2	1	2	<1	4	6	3
California Tonguefish	0	0	<1	1	6	<1	15	6	10	0	<1	<1	0	9	6	0
Barred Sand Bass	0	0	2	0	<1	2	0	8	<1	4	<1	3	2	3	4	4
California Lizardfish	0	0	19	2	<1	0	1	<1	30	0	0	<1	0	1	35	<1
Shiner Perch	0	0	0	16	4	10	0	0	<1	11	0	<1	0	0	0	0
Kelp Bass	0	0	0	0	0	0	0	0	<1	9	0	0	0	0	0	<1
Northern Anchovy	0	0	3	2	0	301	0	5	6	0	0	233	0	0	0	0
Hornyhead Turbot	0	0	0	0	3	<1	4	<1	<1	0	0	0	0	0	0	0
Speckled Sanddab	0	0	3	0	33	0	0	0	4	0	0	0	0	0	0	0
Specklefin Midshipman	0	1	0	2	<1	<1	2	1	4	0	0	<1	0	4	2	<1
Fantail Sole	0	2	1	<1	2	0	0	<1	<1	0	0	0	0	0	<1	0
Spotted Turbot	0	0	2	0	0	1	1	<1	<1	0	0	<1	<1	3	2	<1
Queenfish	0	0	0	0	0	43	0	0	17	0	0	20	0	0	0	0
White Croaker	0	1	2	1	3	13	0	73	182	0	0	0	0	0	0	<1
White Seaperch	1	0	0	6	2	<1	0	<1	<1	4	0	0	0	0	0	0
C%C	N/A	N/A	78	72	76	76	N/A	78	72	72	100	71	95	74	75	75

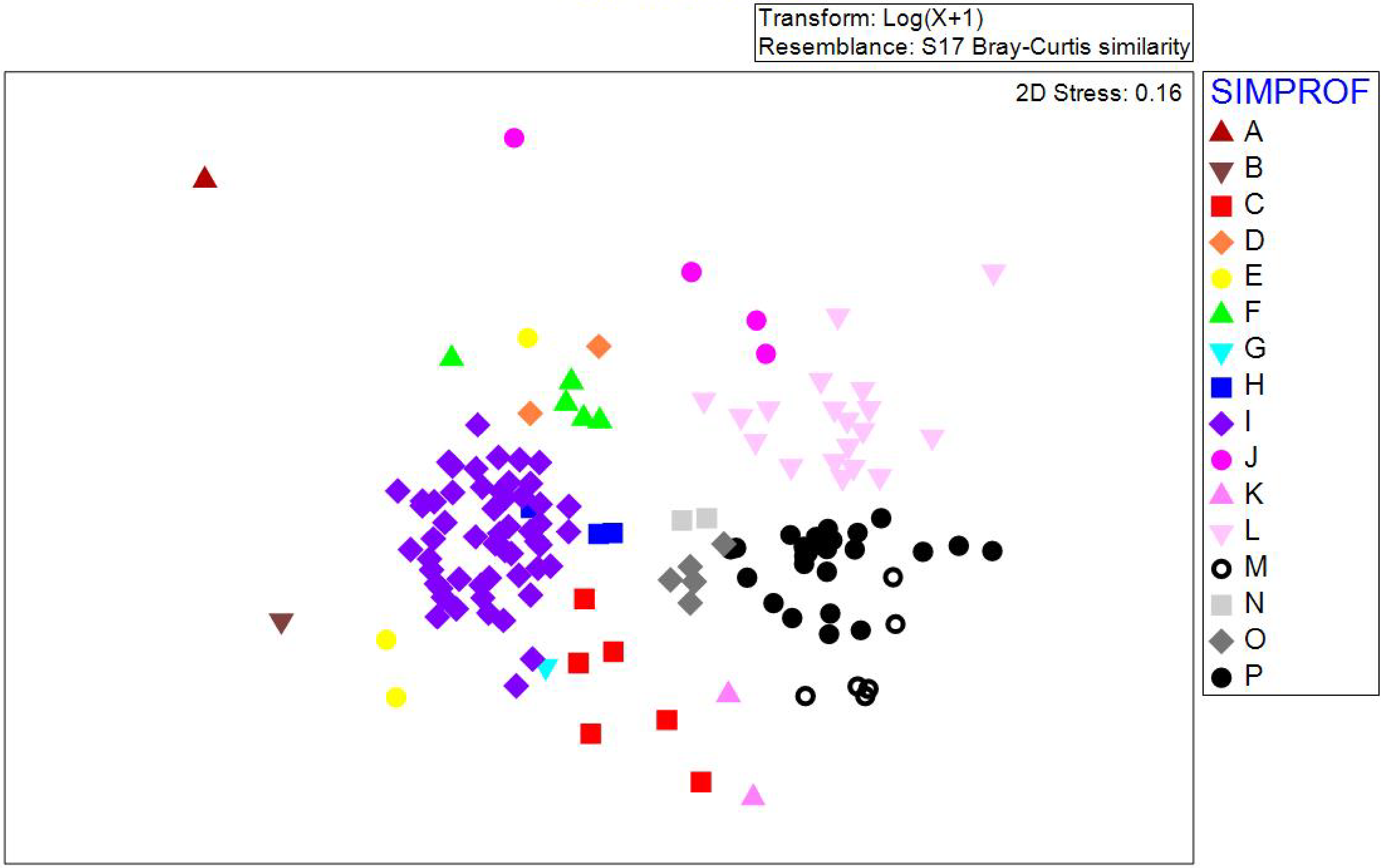

Figure F47. nMDS plot of fish abundance by Similarity Profile (SIMPROF) analysis.

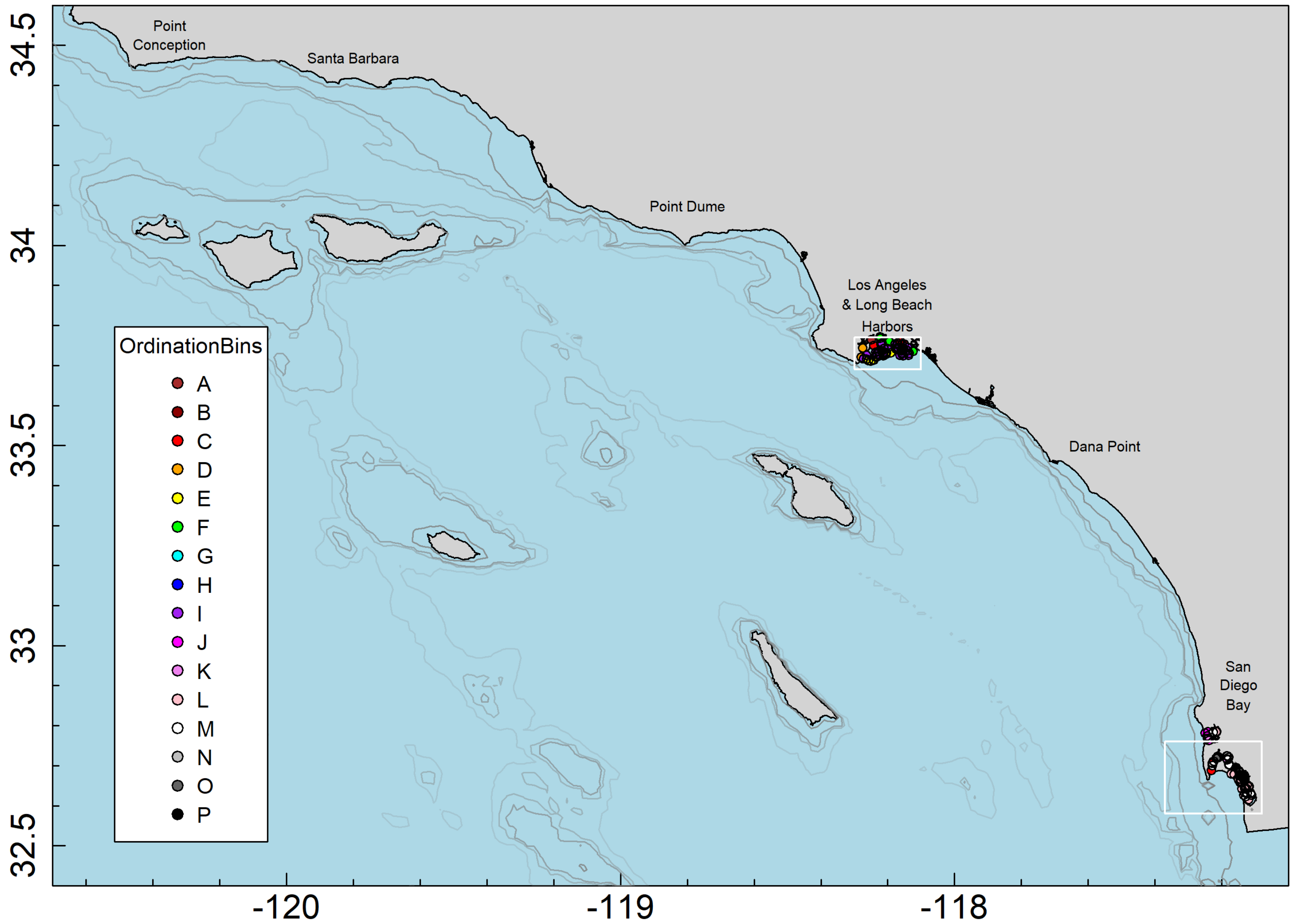

Figure F48. Demersal fish SIMPROF groups in Bays and Harbors – SCB.

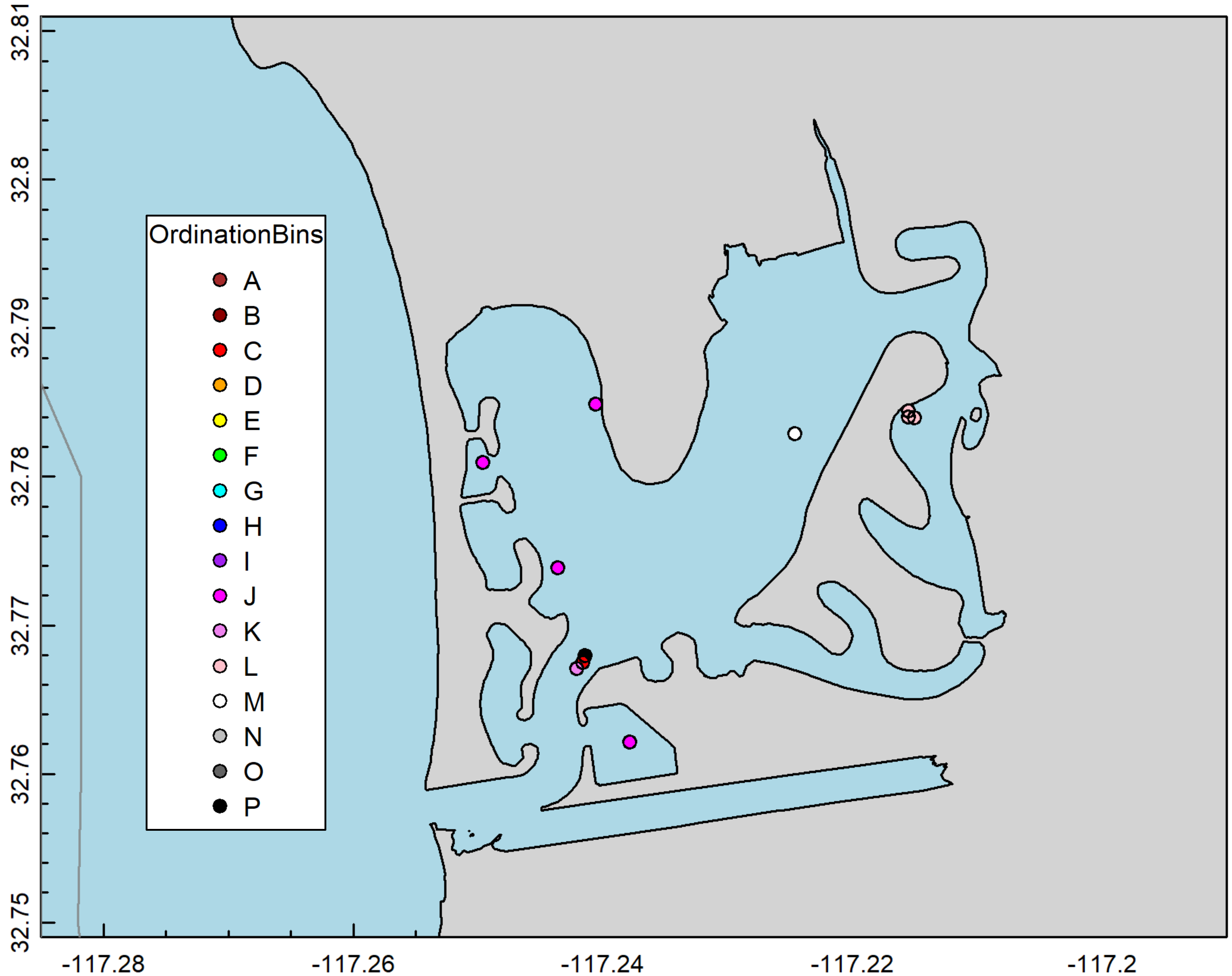

Figure F49. Demersal fish SIMPROF groups in Bays and Harbors – Mission Bay.

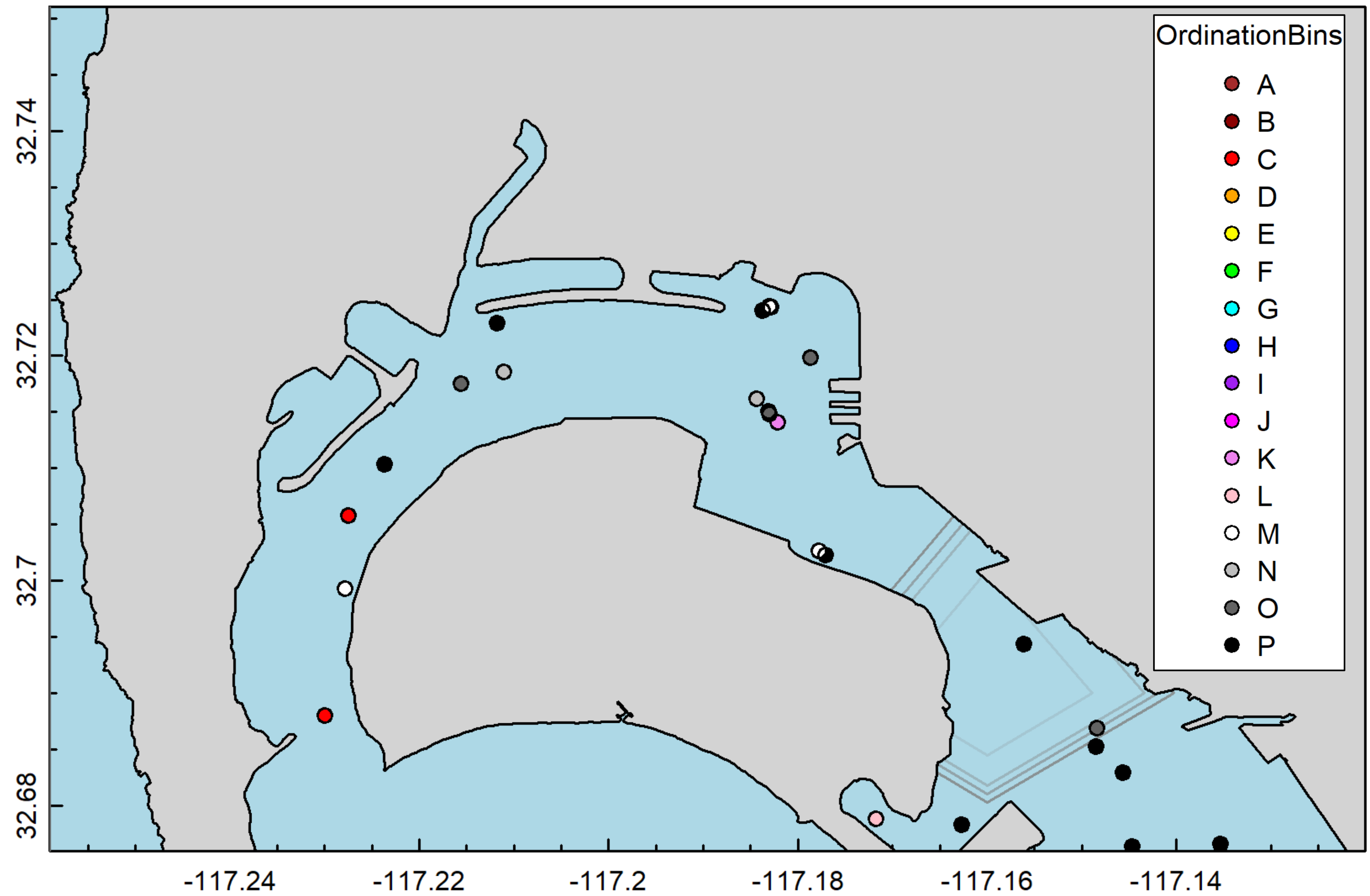

Figure F50. Demersal fish SIMPROF groups in Bays and Harbors – North San Diego Bay (SDB).

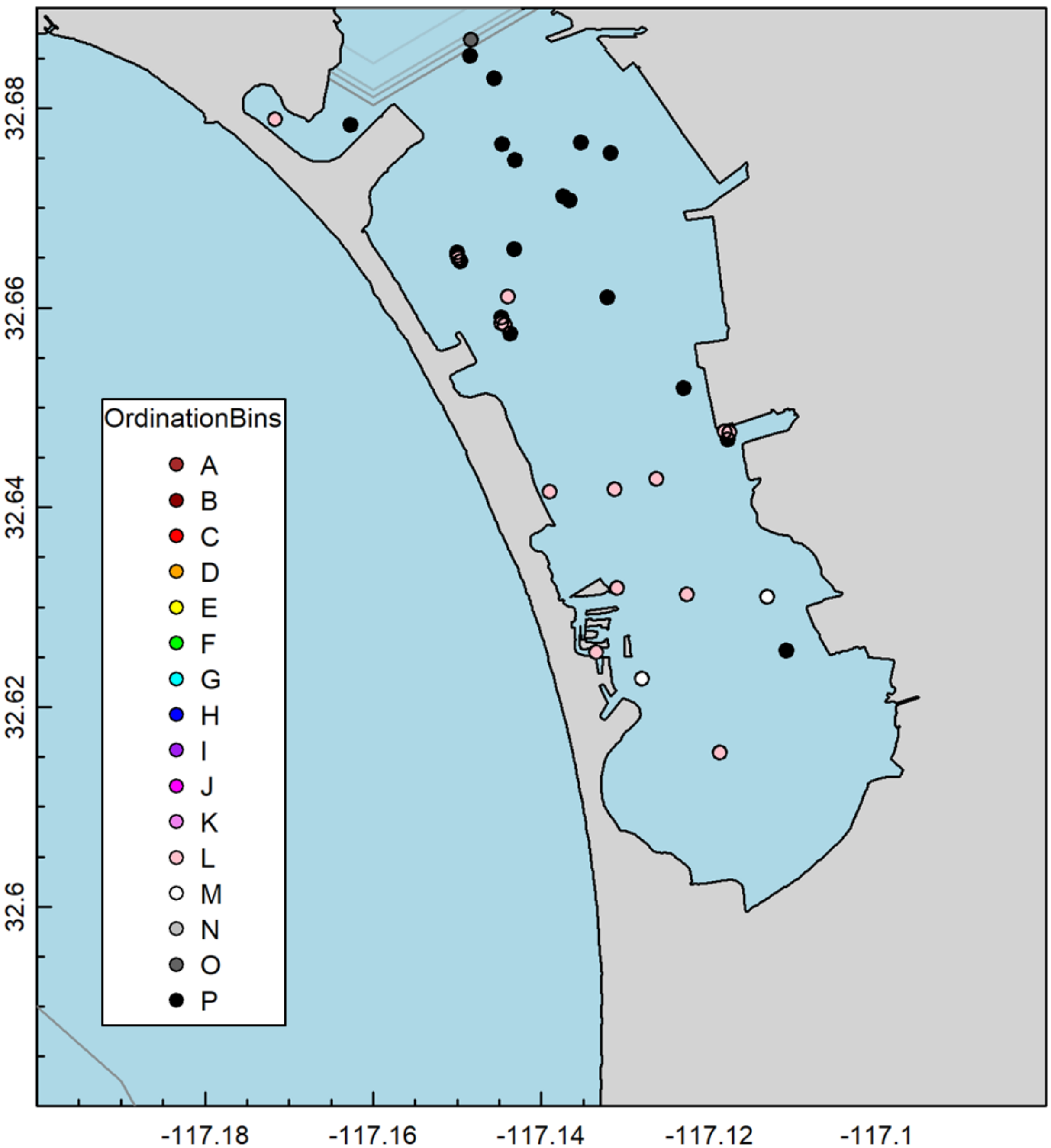

Figure F51. Demersal fish SIMPROF groups in Bays and Harbors – South San Diego Bay (SDB).

Demersal Fish on the Coastal Shelf and Slope

Multivariate analyses of demersal fish communities on the SCB shelf and slope included a total of 906 trawls conducted during Bight surveys (Bight '94 – Bight '18). These analyses resulted in 16 main ecologically-relevant SIMPROF-supported groups, or types of demersal fish assemblages (cluster groups A–P; see Figure 18, Figure 19, and Table 11 in main report). These assemblages represented from 1 to 296 trawls each and ranged from 24 to 41% similarity (mean = 35%) for clusters comprising more than one trawl.

Eleven of the cluster groups (groups A, B, D, F, H, I, J, L, M, N, O) were small "outlier" clusters with ≤ 11 trawls in each group. Sites included in groups A and B were scattered throughout the SCB on the inner shelf at depths ≤ 18 m. For example, group A included trawls from two stations located outside of the Oceanside Marina breakwater, two stations located near Point Mugu, and one station located outside the Dana Marina breakwater (Figure 19A). Three of these trawls (60%) had FRI values possibly indicative of non-reference conditions (FRI > 45, Table 11). Assemblages represented by group A were characterized by low numbers (mean abundance ≤ 3 per haul) of California Halibut, Speckled Sanddab, Shovelnose Guitarfish, and Shiner Perch (Table F68). Group B included trawls from four stations sampled from off Point Conception south to off Camp Pendleton (Figure 19A), all of which had FRI values ≤ 45 (Table 11). These assemblages were characterized by low numbers (mean abundance ≤ 2 per haul) of Speckled Sanddab and Barred Sand Bass (Table F68).

Sites included in group D were located on the inner and middle shelf at depths ≤ 60 m, all of which had FRI values ≤ 45 (Figure 19A, Table 11). Low numbers (mean abundance = 5 per haul) of California Tonguefish and Yellowchin Sculpin were characteristic species of group D assemblages (Table F68). The majority (57%) of sites included in cluster groups H, I, J, L, M, N were located on the upper slope at depths of 200 – 475 m, while another 29% were located on the outer shelf at depths of 125 – 152 m. Of the seven sites included in these groups that were located at depths where the FRI can be calculated, only one (14%) had a FRI value > 45. Assemblages represented by groups H, I, J, L, M, N had very low species richness (mean SR ≤ 4 species per haul), very low abundance (mean abundance ≤ 8 species per haul) and Pacific Sanddabs were absent or very low in numbers. Characteristic or abundant species were limited to Pacific Sanddabs for group H (mean abundance = 2 per haul), Stripetail Rockfish for group J (mean abundance = 8 per haul), Slender Sole and Dover Sole for group N (mean abundance ≤ 4 per haul). The trawl represented by group I included just one Plainfin Midshipman, while the trawl represented by group L included just one Pacific Hagfish. The haul represented by group M included two Black Eelpout, two Shortspine Thornyhead, one Aurora Rockfish, and one Bigfin Eelpout.

Cluster groups F and O had higher mean abundance than the other, smaller groups described above. Sites included in group F were located on the middle shelf at depths of 43-89 m, and spread along the northern Channel Islands, off Santa Barbara, and various locations off Los Angeles County, Orange County, and northern San Diego County (Figure 19A). All had FRI values ≤ 45 (Table 11). The assemblages represented by group F had the highest number of Halfbanded Rockfish (mean abundance = 619 per haul), the second highest number of Pacific Sanddab (mean abundance = 93 per haul), and the second highest number of Shortspine Combfish (mean abundance = 7 per haul) (Table F68). In contrast to group F, sites included in group O were all located on the upper slope, at depths of 420-477 m, and all of these sites were located in the Santa Barbara Basin. The FRI was not calculated for these depths. Assemblages represented by group O were characterized by the highest number of Filetail Cat Shark (mean abundance = 33 per haul) and the third highest number of Slender Sole (mean abundance = 37 per haul).

The remaining clusters (groups C, E, G, K, P) each spanned the entire SCB, representing the transition of common fish assemblages from the inner shelf to the upper slope (Figure 19B, Table 11, Table F68). Group C comprised 41 trawls from inner shelf sites located in small clusters at depths ≤ 30 m (mean depth = 14 m), primarily adjacent to embayments or lagoons. Thirty-seven percent of these trawls had FRI values > 45, likely due to the high proportion of White Croaker (mean abundance = 163 per haul) and Queenfish (mean abundance = 66 per haul) that characterized this group. Group E comprised 206 trawls from inner and middle shelf sites located at depths of 7-69 m (mean = 24 m). Just 11% of these trawls had FRI values > 45. These assemblages were characterized by the highest number of Speckled Sanddab (mean abundance = 84 per haul) and the second highest number of California Lizardfish (mean abundance = 24 per haul). Group G comprised 256 trawls from inner and middle shelf sites at depths of 20-98 m (mean = 54 m). None of these trawls had FRI values > 45. Group G assemblages were characterized by the highest numbers of California Lizardfish (mean abundance = 44 per haul), Yellowchin Sculpin (mean abundance = 36 per haul), Longfin Sanddab (mean abundance = 24 per haul), Longspine Combfish (mean abundance = 20 per haul), California Tonguefish (mean abundance = 10 per haul), and the third highest number of Pacific Sanddab (mean abundance = 62 per haul). Group K comprised 296 trawls from inner and middle shelf sites located at depths of 50-368 m (mean = 157 m). Only 2% of the eligible trawls from group K had FRI values > 45. Assemblages represented by group K were characterized by the highest numbers of Pacific Sanddab (mean abundance = 128 per haul), Slender Sole (mean abundance = 62 per haul), Dover Sole (mean abundance = 35 per haul), Stripetail Rockfish (mean abundance = 26 per haul), and Shortspine Combfish (mean abundance = 16 per haul). Cluster group P comprised 63 trawls from upper slope sites located at depths of 258-479 m (mean = 402 m). The FRI was not calculated for these depths. Group P assemblages were characterized by the highest numbers of Shortspine Thornyhead (8 per haul) and Pacific Hake (5 per haul), and the second highest number of Slender Sole (mean abundance = 47 per haul) and Dover Sole (33 per haul).

Additional analyses of the three largest offshore fish clusters (groups E, G, K) revealed subgroups that also spanned much of the SCB and revealed no discernible patterns in demersal fish assemblages that could be associated with proximity to known pollution sources (Figure F52, Figure F53, Figure F54). As with the 16 main cluster groups A-P, assemblages represented by subgroups E01-E11, G01-G06, and K01-K11 varied in terms of habitat differences and/or the unique composition of fish assemblages. Cluster group E subgroups represented from 3 to 51 trawls and ranged from 35 to 69% similarity (mean = 51%) for clusters with n > 1 (Table F69). The proportion of trawls with FRI values > 45 ranged from 0 - 33% for these subgroups. A BEST/BVSTEP test ($\rho = 0.954$, $p \leq 0.001$, number of permutations = 999) implicated California Halibut, California Lizardfish, California Tonguefish, Curlfin Sole, English Sole, Fantail Sole, Hornyhead Turbot, Longfin Sanddab, Pacific Sanddab, Pink Seaperch, Speckled Sanddab, Spotted Turbot, Vermilion Rockfish, White Seaperch, and Yellowchin Sculpin as being influential to the overall pattern (gradient) of the cluster dendrogram (Figure F52c). Cluster group G subgroups represented from 1 to 178 trawls and ranged from 44 to 53% similarity (mean = 48%) for clusters with n>1 (Table F69). The proportion of trawls with FRI values > 45 ranged from 0 - 1% for these subgroups. A BEST/BVSTEP test (ρ = 0.953, p ≤ 0.001, number of permutations = 999) implicated California Lizardfish, California Tonguefish, Hornyhead Turbot, Longfin Sanddab, Longspine Combfish, Pacific Sanddab, Pink Seaperch, Plainfin Midshipman, Speckled Sanddab, Stripetail Rockfish, and Yellowchin Sculpin as being influential to the overall pattern (gradient) of the cluster dendrogram (Figure F53c). Cluster group K subgroups represented from 1 to 151 trawls and ranged from 36 to 71% similarity (mean = 53%) for clusters with n > 1 (Table F69). The proportion of trawls with FRI values > 45 ranged from 0 - 25% for these subgroups. A BEST/BVSTEP test (ρ = 0.951, *p* ≤ 0.001, number of permutations = 999) implicated Blackbelly Eelpout, Blacktip Poacher, Dover Sole, Halfbanded Rockfish, Longspine Combfish, Pacific Sanddab, Plainfin Midshipman, Shortspine Combfish, Slender Sole, Splitnose Rockfish, and Stripetail Rockfish as being influential to the overall pattern (gradient) of the cluster dendrogram (Figure F54c).

Table F68. Composition of offshore fish cluster groups A–P. For groups with more than one trawl, highlighted values indicate the most characteristic species according to SIMPER analysis and the cumulative percent contribution (C%C) is included at the bottom. For groups with one trawl, highlighted values are top five most abundant species, and N/A (not applicable) is included for C%C.

	Cluster Group															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Number of Trawls:	5	4	41	4	208	11	258	3	1	3	298	1	1	5	6	63
Species	Mean Abundance															
California Halibut	3	0	2	0	1	0	<1	0	0	0	0	0	0	0	0	0
Speckled Sanddab	2	2	12	4	84	15	7	0	0	0	0	0	0	0	0	0
Shovelnose Guitarfish	1	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0
Shiner Perch	1	0	6	0	0	0	<1	0	0	0	0	0	0	0	0	0
Barred Sand Bass	<1	1	<1	0	<1	0	<1	0	0	0	0	0	0	0	0	0
White Croaker	1	0	163	0	<1	0	2	0	0	0	<1	0	0	0	0	0
Queenfish	<1	0	66	0	<1	0	<1	0	0	0	0	0	0	0	0	0
California Tonguefish	<1	0	3	5	3	4	10	0	0	0	1	0	0	0	0	0
Yellowchin Sculpin	0	0	0	5	5	2	38	1	0	0	4	0	0	0	0	0
California Lizardfish	<1	<1	7	1	24	1	44	0	0	0	1	0	0	0	0	0
Hornyhead Turbot	0	0	4	0	4	3	3	<1	0	0	1	0	0	0	0	0
Halfbanded Rockfish	0	0	0	0	0	691	3	0	0	3	7	0	0	0	0	0
Pacific Sanddab	0	0	<1	0	14	93	62	2	0	0	128	0	0	0	0	0
Shortspine Combfish	0	0	0	0	0	7	<1	0	0	<1	16	0	0	0	0	0
Longfin Sanddab	<1	0	1	1	3	0	24	0	0	0	1	0	0	0	0	0
Longspine Combfish	0	0	0	<1	1	8	20	0	0	0	8	0	0	0	0	0
Plainfin Midshipman	0	0	0	0	<1	12	6	0	1	0	12	0	0	0	0	0
Stripetail Rockfish	0	0	0	<1	2	13	5	0	0	8	28	0	0	0	0	<1
Slender Sole	0	0	0	0	0	1	<1	0	0	0	62	0	0	4	37	47
Dover Sole	0	0	0	0	<1	7	3	0	0	0	35	0	0	2	2	33
Pacific Hagfish	0	0	0	0	0	0	0	0	0	0	<1	1	0	<1	1	<1
Black Eelpout	0	0	0	0	0	0	0	0	0	0	0	0	2	<1	0	6
Shortspine Thornyhead	0	0	0	0	0	0	0	0	0	0	<1	0	2	0	0	8
Aurora Rockfish	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Bigfin Eelpout	0	0	0	0	0	0	0	0	0	0	<1	0	1	<1	0	2
Filetail Cat Shark	0	0	0	0	0	0	0	0	0	0	0	0	0	1	33	1
Pacific Hake	0	0	0	0	0	0	0	0	0	<1	3	0	0	0	1	5
C%C	77	88	76	82	75	72	72	100	N/A	100	75	N/A	N/A	98	79	74

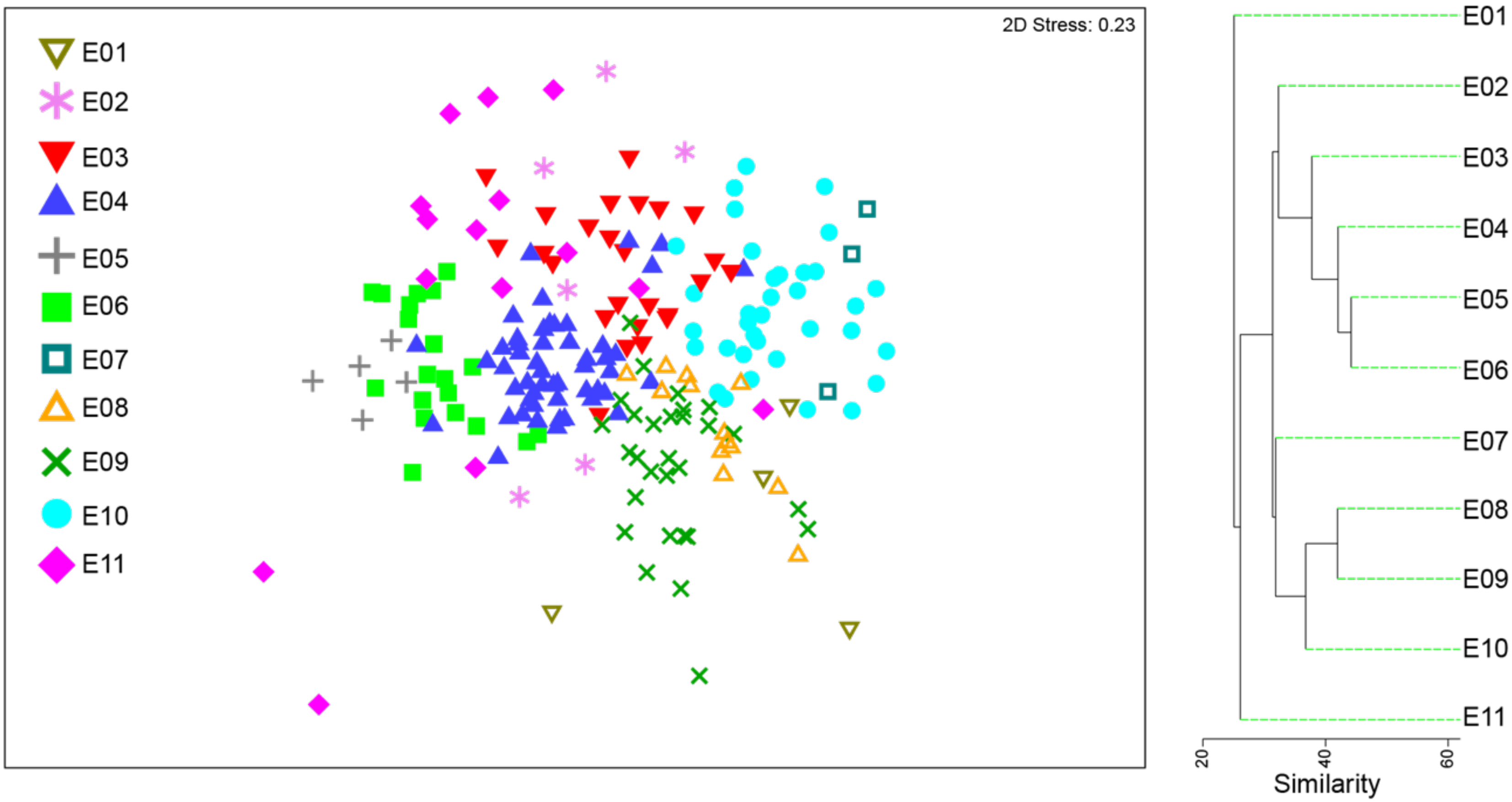

Figure F52a. Results of ordination and cluster analysis of trawls from offshore fish cluster group E presented as a nMDS ordination and dendrogram of main subgroups.

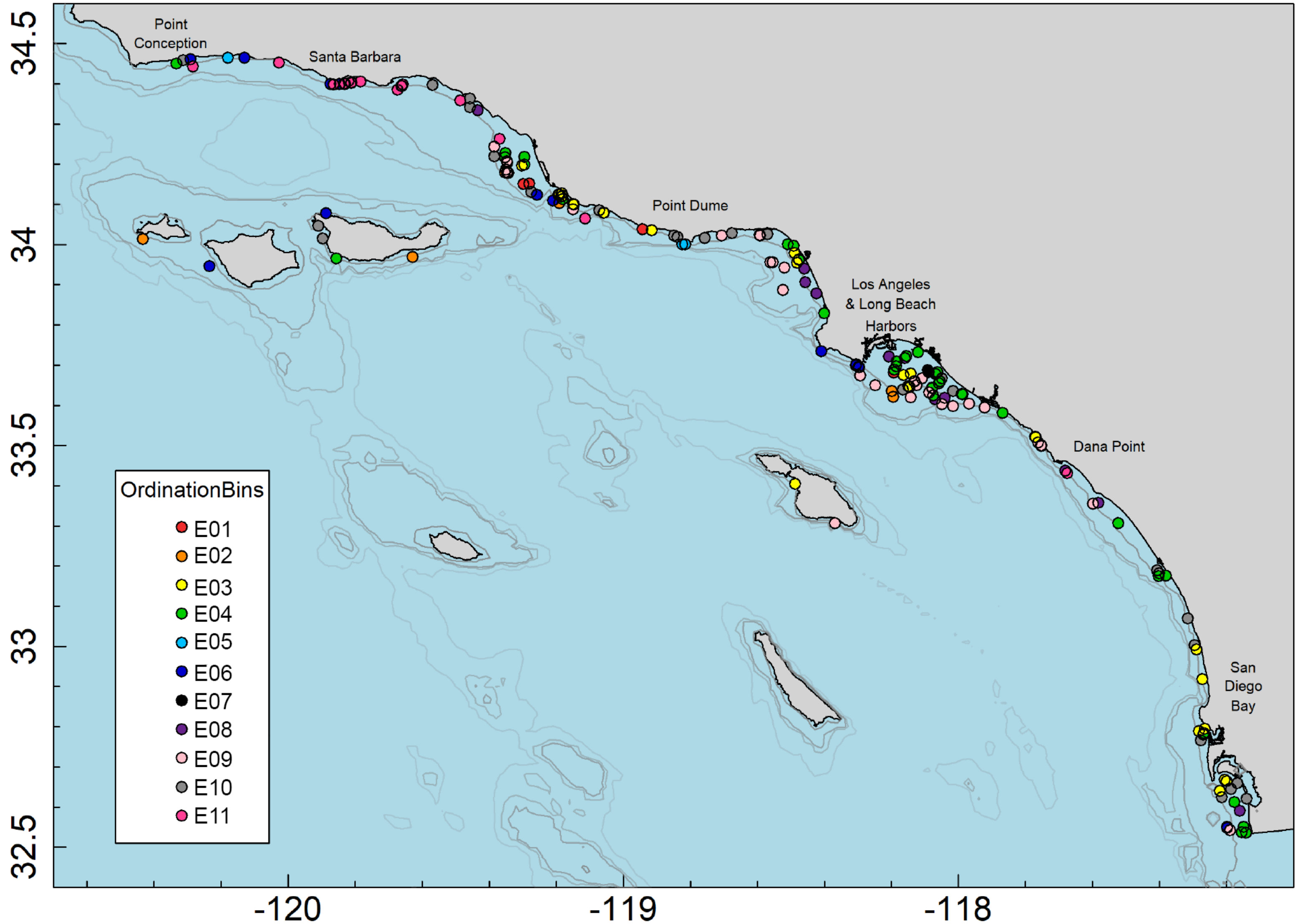

Figure F53b. Results of ordination and cluster analysis of trawls from offshore fish cluster group E presented as a map of subgroups overlaid on station locations.

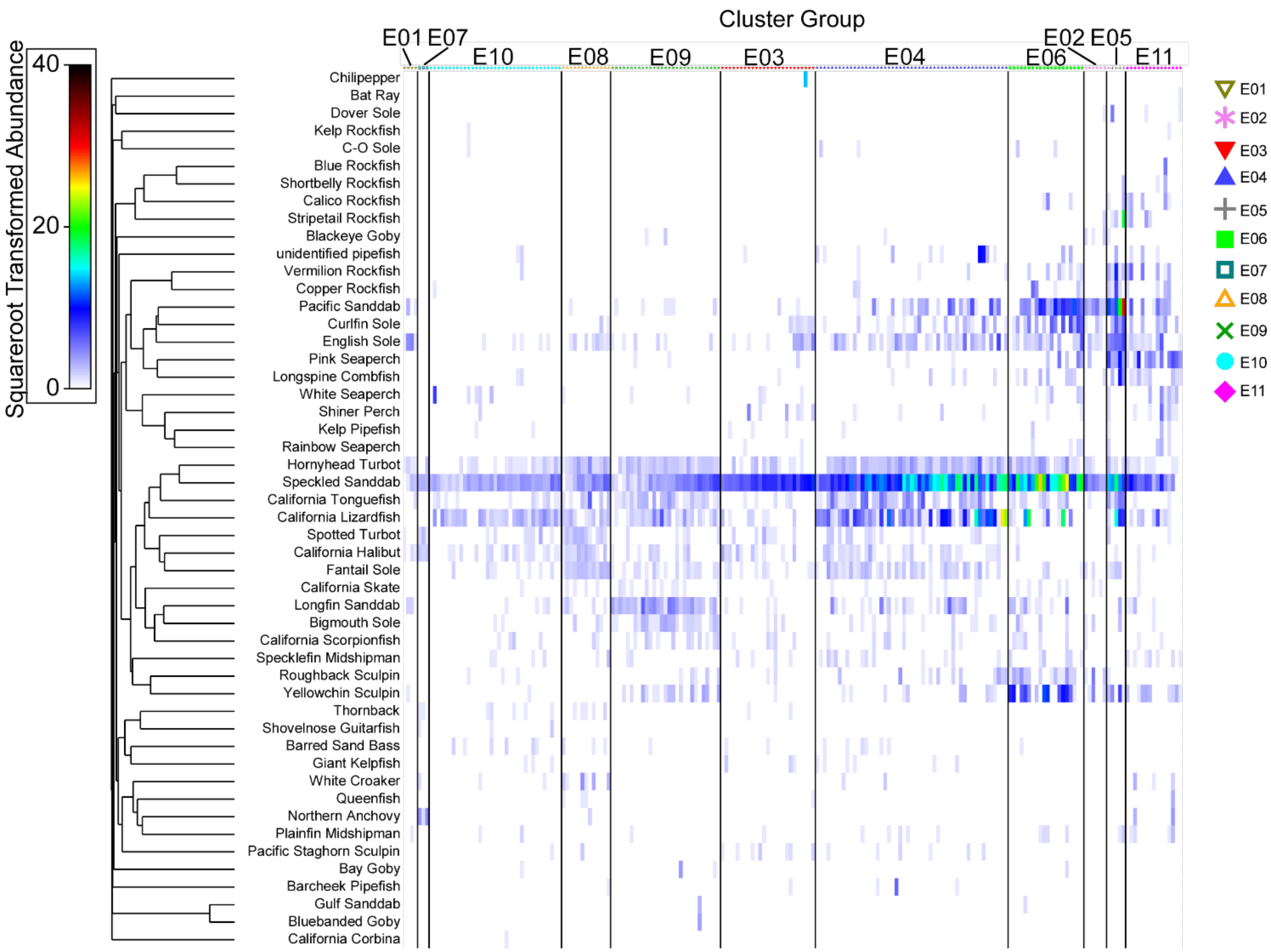

Figure F54c. Results of ordination and cluster analysis of trawls from offshore fish cluster group E presented as a nMDS ordination and dendrogram of main subgroups.

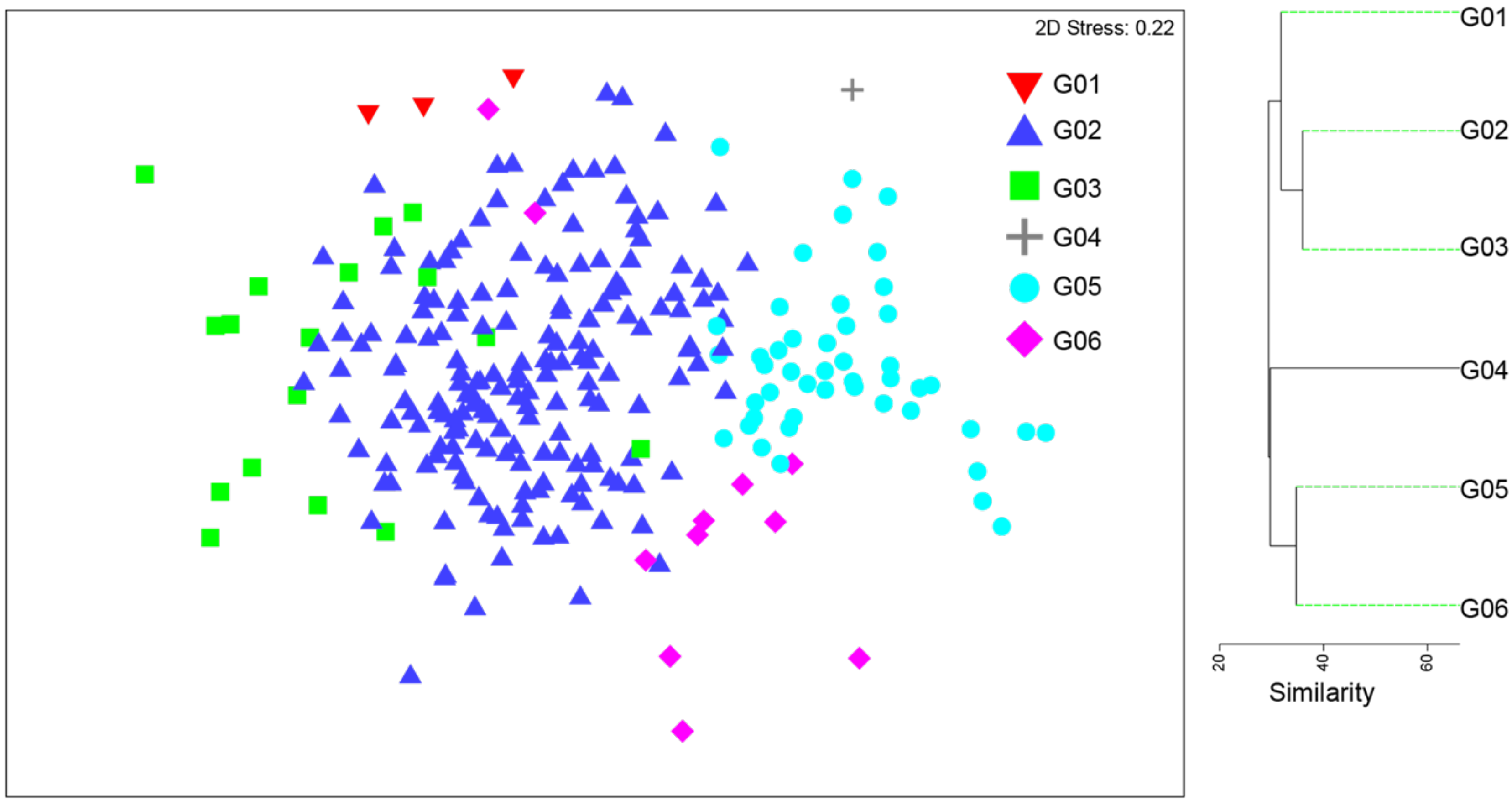

Figure F55a. Results of ordination and cluster analysis of trawls from offshore fish cluster group E presented as a nMDS ordination and dendrogram of main subgroups.

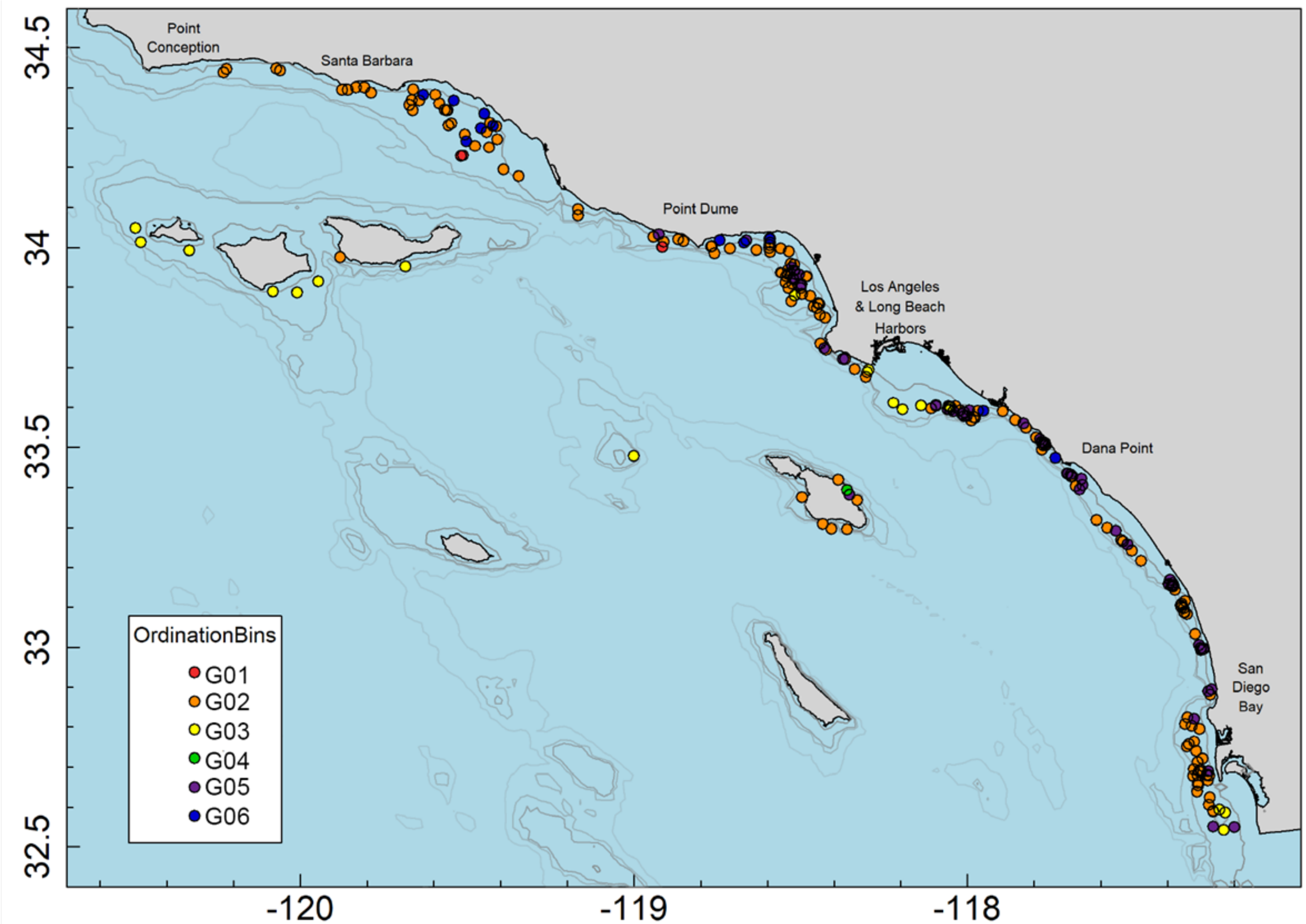

Figure F56b. Results of ordination and cluster analysis of trawls from offshore fish cluster group G. Data are presented as map of subgroups overlaid on station locations.

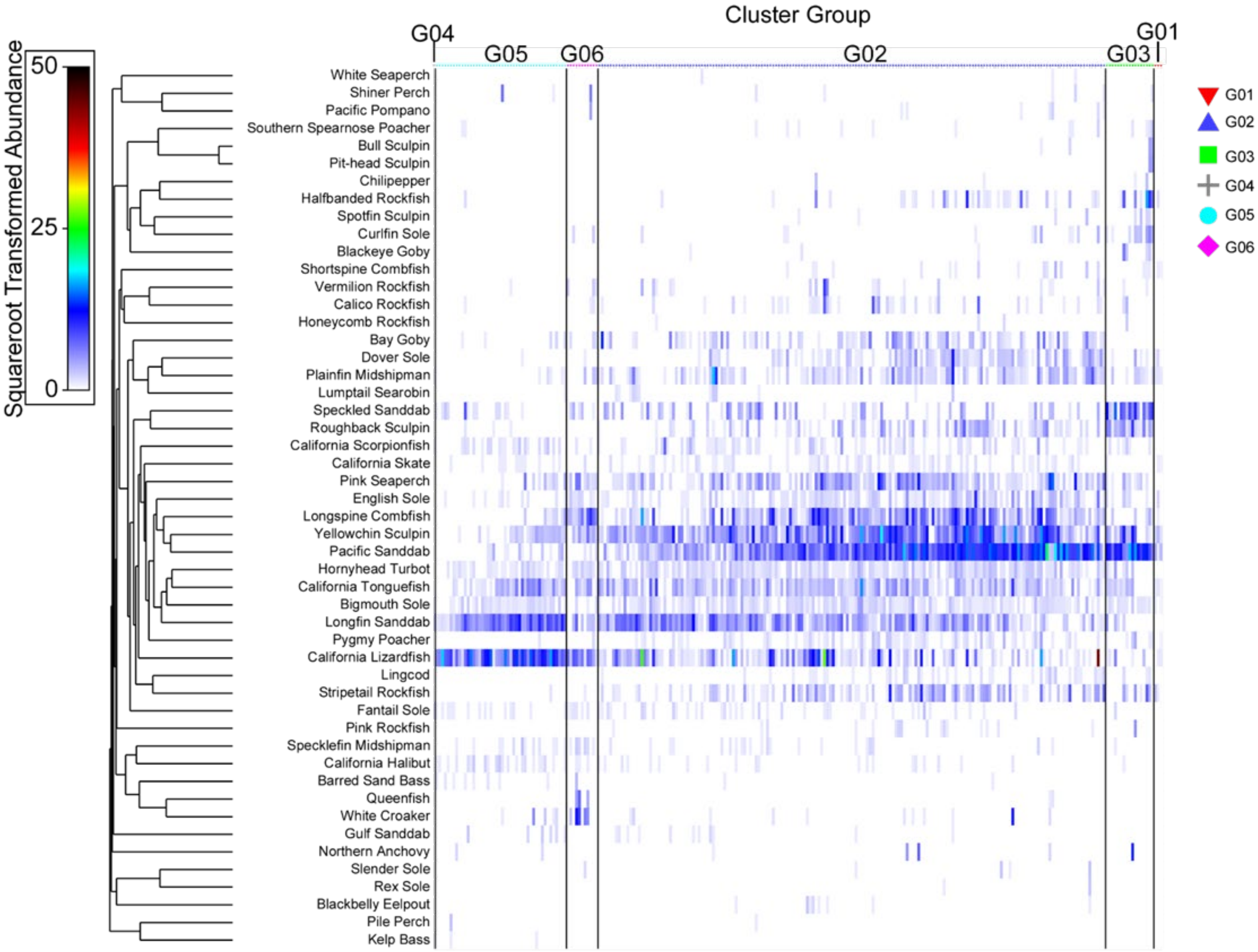

Figure F57c. Results of ordination and cluster analysis of trawls from offshore fish cluster group G. Data are presented as a shade plot of top 50 species by subgroup.

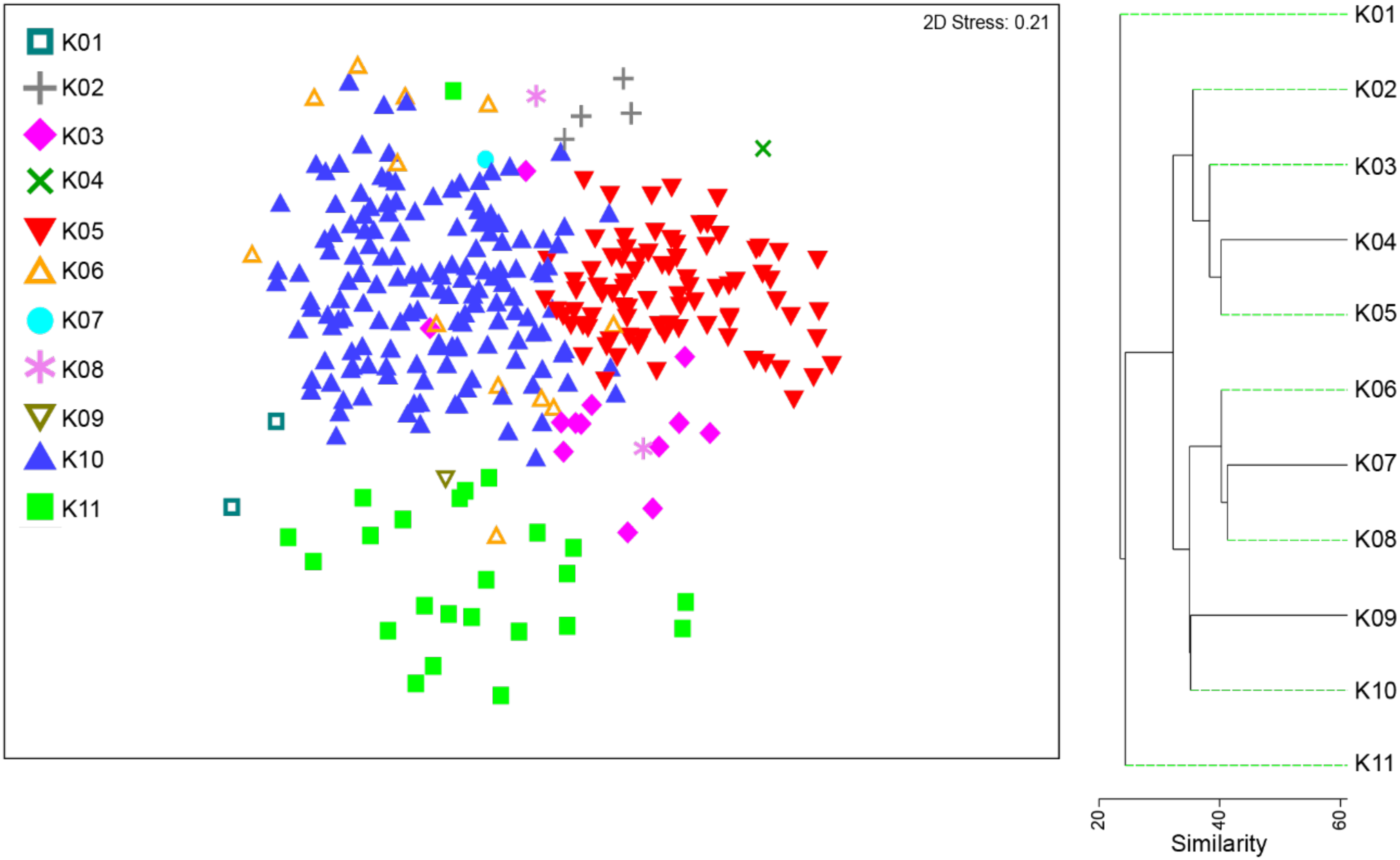

Figure F58a. Results of ordination and cluster analysis of trawls from offshore fish cluster group K. Data are presented as a nMDS ordination and dendrogram of main subgroups.

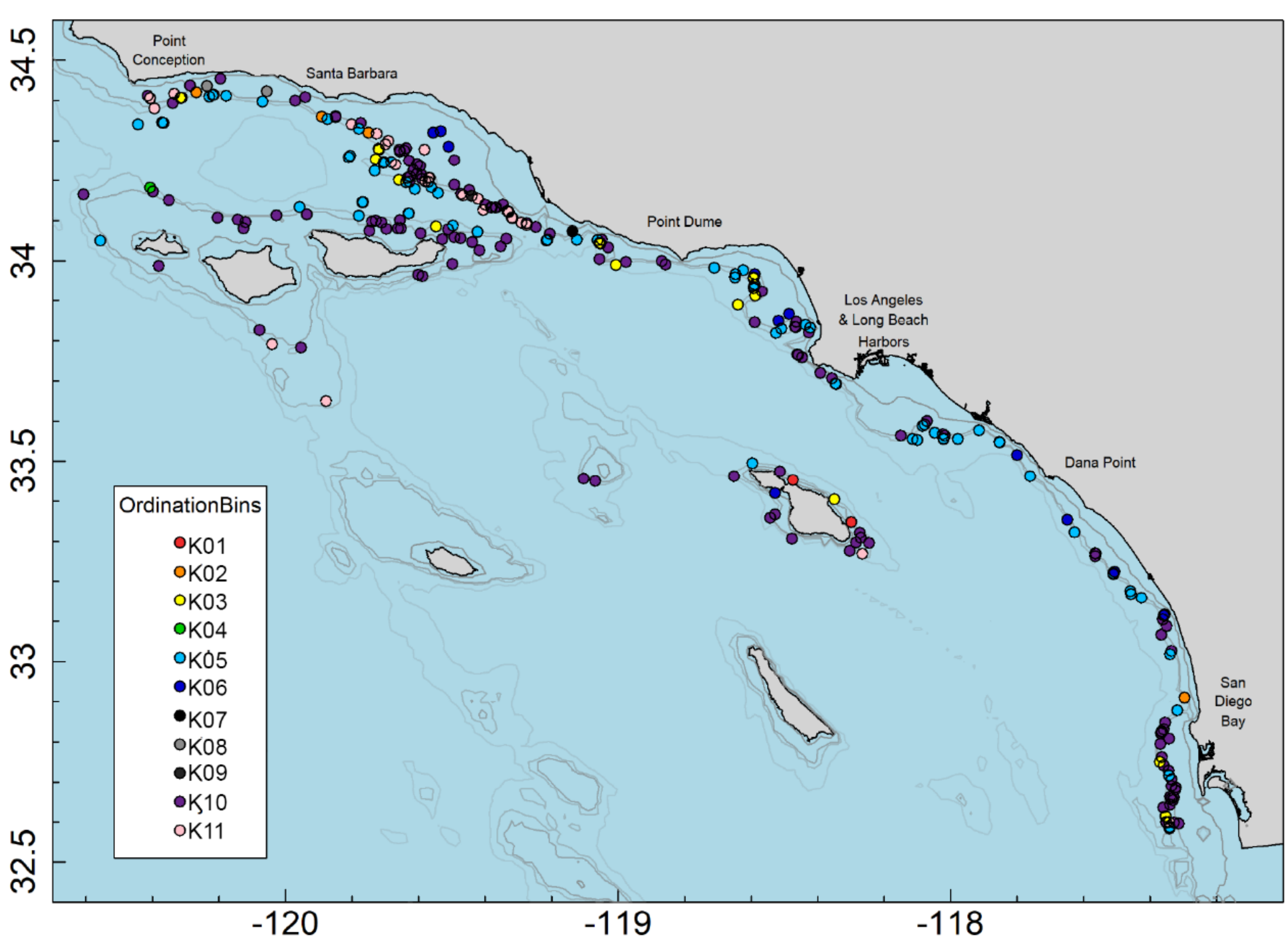

Figure F59b. Results of ordination and cluster analysis of trawls from offshore fish cluster group K. Data are presented as a map of subgroups overlaid on station locations.

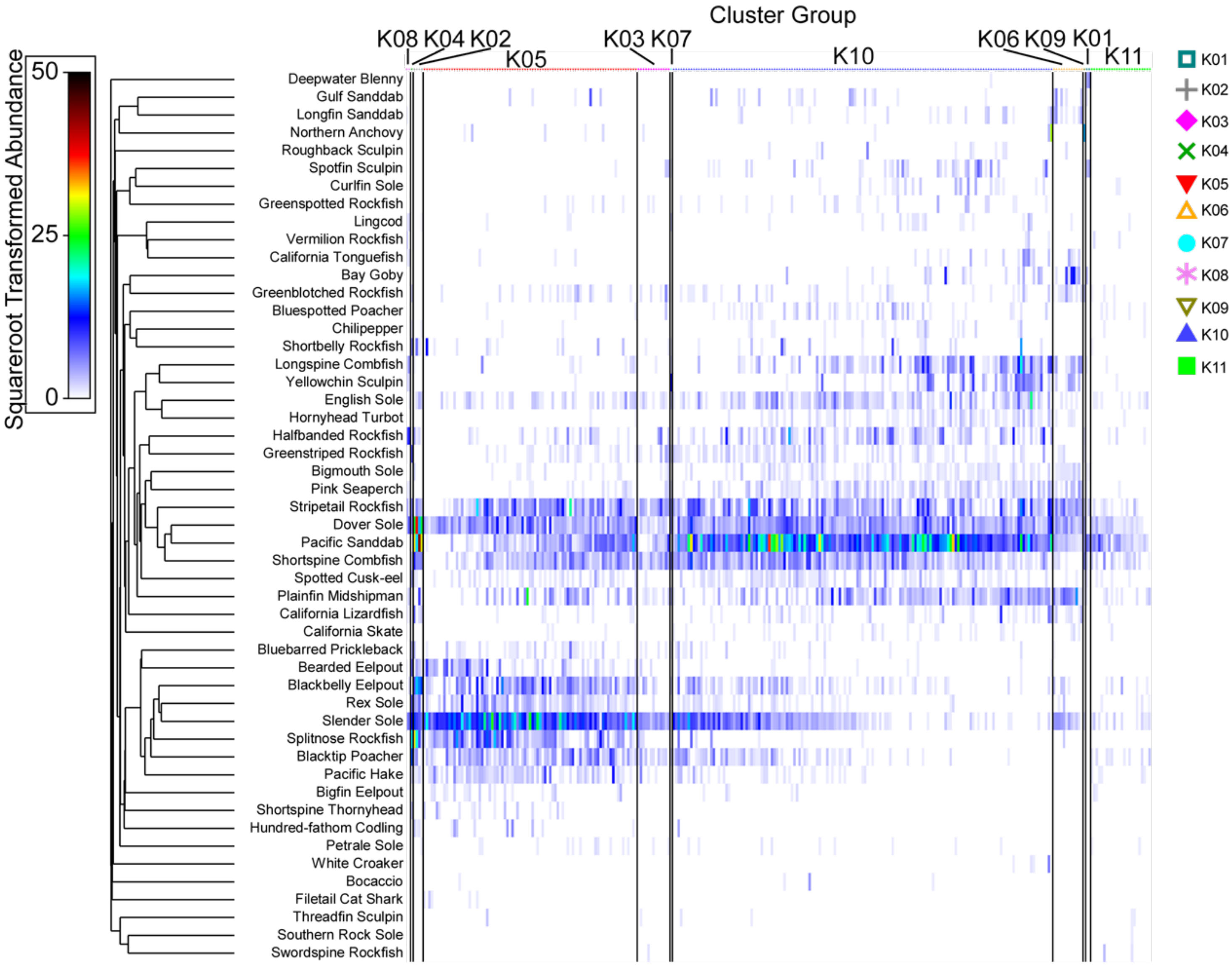

Figure F60c Results of ordination and cluster analysis of trawls from offshore fish cluster group K. Data are presented as a shade plot of top 50 species by subgroup.

Table F69. Description of offshore fish cluster E, G, and K subgroups as defined in Figure 53, Figure 54.

Sub-Groups	Number of Trawls	Average Similarity (%)	Mean Species Richness	Mean Abundance	Depth (m)			FRI Scores			%Trawls by Survey					
					Min	Max	Mean	N/A	n>45	%NR	1994	1998	2003	2008	2013	2018
Group E																
E01	4	43	6	22	19	24	21	0	0	0	50	25	0	25	0	0
E02	6	48	8	55	28	69	45	0	1	17	0	33	33	17	0	17
E03	25	52	6	80	10	31	18	0	8	32	8	4	36	40	4	8
E04	51	55	9	249	8	34	21	0	6	12	2	6	14	12	41	25
E05	5	54	19	878	17	48	34	0	0	0	0	0	20	20	60	0
E06	20	52	12	461	17	56	27	0	4	20	0	5	45	20	25	5
E07	3	69	6	33	15	18	16	0	0	0	67	33	0	0	0	0
E08	13	53	10	53	7	34	20	0	0	0	38	31	0	15	0	15
E09	29	54	9	54	19	65	33	0	0	0	34	41	10	10	0	3
E10	35	49	6	26	9	33	19	0	2	6	20	57	3	9	6	6
E11	15	35	13	112	16	63	28	0	5	33	27	0	33	13	27	0
Group G																
G01	3	52	10	34	50	88	74	0	0	0	0	0	33	33	0	33
G02	178	47	14	289	23	98	57	0	1	1	18	20	26	10	16	10
G03	17	46	13	325	27	95	57	0	0	0	12	24	41	0	0	24
G04	1	*	9	39	46	46	46	0	0	0	0	100	0	0	0	0
G05	46	53	9	166	20	63	44	0	0	0	0	98	0	0	0	2
G06	11	44	12	169	20	77	37	0	0	0	18	36	0	0	45	0
Group K																
K01	2	54	14	104	86	87	87	0	0	0	0	100	0	0	0	0
K02	4	66	19	2592	158	185	169	0	1	25	0	0	0	0	100	0
K03	13	48	11	110	152	222	182	3	0	0	8	31	15	31	0	15
K04	1	*	24	1071	257	257	257	1	—	—	0	0	0	0	100	0
K05	85	52	14	392	127	368	209	37	4	8	14	14	22	16	16	16
K06	12	50	15	191	54	185	110	0	0	0	58	42	0	0	0	0
K07	1	*	21	323	106	106	106	0	0	0	0	0	0	100	0	0
K08	2	71	15	281	71	75	73	0	0	0	0	0	0	0	0	100
K09	1	*	12	371	150	150	150	0	0	0	100	0	0	0	0	0
K10	151	47	15	404	50	230	129	4	0	0	10	25	25	13	17	11
K11	24	36	7	33	71	227	162	1	0	0	21	25	21	4	8	21

* Similarity only calculated for groups with >1 trawl

Multivariate Analyses of Megabenthic Invertebrate Assemblages

Megabenthic Invertebrates in Bays & Harbors

Multivariate analysis of epibenthic invertebrate abundance data assessed community patterns across bays and harbors in the SCB. Abundance data was visualized using an nMDS ordination plot and ANOSIM tests were run to look for significant differences between years and embayments. This analysis revealed the following observations:

- All years were significantly different from one another except for 2013 and 2018, which were not significantly different from one another.
- POLA/POLB was significantly different from all SDB ecoregions and Mission Bay.
- SDB ecoregions were significantly different from one another and from Mission Bay except for SDB - South and SDB – Central as well as SDB – South and Mission Bay, which were not significantly different from one another.

Similarity profile analysis (SIMPROF) was used to confirm the non-random structure of the resultant cluster dendrogram (Clarke et al. 2008), with major ecologically-relevant clusters receiving SIMPROF support retained as cluster groups. These analyses resulted in a total of nine SIMPROF-supported cluster groups, or types of trawl invertebrate assemblages (cluster groups A-I; Table F70, Figure 28), which were overlaid on station maps to examine spatial distribution. These assemblages represented from 4 to 76 trawls each and ranged from 20 to 23% similarity (mean = 22%) for clusters with n>1. A BEST/BVSTEP test (ρ = 0.954, p = 0.0001, number of permutations = 9999) implicated *Acanthoptilum* sp (Sea Pen), *Arcularia tiarula* (Western Mud Nassa), *Astropecten armatus* (Spiny Sand Star), *Bulla gouldiana* (California Bubble Snail), *Ciona intestinalisrobusta* (Sea Squirt), *Crangon nigromaculata* (Spotted Bay Shrimp), *Farfantepenaeus californiensis* (Yellowleg Shrimp), *Musculista senhousia* (Asian Date Mussel), *Navanax inermis* (California Aglaja), *Philine auriformis* (New Zealand Bubble Snail), *Pyromaia tuberculata* (Tuberculata Pear Crab) as being influential to the pattern (gradient) observed in Figure 26. Results of similarity percentages (SIMPER) analysis for each SIMPROF group is shown in Table F70. An nMDS ordination was overlaid on station maps and a shade plot of the 35 species that best resolve groups was created to assist in interpretation of spatial patterns. Group D included the most stations and primarily consisted of POLA/POLB stations, although three stations near the mouth of SDB – North also fell into this group. This group was distinct in its species composition from others by the dominance of target rock shrimp, blackspot shrimp and tuberculate pear crabs. Group H was the other large group that had clear spatial definition as it was located primarily within SDB – Central, SDB – South and inner Mission Bay and may help explain why these ecoregions did not statistically differ from one another. Group F was also composed of SDB – Central and SDB – South stations. Group H was mostly dominated by Asian date mussel, while group F was primarily ascidians such as *S. plicata*, *M. verrucifera*, and *M. squamiger*. Groups C and G were composed of SDB – North, SDB – Central and Mission Bay stations and were characterized by species such as sea pens (*Acanthoptilum* sp*), B. gouldiana*, and *N. inermis*.

The composition of the epibenthic community has shifted over the course of the last two Bight surveys, which can be seen by the E.I. values of the top ten invertebrate species. The 1998-2008 surveys were dominated primarily by sponges, the tuberculate pear crab and the blackspot shrimp, and before shifting dramatically in 2013 and 2018 to the community predominantly being made up of the target rock shrimp. No one species made up a majority of the abundance and biomass from 1998-2008, but in 2013 target rock shrimp made up 47% of the total abundance and 46% of total biomass. In 2018 they accounted for 29% of abundance and 39% of biomass, although this was somewhat skewed by a very large catch of sand dollars in Mission Bay at one station that accounted for 42% of the total abundance and 31% of total biomass. It should also be noted that only a few target rock shrimp have been captured within San Diego Bay, the majority of the target rock shrimp population appears to be centered around POLA/POLB. This shift appears to be in part a result of the target rock shrimp shifting its distribution northward due to warm water events that occur regularly in Southern California, although recent strong El Niños in 1997-1998 and the warm water event in 2013-2015 may have facilitated the persistence of a northern population (Estrada-Ramirez and Calderon-Aguilera 2001; Montagne and Cadien 2001). While these regional events may be landmarks of largescale shifts, there are also more persistent forces that facilitate the establishment of southern species such as the relaxation of the southward California Current, the intensification of the northward California Countercurrent, and the formation and persistence of offshore eddies in the Southern California Bight (Lluch-Belda et al. 2005). While changes in the fish community are less apparent in this study, invertebrate communities with shorter life cycles and larvae with more passive distribution may be subject to these larger oceanographic changes. These climatic forces may explain the changes in species richness and composition for epibenthic invertebrates, which over time may include more subtropical species that are expanding their northern ranges. Continued monitoring of the invertebrate community within the SCB will be critical to assess the impact these new species, some of which become dominant members of the community, may have on other biological communities.

Table F70. Composition of bays and harbors megabenthic invertebrate cluster groups A–I. For groups with more than one trawl, highlighted values indicate the most characteristic species according to SIMPER analysis and the cumulative percent contribution (C%C) is included at the bottom. For groups with one trawl, highlighted values are top five most abundant species, and N/A (not applicable) is included for C%C.

	Cluster Group								
	A	B	C	D	E	F	G	H	I
Number of Trawls	1	2	10	75	3	4	13	29	1
Species	**Mean Abundance**								
Kelletia kelletii	2	0	0	<1	0	0	0	0	0
Pisaster brevispinus	2	0	0	<1	0	0	0	0	0
Pteropurpura festiva	0	7	<1	<1	0	0	0	<1	0
Acanthoptilum sp	0	0	54	<1	0	0	0	<1	0
Crangon nigromaculata	0	0	0	34	0	0	0	0	0
Pyromaia tuberculata	0	0	29	26	0	0	2	<1	0
Sicyonia penicillata	0	0	<1	14	0	0	0	0	0
Farfantepenaeus californiensis	0	0	0	3	1	0	<1	<1	0
Ostrea lurida	0	0	<1	0	2	0	0	0	0
Suberites latus	0	0	<1	0	4	0	<1	0	0
Ciona robusta	0	0	<1	3	0	88	<1	<1	0
Molgula verrucifera	0	0	0	0	0	106	0	0	0
Bulla gouldiana	0	0	<1	<1	0	0	4	5	0
Navanax inermis	0	0	<1	<1	0	7	2	1	0
Silicea sp WS 1	0	0	0	0	0	0	1	0	0
Musculista senhousia	0	0	<1	<1	0	50	0	47	0
Dendraster excentricus	0	0	62	0	0	0	<1	0	6
Renilla koellikeri	0	0	0	0	0	0	0	0	2
Stylatula elongata	0	0	0	<1	0	0	0	0	2
C%C	N/A	100	85	71	100	74	85	76	N/A

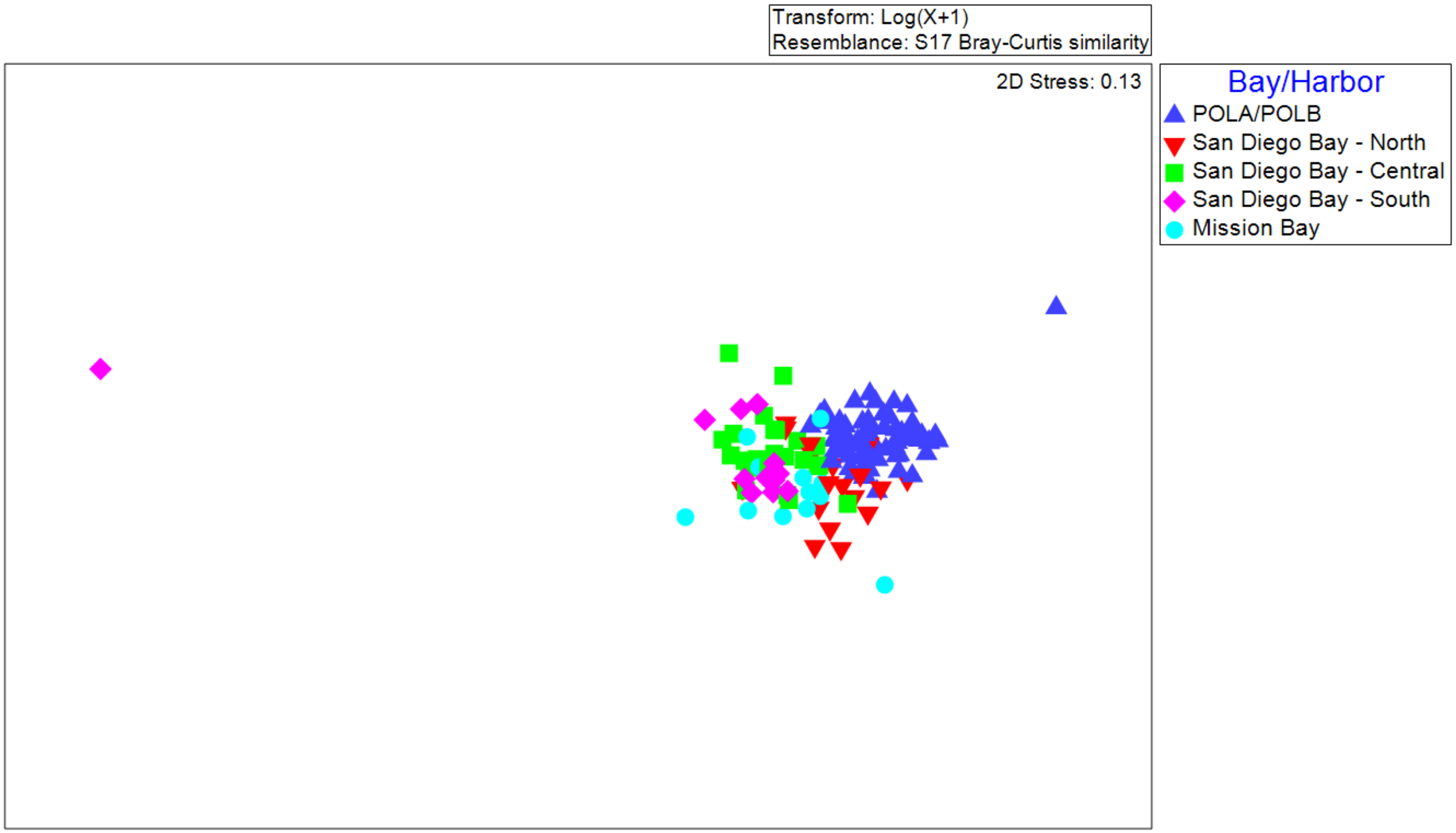

Figure F61. nMDS plot of invertebrate abundance by Bay/Harbor.

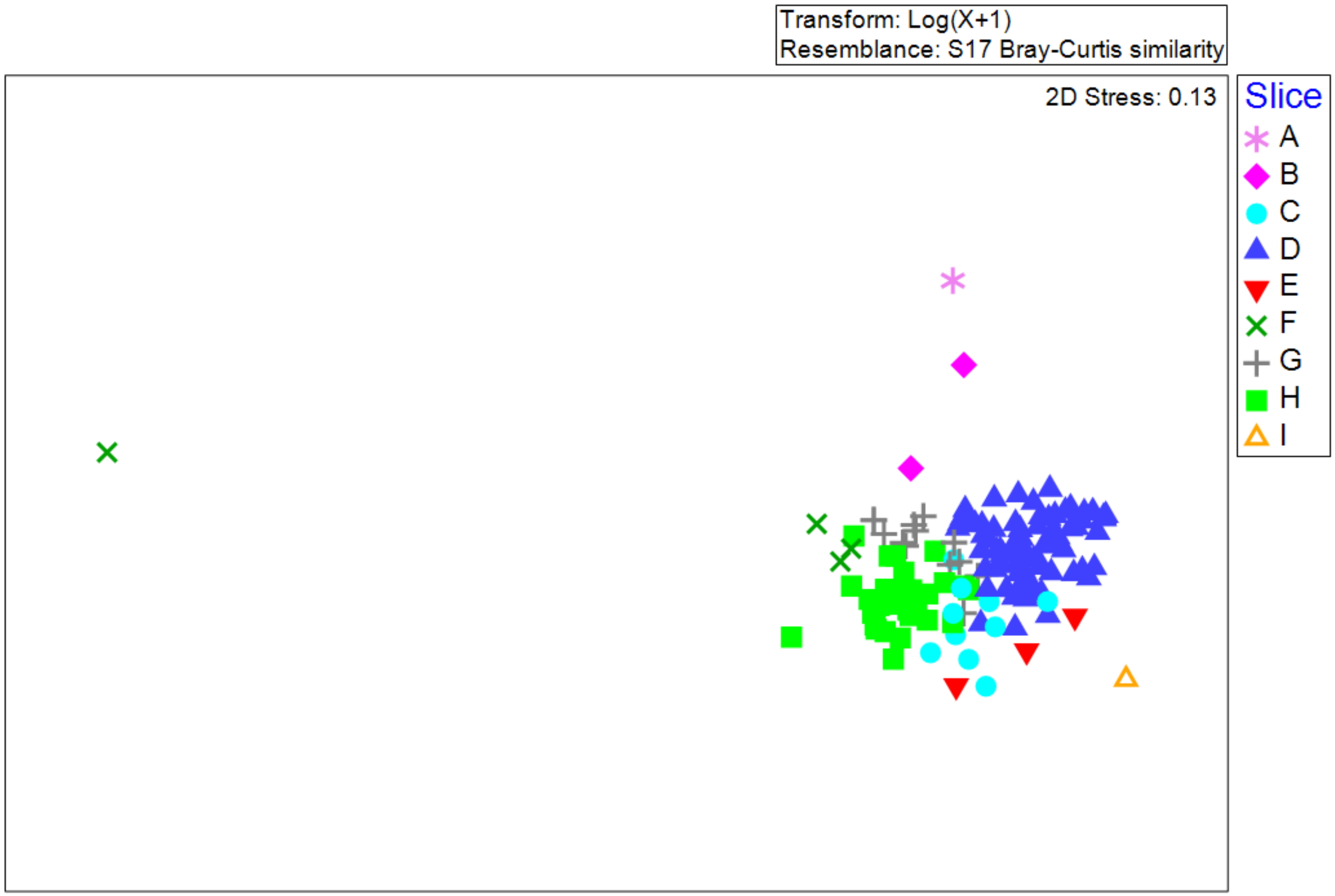

Figure F62a. nMDS plot of invertebrate abundance by Similarity Profile (SIMPROF) analysis.

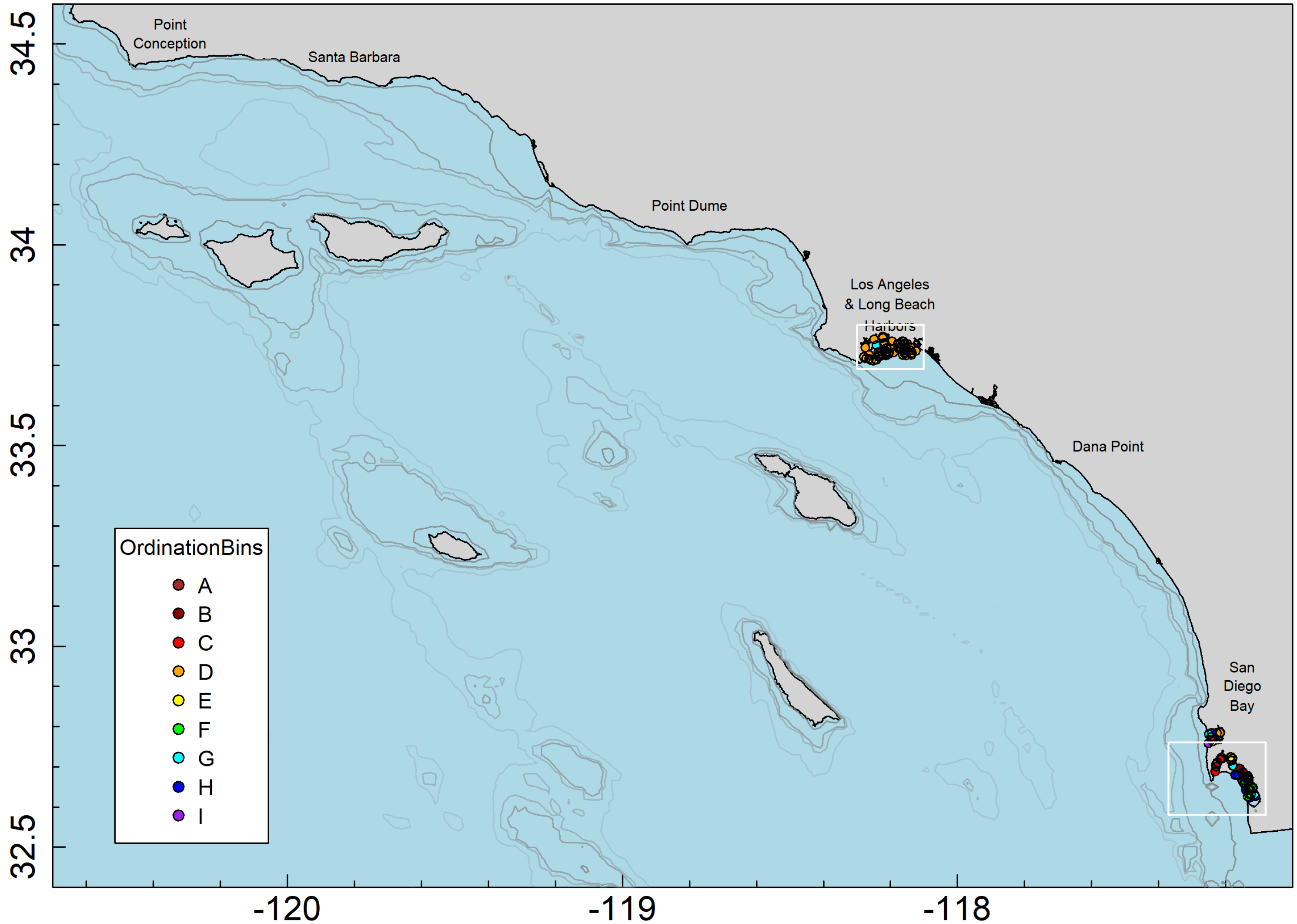

Figure F63b. Demersal invertebrate SIMPROF groups in Bays and Harbors – SC.

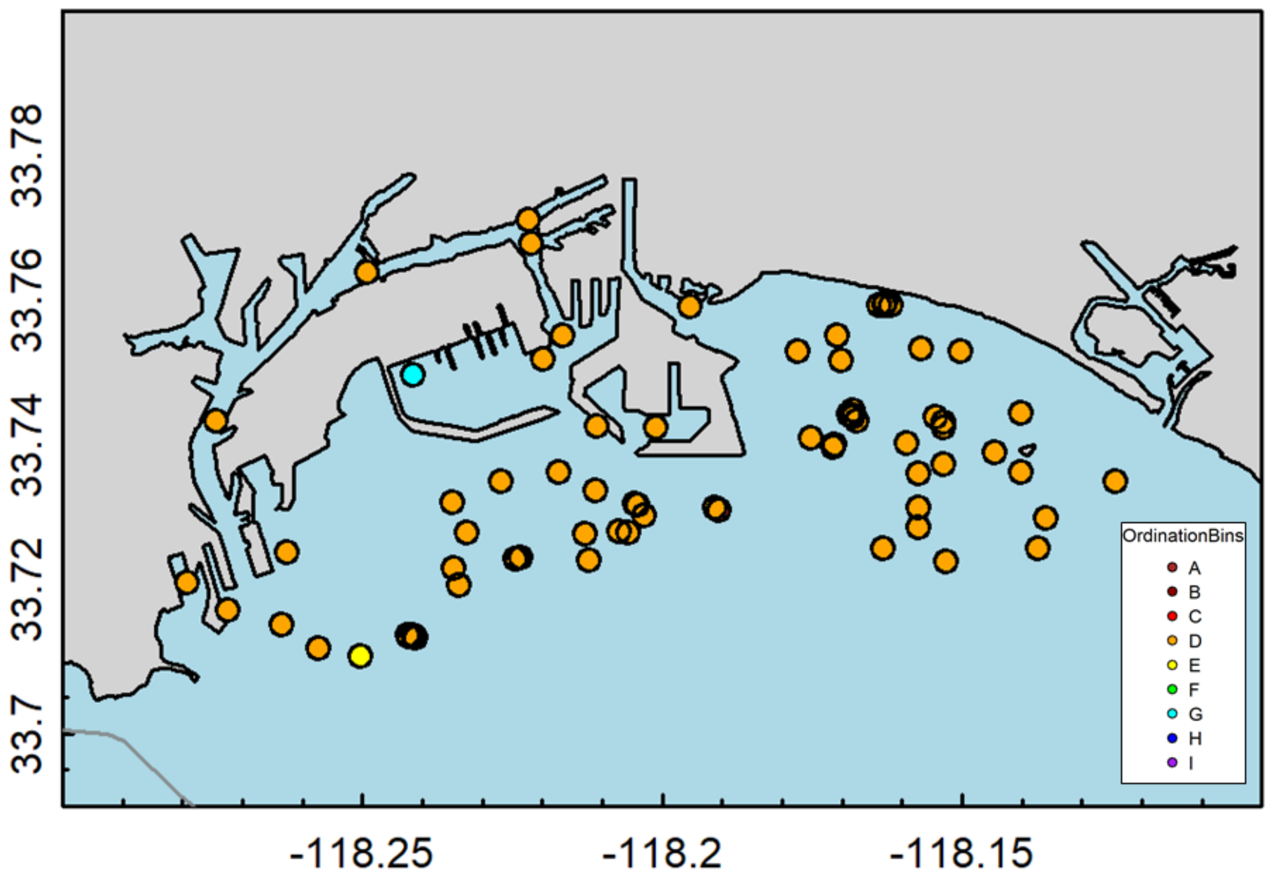

Figure F64c. Demersal invertebrate SIMPROF groups in Bays and Harbors – Ports of Los Angeles/Long Beach.

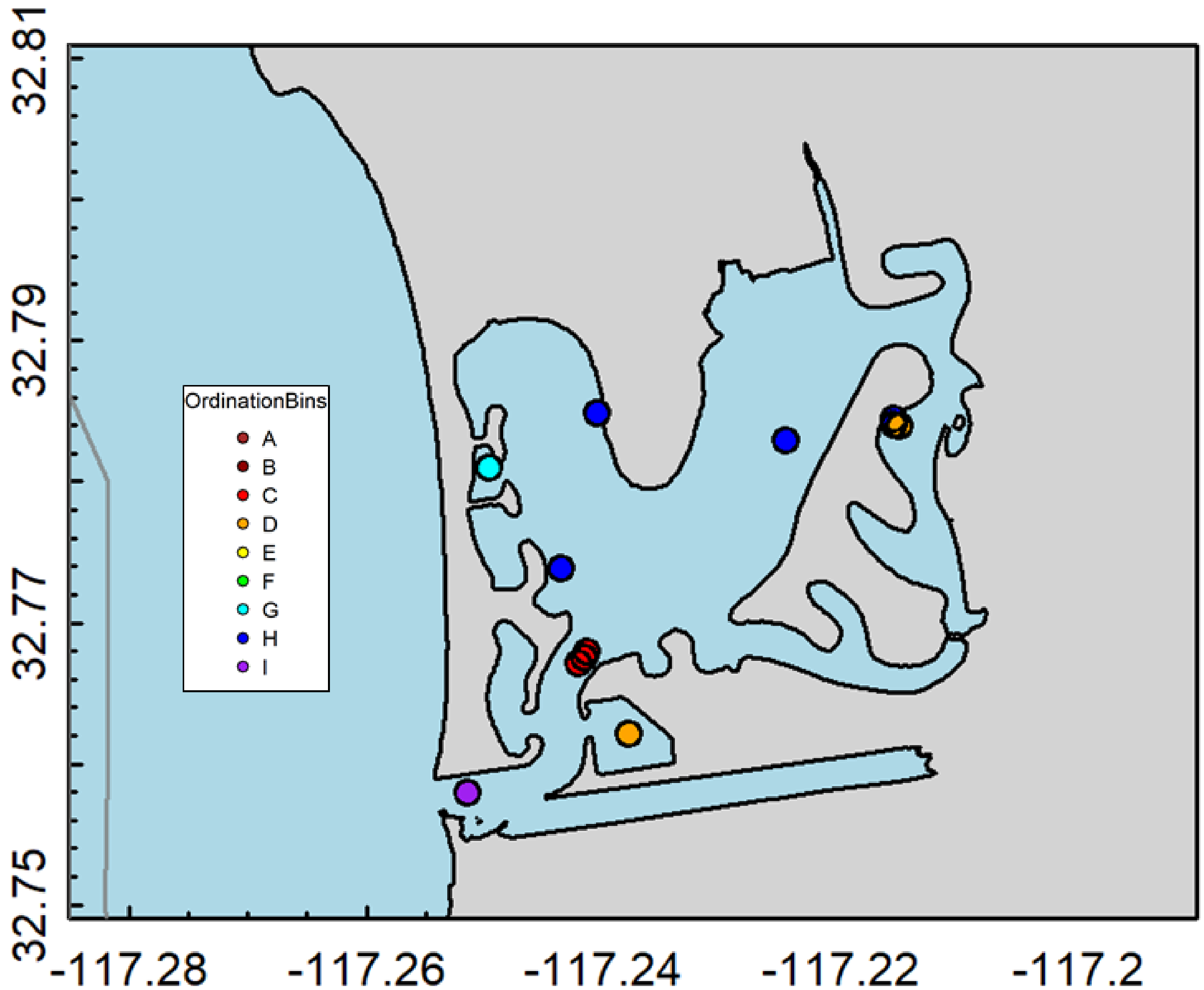

Figure F65d. Demersal invertebrate SIMPROF groups in Bays and Harbors – Mission Bay.

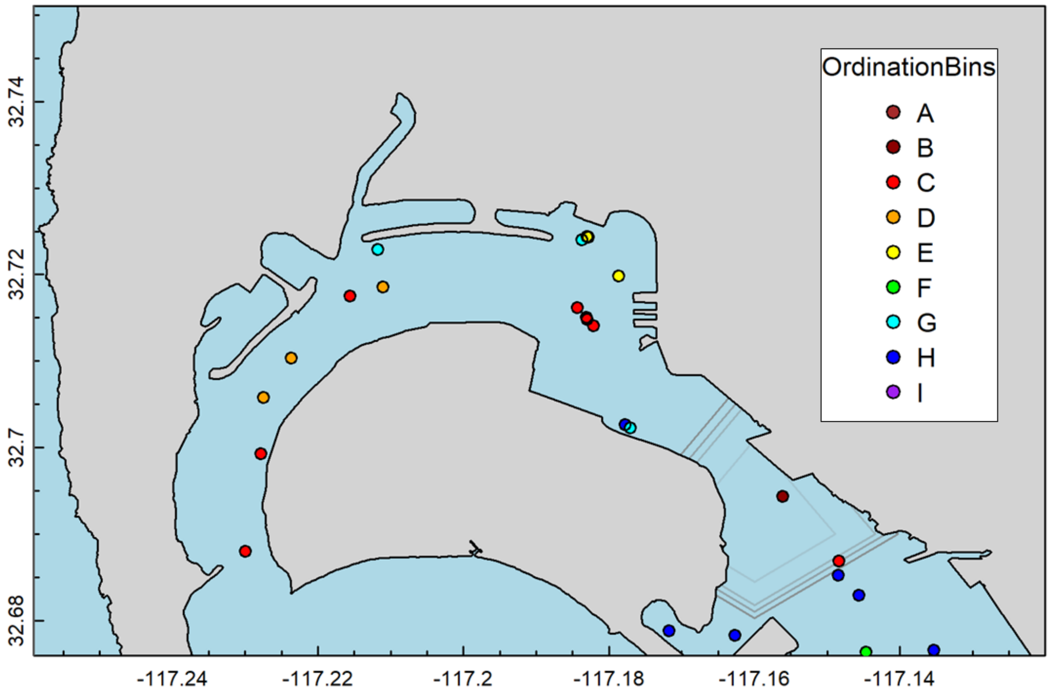

Figure F66e. Demersal invertebrate SIMPROF groups in Bays and Harbors – North San Diego Bay (SDB).

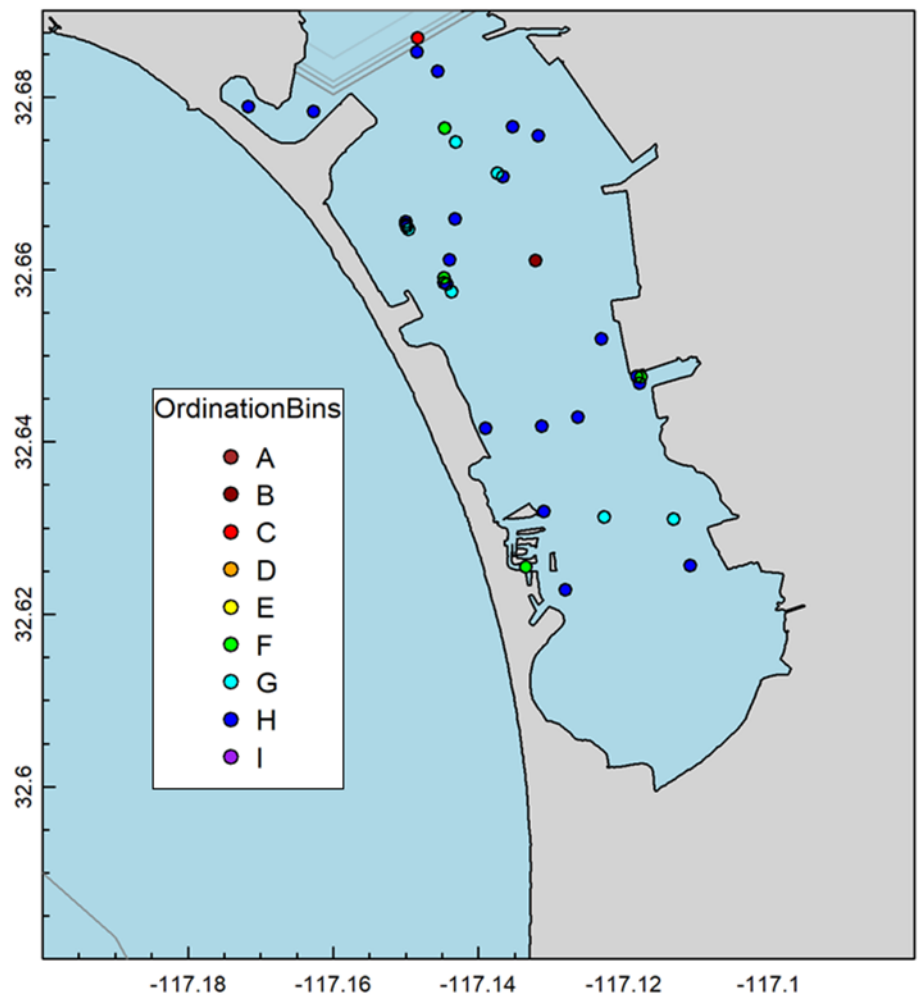

Figure F67f. Demersal invertebrate SIMPROF groups in Bays and Harbors – South San Diego Bay (SDB).

Megabenthic Invertebrates on the Coastal Shelf and Slope

Multivariate analyses of megabenthic invertebrate communities on the SCB shelf and slope included a total of 898 trawls conducted during Bight Surveys (Bight '94 – Bight '18). These analyses resulted in 13 main ecologically-relevant SIMPROF-supported groups, or types of megabenthic invertebrate assemblages (see Figures 29, 30 and Table 12 in main report). These assemblages represented from 1 to 505 trawls each and ranged from 9 to 70% similarity (mean = 29%) for clusters comprising more than one trawl.

Ten of the invertebrate cluster groups (groups A, B, C, D, F, G, H, I, J, L) were small "outlier" clusters of 1 to 5 trawls. With the exception of cluster group F, these trawls had low species richness (1 – 8 species per haul), whereas mean abundance per trawl was highly variable (1 – 735 organisms per haul). Groups A (n = 4 trawls), B (n = 4 trawls), C (n = 1 trawl), and D (n = 1 trawl) included sites located on the inner shelf and shallow middle shelf at depths ≤ 42 m off various beaches and lagoons in San Diego, Ventura, and Santa Barbara Counties. Assemblages represented by group A were characterized by the highest numbers of the Sand Dollar *Dendraster excentricus* (mean abundance = 571 per haul) and the crab *Portunus xantusii* (mean abundance = 2 per haul), while group B assemblages were characterized by the highest numbers of the Kelp Crab *Pugettia producta* (mean abundance = 8 per haul) and the Spanish Shawl Nudibranch *Flabellina iodinea* (mean abundance = 3 per haul) (Table F71). The trawl represented by group C included just one specimen of the sea pen *Stylatula elongata*. The trawl represented by group D included just one specimen of the Spider Crab *Loxorhynchus grandis*. Groups F (n = 1), G (n = 3), H (n = 4), I (n = 2), and J (n = 5) included sites located on the inner, middle, and outer shelf at depths of 20-200 m, primarily off Camp Pendleton, the northern Channel Islands, or elsewhere in the Santa Barbara Basin. The trawl represented by group F comprised 466 specimens of the Brachiopod *Laqueus californianus*, 97 of the sea star *Astropecten ornatissimus*, 94 of the Brachiopod *Terebratalia transversa*, 23 of the Feather Star *Florometra serratissima*, and 12 of the Squat Lobster *Janetogalathea californiensis*, as well as small numbers of nine other species. Group G assemblages were characterized by the second highest number of the Grey Brittle Star *Ophiura luetkenii* (mean abundance = 17 per haul), while group H assemblages were characterized by an average of one specimen of the Yellow Sea Twig *Thesea* sp B per haul, group I assemblages were characterized by an average of three specimens of the Sea Slug *Pleurobranchaea californica* per haul and group J assemblages were characterized by the highest number of the Brittle Star *Ophiopholis bakeri* (mean abundance = 77 per haul). Group L comprised trawls from two stations located on the upper slope at depths of 461 – 477 m within the Santa Barbara Basin. These assemblages were characterized by the highest number of the Sea Snail *Astyris permodesta* (mean abundance = 109 per haul).

The remaining clusters (groups E, K, M) each spanned the entire SCB, representing the transition of common invertebrate assemblages from the inner shelf to the upper slope. Group E comprised 117 trawls from inner and shallow middle shelf sites located at depths ≤ 36 m (mean depth = 17 m). The assemblages represented by this group were characterized by the highest number of the Blackspotted Bay Shrimp *Crangon nigromaculata* (mean abundance = 14 per haul), as well as the Sea Stars *Astropecten californicus* (mean abundance = 2 per haul) and *Astropecten armatus* (mean abundance = 1 per haul). Group K comprised 505 trawls from all offshore strata at depths of 9 – 227 m (mean depth = 61 m). These assemblages were characterized by the highest number of the White Sea Urchin *Lytechinus pictus* (mean abundance = 338 per haul), the Ridgeback

Prawn *Sicyonia ingentis* (mean abundance = 63 per haul), the Sea Star *Astropecten californicus* (mean abundance = 15 per haul) and the California Sea Cucumber *Apostichopus californicus* (mean abundance = 5 per haul). Group M comprised 249 trawls from middle shelf, outer shelf and upper slope sites at depths of 33 – 479 m (mean depth = 252 m). Assemblages represented by group M were characterized by the highest numbers of the Fragile Sea Urchin *Strongylocentrotus fragilis* (mean abundance = 317 per haul), the Pacific Heart Urchin *Brissopsis pacifica* (mean abundance = 264 per haul), the Sea Urchin *Brisaster latifrons* (mean abundance = 163 per haul), the Ridgeback Prawn *Sicyonia ingentis* (mean abundance = 53 per haul), the Shrimp *Neocrangon zacae* (mean abundance = 17 per haul), the Sea Slug *Pleurobranchaea californica* (mean abundance = 3 per haul) and the north Pacific Bigeye *Octopus californicus* (mean abundance = 2 per haul).

Additional analyses of the two largest offshore megabenthic invertebrate clusters (groups K, M) revealed subgroups that also spanned much of the SCB and revealed no discernible patterns in invertebrate assemblages that could be associated with proximity to known pollution sources (Figure F57, Figure F58). As with the 13 main cluster groups A-M, assemblages represented by subgroups K01-K12 nd M01-M13 varied in terms of habitat differences and/or the unique composition of invertebrate assemblages. Cluster group K subgroups represented from 1 to 320 trawls and ranged from 19 to 47% similarity (mean = 31%) for clusters comprising more than one trawl (Table F-9). A BEST/BVSTEP test ($\rho = 0.95$, $p \leq 0.001$, number of permutations = 999) implicated the Sea Pen *Acanthoptilum* sp, the Sea Star *Astropecten californicus*, the Sand Star *Luidia foliolata*, the White Sea Urchin *Lytechinus pictus*, the Vermilion Star *Mediaster aequalis*, the Pacific Red Octopus *Octopus rubescens*, the Spiny Brittle Star *Ophiothrix spiculata*, the Grey Brittle Star *Ophiura luetkenii*, the Bubble Snail *Philine auriformis*, the Sea Slug *Pleurobranchaea californica*, the California Sea Cucumber *Parastichopus californicus*, the Ridgeback Prawn *Sicyonia ingentis*, and the Sea Twig *Thesea* sp B as being influential to the overall pattern (gradient) of the cluster dendrogram (Figure F57c). Cluster group M subgroups represented from 1 to 89 trawls and ranged from 22 to 48% similarity (mean = 39%) for clusters with more than one trawl (Table F-9). A BEST/BVSTEP test ($\rho = 0.952$, $p \leq 0.001$, number of permutations = 999) implicated the Sea Pen *Acanthoptilum* sp, the Sea Urchins *Brisaster latifrons* and *Brisaster townsendi*, the Pacific Heart Urchin *Brissopsis pacifica*, the Basket Star *Gorgonocephalus eucnemis*, the Sand Star *Luidia foliolata*, the Sea Star *Myxoderma platyacanthum*, the Shrimp *Neocrangon resima* and *Neocrangon zacae,* the North Pacific Bigeye Octopus *Octopus californicus*, the Sea Slug *Pleurobranchaea californica*, the Ridgeback Prawn *Sicyonia ingentis*, the Heart Urchin *Spatangus californicus*, the Slender Blade Shrimp *Spirontocaris holmesi*, the Offshore Blade Shrimp *Spirontocaris sica*, and the Fragile Sea Urchin *Strongylocentrotus fragilis* as being influential to the overall pattern (gradient) of the cluster dendrogram (Figure F58c).

Table F71. Composition of offshore megabenthic invertebrate cluster groups A–M. For groups with more than one trawl, highlighted values indicate the most characteristic species according to SIMPER analysis and the cumulative percent contribution (C%C) is included at the bottom. For groups with one trawl, highlighted values are top five most abundant species, and N/A (not applicable) is included for C%C.

	Cluster Group												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Number of Trawls:	4	4	1	1	117	1	3	4	2	5	505	2	249
Species	**Mean Abundance**												
Dendraster excentricus	571	0	0	0	0	0	0	0	0	0	0	0	0
Portunus xantusii	2	0	0	0	1	0	0	0	0	0	0	0	0
Pugettia producta	0	8	0	0	<1	0	0	0	0	0	0	0	0
Flabellina iodinea	0	3	0	0	<1	0	0	0	0	0	<1	0	0
Stylatula elongata	0	0	1	0	<1	0	<1	0	0	0	1	0	0
Loxorhynchus grandis	0	0	0	1	<1	0	0	0	0	0	<1	0	0
Crangon nigromaculata	<1	0	0	0	14	0	5	0	0	0	<1	0	0
Astropecten californicus	0	2	0	0	2	0	0	<1	0	0	15	0	<1
Astropecten armatus	0	0	0	0	1	0	0	0	0	0	0	0	0
Laqueus californianus	0	0	0	0	0	466	0	0	0	0	25	0	3
Astropecten ornatissimus	0	0	0	0	0	97	0	0	0	<1	<1	0	5
Terebratalia transversa	0	0	0	0	0	94	0	0	0	0	0	0	0
Florometra serratissima	0	0	0	0	0	23	0	0	0	0	1	0	<1
Janetogalathea californiensis	0	0	0	0	0	12	0	0	0	1	0	0	0
Ophiura luetkenii	0	0	0	0	0	0	17	0	0	0	74	0	3
Thesea sp B	0	0	0	0	0	0	0	1	0	0	4	0	4
Pleurobranchaea californica	0	0	0	0	0	0	0	0	3	0	1	0	3
Ophiopholis bakeri	0	0	0	0	0	0	0	0	0	77	<1	0	1
Mediaster aequalis	0	0	0	0	0	0	11	0	0	3	1	0	1
Pandalus platyceros	0	0	0	0	0	0	0	0	0	<1	<1	0	7
Lytechinus pictus	0	0	0	0	<1	11	0	0	0	0	338	0	6
Sicyonia ingentis	0	0	0	0	0	0	1	0	0	0	63	0	53
Apostichopus californicus	0	0	0	0	0	0	0	0	<1	0	5	0	1
Astyris permodesta	0	0	0	0	0	0	0	0	0	0	0	109	19
Strongylocentrotus fragilis	0	0	0	0	0	0	1	0	0	0	3	0	317
Brissopsis pacifica	0	0	0	0	0	4	0	0	0	0	0	0	264
Brisaster latifrons	0	0	0	0	0	0	0	0	0	0	0	0	163
Neocrangon zacae	0	0	0	0	0	0	0	0	0	<1	<1	0	17
Octopus californicus	0	0	0	0	0	0	0	0	0	0	0	0	2
C%C	100	76	N/A	N/A	73	N/A	100	74	100	77	70	100	72

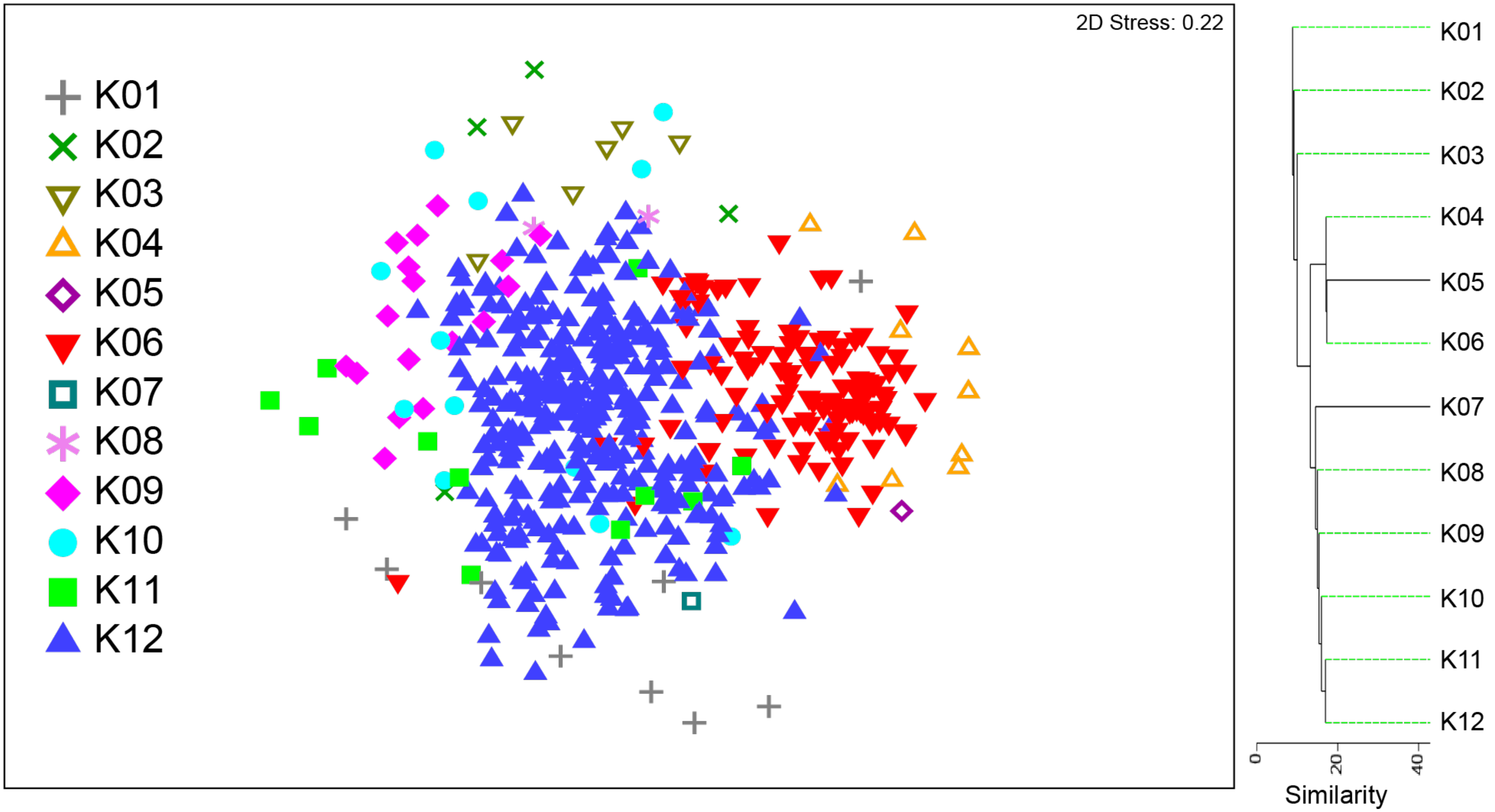

Figure F68a. Results of ordination and cluster analysis of trawls from offshore megabenthic invertebrate cluster group K presented as a nMDS ordination and a dendrogram of main subgroups.

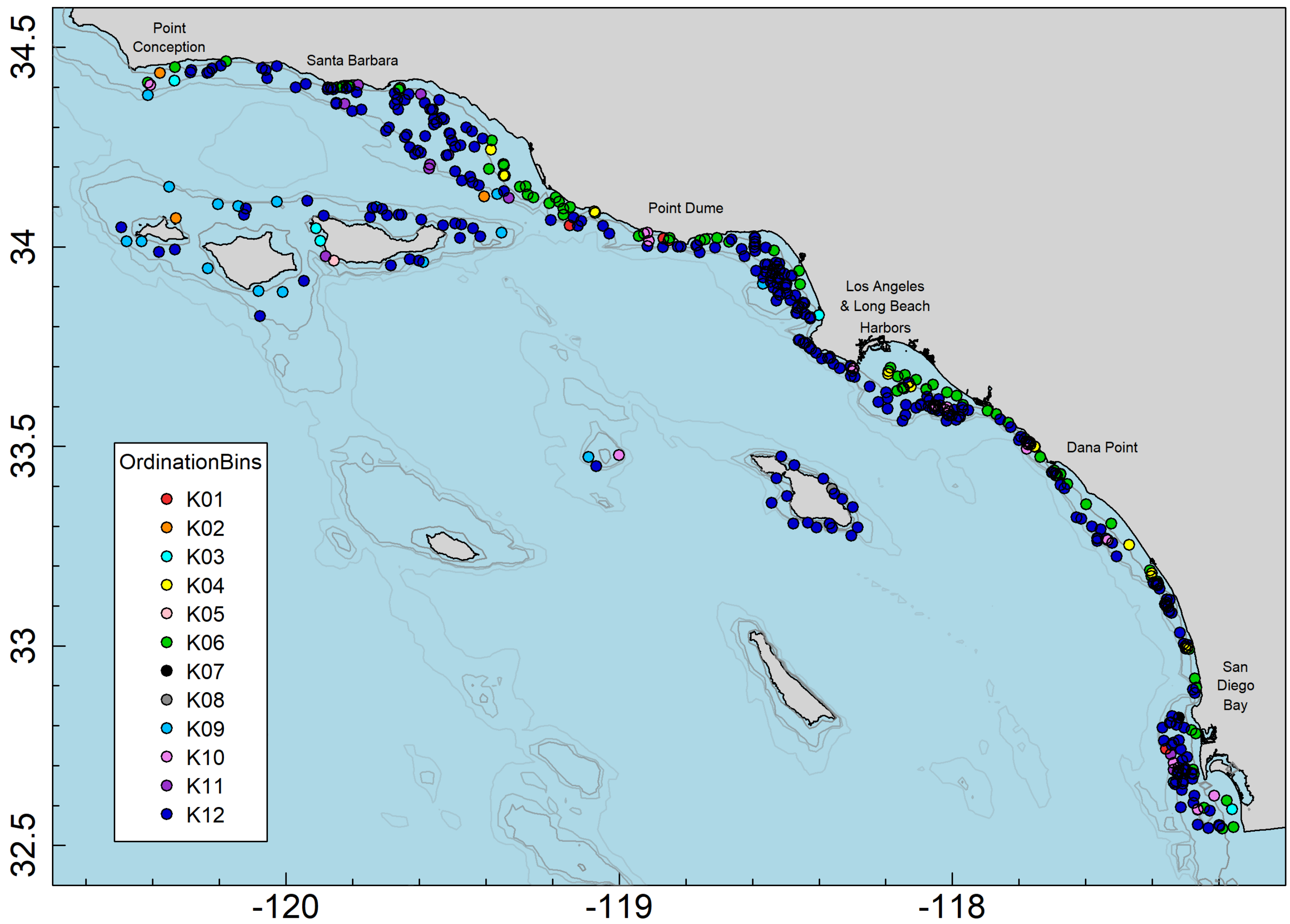

Figure F69b. Results of ordination and cluster analysis of trawls from offshore megabenthic invertebrate cluster group K. Data are presented as a map of subgroups overlaid on station locations.

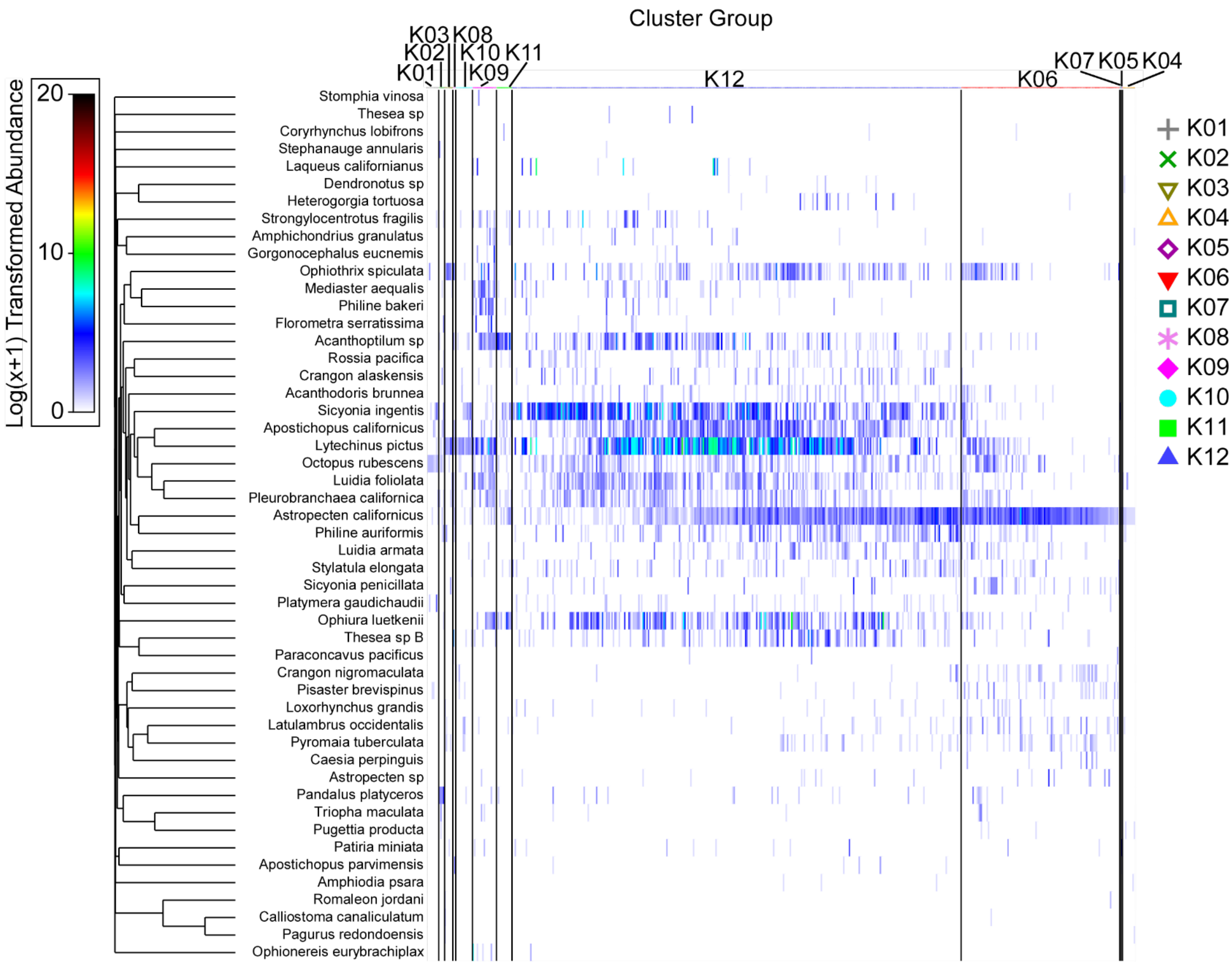

Figure F70c. Results of ordination and cluster analysis of trawls from offshore megabenthic invertebrate cluster group K, presented as a shade plot of top 50 species by subgroup.

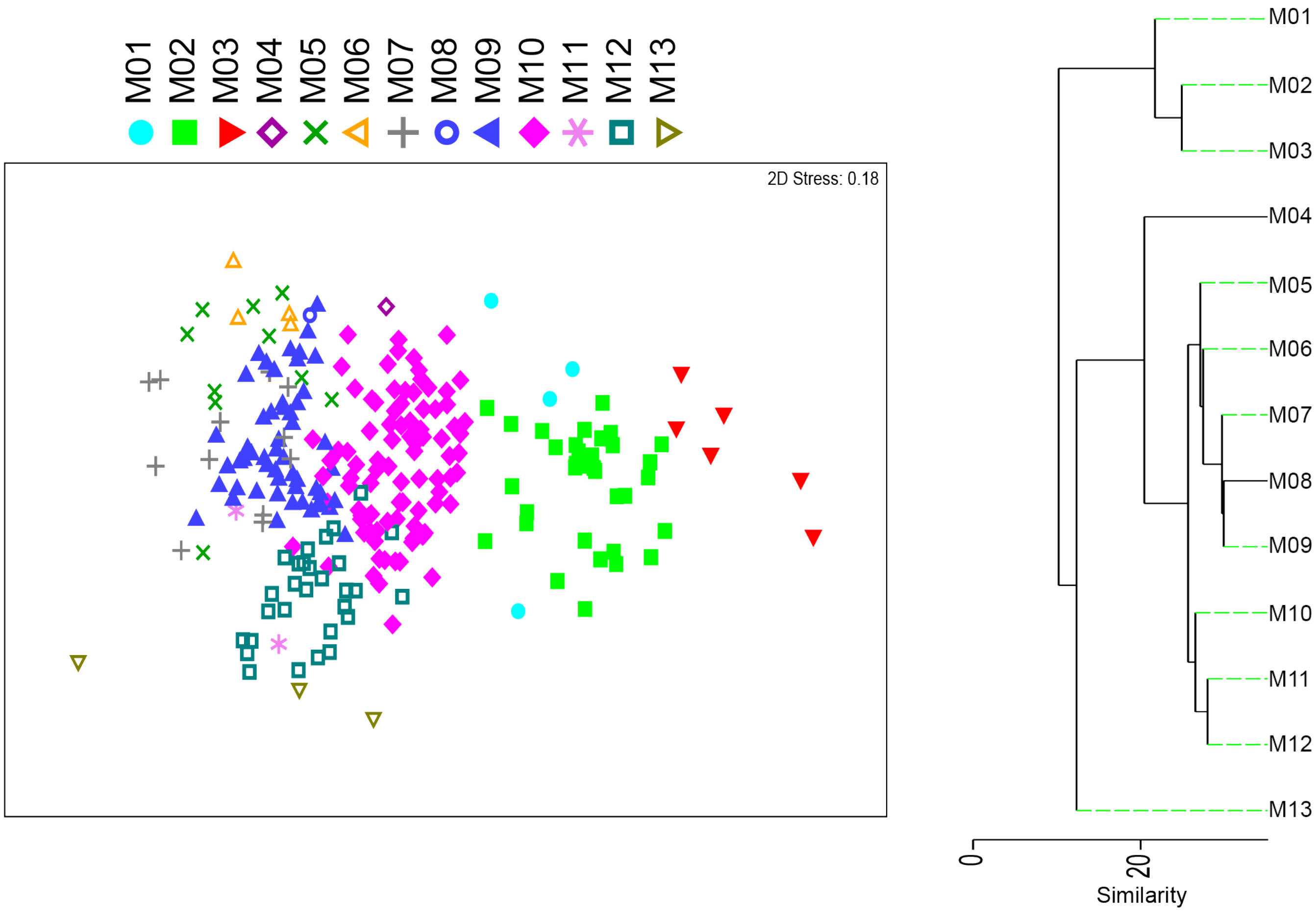

Figure F71a. Results of ordination and cluster analysis of trawls from offshore megabenthic invertebrate cluster group M, presented as a nMDS ordination and a dendrogram of main subgroups.

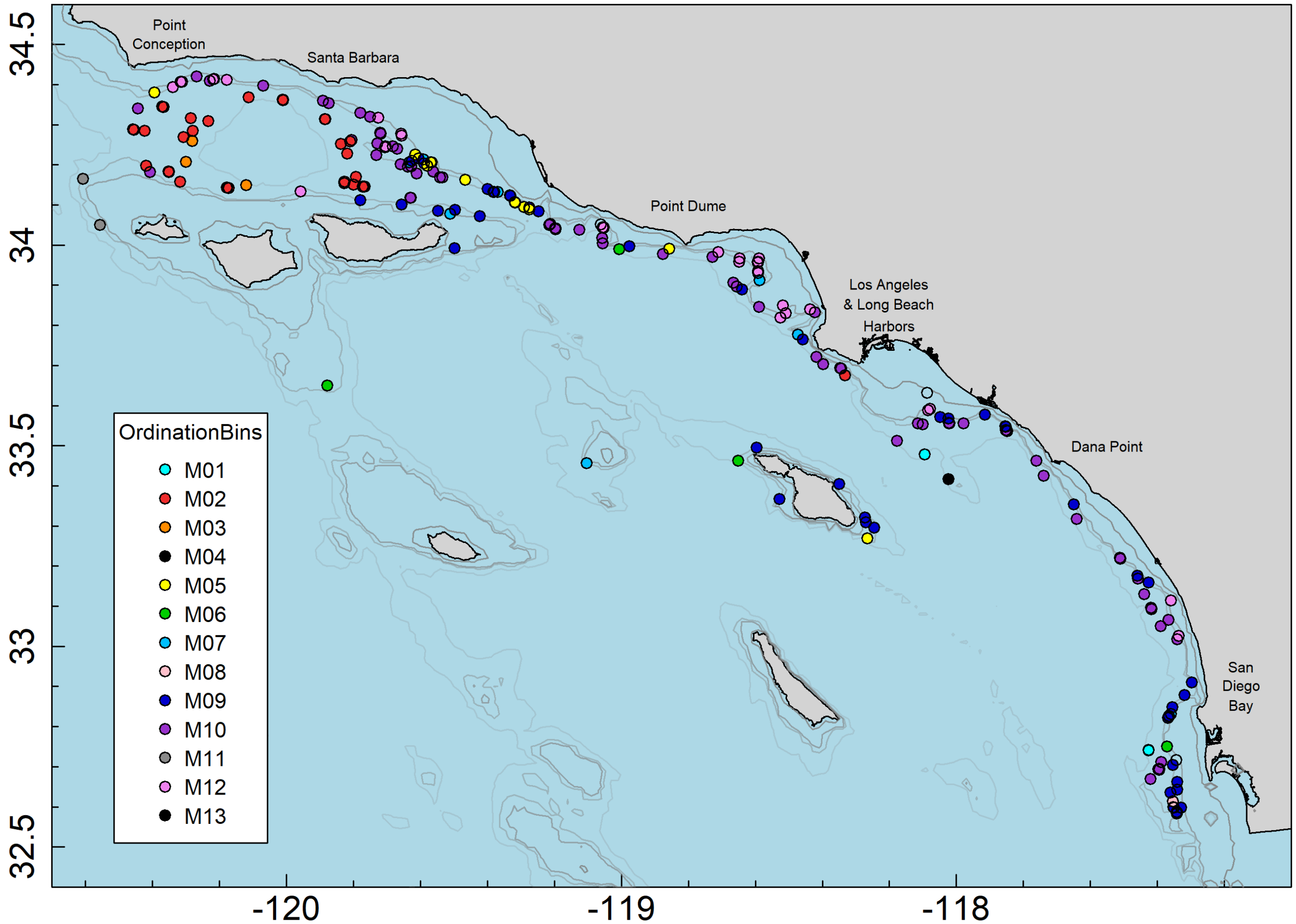

Figure F72b. Results of ordination and cluster analysis of trawls from offshore megabenthic invertebrate cluster group M. Data are presented as a map of subgroups overlaid on station locations.

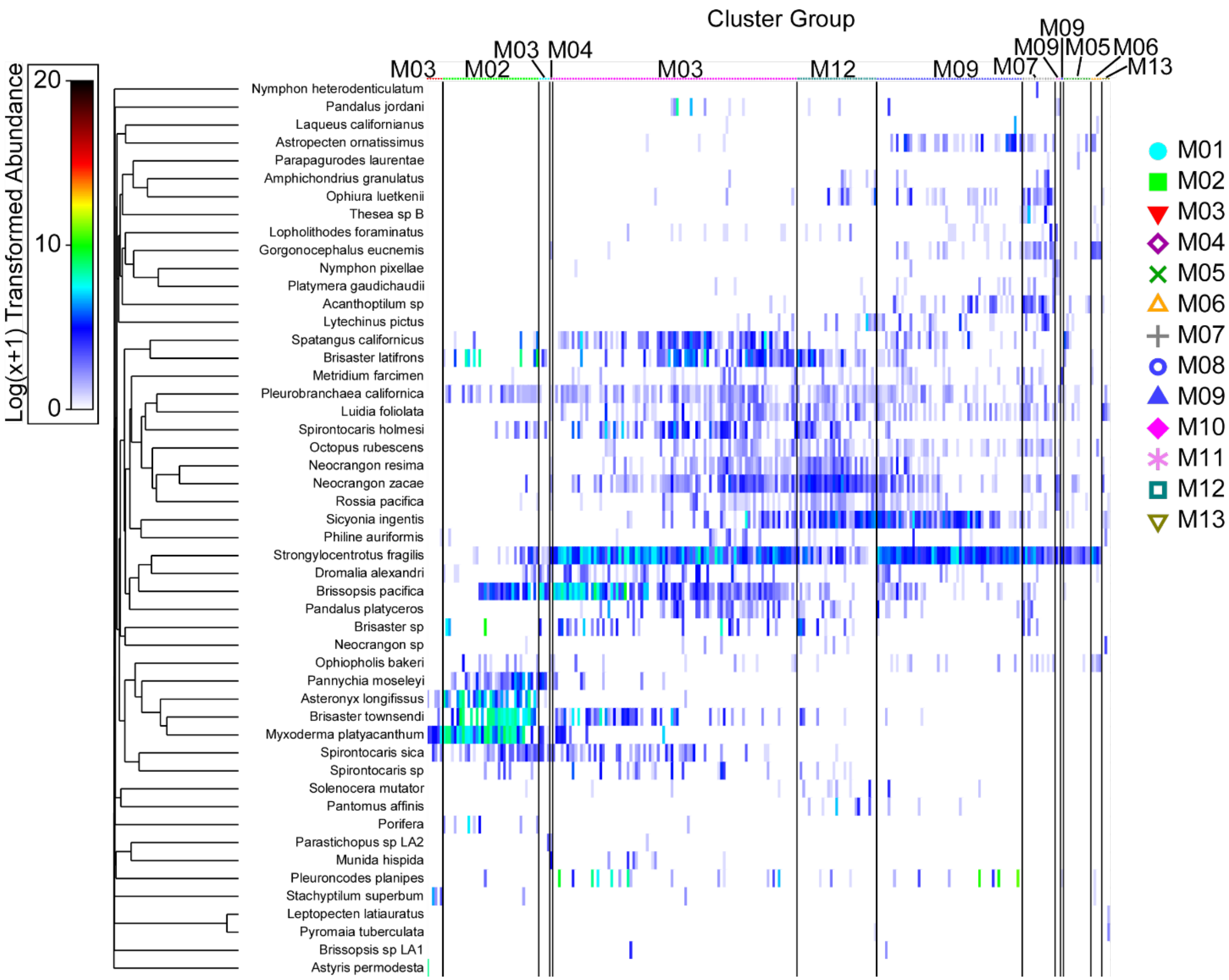

Figure F73c. Results of ordination and cluster analysis of trawls from offshore megabenthic invertebrate cluster group M presented as a shade plot of top 50 species by subgroup.

Table F72. Description of offshore megabenthic invertebrate cluster K and M subgroups as defined in Figure F57 and Figure F58.

Sub-Groups	Number of Trawls	Average Similarity (%)	Mean Species Richness	Mean Abundance	Depth (m)			%Trawls by Survey					
					Min	Max	Mean	1994	1998	2003	2008	2013	2018
Group K													
K01	9	35	4	11	17	149	54	0	22	44	0	22	11
K02	4	22	14	60	22	227	97	0	0	75	25	0	0
K03	6	26	13	45	18	71	32	33	33	0	0	17	17
K04	9	47	2	3	9	30	22	22	44	0	22	0	11
K05	1	*	6	70	24	24	24	0	100	0	0	0	0
K06	113	34	7	55	9	74	28	16	21	16	12	22	12
K07	1	*	17	49	53	53	53	0	100	0	0	0	0
K08	2	19	22	411	38	46	42	0	50	50	0	0	0
K09	17	26	19	366	46	144	96	6	29	59	6	0	0
K10	12	33	6	16	15	103	54	25	33	17	8	0	17
K11	11	35	8	96	18	147	90	9	0	55	0	9	27
K12	320	30	11	858	20	202	71	16	34	20	11	12	7
Group M													
M01	4	39	15	1366	462	479	468	0	0	50	25	25	0
M02	35	45	11	7833	287	461	403	0	0	23	31	31	14
M03	6	37	5	1330	447	479	462	0	0	33	17	33	17
M04	1	*	27	332	350	350	350	0	0	0	100	0	0
M05	10	37	6	70	139	194	175	30	10	20	0	10	30
M06	4	48	12	384	178	196	189	0	50	25	25	0	0
M07	12	37	16	435	89	191	154	0	0	17	8	33	42
M08	1	*	11	221	185	185	185	0	100	0	0	0	0
M09	53	41	11	2493	107	224	171	13	30	15	21	13	8
M10	89	40	14	2205	151	472	274	7	0	22	22	29	19
M11	2	45	14	108	166	198	182	0	0	100	0	0	0
M12	29	42	16	529	100	226	170	21	28	3	14	14	21
M13	3	22	8	48	33	143	105	33	0	33	33	0	0

* Similarity only calculated for groups with >1 trawl

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