

Cross-Shelf Habitat Suitability Modeling for Benthic Macrofauna



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List of Abbreviations and Acronyms

| | |
|--------|---|
| BOEM | Bureau of Ocean Energy Management |
| cm | centimeter |
| CMECS | Coastal and Marine Ecological Classification Standard |
| CTD | Conductivity, Temperature, Depth |
| DO | Dissolved Oxygen |
| DOI | US Department of the Interior |
| EFH | Essential Fish Habitat |
| EIS | Environmental Impact Statement |
| EMAP | Environmental Monitoring and Assessment Program |
| EPA | US Environmental Protection Agency |
| EUNIS | European Nature Information System |
| FRAM | Fisheries Resource Analysis and Monitoring |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| GS | Grain Size |
| µm | micrometer |
| m | meter |
| mm | millimeter |
| MDS | multidimensional scaling |
| MLML | Moss Landing Marine Laboratories |
| MRE | Marine Renewable Energy |
| NCCOS | National Centers for Coastal Ocean Science |
| NETS | North Energy Test Site |
| NMFS | National Marine Fisheries Service |
| NNMREC | Northwest National Marine Renewable Energy Center |
| NOAA | National Oceanic and Atmospheric Administration |
| NSF | National Science Foundation |
| OCNMS | Olympic Coast National Marine Sanctuary |
| OCS | Outer Continental Shelf |
| ODFW | Oregon Department of Fish and Wildlife |
| ODMDS | Ocean Dredged Material Disposal Site |
| ONR | Office of Naval Research |
| OSU | Oregon State University |
| PMEC | Pacific Marine Energy Center |
| PNW | Pacific Northwest |
| SETS | South Energy Test Site |
| ROV | Remotely Operated Vehicle |
| SCCWRP | Southern California Coastal Water Resources Project |
| SETS | South Energy Test Site |
| SGH | Surficial Geologic Habitat |
| TN | Total Nitrogen |
| TOC | Total Organic Carbon |
| USGS | United States Geological Survey |

1 Executive Summary

There is increasing interest in offshore wind development, which is likely to be sited in deeper waters (i.e., the continental slope) on the US west coast as compared to wind installations in northern Europe and the US east coast or to proposed wave energy deployments. While many environmental interactions of marine renewable energy (MRE) deployments have been considered, a certain effect will be localized changes to the seabed, potentially affecting benthic invertebrates living in or on the seafloor. Previous work sponsored by the Bureau of Ocean Energy Management (BOEM) and conducted by Oregon State University (OSU) characterized seafloor habitats for benthic invertebrates on the inner to mid shelf (30 to 130 meters [m] deep). Deeper waters are less studied, and habitat suitability models are not developed for macrofauna (e.g., infauna) of the outer continental shelf and slope. Thus, for this study we sampled deeper waters (60 to 525 m) to expand the domain of the habitat characterization and of the individual species models. Improved models have the potential to inform regional spatial planning processes for future consideration of MRE projects and the necessary consultations associated with leasing (e.g., on Essential Fish Habitat [EFH]). Improved habitat suitability models could also improve site assessments needed for National Environmental Policy Act analysis and may reduce site survey requirements for lease holders.

The two primary outputs for this study are (1) cross-shelf habitat characterizations where benthic habitats are classified based on biological species groupings or assemblage distributions and (2) habitat suitability models for a subset of the macrofauna. The cross-shelf habitat characterization was conducted for the same latitudinal range as the prior BOEM study and includes data from both projects as well as other OSU collected samples for a depth range of 20 to 525 m deep. Outputs focused on linking spatial variability in macrofauna assemblages with measured environmental parameters. The habitat suitability models were developed using the entire US west coast for the latitudinal range by including datasets from additional sources. To determine which macrofauna would be selected for habitat suitability modeling coast-wide, we determined which species were characteristic of the habitats classified and choose those with ranges throughout the study region. Additionally, we included species that comprise a wide range of tolerance/sensitivity to pollution. Finally, all seven of the species modeled previously were included in the final list of 44 species for which we conducted habitat suitability modeling. This study was a joint effort with the National Centers for Coastal Ocean Science (NCCOS). NCCOS took environmental and biological data from this study and built habitat suitability models. NCCOS will issue a separate BOEM report under Interagency Agreement Number M16PG00014.

Significant differences in macrofauna species assemblages were found across depth and in different sediment types. Depth was the primary structuring variable (i.e., macrofauna species assemblages first separated by depth) with sediment parameters (percent fines, grain size, and total organic carbon) secondary and nearly as statistically important. The depth break of ~90 m was the first major environmental variable that correlated with major differences among assemblages among our stations, which is not a classically described depth break for shelf fauna. Beyond the 90-m break point, we detected secondary changes in assemblage composition at 43 m and 200 m. Within each of these depth zones on the shelf, we detected significant differences in assemblages related to different sediment grain sizes. Below the 200-m break – a depth traditionally delineating the continental shelf and slope – subsequent depth breaks were detected at 221 m and 445 m. Knowing how macrofaunal communities respond to changes in grain size and depth can inform future site surveys and led us to develop tools for mapping macrofauna based primarily on these physical factors.

This study provides BOEM with information on seafloor habitats and invertebrate communities in consideration of Outer Continental Shelf (OCS) renewable energy development. Overall, the information derived from this study has greatly contributed to the greater body of knowledge regarding seafloor habitats and invertebrate communities in the Pacific Northwest (PNW).

2 Introduction to the Study

The seafloor is an important resource as habitat for commercial fisheries and supports the trophic base for many ecologically important and regulated marine species. The vast majority of benthic habitats in waters past the photic zone consist of unconsolidated sediments where macrofaunal (infaunal) and epifaunal invertebrate species play an important role in serving as trophic links between water column and benthic primary productivity and higher trophic levels (Snelgrove et al. 1998; Kędra et al. 2015). A benthic habitat type is defined as, “a particular environment which can be distinguished by its abiotic characteristics and associated biological assemblage, operating at particular, but dynamic spatial and temporal scales in a recognizable geographic area (ICES 2006).” These invertebrates are a key part of defining unconsolidated sediment habitats because species represent long-term environmental conditions (Elliot 1994), both responding to and affecting local sedimentary processes (Gray 1974, Rhoads 1974, Aller and Aller 1998), benthic boundary layer flow (Friedrichs and Graf 2009), and biochemical cycling (Josefson and Rasmussen 2000; Laverock et al. 2014). Macrofauna-based assessment indices have been developed to quantify these responses and are a primary biological tool utilized worldwide to evaluate the overall condition or health of benthic habitats in a variety of regulatory or disturbance assessment contexts (e.g., waste water discharge, dredge disposal) around the world (Gillett et al. 2015; Diaz et al. 2004).

Despite the wide-use of assessment indices in water-quality based coastal regulation, the use of macrofauna to classify benthic habitats as a means to inform planning applications is not always possible nor done consistently (Reiss et al. 2015). In US Federal waters on the continental shelf, marine planning primarily addresses commercial fishing, conservation, and energy development. Laws and regulations specifically state the importance of benthic habitats. For example, the Magnuson-Stevens Fishery Conservation and Management Act regulates commercial ground fisheries and recognizes benthic habitat integration for fish species food and shelter through Habitats of Particular Concern and Essential Fish Habitat designations. Conservation of marine resources in the National Marine Sanctuaries on the US west coast covers 13,000 square miles of the seafloor. Macrofauna-focused analysis could assist with conservation (Bremner 2008) and inform spatial planning for groundfisheries (Thrush and Dayton 2002) and fish farming (Tomassetti and Porrello 2005). The Outer Continental Shelf Lands Act states the need to characterize and monitor benthic habitats in areas potentially impacted by energy development. Deep-sea coral distributions currently are utilized to delineate habitats of concern or warrant protection as these organisms are themselves fragile and characterize emergent bottom structure of limited extent and thus are consequently of increased concern. However, the much more extensive soft sediments are not themselves uniform, and also harbor areas which should be of concern. Prior to oil and gas leasing offshore southern and central California, extensive macrofauna data was collected (Hyland et al. 1991; Lissner 1989) but not utilized for planning purposes. In contrast, research has been conducted in the Alaskan arctic to link macrofauna data with higher trophic species (Kędra et al. 2015) and has informed energy policy in the Beaufort and Chukchi Seas.

Macrofauna assemblages represent the biological community most likely to be impacted by energy development. Further, the area of impact to benthic organisms could be larger than the direct footprint of development. Since sediment grain size often determines which animals can live in the sediment, changes to sediment movement due to ocean energy extraction or alterations of flow around large device arrays may affect the distribution of invertebrate species that are dependent on grain size, near-bottom sedimentation and particle loads (Etnoyer and Morgan 2003). In this study we conducted macrofauna community analysis and correlated it with environmental covariates as an approach for applied decision-making at the regional scale needed for planning applications of the US west coast seafloor.

A prior regional analysis (referenced as Benthic Habitat Characterization; BOEM-BHC, Henkel et al. 2014) was spatially comprehensive within the mid- to inner-continental shelf (30 to 130 m) that wave

energy projects have targeted – the primary focus of offshore renewables at the time. In 2018, BOEM issued a Call for Information and Nominations for areas with water depths from 300 to 1,200 m (Fed Reg 2018). These deeper waters are less studied, and habitat suitability models have not been developed for macrofauna of the outer shelf and slope. Thus, we aimed to sample these deeper waters in order to expand the domain of the habitat characterization and habitat suitability models developed in the 2014 BHC project. Additionally, since the time of the BHC project, there has been greater interest in siting renewable energy projects offshore California. Thus, we aimed to expand the latitudinal range of the models as well by utilizing previously gathered data from various other survey programs in California as well as in Oregon. Evaluating and improving the spatial extent of habitat suitability models is necessary before they can be useful tools for siting and permitting.

The following chapters step through the study components. Chapter 3 describes box core surveys and subsequent analyses to describe macrofaunal invertebrate species assemblages and the classification of benthic habitat in the northern portion of the planning region. Chapter 4 describes the processes used for selecting species modeled for habitat suitability throughout the entire planning region from the California-Mexico border to Vancouver, Washington.

3 Cross-shelf Habitat Classification

3.1 Purpose

New technologies are in development to produce renewable energy (wave, wind, etc.) to reduce dependence on fossil fuels. The energetic continental shelf of the PNW is particularly appealing for marine renewable energy development and areas of the seafloor have the potential to be leased to developers for this purpose. An assessment of potential impacts on marine environments is needed, but the lack of baseline data on the characteristics, distribution, abundance and condition of seabed habitats limits our ability to predict how they might change. However, even before seabed habitat distribution, abundance and condition can be assessed, a better approach for classification of seabed habitats is necessary. In the rationale for Session G: Habitat Modelling and Mapping for better assessment and monitoring of our seas at the ICES Annual Science Conference in 2011, conveners stated, “empirical evidence shows this new categorisation [EUNIS] results in a poor match between modelled and observed biotopes; primarily because the boundaries between classes have not been defined because of any known effect on benthic community distribution”. This knowledge gap also affects other aspects of marine spatial planning, including evaluation of potential impacts on biological resources such as fisheries and other higher trophic levels that may respond to the distribution of benthic communities rather than physical features.

Due to their living position and life history, macrobenthic fauna are both indicators of sediment characteristics and sensitive to changes to sediment conditions; thus, they are the biological community most likely to be impacted by seafloor development. Not only do they serve as a food source for higher trophic levels, they also are a link between toxicants in the sediments and bioaccumulation in tissues of fishes, marine mammals, birds, and humans. Thus, benthic macrofauna have long been used as indicators of both habitat and environmental status and trends. Planning for both offshore renewable energy and fisheries management is ongoing across the shelf and slope-shelf transition zone in the PNW, driving the need for better understanding of the distributions of habitats as it relates to these critical, low trophic level species.

In southern California, where there are extensive long-term macrobenthic fauna-based regional monitoring programs in place across the continental shelf and slope (Schiff et al. 2016), depth has been considered to be the primary variable structuring macrofaunal invertebrate species distributions with other

factors such as dissolved oxygen, grain size, and total organic carbon being secondary (SAIC 1986, Lissner 1989, Hyland et al. 1991, Bergen et al. 2001, Gillett et al. 2017). Henkel and Politano (2017) focused on the mid-continental shelf (50 to 110 m) macrofauna of the PNW and defined important breaks in sediment characteristics that resulted in different macrofaunal assemblages within that depth range in the region. Across a broader latitudinal (US west coast) range and slighter greater depth expanse (30 – 130 m), Henkel and Nelson (2018) similarly found within-region differences based on low percentages of fine sediment along with latitudinal breaks in species assemblages, potentially related to temperature and/or upwelling. However, because of the relatively limited depth range in both studies, we were not able to determine if/where significant depth breaks in macrofaunal assemblages occur across the entirety of the shelf and slope, if those breaks are consistent with those observed in Southern California, or if the sediment classifications defined in the previous studies apply across the broader geographic scope of the outer shelf and slope of the PNW.

The purpose of this study was to understand how macrofauna are distributed in relation to physical factors across the shelf and the upper slope (~20 to 525 m) from Mendocino, California, to Grays Harbor, Washington. The objective was to classify sedimentary benthic habitats as defined by the macrofaunal organisms. We specifically sought to determine (1) where significant depth-related breaks in species assemblages occurred; (2) what sediment differences correlate with different species assemblages; and (3) if regional differences were detectable in this sampled range. The results of this effort will more accurately characterize a large seafloor expanse and assess the impacts of marine renewable energy development.

3.2 Methods

3.2.1 Study Area

The study area ranged from Fort Bragg, California (39.5 °N) to Grays Harbor, Washington (47.0 °N) on the west coast seafloor of the continental United States. From 2010 to 2012 a total of 242 samples were collected from nine distinct sites in this range; within each site, sample stations were randomly determined using Generalized Random Tessellation Stratified methods (GTRS; Stevens and Olsen 2004) as described in Henkel and Politano (2017). In early summers 2014 and 2015, we collected 77 samples from 60 to 500 m deep along regularly spaced (0.5 degrees latitude) offshore transects from Brookings to the Columbia River, Oregon. An additional site near Newport, Oregon, was sampled in June of 2015, within which 17 stations were arranged on a regular grid. In summer 2016, we sampled 68 additional stations from Coos Bay to Tillamook, Oregon, from 64 to 525 m deep. Thus, a total of 404 samples ranging from 18 to 525 m deep were available for analysis (Figure 1; Table of all station locations in the Appendix).

3.2.2 Sample Collection and Processing

At each station, samples were collected with a modified Grey-O'Hara 0.1 m² box core. One box core sample was taken at each station. Only samples with a penetration depth of at least 5 centimeters (cm) and no slumping or other evidence of disturbance (i.e., by washing) were accepted for processing. Approximately 80 milliliters (mL) of sediment were collected from the undisturbed surface layer for grain size analysis. Any organisms noticed in the sediment subsample were removed and placed in the organism sample at the time of collection (occasionally a specimen was detected when conducting the sediment analysis). The remainder of the collected core was sieved onboard through a 1.0 millimeter (mm) mesh screen, and all collected organisms (both infauna living in the sediment and small epifauna which may have been on the surface – hereafter collectively called macrofauna) were preserved in a mixture of 10% buffered formalin and seawater. At most stations (primarily excluding the 2014 and 2015 offshore sampling) vertical water-column profiles of conductivity, temperature, dissolved oxygen, pH,

and fluorescence were obtained with a Sea-Bird Electronics CTD (conductivity, temperature, depth) unit equipped with additional sensors. Depth was recorded from the vessels' echosounder at the time the box corer hit the bottom.

Upon return to the laboratory, organisms were transferred to 70% ethanol then sorted into major taxonomic groups by OSU staff. Crustaceans, polychaetes, other worm-like creatures, and a portion of the molluscs were sent to contracted taxonomic experts. OSU laboratory staff identified other molluscs, echinoderms, and any remaining taxa.

Sediment from the top of the core was analyzed using a Beckman Coulter Laser Diffraction Particle Size Analyzer (LD-PSA) to determine mean and median grain size and percent fines (silt/clay; portion less than 62.5 micrometer [μm]; Wentworth 1922). In most cases, sand (62.5 μm to 2 mm) was the balance of the sample. Where grain sizes larger than 2 mm (maximum size for the LD-PSA) were encountered, these samples were fractioned and the percent gravel (that fraction greater than 2 mm) was determined by weight. The balance of the fraction was then analyzed by the LD-PSA to determine % sand and silt/clay and grain size (the mean/median grain sizes are thus not representative of the full composition of the sediment). Approximately one quarter ($n = 110$) of the sediment samples were analyzed for percent total organic carbon (TOC) and total nitrogen (TN) using an NA1500 Elemental Analyzer operated by staff in the College of Earth, Ocean, and Atmospheric Sciences at OSU.

3.2.3 Statistical Analysis

A variety of multivariate analyses were undertaken using PRIMER 6th Edition (Clarke and Gorley 2006). Abundance data were 4th root transformed to reduce the influence of highly abundant species without giving as much weight to rare species as would the more severe $\log(x+1)$ (Clarke and Warwick 2001). A Bray-Curtis similarity matrix was created for the 404 samples and a multidimensional scaling (MDS) plot was created. As Henkel and Politano (2017) determined that stations containing gravel and those with less than 1% fines hosted significantly different assemblages, and Henkel and Nelson (2018) detected a significant difference in assemblages at a break of 5% fines, we first coded the MDS with sediment classes representing these and other breaks in percent fines (Figure 2). As expected, the gravel-containing stations were rather separate from the rest of the stations. These stations represent a unique habitat type with its own assemblage of organisms (characterized mostly by polychaetes; Henkel and Politano 2017); however their inclusion in this analysis would make other differences within gravel-free sediment difficult to resolve; thus, we removed all 11 stations that contained gravel. Additionally, we removed from the dataset any taxon that had only a single observation. A new resemblance matrix was created using the remaining 393 samples. We used the similarity matrix to create a dendrogram by agglomerative cluster analysis with group-average linking and the Similarity Profiles (SIMPROF) procedure to identify significant clusters based only similarities in macrofaunal abundance. Using a SIMPROF significance threshold of 1%, the dendrogram included 76 multi-station clusters and 15 individual samples as outliers (Figure 3). These outliers were removed from the remainder of the analysis for a final dataset of 378 samples.

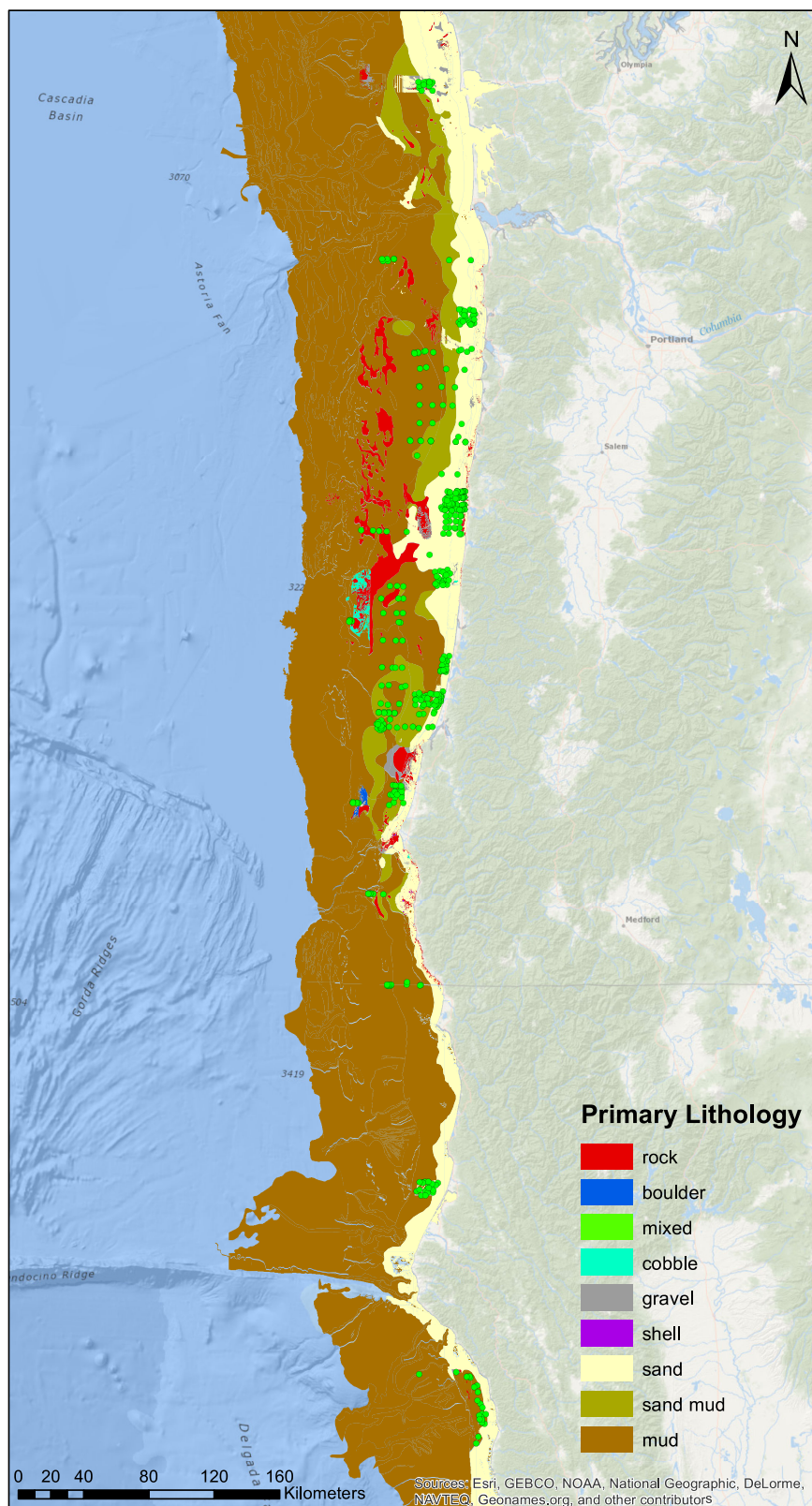


Figure 1. Macrofaunal grab samples (n = 404) gathered for habitat classification.
The base map is the primary lithology as described in the BOEM-BHC project (Goldfinger et al. 2014).

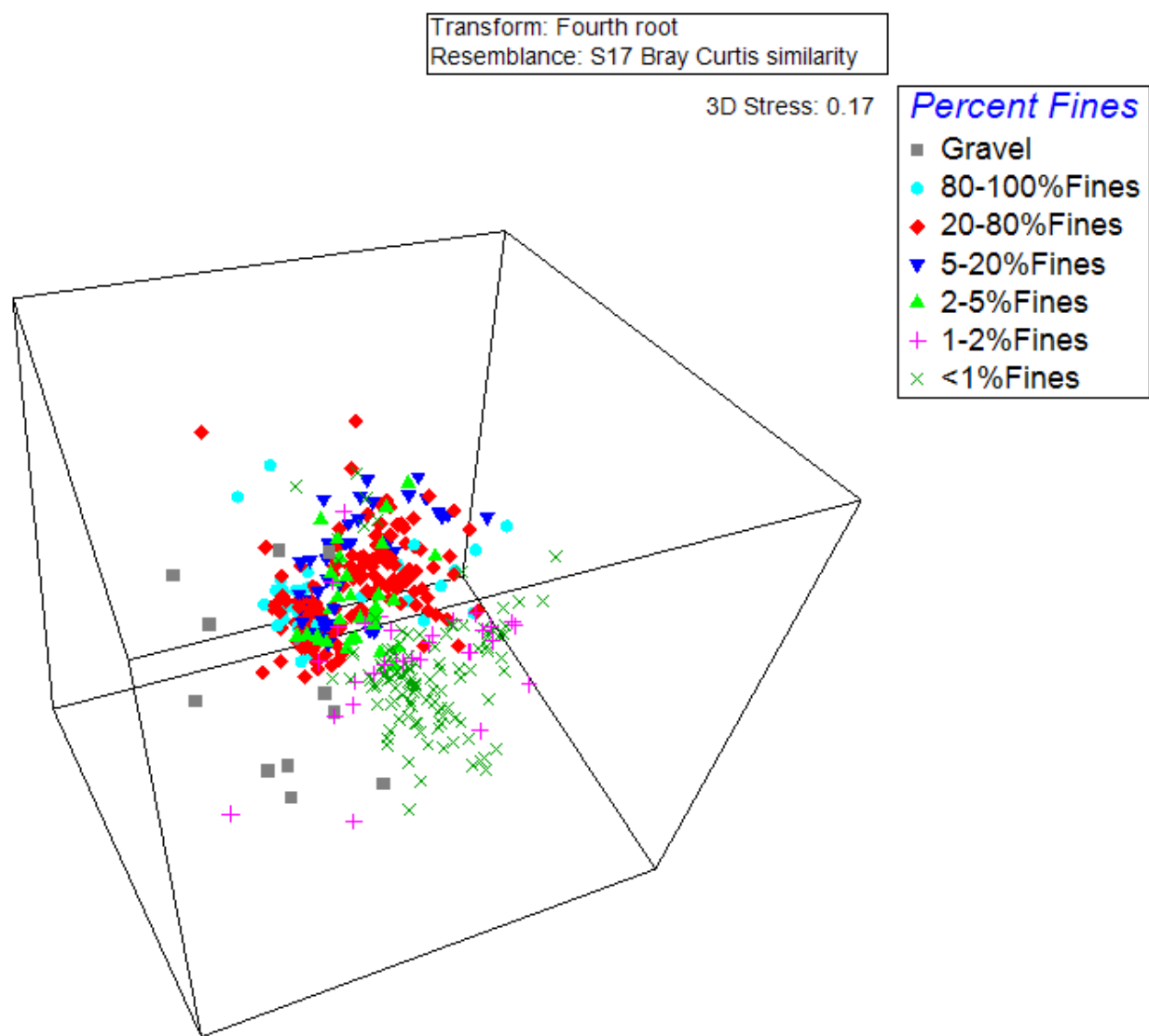


Figure 2. Three-dimensional nMDS plot of all 404 stations.
Gravel stations are grey boxes on the left side of the plot.

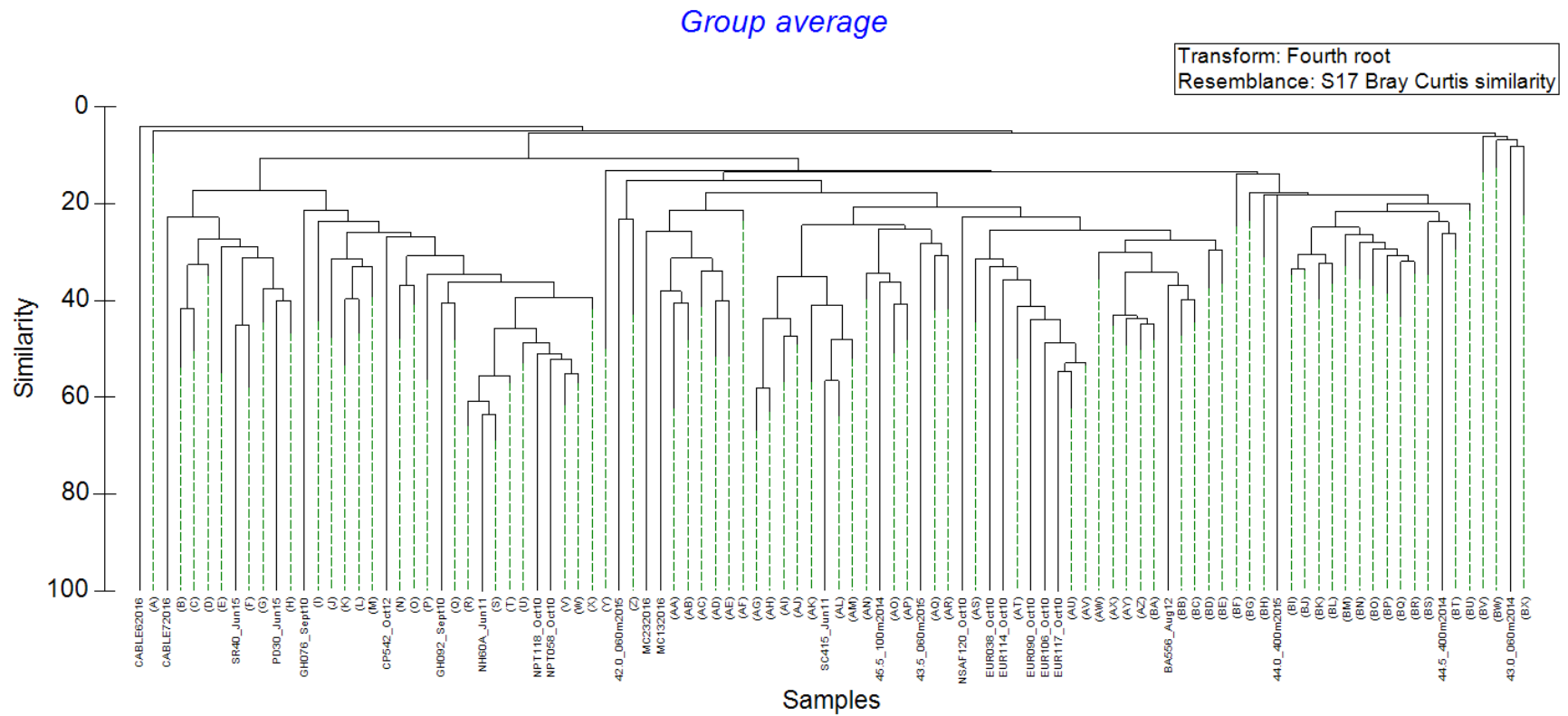


Figure 3. Dendrogram developed using the 393 stations (gravel-containing stations removed prior) showing the multi-station clusters (groups indicated with letters in parentheses) and the singletons.
 Significance evaluated at the 1% level found 76 distinct groups and 15 singletons, which were removed for final analysis.

A final resemblance matrix of the 378 stations was created for the entire suite of taxa, and individual matrices were created for polychaetes, molluscs, crustaceans, and echinoderms. These resemblance matrices were then compared between all pairs of sub-groups, and sub-groups were compared to the matrix based on all taxa using the RELATE procedure in PRIMER to determine if patterns were similar for the different subgroups and which subgroup was most similar to the matrix generated with all taxa.

The final set of 378 stations were plotted on 2-D and 3-D MDS planes and potential physical correlates to MDS axes were assessed. Here we included all station and sample data [Latitude, Depth, sediment fraction less than 62.5 μm (Fines%), Mean Grain Size, Median Grain Size, total organic carbon (TOC), total nitrogen (TN), and bottom values from CTD casts (Temperature, DO, Salinity, Fluorescence, Turbidity, Beam Transmission, and pH)]. We also included upwelling indices from NOAA's Pacific Fisheries Environmental Laboratory (<https://www.pfeg.noaa.gov/products/PFELData/upwell/monthly/upindex.mon>) for the month of sampling (UpwellingMon), the previous month (UpwellingPrev), and the average for the year (UpwellingYear) for the latitudinal zone of each of the stations. Those parameters with greater than $R = 0.4$ to any MDS axis were plotted on the included 2-D plot.

To determine which measured environmental factors "best" described the distribution of macrofaunal invertebrates across the study region, the BIO-ENV (BEST) procedure was used to find the subset of environmental variables (summarized as pairwise normalized Euclidean distance) with the strongest Spearman rank correlations to the macrofauna observed among the samples (summarized as pairwise Bray Curtis similarities). The BEST procedure requires a complete inventory of biological and environmental data at all stations in the two similarity matrices for analysis; thus, only Latitude, Longitude, Depth, Fines%, Mean Grain Size, Median Grain Size, UpwellingMon, UpwellingPrev, and UpwellingYear could be considered in the analysis of all stations. We additionally conducted a BEST analysis using only the stations ($n = 249$) for which we had the majority of the environmental data (16 variables; Table 1). In both cases environmental data were normalized prior to running the procedure.

Table 1. The 16 environmental variables for which we had data for most (249) stations.

Variables in italics are those for which we had data for all (378 stations).

| Station Data | Sediment Data | CTD Data | Indices |
|------------------|-----------------|------------------|----------------------|
| <i>Latitude</i> | <i>Fines%</i> | Temperature | <i>UpwellingMon</i> |
| <i>Longitude</i> | <i>MeanGS</i> | Dissolved Oxygen | <i>UpwellingPrev</i> |
| <i>Depth</i> | <i>MedianGS</i> | Salinity | <i>UpwellingYear</i> |
| | TOC | Fluorescence | |
| | TN | pH | |

The variables determined to be highly correlating with the species assemblage patterns were then used as the starting point to classify the stations in the LINKTREE procedure in PRIMER 6. The LINKTREE procedure is a form of constrained cluster analysis involving a divisive partition of the biotic community samples into ever smaller groups, but in which each division has an 'explanation' in terms of a threshold on one of the environmental variables (Clarke et al. 2008). We constrained the minimum group size to be two stations (so as not to have singletons) and used the SIMPROF procedure (using the Bray-Curtis similarity index) to finalize the tree when there were no significant differences ($p < 0.01$) among the remaining stations. Within a resulting LINKTREE, each branch of the tree corresponds to a group of samples with similar macrofaunal composition (based on taxon and abundance); each split maximizes the Analysis of Similarity (ANOSIM) R statistic between macrofaunal groups and reports the threshold value of the environmental variable associated with that division (Clarke et al. 2008). If a threshold in more

than one environmental variable corresponds to a break between groups of stations in the LINKTREE, threshold values for both variables are reported. We wanted to explore which combination of physical variables yielded the most parsimonious LINKTREE (i.e., the fewest number of splits). Thus, we created LINKTREES using each of the physical parameters individually, in pairs, in trios, in groups of four, and with all the potential predictors.

Additionally, abundance, areal taxa richness, and Shannon-Weiner diversity were calculated from the 378 stations (samples) and plotted against depth to summarize how macrofaunal abundance and diversity changed across the shelf and the upper slope and the significance of that relationship was tested using linear regression. Abundance equals the number of all animals per station, areal (sample) richness is the number of taxa per box core (0.1 m² area of seafloor), and numerical richness is the number of taxa per number of individuals at a station. Shannon's diversity index (H' diversity) weights the geometric mean of the proportional abundances of the taxon groups.

3.3 Results

The final dataset for analysis of 378 stations ranged from 18.2 m deep to 525 m deep and from 39.5° to 47° N. Actual penetration depth of the box corer averaged 21.3 cm with a median of 23.75 cm for an average total core volume of over 2000 cm³.

The highest correlations among environmental parameters were between percent fine sediment and mean and median grain size (-0.76/-0.77), as expected as they are different measures of the same component. The second highest correlations were between TOC/TN and percent fine sediment (0.84/0.81) followed by TOC/TN correlations with depth (0.78/0.79). Latitude correlated most strongly with upwelling (as we based the upwelling indices on the latitude of the stations) and secondarily with percent fines (-0.60). Correlates among all environmental variables are given in Figure A-1 in the Appendix.

Organism abundances ranged from 10 to 542 individuals per 0.1 m² grab, and sample richness ranged from 5 to 64 taxa per grab. In total, 757 taxa were identified and included for analysis, most to the species level. Seven of the top ten most abundant species in the entire dataset were bivalves with two polychaetes and the pea crab, *Pinnixa occidentalis* complex, making up the other three (see Tables A-2 through A-5 in the Appendix). Overall, both organism abundance and sample richness (per 0.1 m²) declined significantly ($p < 0.001$) with depth; however, no significant response to depth was detected for Shannon's diversity index ($p = 0.753$) while numerical species richness (number of taxa per number of individuals per grab) significantly increased ($p < 0.001$) with depth (Figure 4). The resemblance matrix generated with the full suite of taxa was most similar to molluscs only with a Rho of 0.828 and secondarily similar to the polychaetes only with a Rho of 0.751. The resemblance matrices of the different groups compared amongst each other were not highly related (Table 2).

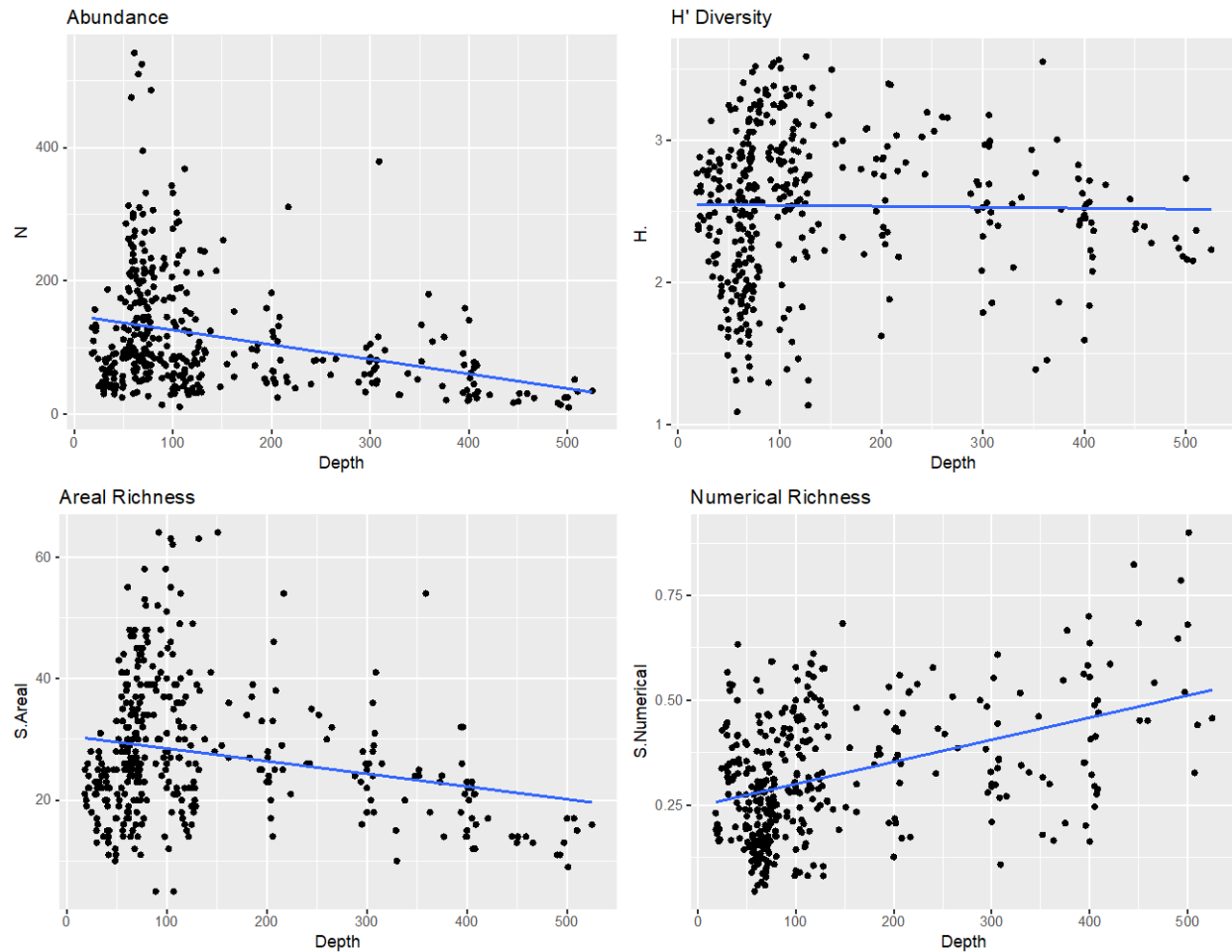


Figure 4. Response to depth for abundance (a), areal (sample) richness (b), H' diversity (c), and numerical richness (d).

Table 2. RELATE values for resemblance matrices generated from different suites of taxa.

| Taxon Group | Taxon Group | RELATE Value |
|-------------|-------------|--------------|
| All taxa | Molluscs | 0.828 |
| All taxa | Polychaetes | 0.751 |
| All taxa | Crustaceans | 0.461 |
| All taxa | Echinoderms | 0.377 |
| Polychaetes | Molluscs | 0.392 |
| Polychaetes | Crustaceans | 0.269 |
| Polychaetes | Echinoderms | 0.230 |
| Molluscs | Crustaceans | 0.304 |
| Molluscs | Echinoderms | 0.200 |
| Crustaceans | Echinoderms | 0.127 |

The MDS indicated a separation of assemblages with less than 2% fines, with 2-5% fines intermediate between those low silt containing stations and the remainder. Stations with >5% fines did not appear to further separate based on Folk (1974) defined breaks in silt content (Figure 5). Depth was the highest correlate with MDS1 ($r = -0.725$ for 2-D) with sediment grain size parameters the second highest correlate with MDS1. Stress was quite high for the 2-D MDS, and there were no correlates higher than 0.5 with the second MDS axis. Thus, the correlates to the 3-D MDS were determined and reported (Table 3). Depth and sediment grain size parameters remained the highest correlates of MDS1, followed by CTD parameters and the upwelling index for the previous month. Depth (again) and dissolved oxygen were the highest correlates of MDS2. All correlations of environmental variables with MDS3 were low.

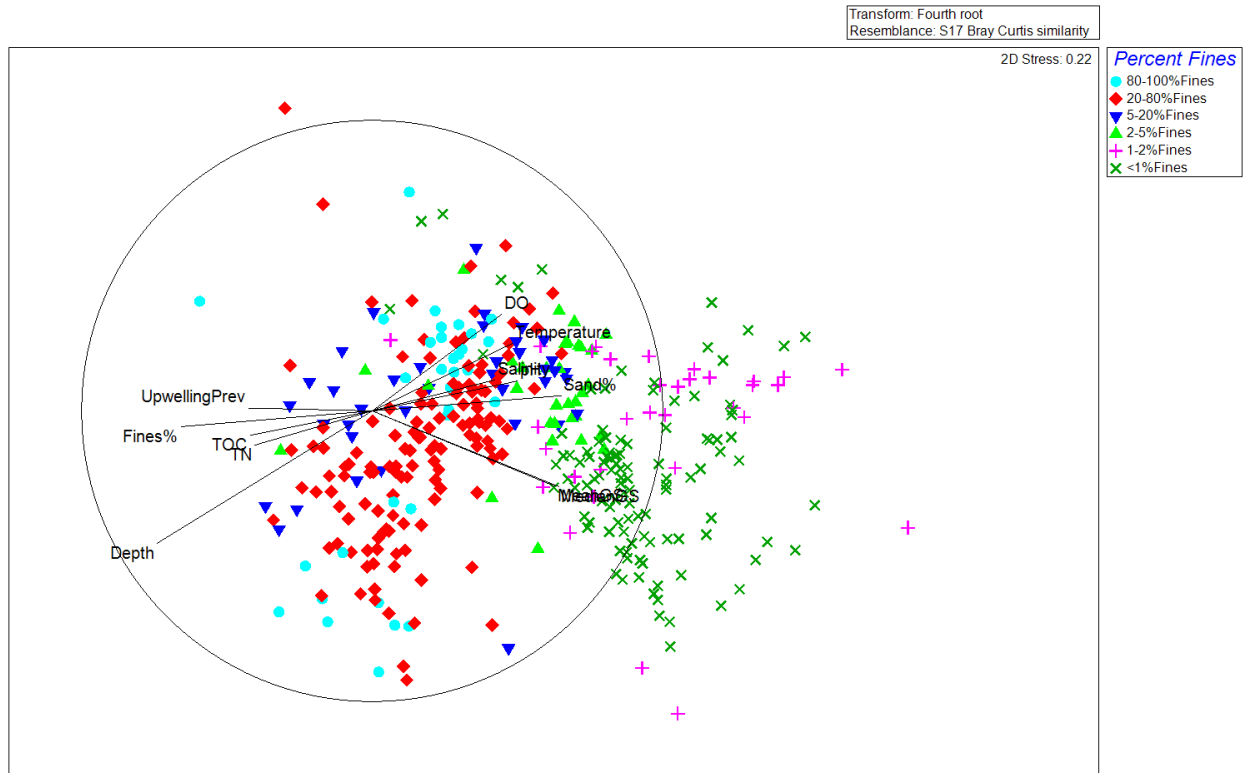


Figure 5. MDS of final 378 samples with vectors for environmental variables correlating at least 0.4 with MDS1 (listed in Table 3).

Stations are plotted according to the Folk (1974) percent fines classification with the addition of <1% and 1-2% fines based on the findings of Henkel and Politano (2017).

Table 3. Correlates with the 3-D MDS axes.

Variables were included in the table if they correlated >0.4 with any axis on the 3-D MDS plot. Bolded values on MDS1 are included on Figure 5.

| | Depth | Fines% | Mean GS | Median GS | TOC | TN | Temp | DO | Salinity | pH | Upwell Prev |
|------|--------------|--------------|---------------|---------------|--------------|--------------|---------------|---------------|---------------|---------------|----------------|
| MDS1 | 0.722 | 0.702 | -0.684 | -0.695 | 0.446 | 0.424 | -0.468 | -0.412 | -0.414 | -0.488 | 0.472 |
| MDS2 | -0.502 | -0.125 | -0.221 | -0.217 | -0.111 | -0.143 | 0.238 | 0.362 | 0.124 | 0.117 | -0.028 |
| MDS3 | 0.162 | -0.268 | 0.055 | 0.035 | -0.196 | -0.177 | -0.321 | -0.176 | -0.268 | -0.283 | -0.201 |

The BEST match between the biological data and the environmental data for which we had complete coverage used just two variables: depth and median grain size, with a rather high correlation ($r = 0.643$); however, we could not take any water column parameters or sediment TOC/TN into account in the full BEST analysis because we did not have data for all stations. Using just the stations ($n = 249$) for which we had the majority of environmental data (Table 1) the highest correlation used depth, mean grain size, median grain size, TOC, and fluorescence with $r = 0.655$ (using just depth and median grain size with the subset of stations resulted in $r = 0.637$). Despite being included in the BEST results, fluorescence's highest correlation with any MDS axis was just -0.283 with MDS1.

The initial LINKTREE run using only depth and median grain size resulted in 101 splits. Adding latitude resulted in a LINKTREE with 71 splits: the lowest number of splits with the fewest variables (see Table A-6 in the Appendix for all options) and only two more than using all the physical parameters, for a total of 72 distinct groupings of stations (Figure 6). Among the 71 splits, four minor splits (F, K, Q, AH) could be described by more than one of the three environmental variables. ANOSIM of these 72 groups had a global R of 0.892. We grouped the 72 termini of the LINKTREE into 12 major habitats based on a cut-off of 25% separation, plus one further major sediment split at $B=18.6\%$ (separating groups IV and V). We did not include splits with higher $B\%$ that resulted in < 5 stations on a terminus as we deemed those more outliers rather than separate habitats. Analyzing these 12 habitat types using ANOSIM resulted in a global R of 0.792.

The average values of the physical parameters that correlated with the MDS axes are given in Table 4 for each habitat group. Also shown are the average number of species and the average number of organisms per 0.1 m^2 box core grab. The individual average abundance per 0.1 m^2 box core and the cumulative percentage contribution to within group similarity of the top 12 "characteristic" species (those species whose abundances are highly contributing to the average similarity within a group as determined by SIMPER) of the 12 regional habitat groups determined by the LINKTREE analysis are shown in Table 5.

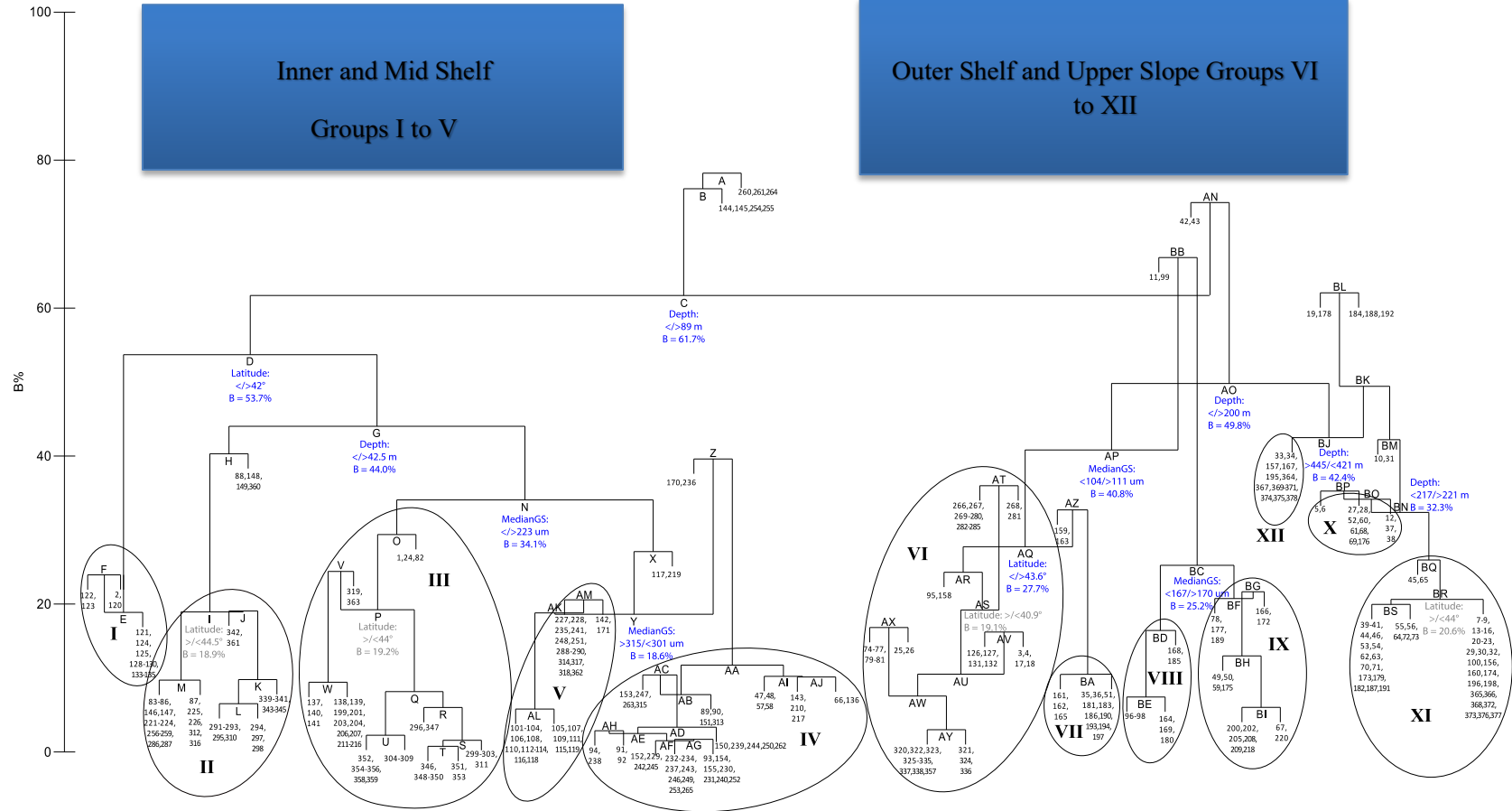


Figure 6. Final LINKTREE of 378 stations using depth, median grain size, and latitude to determine splits. Breaks that were used to determine the 12 regional-habitat groups are detailed in blue.

Table 4. Number of stations, average physical properties, sample richness, and organism abundance per grab for the stations that make up each of the 12 regional-habitat groups as well as the averages for the outliers in each depth division.

| Supervised Group | N | Depth (m) | Fines % | Mean GS | Median GS | TOC | TN | Temp (°C) | DO (m/L) | Salinity | pH | Avg. Rich | Avg. Abund. |
|--------------------------------|----|-----------|---------|---------|-----------|-------|-------|-----------|----------|----------|------|-----------|-------------|
| I: Mid-Shelf Muddy NorCal | 13 | 65.2 | 68.4 | 53.2 | 48.7 | 0.72% | 0.07% | 9.01 | 3.10 | 33.72 | 7.81 | 41.7 | 167.2 |
| II: Inner Shelf (Clean Sand) | 41 | 33.8 | 0.5 | 256.6 | 236.0 | 0.07% | 0.01% | 8.01 | 2.52 | 33.66 | 7.73 | 21.2 | 68.6 |
| III: Mid Shelf <223 um | 48 | 69.6 | 7.8 | 185.3 | 175.7 | 0.31% | 0.03% | 7.58 | 1.90 | 33.79 | 7.69 | 37.3 | 195.1 |
| IV: Mid Shelf <301 um | 46 | 63.7 | 0.4 | 286.8 | 251.4 | 0.08% | 0.01% | 7.71 | 1.69 | 33.76 | 7.67 | 26.3 | 179.6 |
| V: Mid Shelf >315 um | 33 | 63.9 | 0.4 | 459.6 | 430.1 | 0.07% | 0.01% | 7.79 | 1.68 | 33.78 | 7.73 | 20.8 | 94.1 |
| VI: Outer Shelf <104 um North | 15 | 161.5 | 50.0 | 72.4 | 68.2 | 1.38% | 0.14% | 7.28 | 1.78 | 33.82 | 7.71 | 30.9 | 103.9 |
| VII: Outer Shelf <104 um South | 59 | 114.9 | 63.2 | 55.4 | 48.3 | 0.91% | 0.10% | 8.31 | 2.02 | 33.68 | 7.72 | 27.7 | 111.0 |
| VIII: Outer Shelf 111-167 um | 8 | 122.3 | 9.3 | 152.5 | 145.9 | 0.59% | 0.06% | 7.49 | 1.83 | 33.88 | 7.72 | 47.4 | 184.4 |
| IX: Outer Shelf >170 um | 17 | 100.2 | 3.5 | 230.5 | 205.8 | 0.26% | 0.03% | 7.49 | 1.81 | 33.82 | 7.72 | 43.4 | 147.5 |
| X: Slope Break | 13 | 207.4 | 38.7 | 144.9 | 118.5 | 1.24% | 0.14% | 7.30 | 2.35 | 33.96 | 7.88 | 29.2 | 96.5 |
| XI: Upper Slope | 48 | 336.1 | 47.5 | 90.1 | 76.5 | 1.47% | 0.16% | 6.42 | 1.45 | 34.02 | 7.78 | 23.7 | 75.8 |
| XII: Slope | 13 | 484.2 | 80.9 | 39.0 | 28.4 | 1.62% | 0.17% | 5.28 | 0.69 | 34.13 | 7.66 | 13.6 | 25.7 |
| Inner Shelf Outlier | 4 | 19.0 | 0.55 | 197.6 | 193.3 | n.d. | n.d. | 7.84 | 2.13 | 33.67 | 7.70 | 21.3 | 106.0 |
| Mid Shelf Outlier | 7 | 70.2 | 0.8 | 508.6 | 479.4 | 0.12% | 0.02% | 7.63 | 1.35 | 33.83 | 7.65 | 17.9 | 60.1 |
| Outer Shelf Outlier | 4 | 124.5 | 16.6 | 325.3 | 272.2 | n.d. | n.d. | 7.68 | 2.31 | 33.87 | 7.72 | 15.0 | 48.3 |
| Slope Outlier | 9 | 354.1 | 65.6 | 96.7 | 73.2 | 2.46% | 0.29% | 6.56 | 1.51 | 34.03 | 7.81 | 22.2 | 57.2 |

Table 5. The top 12 characteristic species of the 12 regional habitat groups.

Species and percent characteristic (Cum. %) were determined using SIMPER. Average abundance per 0.1 m² box core in each group and the cumulative percentage contribution to within group similarity are listed.

| | | | | | |
|-------------------------------------|-----------|--------|------------------------|--|--|
| I. Mid-Shelf Muddy NorCal | | | Avg. similarity: 41.15 | | |
| | Av. Abund | Cum. % | | | |
| <i>Axinopsida serricata</i> | 33.2 | 9.62 | | | |
| <i>Ennucula tenuis</i> | 16.3 | 18.12 | | | |
| <i>Ninoe gemmea</i> | 4.3 | 23.21 | | | |
| <i>Ampelisca careyi</i> | 2.7 | 28.25 | | | |
| <i>Magelona longicornis</i> | 1.5 | 32.69 | | | |
| <i>Macoma spp</i> | 1.7 | 36.72 | | | |
| <i>Sternaspis fossor</i> | 3.2 | 40.69 | | | |
| <i>Acteocina spp</i> | 1.4 | 44.56 | | | |
| <i>Euclymeninae spp</i> | 0.9 | 48.09 | | | |
| <i>Turbonilla spp</i> | 0.8 | 51.62 | | | |
| <i>Paraprionospio alata</i> | 0.8 | 55.12 | | | |
| <i>Maldane sarsi</i> | 1.2 | 57.93 | | | |
| II. Inner Shelf Clean Sand | | | Avg. similarity: 30.60 | | |
| | Av. Abund | Cum. % | | | |
| <i>Callianax pycna</i> | 1.6 | 9.40 | | | |
| <i>Carinoma mutabilis</i> | 1.0 | 17.88 | | | |
| <i>Scoloplos acmeceps</i> | 0.7 | 24.60 | | | |
| <i>Majoxiphalus major</i> | 0.6 | 30.58 | | | |
| <i>Dendraster excentricus</i> | 0.3 | 35.74 | | | |
| <i>Chaetozone bansei</i> | 0.3 | 40.41 | | | |
| <i>Nephtys caecoides</i> | 0.2 | 44.91 | | | |
| <i>Rhepoxynius vigitegus</i> | 0.4 | 48.96 | | | |
| <i>Magelona sacculata</i> | 0.2 | 53.00 | | | |
| <i>Eohaustorius sencillus</i> | 0.3 | 56.73 | | | |
| <i>Rhepoxynius spp</i> | 0.2 | 60.42 | | | |
| <i>Eohaustorius sawyeri</i> | 0.2 | 63.84 | | | |
| III. Mid Shelf <223 um | | | Avg. similarity: 31.78 | | |
| | Av. Abund | Cum. % | | | |
| <i>Axinopsida serricata</i> | 37.2 | 14.51 | | | |
| <i>Ennucula tenuis</i> | 2.4 | 20.85 | | | |
| <i>Pinnixa occidentalis</i> complex | 3.0 | 25.72 | | | |
| <i>Acila castrensis</i> | 1.6 | 30.60 | | | |
| <i>Amphiodia urtica</i> | 0.7 | 34.05 | | | |
| <i>Onuphis iridescentis</i> | 0.4 | 37.17 | | | |
| <i>Kurtiella tumida</i> | 1.4 | 40.24 | | | |
| <i>Scoletoma luti</i> | 0.5 | 42.91 | | | |
| <i>Ampelisca careyi</i> | 0.3 | 45.56 | | | |
| <i>Nephtys spp</i> | 0.2 | 48.07 | | | |
| <i>Cylichna attonsa</i> | 0.2 | 50.56 | | | |
| <i>Rhepoxynius spp</i> | 0.2 | 52.86 | | | |
| IV. Mid Shelf <301 um | | | Avg. similarity: 39.72 | | |
| | Av. Abund | Cum. % | | | |
| <i>Axinopsida serricata</i> | 32.6 | 15.01 | | | |
| <i>Nutricola lordi</i> | 29.0 | 27.73 | | | |
| <i>Cylichna attonsa</i> | 4.2 | 37.10 | | | |
| <i>Magelona sacculata</i> | 1.2 | 42.57 | | | |
| <i>Ampelisca careyi</i> | 1.0 | 47.88 | | | |
| <i>Euphilomedes carcharodonta</i> | 0.9 | 52.26 | | | |
| <i>Callianax baetica</i> | 0.8 | 56.53 | | | |
| <i>Spiophanes norrisi</i> | 0.4 | 59.99 | | | |
| <i>Onuphis iridescentis</i> | 0.5 | 63.36 | | | |
| <i>Alia gausapata</i> | 0.6 | 66.56 | | | |
| <i>Glycinde armigera</i> | 0.3 | 69.69 | | | |
| <i>Carinoma mutabilis</i> | 0.2 | 71.88 | | | |
| V. Mid Shelf >315 um | | | Avg. similarity: 35.22 | | |
| | Av. Abund | Cum. % | | | |
| <i>Nutricola lordi</i> | 10.0 | 14.78 | | | |
| <i>Ophelia assimilis</i> | 3.2 | 26.59 | | | |
| <i>Spiophanes norrisi</i> | 1.1 | 34.13 | | | |
| <i>Tellina nukuloides</i> | 1.0 | 41.23 | | | |
| <i>Axinopsida serricata</i> | 1.9 | 48.28 | | | |
| <i>Callianax baetica</i> | 0.6 | 54.40 | | | |
| <i>Cylichna attonsa</i> | 0.4 | 58.66 | | | |
| <i>Aphelochaeta spp</i> | 0.5 | 62.77 | | | |
| <i>Axiotella rubrocincta</i> | 0.3 | 66.80 | | | |
| <i>Alia gausapata</i> | 0.2 | 69.94 | | | |
| <i>Microspio pigmentata</i> | 0.1 | 72.52 | | | |
| <i>Pinnixa occidentalis</i> complex | 0.1 | 74.65 | | | |

| | | | | | |
|----------------------------------|------------------------|--------|----------------------------------|------------------------|--------|
| VI. Outer Shelf <104 um South | Avg. similarity: 32.38 | | VII. Outer Shelf <104 um North | Avg. similarity: 33.42 | |
| | Av. Abund | Cum. % | | Av. Abund | Cum. % |
| <i>Axinopsida serricata</i> | 14.5 | 13.32 | <i>Axinopsida serricata</i> | 17.7 | 13.92 |
| <i>Acila castrensis</i> | 3.3 | 22.16 | <i>Rhabdus rectius</i> | 4.8 | 22.73 |
| <i>Macoma carlottensis</i> | 2.9 | 30.88 | <i>Adontorhina cyclia</i> | 1.7 | 29.79 |
| <i>Amphioplus strongyloplax</i> | 1.0 | 37.22 | <i>Pectinaria californiensis</i> | 1.7 | 36.61 |
| <i>Onuphis iridescens</i> | 0.7 | 43.30 | <i>Galathowenia oculata</i> | 2.6 | 42.43 |
| <i>Adontorhina cyclia</i> | 0.5 | 47.50 | <i>Euclymeninae spp</i> | 0.5 | 46.18 |
| <i>Rhabdus rectius</i> | 0.5 | 51.15 | <i>Macoma carlottensis</i> | 0.5 | 49.92 |
| <i>Brisaster latifrons</i> | 0.2 | 53.99 | <i>Onuphis iridescens</i> | 0.4 | 53.60 |
| <i>Ninoe gemmea</i> | 0.2 | 56.69 | <i>Heterophoxus spp</i> | 0.5 | 57.13 |
| <i>Sternaspis fossor</i> | 0.2 | 59.32 | <i>Amphioplus macraspis</i> | 0.2 | 60.16 |
| <i>Paraprionospio alata</i> | 0.1 | 61.93 | <i>Ninoe gemmea</i> | 0.2 | 62.98 |
| <i>Ennucula tenuis</i> | 0.2 | 64.11 | <i>Amphiodia urtica</i> | 0.1 | 65.55 |
| VIII. Outer Shelf 111-167 um | Avg. similarity: 33.37 | | IX. Outer Shelf >170 um | Avg. similarity: 31.08 | |
| | Av. Abund | Cum. % | | Av. Abund | Cum. % |
| <i>Spiochaetopterus costarum</i> | 12.5 | 6.23 | <i>Pista estevanica</i> | 1.9 | 5.19 |
| <i>Paraprionospio alata</i> | 1.5 | 11.97 | <i>Acila castrensis</i> | 1.5 | 9.98 |
| <i>Axinopsida serricata</i> | 6.2 | 17.65 | <i>Amphiodia urtica</i> | 1.1 | 14.70 |
| <i>Magelona longicornis</i> | 3.3 | 22.77 | <i>Axinopsida serricata</i> | 2.6 | 19.12 |
| <i>Rhabdus rectius</i> | 3.1 | 27.53 | <i>Onuphis iridescens</i> | 1.0 | 23.36 |
| <i>Amphioplus macraspis</i> | 2.0 | 32.28 | <i>Cylichna attonsa</i> | 1.0 | 27.55 |
| <i>Nephtys ferruginea</i> | 1.2 | 36.91 | <i>Magelona berkeleyi</i> | 1.6 | 31.52 |
| <i>Paradiopatra parva</i> | 1.3 | 41.22 | <i>Ennucula tenuis</i> | 1.5 | 35.36 |
| <i>Euclymeninae spp</i> | 1.1 | 45.13 | <i>Prionospio steenstrupi</i> | 1.6 | 39.13 |
| <i>Myriochele gracilis</i> | 1.8 | 48.53 | <i>Glycera nana</i> | 0.4 | 42.26 |
| <i>Thyasira flexuosa</i> | 0.8 | 51.85 | <i>Huxleyia munita</i> | 0.8 | 45.18 |
| <i>Glycinde armigera</i> | 0.4 | 54.68 | <i>Paraprionospio alata</i> | 0.4 | 48.01 |

| | | | | | |
|----------------------------------|------------------------|--------|----------------------------------|------------------------|--------|
| X. Slope Break (200 – 221 m) | | | XI. Upper Slope (221–445 m) | | |
| | Avg. similarity: 24.27 | | | Avg. similarity: 29.33 | |
| | Av. Abund | Cum. % | | Av. Abund | Cum. % |
| <i>Axinopsida serricata</i> | 3.8 | 13.04 | <i>Huxleyia munita</i> | 8.8 | 16.68 |
| <i>Adontorhina cyclia</i> | 2.4 | 25.59 | <i>Galathowenia oculata</i> | 1.9 | 25.29 |
| <i>Galathowenia oculata</i> | 4.4 | 33.70 | <i>Gadila tolmiei</i> | 0.9 | 33.74 |
| <i>Heterophoxus spp</i> | 0.3 | 39.18 | <i>Onuphis iridescens</i> | 0.8 | 41.78 |
| <i>Onuphis iridescens</i> | 0.5 | 43.80 | <i>Brisaster latifrons</i> | 0.4 | 48.61 |
| <i>Sternaspis assimilis</i> | 0.2 | 48.08 | <i>Ennucula tenuis</i> | 0.4 | 54.89 |
| <i>Rhabdus rectius</i> | 0.2 | 52.26 | <i>Chaetoderma argenteum</i> | 0.4 | 60.69 |
| <i>Maldane sarsi</i> | 0.2 | 56.32 | <i>Rhabdus rectius</i> | 0.2 | 64.65 |
| <i>Aricidea (acmira) simplex</i> | 0.2 | 59.26 | <i>Adontorhina cyclia</i> | 0.2 | 67.97 |
| <i>Amphioplus macraspis</i> | 0.1 | 62.18 | <i>Amphioplus macraspis</i> | 0.1 | 70.76 |
| <i>Huxleyia munita</i> | 0.1 | 64.22 | <i>Axinopsida serricata</i> | 0.1 | 73.41 |
| <i>Mendicula ferruginosa</i> | 0.1 | 66.25 | <i>Pectinaria californiensis</i> | 0.1 | 75.86 |
| XII. Slope (445 – 525 m) | | | | | |
| | Avg. similarity: 28.05 | | | | |
| | Av. Abund | Cum. % | | | |
| <i>Huxleyia munita</i> | 1.00 | 17.16 | | | |
| <i>Rhabdus rectius</i> | 0.50 | 29.31 | | | |
| <i>Maldane sarsi</i> | 0.70 | 40.54 | | | |
| <i>Chaetoderma argenteum</i> | 0.30 | 49.52 | | | |
| <i>Glycinde armigera</i> | 0.10 | 56.33 | | | |
| <i>Phoronidae sp</i> | 0.20 | 61.89 | | | |
| <i>Gadila tolmiei</i> | 0.06 | 66.47 | | | |
| <i>Brisaster latifrons</i> | 0.04 | 70.27 | | | |
| <i>Cerebratulus spp</i> | 0.03 | 73.44 | | | |
| <i>Praxillella gracilis</i> | 0.03 | 76.27 | | | |
| <i>Eucranta aniculata</i> | 0.03 | 79.08 | | | |
| <i>Artacama coniferi</i> | 0.03 | 81.76 | | | |

The first major split in the LINKTREE (C) was associated with a depth break at 89 m. We classified the shallower side of this split (left side of the tree) as mid and inner shelf habitats. Within this group, the next split (D) was a latitude split at 42°, which is essentially the Oregon-California (OR-CA) border. Stations on the left side of this split were from the site off Eureka, California, except for one: the southern-most station sampled in Oregon. This “Mid-Shelf Muddy NorCal” group (Group I) of stations ranged 52 to 77 m deep and had much higher percent fine sediment (68.4%) than the rest of the mid to inner shelf stations (average 2.5%). The mid-shelf, muddy northern California community was characterized by the ubiquitous bivalves *Axinopsida serricata* and *Ennucula tenuis*. Unique to Group I were the polychaetes *Ninoe gemmea*, *Magelona longicornis*, and *Sternaspis fossor*, which are uncommon on the sandier, mid-shelf stations of Oregon.

The next split (G) define a break between the inner- and mid-shelf. Stations on the shallower side of this split ranged 18.2 to 42.5 m deep and consisted mostly of clean sand (0 – 1.82% fines) with average median grain size of 235 µm; thus, we called this “Inner Shelf Clean Sand” (Group II). The top characteristic species of this group were the snail *Olivella (Callianax) pycna*, the nemertean, *Carinoma mutabilis*, the polychaete, *Scoloplos acmeceps*, the amphipod, *Majoxiphalus major*, and the sand dollar, *Dendraster excentricus*, of which only the polychaete was characteristic in any other habitats. Notably, no bivalves were in the top 12 characteristic species for the Inner Shelf Clean Sand habitat. A subsequent split in this group was detected at 44.5° latitude with a separation value of 18.9%.

On the mid-shelf (depths 42.8 – 88 m) the next split (N) was at $</>223$ µm. On the mid-shelf where grain sizes were less than 223 µm (left side of split N, Group III), stations averaged 7.8% fines and hosted slightly different assemblages in the north and south of the study region (44.0 °N split P, with a similarity of 18.6%, similar in separation value and latitude as found in Group II). As in California at these depths, the bivalves *A. serricata* and *E. tenuis* were highly characteristic, and these regions shared three other characteristic species. Additionally, the pea crab, *Pinnixa occidentalis* complex, and the bivalves, *Kurtiella tumida* and *Acila castrensis* were highly contributing (particularly in the south) as well as the brittle star *Amphiodia urtica* and *Onuphis iridescentis* (particularly in the north). Larger than 223 µm, stations were further subdivided into $<301/>315$ µm (split Y, Group IV and V). Here, bivalves were abundant, particularly *Nutricula lordi* and the ubiquitous *A. serricata*, along with the gastropods *Cylichna attonsa*, *Callianax baetica*, and *Alia gausapata*. The larger grain sized group (Group V) had the bivalve *Tellina nukuloides* as the 4th most characteristic species, which was uncommon among stations in the <301 µm group (Group IV) and *A. serricata* was far less abundant in this grain size class than anywhere else on the mid shelf. Most differences between Groups IV and V were in the characteristic polychaetes: only *Spiophanes norrisi* was shared.

The deeper waters (right side of C) were structured similarly to the inner and mid shelf groups, having three grain size groups and lower separation latitudinal breaks within four Outer Shelf and three slope groups. The four outer shelf groups (89 to 200 m and left side of AO) are defined by grain size. The smaller grain size stations (< 104 µm) split into a southern (Group VI) and northern (Group VII) groups (AQ at a latitude of 43.6°). This latitudinal break is similar to the break found in the mid-shelf within Group III at 44.0° and inner-shelf Group II at 44.5°. At these smaller grain size (< 104 µm) stations, bivalves *Macoma carlottensis* and *Adontorhina cyclia* (both regions) and *Acila castrensis* (in the south, Group VI) were more characteristic than the less abundant, *E. tenuis*. *Amphioplus* spp. brittle stars (different species in north and south) replaced *A. urtica*, and the heart urchin *Brisaster latifrons* was characteristic of the southern group (Group VI). The scaphopod, *Rhabdus rectius* was characteristic of both groups. Within the southern group (Group VI), a second latitudinal break was detected at 40.9° latitude (isolating the California stations from southern Oregon) with a Similarity (B) value of 19.1%. In the Outer Shelf > 111 µm group there was a secondary split at $<167/>170$ µm (BC forming Groups VIII and IX). In the Outer Shelf 111-167 µm group (Group VIII) polychaetes were the most highly

contributing species along with *A. serricata*, *R. rectius*, and *A. macraspis*. In the largest grain size class on the outer shelf (>170 μm , Group IX), a different suite of polychaetes was characteristic, along with, *Amphiodia urtica*, *Acila castrensis* and *Cylichna attonsa*, all of which are characteristic of mid-shelf stations with similar grain size (Group III).

Split AO represents the 200 m shelf-slope break. The next split (BJ) isolated stations 445 m to 525 m with no subsequent distinctions based on sediment characteristics or latitude (although we only sampled stations that deep from 43.40°N to 43.75 °N). The Slope assemblage (Group XII) had only 28.05% within group similarity and was characterized primarily by the bivalve, *Huxleyia munita*, and the scaphopod, *Rhabdus rectius*. Polychaetes *Maldane sarsi* and *Glycinde armigera* and the “glistenworm” *Chaetoderma argenteum*, a shell-less mollusc, also were in the top five characteristic species. Split BN then isolated stations less than 217 m deep on the slope. These Slope Break stations (Group X) had the lowest within group similarity (24.27%; constituting three separate groups on the LINKTREE) and were characterized by both common shelf and slope taxa. A latitudinal break at 44 °N (BR) – as on the shelf – was detected in the remaining 56 Upper Slope stations between 224 and 445 m deep. Collectively, the Upper Slope stations were characterized primarily by the bivalve, *Huxleyia munita*, polychaetes, *Galathowenia oculata* and *Onuphis iridescens* and scaphopods *Gadila tolmiei* and *Rhabdus rectius* (particularly in the south). The bivalves *Ennucula tenuis* and *Adontorhina cyclia*, the heart urchin, *B. latifrons*, and the glistenworm *C. argenteum* also were characteristic.

3.4 Discussion

Establishing an understanding of benthic species-habitat associations over broad spatial scales is useful to marine spatial planning for many purposes including the siting and evaluating offshore renewable energy projects. Just as isolated mapping data was not sufficient for the groundfish EFH process, knowing that 100 worms were found in sand at one specific site does not alone provide the tools for resource managers to assess benthic resources or describe potential impacts from human activities on the sea floor. However, knowing the distributions of benthic invertebrates at a regional scale provides data applicable to cumulative impact assessments and context for project-specific surveys.

We sought to classify benthic sedimentary habitats across the shelf and upper slope in the PNW based on the macrofaunal organisms living in and on the sediment. This and a previous BOEM study (Henkel et al. 2014) represent the first attempts to examine spatial variability in macrofaunal communities with consistent sampling and identification methodology from the inner shelf, across the shelf break, and down the slope in the eastern north Pacific.

Previous studies in the region focused only on the mid to outer shelf, and did not find major distinctions in macrofauna assemblages based on depth but found very distinct breaks correlated with sediment characteristics (Henkel and Politano 2017, Henkel and Nelson 2018). In this current study, spanning a much broader depth range, we did find major differences in macrofauna assemblages based on depth with subsequent distinctions related to sediment characteristics within major depth zones. This pattern follows that observed by Lissner (1989) in the northern and central California planning regions, where the major pattern in benthic community sampled between 90 and 600 m deep was related first to depth and then sediment-size characteristics, while other inter-basin differences (e.g., temperature and dissolved oxygen) appeared to have minor influence. Similarly, Bergen et al. (2001) sampled fauna from 10 to 200 m deep in southern California and found depth and secondary grain size-related distinctions, but did not identify any influence of latitude in defining assemblages. Our BEST result ($\text{Rho} = 0.643$ using just depth and median grain size) is numerically similar to the findings of Shumchenia and King (2010) from Narragansett Bay, where they found $\text{Rho} = 0.689$ with water depth, percent sand, and standard deviation of backscatter as variables.

We expected the shelf-slope break to be the most dramatic break in macrofauna assemblages. In Oregon the outer edge of the shelf has been reported as ranging 130 to 183 m deep (Byrne and Panshin 1977), and BOEM defines the edge of the OCS as 200 m consistent with Mendal (1964) and Davis (1972). However, the break in physical parameters resulting in the most distinctive assemblages was depth at ~90 m. Although unexpected, a transition at this depth has been reported before. While Bergen et al. (2001) classified the outer shelf as beyond 115 m, they explained that the transition between the two assemblages was found at depths of 90 to 115 m and cited earlier surveys conducted by the Hancock Foundation that found the deeper limit of their mid-depth assemblage to be 92 m (Barnard and Hartman 1959, Barnard and Ziesenhenné 1960, Jones 1964, 1969). This assemblage break at 90 m was also found when Henkel et al. (2014) used cluster analysis on the 2003 WEMAP macrofaunal dataset in the BOEM-BHC project. In describing the distribution of organic carbon in surface sediment in the northeast Pacific Ocean, Gross et al. (1972) referred to the inner continental shelf as < 90 m and the outer continental shelf as 90 – 180 m, supporting the 90 m delineation in macrofaunal clusters found by our study; associating TOC differences with this boundary may suggest that sediment organic carbon may be the causative factor in this observed depth break on the shelf. While depth and TOC were strongly positively correlated at our sampled stations (Figure A-1) without an obvious break at 90 m (Figure A-2), deeper than 90 m, there are no stations with less than 0.15% TOC. In our current study, deeper than 90 m the next major break was at 200 m, consistent with what is considered the edge of the continental shelf (Mendal 1964, Davis 1972) and the major break in the dendrogram constructed by Lissner (1989) for central and northern California OCS macrofauna collected from 90 to 600 m deep.

Beyond 200 m, stations deeper than 445 m held distinct assemblages, a depth break similar to the edge of the mid-slope as reported by Lissner (450 m) and consistent with the break in Hyland's (1991) stations where a break was detected between 410 and 565 m (no stations in between were sampled). Shallower than 90 m, we detected a depth break at ~43 m. This is slightly shallower than the distinct break in bivalve assemblages in Oregon reported by Voochries et al. (2018; 50 m), but the same as the deeper bounds of the shallow clusters determined in Bergen et al. (2001) for southern California. The approach used by Lissner (1989) and Bergen et al. (2001) was to build cluster dendrograms based on the macrofaunal assemblages, correlate those clusters with physical parameters, and then rank which parameters most contributed. In our approach, we used the LINKTREE routine to find breaks in the physical parameters that maximized differences among the biological assemblages at the stations. Considering that the studies were conducted in three different regions with overlapping but not continuous depth ranges using different statistical approaches, it is remarkable that similar depth delineations were found among them.

In addition to the species composition changes with depth, species richness also varied with depth. The number of species per grab (sample or areal richness) and the number of organisms per grab (abundance) declined with depth, and both of these trends also were described by Lissner (1989) and Oliver et al. (2011). Since the number of species can be positively related to the number of individuals, there is an argument that a decline in the number of species per area may simply be the result of having fewer individuals in the sample (Gotelli and Colwell 2001). Standardizing by number of individuals avoids this statistical problem; although Oliver et al. (2011) argue for the importance of comparing communities in a known spatial context. In our study, when the number of species per grab was standardized by the number of organisms per grab the resulting numerical richness actually was highest at the deepest depth. At stations less than 90 m the numerical richness averaged 0.26, on the outer shelf (90 to 200 m) it averaged 0.35, the Slope Break averaged 0.38, the Upper Slope averaged 0.39, and on the Slope (445 to 525 m) it was 0.59 as has been found in other studies where numerical species richness peaks along the slope (Rex 1981, 1983; Levin et al. 2001). In contrast, Oliver et al. (2011) found that numerical species richness was quite similar across depths off California while Menot et al. (2010) found it to be highest along continental margins.

Within each of the depth zones, while further distinctions among macrofaunal assemblages were related to sediment characteristics – primarily median grain size – the biologically relevant breaks in grain size differed between the mid-shelf, outer-shelf, and slope. This lack of a consistent pattern across depths may be why other authors have reported grain size characteristics to be relatively more important at the local scale (e.g., Reiss et al. 2010). On the mid-shelf (43 – 90 m) in Oregon/Washington there appear to be three biologically defined habitats with increasing sediment grain size (III: < 223 μm , IV: < 301 μm , and V: > 315 μm). The < 223 μm break described herein is essentially the > 1% fine sediment described in Henkel and Politano (2017), and reinforces the additional break around 300 μm ; it is not surprising as the 137 stations sampled in that study were a subset of the 404 analyzed in this effort. However, this > 223 μm (< 1% fines) group now includes stations from 45° to 46°N (north of Newport and south of Nehalem, Oregon), which was a major latitudinal gap in Henkel and Politano (2017). These clean sand groups are notable due to the overall low species density (average ~ 23 taxa per grab) relative to other shelf groups (~37 taxa per grab).

In the silt-containing mid-shelf Oregon/Washington stations (< 223 μm), we detected a latitudinal gap between 43.8° and 44.5°N with groups of stations clustering north and south of that gap. This gap is, in part, due to the fact that no silt-containing stations were sampled on the mid-shelf of the central Oregon coast as the clean sand extends further offshore in this region. While these groups were delineated in the LINKTREE using latitude, they also represent a divergence of sediment types, with the northern stations averaging 189 μm (0.24% TOC) and the southern stations averaging 165 μm (0.35% TOC), although latitude was used because a clear threshold in grain size or TOC could not be correlated with the station groupings by the LINKTREE routine. Sediment grain size data are often correlated with infaunal community parameters to try to establish relationships between them (Henkel and Politano 2017). However, Snelgrove and Butman (1994) found little evidence that grain size alone was a causative factor in determining species distributions, as hydrodynamic energy and organic content of the sediment vary with grain size and can directly influence feeding and settling dynamics of benthic fauna more so than the particle size. The mid-shelf, muddy northern California stations had ten times the percentage of fine sediment, much smaller grain size, and twice the TOC content compared to the stations at the same depth in the smallest grain size in Oregon. Although our current study did not resolve differences among sediment and other potential factors related to latitude, Henkel and Nelson (2018) also identified a latitudinal break in macrofaunal composition at the OR-CA border even after accounting for differences related to the > 5% fines threshold, indicating factors related to hydroclimate and/or species dispersal likely play a role.

On the outer shelf (90 – 200 m deep), differences in macrofaunal assemblages also distinguished among three grain size classes with breaks at ~110 μm and ~170 μm median grain size. Henkel and Politano (2018) reported a similar break at ~112 μm . When considering outer shelf stations with smaller grain size (< 104 μm ; groups VI and VII), northern and southern (break at 43.6°) assemblages were again distinguished as on the mid-shelf with the more northern group having slightly larger median grain size; however, on the outer shelf the northern stations also had higher percent TOC (1.38% vs. 0.91%). While this seems contrary to the classic relationship between grain size or percent fines and TOC, Gross et al. (1972) note that “although there is substantial variation, the amount of organic carbon in the sediment at any depth is usually...lowest near the OR-CA boundary”, indicating a latitudinal trend in TOC that may be driven by other factors. The Outer Shelf < 104 μm South group (IV) also differed from the rest of the outer shelf groups by having warmer, more oxygenated bottom water. Finally, it contained a subsequent split between southern Oregon and stations from the northern San Andreas Fault area of California. This is consistent with the split on the mid-shelf separating our Eureka stations from southern Oregon and both are consistent with the break detected by Henkel and Nelson (2018) at the OR-CA border in the 2003 EMAP samples. The Outer Shelf 111 – 167 μm group (VIII) was similar in average depth to the smaller

grain size groups, but had approximately half the TOC content). The largest grain size group on the Outer Shelf (>170 μm ; IX) again had less than half the TOC content of group VIII.

On the slope, we identified three major depth ranges (as on the shelf) which we termed Slope Break, Upper Slope, and Slope. Further distinctions within those depth zones on the slope were not defined by the LINKTREE by breaks in sediment grain size; however, in the Upper Slope group (XI) a similar latitudinal break (at 44 °N) was detected as on mid-shelf. This latitudinal break corresponds to a break in sediment type, where more northern stations average larger grain size while the more southern stations average smaller; however, TOC conditions were similar in both regions at these Upper Slope stations. Among all the slope stations, grain sizes, percent fines, and TOC all were similar to the smallest grain size class defined on the outer shelf. However, percent fines and TOC increased with slope depth along with median grain size, temperature, oxygen, and pH decreasing, making it challenging to determine the actual drivers for assemblage differences across slope depths. Hyland et al. (1991) attributed depth-related patterns in abundances and diversity to a dissolved oxygen gradient. While we were not able to include dissolved oxygen as a potential factor in the BEST analysis (as we did not have data for all stations), it was the second highest correlate with MDS2 and is anti-correlated with depth.

3.4.1 Relationship to Offshore Development

Newer approaches are needed for sea floor planning and predicting an/or assessing impacts occurring at wide spatial scales. Macrofauna are an established tool to quantify the relative degree of anthropogenic impact, used most often in point source discharges occurring in defined areas of the ocean floor (Muxika et al. 2007, Ranasinghe et al. 2012). However, accurately assessing biotic condition over large spatial scales can be logistically challenging, especially when factoring in the water depths of the continental shelf and slope. Habitat mapping classified by surficial geology – used as a proxy for biological habitats – has commonly been used in ocean sea floor planning decisions, yet many suggest changes to the sediment classifications within EUNIS (Galparsoro et al. 2012), and CMECs (Henkel and Politano 2017) need to be made to better reflect the biological communities (Shumchenia and King 2010).

An improved approach would be to quantify the relationship between the species distributions and the environment, using local, faunal-based survey data to inform large-scale modeling of species occurrence predicted from more easily measurable environmental data (Dutertre et al. 2013). Here, we used differences in species assemblages to find meaningful breaks in more easily measured environmental data in order to develop habitat classifications. For planning, these results can be used to set expectations of what macrofaunal species are likely to occur in particular habitat types. As a case study, we can apply our soft bottom habitat characterizations to two marine hydrokinetic projects proposed in the PNW that would be expected to have direct or indirect impacts on soft sediment benthic communities (Dannheim et al. 2019; Boehlert and Gill 2010). The two projects are at different stages and follow distinct permitting pathways. Yet the results of this study can guide the design and define the reference areas and area of potential impact for both.

While both Oregon and northern California have strong wind and wave resources, are of interest for marine renewable energy development, and may have similar impacting factors to the seafloor, projects could be located in different sea floor soft bottom habitats with very different macrofaunal assemblages. PacWave South is in the final permitting stages offshore Newport, Oregon (central Oregon), to be a testing center for wave-powered marine hydrokinetic devices. The seafloor at PacWave South is Mid Shelf Clean Sand (Groups IV and V, average depth 63 m), which is a distinct medium to coarse sand-dominated stretch of the Oregon central mid shelf. In contrast, offshore Eureka, California (northern California, average depth 900 m), where there is also interest in renewable energy, the seafloor is deeper. This area is deeper than the studied area, but is most closely associated with the deepest Slope habitat group (Group XII, average depth 484 m). That group has the highest TOC and percent fines of the areas sampled in this project, while also being in the latitudinal range of the Mid Shelf California Mud group

(Group I, average depth 65 m), which has the second highest percent fines; thus we expect the area offshore Eureka to have high percentages of silt and TOC. In addition to hosting different macrofaunal assemblages, soft bottom community recovery differs depending on the local sediment and flow conditions (Kaiser et al. 2000, Bergman et al. 2015, Silberberger et al. 2019). We hypothesize then that the physical and biological responses to impacting factors and ecological recovery will be different in central mid shelf Oregon versus the upper slope of northern California. Having this expectation prior to development, instead of a post-hoc discovery, will aid in planning and the development of monitoring plans.

A regional characterization of the macrofaunal communities is needed to establish context for projects prior to development. However, the long-term need is to understand the alterations to ecological functioning and ecological processes that result from seafloor impacts (Dannheim et al. 2019). This means that to understand the macrofauna distribution at a finer temporal and spatial scale within a region, more hydrodynamic parameters need to be measured consistently (Dutertre et al. 2013). For artificial reef effects associated with offshore structures, TOC and nitrogen may become important signals as there is some evidence that artificial (oyster shell) reefs increase TOC and TN content in surface sediments (Xu et al. 2014). Further, to understand the impacts of development and the condition of the seafloor over time, the macrofauna species and communities should be linked to benthic condition indices. A site-specific response relies on knowing the functional role of the species of interest. Linking macrofauna condition to the ecological processes (Frid 2011) means that we need to next understand the forage value (Bond et al. 1999) and trophic links to groundfish species important in the PNW. Finally, ecological function needs to be evaluated in the context of many other stressors such as changing climate and fishing impacts (Cada et al. 2007, Birchenough et al. 2015, Dannheim et al. 2019). This work is a step towards utilizing predictive modeling and quantifying species abiotic relationships with the aim at identifying ecosystem consequences of changes to various environmental factors (Mélédér et al. 2010; Dutertre et al. 2013).

3.4.2 Conclusions

This study classified the macrofaunal communities of the PNW continental shelf and upper slope soft bottom into 12 habitats. These habitats represent key depth and sediment-related breaks in macrofaunal community composition. Our results are consistent with the pattern of depth-related macrofauna assemblages throughout the California Current, supported by several studies in different parts of the California Current spanning over 30 years. Sediment characteristics were important parameters not just on the inner to mid-shelf as determined in Henkel and Politano (2017), but also further across the shelf and down the slope. In classifying these habitats, we can create a context for describing the current communities in the region for soft bottom; a region undergoing changes in ocean hydrology, changes in bottom trawling pressure, and of growing interest for energy development projects. Establishing a soft bottom characterization for the PNW offshore will aid in the increasingly standardized and quantitative assessments of impacts.

4 Data Gathering and Species Selection for Region-wide Habitat Suitability Modeling

4.1 Purpose

A prior regional analysis of benthic habitat distribution (referenced as Benthic Habitat Characterization BOEM-BHC, Henkel et al. 2014) was motivated by wave energy project proposals in northern California and Oregon. Since that analysis, there has been greater interest in siting marine renewable energy projects in deeper waters of the continental slope, as well as waters further south in central and southern California. In response to this increase in geographic scope, we aimed to expand the depth and latitudinal range of habitat suitability models, like those developed in the BHC project, by incorporating other survey programs in California as well as Oregon. These models will be designed and run by NCCOS (they are not updates of the same BayesNet models from the 2014 BHC project) and will be described in a separate BOEM report that NCCOS will develop under Interagency Agreement Number M16PG00014.

4.2 Study Area

The data for this chapter spanned from the California-Mexico border to Vancouver, Washington (Figure 7). Sample data are from stations 3 to 1023 m deep.

4.3 Approach

Additional BOEM-funded research by the Southern California Coastal Water Research Project (SCCWRP) offered the opportunity to incorporate the many years of macrofaunal samples collected as part of the Southern California Bight Regional Monitoring Program (Schiff et al. 2016) to potentially expand the domain of the habitat suitability models to the entire lower US west coast. However, this combination of the OSU samples (spanning Fort Bragg, California, to Grays Harbor, Washington) plus the SCCWRP data left a large portion of the California coast without observations (e.g., Monterey, San Francisco, Humboldt). To fill these spatial gaps, we sought data from previous sampling programs carried out by various entities in the central and northern California region (e.g., EPA-WEMAP, EPA-Army Corps dredge disposal sampling, NOAA, municipalities). Thus, we endeavored to obtain as many of those records as possible to gain more complete coverage of the lower states of the US west coast.

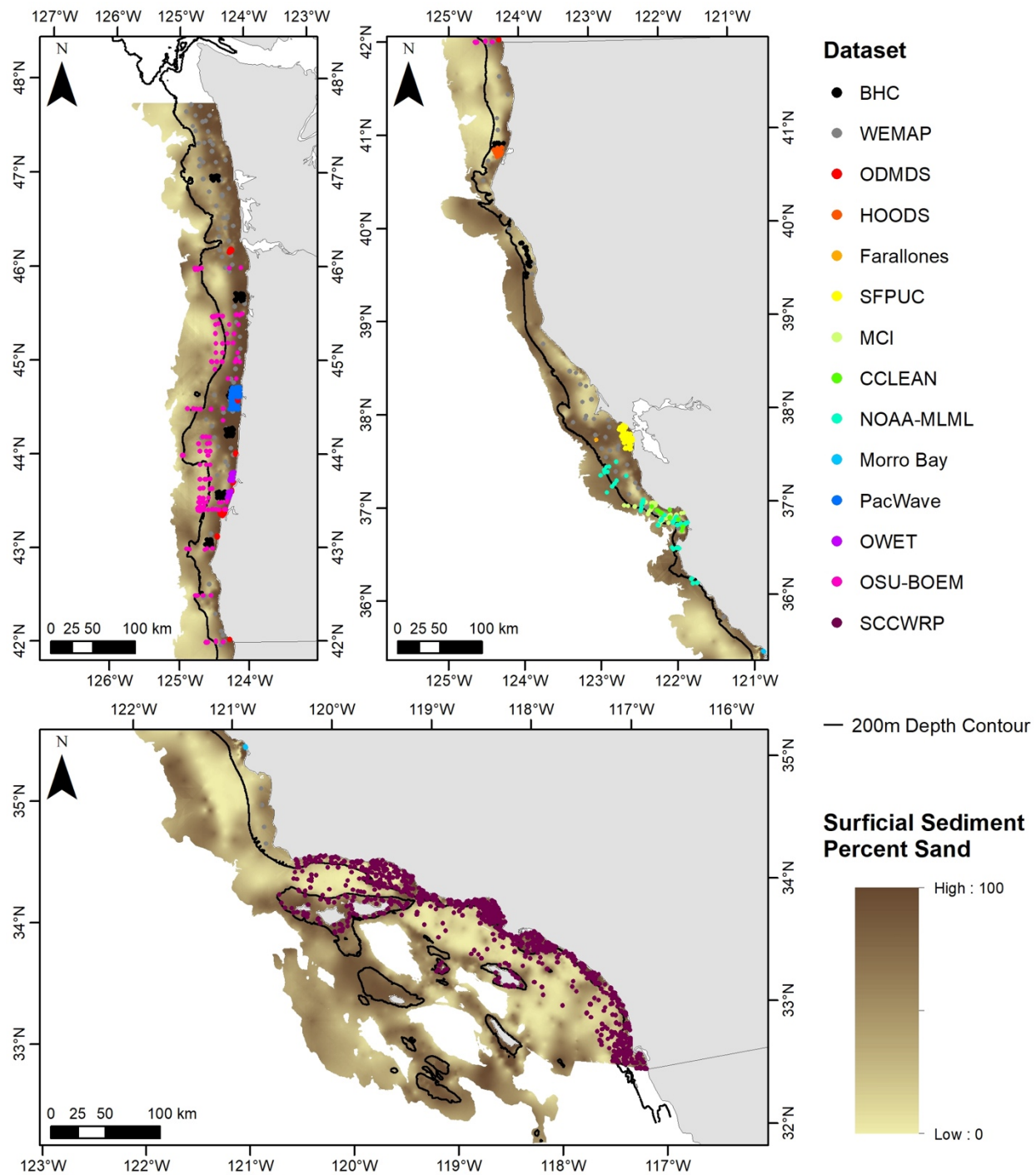


Figure 7. Station locations for the 14 datasets included for modeling.

Details of each dataset are included in Table 6. The base map shows the surficial sediment percent sand and the 200 m depth contour.

4.4 Data Collection and Processing

The Henkel lab provided many of the northern region datasets including data from this BOEM-funded study and the BOEM-BHC project as well as data from in and around the PacWave facilities operated by OSU's Pacific Marine Energy Center and from a project off Reedsport and Coos Bay, Oregon, funded by the Oregon Wave Energy Trust. The EMAP data are available for download from the National Coastal Assessment Coastal Data Search Engine: <https://oaspub.epa.gov/coastal/coast.search>. The 2003 EMAP data for California north of Point Conception, Oregon, and Washington were included in the MS Access database developed by the Henkel lab. Additional SCCWRP data was obtained directly from David Gillett and used for determining model species but were not included in the MS Access database. ODMDS data from Oregon was obtained directly from the US Army Corps of Engineers (USACE), facilitated by previous collaborative projects between Henkel and USACE/US Environmental Protection Agency (EPA). Metadata from the MCI, CLLEAN, and NOAA Monterey sampling are available on the MLML website and data were subsequently provided by MLML upon request. The SF Offshore and HOODS data were provided by Walt Nelson, former Asst. to Division Director of the Western Ecology Division of the EPA. Shallow water Morro Bay station data were obtained from the City of Morro Bay and Cayucos Sanitary District Offshore Monitoring and Reporting Program available from the city's website: <http://www.morro-bay.ca.us/ArchiveCenter/ViewFile/Item/2757>. Collectively, these datasets spanned 1994 to 2016 from 15 to 535 m deep for a total of 1835 records (Table 5). All records contained macrofaunal count data, station location, depth, and at least percent fines for the sediment. Some datasets had additional physical data.

All data from north of Point Conception were entered into a Microsoft Access database and a "taxon reduced" query was created from the various data sets. Because projects often had different spelling for the same animal (e.g., *Acteocina* sp vs *Acteocina* spp vs *Acteocina* spp.) over 3000 unique taxa were generated. Sometimes different scientific names were used, including older names no longer recognized as valid by the scientific community. Additionally, there were many misspelled entries and common names were occasionally used. In some instances, the stage of the animal was included in the text (e.g., *Aeolidiacea* sp. Juv.) and there were other name differences making merging the data sets difficult. So, a secondary column was created and used in a query to aggregate all the similar species together. The World Register of marine species (WoRMS; accessed in 2017) was used to cross check species names and select valid species names. In some instances, it was not possible to determine what the animal was at the species level and a taxa name was chosen at the lowest possible level (e.g., Cuke-like *Anemone* became *Actiniaria* sp). It was from this query "Total Taxon Reduced" that all data were pulled for the statistical analyses described below.

Table 6. Datasets collated by Henkel lab and included in Microsoft Access Database.

| Dataset label (Fig 7) | Collection type | Sieve mesh size (mm) | Region | Years | Depth range (m) | No. of Records | Dataset sources |
|-----------------------|-----------------------------|----------------------|---------------------|------------------------------|-----------------|----------------|--|
| BHC | Box core | 1 | WA, OR, northern CA | 2010-2012 | 49-133 | 150 | Benthic habitat characterization (BHC) surveys from Oregon State University (OSU); Henkel et al. 2014 |
| WEMAP | van Veen | 1 | WA, OR, CA | 2003 | 28-126 | 147 | Environmental monitoring & assessment program (EMAP) data provided by Environmental Protection Agency (EPA); Nelson et al. 2008. |
| ODMDS | Box core | 0.5 | OR | 2008, 2009, 2013, 2014, 2016 | 10-85 | 309 | Designated ocean dredged material disposal sites (ODMDS) from 7 Oregon sites provided by EPA Region 10 |
| HOODS | van Veen | 0.5 | northern CA | 2008, 2014 | 31-92 | 44 | Humboldt open ocean disposal site (HOODS) data provided by EPA Region 9 |
| Farallones | van Veen | 1 | central CA | 2009 | 8-34 | 12 | Assessing potential resource utilization by Gray Whales in the Gulf of the Farallones National Marine Sanctuary; data provided by EPA Region 9 |
| SFPUC | van Veen | 0.5 | central CA | 2004, 2005, 2010 | 12-35 | 154 | San Francisco offshore provided by the San Francisco Public Utility Commission |
| MCI | Smith-McIntyre | 0.5 | central CA | 1999 | 10-450 | 83 | Surveys in Monterey Bay National Marine Sanctuary for MCI Worldcom (ABA Consultants 2000) data provided by Moss Landing Marine Laboratories (MLML) Benthic Lab |
| CCLEAN | Smith-McIntyre/ van Veen | 0.5 | central CA | 2001-06, 2008-10, 2015 | 80 | 90 | Central Coast Long-term Environmental Assessment Network (CCLEAN) data provided by MLML Benthic Lab |
| NOAA-MLML | Smith-McIntyre | 0.5 | central CA | 2004, 2005 | 80-476 | 53 | Data collected by NOAA and provided by MLML Benthic Lab |
| Morro Bay | Young Modified van Veen | 1 | central CA | 2015 | 15 | 7 | City of Morro Bay and Cayucos Sanitary District Offshore Monitoring and Reporting Program |
| PacWave | Box core | 1 | central OR | 2010-2016 | 20-70 | 597 | PacWave test sites data collected by Henkel funded by various sources |
| OWET | Box core | 1 | southern OR | 2011 | 24-90 | 42 | Data collected by Henkel funded by Oregon Wave Energy Trust (OWET) |
| OSU-BOEM | Box core | 1 | OR | 2014-2016 | 60-525 | 147 | Current report |

4.5 Statistical Analyses

We first attempted to conduct multivariate analyses on the entire dataset. These analyses included creating a dissimilarity matrix and producing non-parametric MDS plots and cluster dendrograms to visualize how stations grouped together based on the macrofaunal assemblages collected. Including all of the records from the southern California Bight made the dataset too big for PRIMER or R to handle in a timely manner. So, we first analyzed the data included in the MS Access database only north of Point Conception. Within this study area, multivariate analysis indicated a strong break between samples collected using a 1.0 mm mesh sieve and those collected using a 0.5 mm mesh. Thus, analyses to identify candidate species for modeling (not the final modeling) were conducted using only samples obtained by using a 1.0 mm mesh size. Once this approach was decided, we then used the Bight Survey data from just 2003 at this stage as those were temporally consistent with the rest of the WEMAP samples, which was the major source of station data for central and northern California (Nelson et al. 2008). Using this final dataset for assemblage determination ($n = 1483$ stations), we conducted cluster analysis with SIMPROF set at the 1% significance level to determine statistically significant groups of the 1483 stations followed by SIMPER analyses to determine which species contributed to the similarities within groups and differences between them.

We then determined the number of times each species was indicated as being significant contributors to the similarities within groups overall and within each ecoregion (OR/WA, NorCal, Southern California Bight). Species were then considered for potential as model species if they were frequently significant contributors to the similarities within group, or if they were determined to be frequent distinguishers between the 12 major habitat groups in the in the previous chapter. These species were added separately because they included species that were discriminating on the slope, where we had little coverage in the remainder of the study region. Thus, in the analysis of the entire region, they were not necessarily frequently occurring characteristic species. Additional refinements were made for the final list of candidate species for modeling. For example, species that were significant contributors to the similarities within groups for only one ecoregion were only considered if we had additional evidence that their presence/absence contributed to differences among habitats within that region (and weren't just defining the region). Because samples were biased to the northern part of the region, when one species in a genus was a frequent distinguisher in the north and a conspecific was more common in the south, we added the southern conspecific to the list of species to be modeled. We also prioritized species that had a p-code pollution tolerance scores of less than 30 in the SCCWRP database, favoring species that were representative of non-impacted conditions. (For the p-codes, a higher number indicates greater tolerance to pollution; Smith et al. 2001). Finally, if not already included, we added taxa that we had previously modeled in the BOEM-BHC project in order to compare model outputs between model approaches.

Finally, we checked the frequency of occurrence of each of the selected species to ensure there were enough occurrences (not just large abundances at a few stations) to be useful for modeling. In order to be considered for modeling, we aimed for at least 10% overall occurrence in the northern study region; however, this was not always possible for slope species as the number of slope samples was low relative to the entire dataset. While the initial lists of potential model species were derived based only on the 1 mm mesh sieve studies, occurrence data was based on all the datasets.

4.6 Results

The cluster analysis with a SIMPROF threshold of 1% resulted in 303 significantly different groups. There were 147 significant groups detected in the PNW Region (Oregon and Washington), 29 groups in the Northern California (above Point Conception) Region, and 127 groups in Southern California (the Bight data). Forty-three taxa were selected as the final list recommended for future habitat suitability modeling (Table 7). Polychaetes were the most frequent group considered to be characteristic of and/or

distinguishing between macrofaunal assemblages and 22 taxa were selected for modeling; taxonomic changes over the course of the sampling efforts resulted in some suspected synonymys being lumped together. Molluscs were the second most frequent characteristic/distinguishing taxa, and eight bivalves, six gastropods, and the caudofoveatan, *Chaetoderma argenteum* (which was a slope distinguishing species), were selected for modeling. The most frequently overall characteristic species (contributing to the similarity of the stations within a group) was the ubiquitous bivalve, *Axinopsida serricata*, which was characteristic in 95 of the 303 groups. Thus, while widespread, we would expect to model some unsuitable habitat for this species as it was not found to be highly characteristic of all macrofaunal assemblages. Only three crustacea were determined to be highly characteristic of assemblages or distinguishing among them: the mud-tolerant shelf amphipod, *Ampelisca careyi*, the highly abundant pea crab, *Pinnixa occidentalis* complex, and the ostracod, *Euphilomedes carcharodonta*. Three echinoderms were also determined to be highly characteristic of assemblages or distinguishing among them: two ophiuroids and the heart urchin, *Brisaster latifrons*, which was indicative of the outer shelf and slope with the smallest grain sizes.

The results of the models (maps, environmental predictors, and model summaries) will be provided and discussed in a subsequent publication from NCCOS.

Table 7. The 43 taxa recommended for future habitat suitability modeling.

The Times Characteristic Total column (Times Char Total) indicates the number of times a taxon was characteristic in statistically significant clustered groups (n = 303 total clusters). The percentage of groups for which a taxon was characteristic are separated into three latitudinal areas from north to south: PNW (Oregon and Washington), NorCal (California, north of Point Conception), and Bight (California, south of Point Conception, Southern California Bight). The North Occur column indicates the number of stations at which taxa were collected north of Point Conception (PNW and NorCal combined). The Bight Occur column indicates the number of times taxa were collected during sampling in the Southern California Bight (Gillet et al. 2017). The total possible number of occurrences in the north is 1795 (the total number of sampling events or station visits) and 1209 in the Southern California Bight. Bight p-code values are the relative degree of pollution tolerance/sensitivity quantified by taxon and by depth in the Southern California Bight (Smith et al. 2001). The plus symbol (+) indicates species discriminating among habitats in the previous chapter. The asterisk symbol (*) indicates the seven species that were modeled for the BOEM-BHC project (Henkel et al. 2014).

| | Times Char Total | % of Groups PNW | % of Groups NorCal | % of Groups Bight | North Occur | Bight Occur | Bight p-code (0-30 m) | Bight p-code (30-120 m) | Bight p-code (120-300 m) |
|--|------------------------|-----------------------|--------------------------|-------------------------|----------------|----------------|--|-------------------------------|--------------------------------|
| <i>Acila castrensis</i> | 29 | 18% | 7% | 1% | 302 | 33 | -10.711 | 25.26 | |
| <i>Adontorhina cyclia</i> ⁺ | 30 | 16% | 10% | 3% | 171 | 107 | -21.116 | -7.526 | |
| <i>Alia (Astyris) gausapata</i> [*] | 28 | 19% | | | 562 | 1 | No p-code | | |
| <i>Ampelisca careyi</i> | 57 | 22% | 28% | 13% | 597 | 426 | 16.113 | -11.303 | -7.789 |
| <i>Amphiodia urtica</i> | 51 | 12% | 24% | 21% | 452 | 133 | 48.713 | -8.565 | -12.225 |
| <i>Amphioplus macraspis</i> ⁺ | 11 | 7% | | | 84 | 0 | Not present | | |
| <i>Axinopsida serricata</i> [*] | 95 | 48% | 34% | 12% | 936 | 367 | 69.746 | 26.965 | 60.36 |
| <i>Brisaster latifrons</i> ⁺ | 18 | 9% | 3% | 3% | 158 | 0 | <i>Brisaster</i> sp. | | 2.95 |
| <i>Callianax pycna</i> [*] | 18 | 12% | | | 423 | 1 | No p-code | | |
| <i>Chaetoderma argenteum</i> ⁺ | 5 | 3% | | | 62 | 0 | Not present; other <i>Chaetoderma</i> spp listed | | |
| <i>Chloeia pinnata</i> ⁺ | 31 | 3% | 10% | 19% | 179 | 400 | 37.607 | 19.019 | 26.917 |
| <i>Cylichna attonsa</i> | 53 | 36% | | | 812 | 0 | Not present; other <i>Cylichna</i> spp listed | | |
| <i>Ennucula tenuis</i> [*] | 34 | 18% | 10% | 4% | 412 | 141 | 15.558 | -0.374 | -4.549 |
| <i>Euphilomedes carcharodonta</i> | 52 | 12% | 24% | 21% | 368 | 432 | 71.111 | 59.539 | 42.635 |
| <i>Gadila tolmiei</i> ⁺ | 7 | 5% | | | 59 | 35 | No p-code | | |
| <i>Galathowenia oculata</i> ⁺ | 25 | 15% | 10% | | 323 | 4 | -2.075 | -3.221 | -2.633 |
| <i>Glycera nana/tesselata</i> | 44 | 11% | 28% | 16% | 416 | 509 | 50.612 | 39.829 | 53.637 |
| <i>Glycinde armigera</i> ⁺ | 52 | 22% | 17% | 12% | 750 | 372 | 19.129 | 19.126 | 38.526 |
| <i>Huxleyia munita</i> ⁺ | 18 | 12% | | 1% | 126 | 30 | | | -66.319 |

| | Times Char Total | % of Groups PNW | % of Groups NorCal | % of Groups Bight | North Occur | Bight Occur | Bight p-code (0-30 m) | Bight p-code (30-120 m) | Bight p-code (120-300 m) |
|---|------------------------|-----------------------|--------------------------|-------------------------|----------------|----------------|---|-------------------------------|--------------------------------|
| <i>Kurtiella tumida</i> | 42 | 11% | 31% | 13% | 585 | 361 | 45.575 | 59.199 | 51.633 |
| <i>Leitoscoloplos pugettensis</i> * | 51 | 20% | | 17% | 600 | 206 | 42.489 | 47.53 | 8.019 |
| <i>Macoma carlottensis</i> | 35 | 22% | 10% | | 441 | 87 | 106.04 | 115.822 | 76.711 |
| <i>Magelona berkeleyi</i> * | 4 | 3% | | | 125 | 66 | 26.808 | 29.525 | -29.055 |
| <i>Magelona sacculata</i> | 40 | 27% | 3% | | 895 | 25 | -8.299 | 32.344 | |
| <i>Maldane sarsi</i> * | 27 | 7% | 24% | 7% | 312 | 364 | 18.308 | 9.273 | 17.309 |
| <i>Ninoe gemmea</i> | 12 | 5% | 14% | | 127 | 0 | 42.018 | 23.234 | 41.577 |
| <i>Ninoe tridentata</i> | 3 | | 3.4% | 1.6% | 76 | 205 | 42.018 | 23.234 | 41.577 |
| <i>Nutricula lordi</i> * | 27 | 18% | | | 305 | 3 | | No p-code | |
| <i>Onuphis iridescens</i> * | 55 | 30% | 24% | 3% | 755 | 140 | 19.245 | 29.726 | 35.694 |
| <i>Paraprionospio alata/pinnata</i> | 60 | 12% | 31% | 26% | 498 | 795 | 10.608 | 21.746 | 38.608 |
| <i>Phoronidae sp</i> * | 36 | 11% | 7% | 14% | 75 | 449 | 17.859 | 8.077 | -2.306 |
| <i>Pinnixa occidentalis</i> complex | 29 | 11% | 31% | 3% | 292 | 29 | 39.228 | 24.216 | 41.247 |
| <i>Polycirrus spp</i> | 8 | | 7% | 5% | 246 | 439 | -1.05 | -5.026 | 1.856 |
| <i>Praxillella gracilis</i> * | 3 | 1% | 3% | | 98 | 33 | 12.968 | 15.645 | 10.416 |
| <i>Prionospio (prionospio) jubata</i> | 42 | 6% | 21% | 21% | 159 | 596 | 55.502 | 31.466 | 32.647 |
| <i>Pulsillum salishorum</i> * | 11 | 7% | | | 135 | 0 | | Not present | |
| <i>Rhabdus rectius</i> * | 23 | 14% | 7% | | 210 | 58 | 34.765 | 41.919 | 29.978 |
| <i>Scoletoma luti</i> | 24 | 12% | 21% | | 455 | 0 | 49.381 | 30.228 | 19.076 |
| <i>Spiophanes berkeleyorum/kimballi</i> | 62 | 16% | 38% | 22% | 734 | 692 | 24.199 | 33.753 | 38.763 |
| <i>Spiophanes duplex</i> | 54 | | 14% | 39% | 0 | 800 | 6.131 | 8.546 | -1.569 |
| <i>Spiophanes norrisi</i> | 60 | 29% | 14% | 10% | 102 | 353 | -2.309 | 12.055 | -23.746 |
| <i>Sternaspis assimilis</i> * | 3 | 2% | | | 39 | 0 | Not present; other <i>Sternaspis spp</i> listed | | |
| <i>Sternaspis affinis/fossor</i> * | 37 | 9% | 24% | 13% | 283 | 405 | 34.246 | -17.301 | -1.458 |

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Appendix: Additional Tables and Figures in Support of Chapter 3

Table A-1. Station data for the 404 samples considered in Chapter 3.

| Station | Year | Latitude | Longitude | Depth |
|---------------|------|----------|-----------|-------|
| 42.0_060m2014 | 2014 | 42.0035 | -124.366 | 56 |
| 42.0_060m2015 | 2015 | 42.00153 | -124.373 | 64 |
| 42.0_100m2014 | 2014 | 42.00345 | -124.471 | 99 |
| 42.0_100m2015 | 2015 | 42.01683 | -124.470 | 103 |
| 42.0_200m2014 | 2014 | 41.99835 | -124.589 | 215 |
| 42.0_200m2015 | 2015 | 42.00127 | -124.586 | 202 |
| 42.0_300m2014 | 2014 | 41.9948 | -124.605 | 329 |
| 42.0_300m2015 | 2015 | 42.00163 | -124.602 | 306 |
| 42.0_400m2014 | 2014 | 41.99827 | -124.617 | 394 |
| 42.0_400m2015 | 2015 | 42.00193 | -124.618 | 400 |
| 42.5_100m2014 | 2014 | 42.50048 | -124.657 | 100 |
| 42.5_200m2015 | 2015 | 42.50198 | -124.731 | 216 |
| 42.5_300m2014 | 2014 | 42.50257 | -124.749 | 308 |
| 42.5_300m2015 | 2015 | 42.50048 | -124.756 | 302 |
| 42.5_400m2014 | 2014 | 42.50205 | -124.768 | 400 |
| 42.5_400m2015 | 2015 | 42.50128 | -124.770 | 396 |
| 43.0_060m2014 | 2014 | 43.00450 | -124.521 | 59 |
| 43.0_100m2014 | 2014 | 43.00667 | -124.594 | 99 |
| 43.0_100m2015 | 2015 | 42.99173 | -124.628 | 112 |
| 43.0_200m2014 | 2014 | 42.99922 | -124.854 | 202 |
| 43.0_300m2014 | 2014 | 43.00203 | -124.869 | 288 |
| 43.0_300m2015 | 2015 | 43.00000 | -124.870 | 295 |
| 43.0_400m2014 | 2014 | 43.00275 | -124.899 | 398 |
| 43.0_400m2015 | 2015 | 42.99938 | -124.898 | 395 |
| 43.5_060m2014 | 2014 | 43.51248 | -124.297 | 61 |
| 43.5_060m2015 | 2015 | 43.50038 | -124.302 | 63 |
| 43.5_100m2014 | 2014 | 43.49880 | -124.381 | 101 |
| 43.5_100m2015 | 2015 | 43.49542 | -124.413 | 110 |
| 43.5_200m2014 | 2014 | 43.49990 | -124.599 | 204 |
| 43.5_200m2015 | 2015 | 43.49928 | -124.598 | 206 |
| 43.5_300m2014 | 2014 | 43.50262 | -124.644 | 299 |
| 43.5_300m2015 | 2015 | 43.49900 | -124.644 | 300 |
| 43.5_400m2014 | 2014 | 43.50285 | -124.678 | 399 |
| 43.5_400m2015 | 2015 | 43.49900 | -124.677 | 401 |
| 43.5_500m2014 | 2014 | 43.50272 | -124.720 | 497 |
| 43.5_500m2015 | 2015 | 43.50017 | -124.721 | 507 |
| 44.0_150m2014 | 2014 | 43.99732 | -124.569 | 148 |
| 44.0_150m2015 | 2015 | 43.99983 | -124.581 | 155 |

| Station | Year | Latitude | Longitude | Depth |
|---------------|------|----------|-----------|-------|
| 44.0_200m2014 | 2014 | 44.00373 | -124.940 | 217 |
| 44.0_200m2015 | 2015 | 43.99917 | -124.940 | 209 |
| 44.0_300m2014 | 2014 | 44.00635 | -124.953 | 309 |
| 44.0_300m2015 | 2015 | 43.99815 | -124.955 | 306 |
| 44.0_400m2014 | 2014 | 44.00435 | -124.957 | 352 |
| 44.0_400m2015 | 2015 | 43.99680 | -124.960 | 393 |
| 44.5_100m2015 | 2015 | 44.49817 | -124.532 | 107 |
| 44.5_200m2015 | 2015 | 44.49983 | -124.688 | 202 |
| 44.5_300m2015 | 2015 | 44.49983 | -124.746 | 307 |
| 44.5_400m2014 | 2014 | 44.50278 | -124.884 | 359 |
| 44.5_400m2015 | 2015 | 44.50333 | -124.792 | 394 |
| 45.0_060m2014 | 2014 | 44.99967 | -124.090 | 61 |
| 45.0_060m2015 | 2015 | 44.9967 | -124.090 | 65 |
| 45.0_100m2014 | 2014 | 44.99977 | -124.164 | 101 |
| 45.0_100m2015 | 2015 | 44.99917 | -124.165 | 107 |
| 45.0_200m2014 | 2014 | 45.00467 | -124.359 | 200 |
| 45.0_200m2015 | 2015 | 44.99983 | -124.359 | 204 |
| 45.0_300m2014 | 2014 | 45.00338 | -124.439 | 300 |
| 45.0_300m2015 | 2015 | 45.00067 | -124.438 | 304 |
| 45.0_400m2014 | 2014 | 45.00492 | -124.521 | 402 |
| 45.0_400m2015 | 2015 | 44.99983 | -124.517 | 407 |
| 45.5_060m2014 | 2014 | 45.49530 | -124.088 | 66 |
| 45.5_060m2015 | 2015 | 45.51250 | -124.053 | 64 |
| 45.5_100m2014 | 2014 | 45.50303 | -124.150 | 107 |
| 45.5_100m2015 | 2015 | 45.50583 | -124.133 | 104 |
| 45.5_200m2014 | 2014 | 45.49460 | -124.424 | 208 |
| 45.5_200m2015 | 2015 | 45.49600 | -124.414 | 207 |
| 45.5_300m2014 | 2014 | 45.48427 | -124.469 | 294 |
| 45.5_300m2015 | 2015 | 45.48850 | -124.471 | 306 |
| 45.5_400m2014 | 2014 | 45.48588 | -124.502 | 408 |
| 45.5_400m2015 | 2015 | 45.48100 | -124.497 | 405 |
| 46.0_060m2015 | 2015 | 46.00150 | -124.066 | 61 |
| 46.0_100m2015 | 2015 | 46.00000 | -124.239 | 106 |
| 46.0_200m2014 | 2014 | 46.00088 | -124.673 | 201 |
| 46.0_200m2015 | 2015 | 45.99950 | -124.678 | 206 |
| 46.0_300m2014 | 2014 | 45.98730 | -124.722 | 300 |
| 46.0_300m2015 | 2015 | 46.00000 | -124.728 | 296 |
| 46.0_400m2014 | 2014 | 45.98842 | -124.762 | 409 |
| 46.0_400m2015 | 2015 | 45.99917 | -124.770 | 405 |
| BA543_Sept12 | 2012 | 43.04990 | -124.620 | 128 |
| BA544_Sept12 | 2012 | 43.0331 | -124.584 | 100 |

| Station | Year | Latitude | Longitude | Depth |
|--------------|------|----------|-----------|-------|
| BA548_Aug12 | 2012 | 43.0657 | -124.568 | 91 |
| BA551_Sept12 | 2012 | 43.0502 | -124.604 | 128 |
| BA552_Aug12 | 2012 | 43.1016 | -124.602 | 128 |
| BA555_Sept12 | 2012 | 43.0486 | -124.533 | 91 |
| BA556_Aug12 | 2012 | 43.1007 | -124.551 | 91 |
| BA560_Sept12 | 2012 | 43.0674 | -124.585 | 109 |
| BA563_Sept12 | 2012 | 43.0333 | -124.533 | 73 |
| BA564_Aug12 | 2012 | 43.0827 | -124.534 | 73 |
| BA568_Aug12 | 2012 | 43.0998 | -124.584 | 100 |
| BA572_Aug12 | 2012 | 43.0664 | -124.534 | 109 |
| BA576_Sept12 | 2012 | 43.0659 | -124.587 | 118 |
| BA579_Sept12 | 2012 | 43.0495 | -124.568 | 100 |
| BA580_Aug12 | 2012 | 43.0994 | -124.539 | 67 |
| BB20A_Jun11 | 2011 | 44.726 | -124.090 | 21.9 |
| BB20B_Jun11 | 2011 | 44.72633 | -124.090 | 21.1 |
| BB30A_Jun11 | 2011 | 44.72633 | -124.100 | 30.2 |
| BB30B_Jun11 | 2011 | 44.72633 | -124.100 | 29.9 |
| BB40A_Jun11 | 2011 | 44.72467 | -124.110 | 42.5 |
| BB40B_Jun11 | 2011 | 44.72467 | -124.110 | 42 |
| BB50A_Jun11 | 2011 | 44.72367 | -124.120 | 49.7 |
| BB50B_Jun11 | 2011 | 44.72333 | -124.120 | 49.5 |
| BB60A_Jun11 | 2011 | 44.7275 | -124.150 | 59.7 |
| BB60B_Jun11 | 2011 | 44.72667 | -124.150 | 59.6 |
| BB70A_Jun11 | 2011 | 44.71767 | -124.210 | 72.5 |
| BB70B_Jun11 | 2011 | 44.72217 | -124.210 | 72.1 |
| CABLE12016 | 2016 | 43.42262 | -124.637 | 193 |
| CABLE22016 | 2016 | 43.41898 | -124.578 | 144 |
| CABLE32016 | 2016 | 43.42395 | -124.519 | 114 |
| CABLE42016 | 2016 | 43.42493 | -124.459 | 104 |
| CABLE52016 | 2016 | 43.41992 | -124.415 | 89 |
| CABLE62016 | 2016 | 43.42522 | -124.341 | 34 |
| CABLE72016 | 2016 | 43.42648 | -124.311 | 20 |
| CABLE82016 | 2016 | 43.42322 | -124.683 | 338 |
| CP541_Oct12 | 2012 | 44.283 | -124.248 | 70 |
| CP542_Oct12 | 2012 | 44.2355 | -124.269 | 74 |
| CP545_Oct12 | 2012 | 44.2583 | -124.234 | 66 |
| CP546_Oct12 | 2012 | 44.2287 | -124.242 | 69 |
| CP549_Oct12 | 2012 | 44.2943 | -124.216 | 61 |
| CP550_Oct12 | 2012 | 44.2473 | -124.284 | 75 |
| CP553_Oct12 | 2012 | 44.2412 | -124.220 | 62 |
| CP554_Oct12 | 2012 | 44.2867 | -124.272 | 73 |

| Station | Year | Latitude | Longitude | Depth |
|--------------|------|----------|-----------|-------|
| CP557_Oct12 | 2012 | 44.2735 | -124.196 | 56 |
| CP558_Oct12 | 2012 | 44.222 | -124.292 | 77 |
| CP561_Oct12 | 2012 | 44.2112 | -124.216 | 62 |
| CP562_Oct12 | 2012 | 44.2823 | -124.309 | 78 |
| CP565_Oct12 | 2012 | 44.2792 | -124.250 | 69 |
| CP566_Oct12 | 2012 | 44.2182 | -124.252 | 72 |
| CP569_Oct12 | 2012 | 44.209 | -124.248 | 71 |
| CP570_Oct12 | 2012 | 44.2058 | -124.294 | 78 |
| CP573_Oct12 | 2012 | 44.263 | -124.223 | 62 |
| CP574_Oct12 | 2012 | 44.2143 | -124.305 | 80 |
| CP577_Oct12 | 2012 | 44.2368 | -124.203 | 58 |
| CP578_Oct12 | 2012 | 44.2573 | -124.297 | 77 |
| EUR002_Oct10 | 2010 | 40.914 | -124.222 | 52 |
| EUR006_Oct10 | 2010 | 40.8789 | -124.260 | 61 |
| EUR018_Oct10 | 2010 | 40.9021 | -124.236 | 55 |
| EUR022_Oct10 | 2010 | 40.8593 | -124.254 | 55 |
| EUR034_Oct10 | 2010 | 40.9139 | -124.283 | 75 |
| EUR038_Oct10 | 2010 | 40.8656 | -124.374 | 123 |
| EUR045_Oct10 | 2010 | 40.8841 | -124.292 | 73 |
| EUR050_Oct10 | 2010 | 40.9204 | -124.314 | 89 |
| EUR054_Oct10 | 2010 | 40.9144 | -124.337 | 102 |
| EUR061_Oct10 | 2010 | 40.8676 | -124.309 | 75 |
| EUR066_Oct10 | 2010 | 40.9086 | -124.261 | 64 |
| EUR074_Oct10 | 2010 | 40.9197 | -124.289 | 77 |
| EUR082_Oct10 | 2010 | 40.9116 | -124.330 | 97 |
| EUR090_Oct10 | 2010 | 40.8728 | -124.253 | 57 |
| EUR098_Oct10 | 2010 | 40.8759 | -124.354 | 104 |
| EUR101_Oct10 | 2010 | 40.8578 | -124.295 | 68 |
| EUR106_Oct10 | 2010 | 40.8432 | -124.339 | 79 |
| EUR109_Oct10 | 2010 | 40.8862 | -124.285 | 71 |
| EUR114_Oct10 | 2010 | 40.9159 | -124.354 | 118 |
| EUR117_Oct10 | 2010 | 40.8429 | -124.310 | 57 |
| GH004_Sept10 | 2010 | 46.9312 | -124.393 | 58 |
| GH020_Sept10 | 2010 | 46.9783 | -124.397 | 56 |
| GH047_Sept10 | 2010 | 46.9468 | -124.502 | 82 |
| GH063_Sept10 | 2010 | 46.9296 | -124.481 | 78 |
| GH076_Sept10 | 2010 | 46.9781 | -124.449 | 66 |
| GH084_Sept10 | 2010 | 46.9688 | -124.404 | 60 |
| GH092_Sept10 | 2010 | 46.9815 | -124.423 | 63 |
| GH103_Sept10 | 2010 | 46.9758 | -124.465 | 71 |
| GH111_Sept10 | 2010 | 46.9571 | -124.500 | 80 |

| Station | Year | Latitude | Longitude | Depth |
|--------------|------|----------|-----------|-------|
| GH119_Sept10 | 2010 | 46.9783 | -124.509 | 79 |
| GH122_Sept10 | 2010 | 46.9619 | -124.463 | 71 |
| GH165_Sept10 | 2010 | 46.956 | -124.420 | 63 |
| GH221_Sept10 | 2010 | 46.9783 | -124.418 | 61 |
| MB20A_Jun11 | 2011 | 44.69567 | -124.090 | 19.9 |
| MB20B_Jun11 | 2011 | 44.69567 | -124.090 | 19.6 |
| MB30A_Jun11 | 2011 | 44.691 | -124.100 | 30.1 |
| MB30B_Jun11 | 2011 | 44.69383 | -124.100 | 30.2 |
| MB40A_Jun11 | 2011 | 44.6925 | -124.110 | 41.7 |
| MB40B_Jun11 | 2011 | 44.6925 | -124.110 | 40.6 |
| MB50A_Jun11 | 2011 | 44.692 | -124.140 | 52.6 |
| MB50B_Jun11 | 2011 | 44.69183 | -124.140 | 52.2 |
| MB60A_Jun11 | 2011 | 44.6905 | -124.150 | 59.6 |
| MB60B_Jun11 | 2011 | 44.52267 | -124.160 | 59.4 |
| MB70A_Jun11 | 2011 | 44.69033 | -124.220 | 69.6 |
| MB70B_Jun11 | 2011 | 44.68967 | -124.230 | 69.6 |
| MC102016 | 2016 | 43.74947 | -124.621 | 307 |
| MC112016 | 2016 | 43.74995 | -124.700 | 459 |
| MC12016 | 2016 | 43.55032 | -124.568 | 195 |
| MC122016 | 2016 | 43.900 | -124.550 | 162 |
| MC132016 | 2016 | 43.89965 | -124.600 | 215 |
| MC142016 | 2016 | 43.89992 | -124.699 | 224 |
| MC152016 | 2016 | 44.05037 | -124.550 | 132 |
| MC162016 | 2016 | 44.05015 | -124.600 | 138 |
| MC172016 | 2016 | 44.12985 | -124.720 | 112 |
| MC182016 | 2016 | 44.13042 | -124.550 | 114 |
| MC192016 | 2016 | 44.12983 | -124.589 | 123 |
| MC202016 | 2016 | 44.05 | -124.70 | 126 |
| MC212016 | 2016 | 44.1984 | -124.551 | 105 |
| MC22016 | 2016 | 43.5507 | -124.706 | 500 |
| MC222016 | 2016 | 44.20003 | -124.598 | 110 |
| MC232016 | 2016 | 44.19985 | -124.654 | 114 |
| MC242016 | 2016 | 44.37492 | -124.353 | 75 |
| MC272016 | 2016 | 44.82057 | -124.149 | 64 |
| MC282016 | 2016 | 44.82028 | -124.272 | 116 |
| MC312016 | 2016 | 44.9203 | -124.463 | 252 |
| MC32016 | 2016 | 43.54563 | -124.652 | 363 |
| MC332016 | 2016 | 45.02668 | -124.146 | 102 |
| MC342016 | 2016 | 45.00078 | -124.360 | 201 |
| MC362016 | 2016 | 45.09857 | -124.121 | 92 |
| MC372016 | 2016 | 45.09978 | -124.350 | 240 |

| Station | Year | Latitude | Longitude | Depth |
|---------------|------|----------|-----------|-------|
| MC382016 | 2016 | 45.0999 | -124.450 | 352 |
| MC392016 | 2016 | 45.19963 | -124.195 | 151 |
| MC402016 | 2016 | 45.20003 | -124.270 | 180 |
| MC412016 | 2016 | 45.1996 | -124.352 | 330 |
| MC42016 | 2016 | 43.64325 | -124.551 | 195 |
| MC422016 | 2016 | 45.19977 | -124.452 | 405 |
| MC432016 | 2016 | 45.2996 | -124.179 | 132 |
| MC442016 | 2016 | 45.30025 | -124.280 | 186 |
| MC452016 | 2016 | 45.30383 | -124.458 | 265 |
| MC462016 | 2016 | 45.29953 | -124.455 | 400 |
| MC472016 | 2016 | 45.39643 | -124.106 | 93 |
| MC482016 | 2016 | 45.40038 | -124.249 | 162 |
| MC492016 | 2016 | 45.40818 | -124.405 | 245 |
| MC502016 | 2016 | 45.39978 | -124.453 | 377 |
| MC52016 | 2016 | 43.64968 | -124.520 | 162 |
| MC522016 | 2016 | 45.48963 | -124.353 | 183 |
| MC62016 | 2016 | 43.649 | -124.700 | 493 |
| MC72016 | 2016 | 43.65158 | -124.648 | 375 |
| MC82016 | 2016 | 43.75062 | -124.550 | 185 |
| MC92016 | 2016 | 43.74967 | -124.600 | 260 |
| NEH007_Sept10 | 2010 | 45.7112 | -124.109 | 87 |
| NEH011_Sept10 | 2010 | 45.6586 | -124.156 | 104 |
| NEH015_Sept10 | 2010 | 45.6552 | -124.033 | 63 |
| NEH023_Sept10 | 2010 | 45.6713 | -124.140 | 99 |
| NEH027_Sept10 | 2010 | 45.653 | -124.053 | 70 |
| NEH031_Sept10 | 2010 | 45.7269 | -124.068 | 76 |
| NEH035_Sept10 | 2010 | 45.6469 | -124.147 | 101 |
| NEH039_Sept10 | 2010 | 45.6702 | -124.085 | 81 |
| NEH043_Sept10 | 2010 | 45.6924 | -124.049 | 71 |
| NEH051_Sept10 | 2010 | 45.7264 | -124.135 | 94 |
| NEH055_Sept10 | 2010 | 45.7094 | -124.130 | 94 |
| NEH059_Sept10 | 2010 | 45.705 | -124.027 | 64 |
| NEH071_Sept10 | 2010 | 45.6552 | -124.070 | 76 |
| NEH075_Sept10 | 2010 | 45.646 | -124.061 | 73 |
| NEH079_Sept10 | 2010 | 45.6997 | -124.043 | 69 |
| NEH083_Sept10 | 2010 | 45.7208 | -124.109 | 86 |
| NEH087_Sept10 | 2010 | 45.6749 | -124.036 | 67 |
| NEH091_Sept10 | 2010 | 45.6908 | -124.102 | 86 |
| NEH095_Sept10 | 2010 | 45.7229 | -124.039 | 62 |
| NEH099_Sept10 | 2010 | 45.6625 | -124.122 | 94 |
| NEH107_Sept10 | 2010 | 45.6968 | -124.114 | 88 |

| Station | Year | Latitude | Longitude | Depth |
|---------------|------|----------|-----------|-------|
| NEH115_Sept10 | 2010 | 45.7288 | -124.153 | 100 |
| NH20A_Jun11 | 2011 | 44.6535 | -124.090 | 22.4 |
| NH20B_Jun11 | 2011 | 44.65333 | -124.090 | 21.6 |
| NH30A_Jun11 | 2011 | 44.6535 | -124.100 | 32.6 |
| NH30B_Jun11 | 2011 | 44.6535 | -124.100 | 32 |
| NH40A_Jun11 | 2011 | 44.652 | -124.110 | 40.9 |
| NH40B_Jun11 | 2011 | 44.652 | -124.110 | 41.6 |
| NH50A_Jun11 | 2011 | 44.65283 | -124.150 | 49.3 |
| NH50B_Jun11 | 2011 | 44.6525 | -124.150 | 49.2 |
| NH60A_Jun11 | 2011 | 44.65383 | -124.180 | 58.9 |
| NH60B_Jun11 | 2011 | 44.65317 | -124.180 | 58.8 |
| NH70A_Jun11 | 2011 | 44.65167 | -124.230 | 71 |
| NH70B_Jun11 | 2011 | 44.65117 | -124.230 | 70.9 |
| NPT003_Oct10 | 2010 | 44.6545 | -124.243 | 74 |
| NPT010_Oct10 | 2010 | 44.687 | -124.197 | 69 |
| NPT013_Oct10 | 2010 | 44.6323 | -124.225 | 67 |
| NPT014_Oct10 | 2010 | 44.704 | -124.197 | 67 |
| NPT019_Oct10 | 2010 | 44.6375 | -124.271 | 77 |
| NPT026_Oct10 | 2010 | 44.67 | -124.192 | 67 |
| NPT030_Oct10 | 2010 | 44.718 | -124.158 | 61 |
| NPT042_Oct10 | 2010 | 44.6838 | -124.152 | 55 |
| NPT046_Oct10 | 2010 | 44.6553 | -124.226 | 70 |
| NPT057_Oct10 | 2010 | 44.626 | -124.148 | 50 |
| NPT058_Oct10 | 2010 | 44.658 | -124.188 | 62 |
| NPT062_Oct10 | 2010 | 44.6888 | -124.226 | 69 |
| NPT067_Oct10 | 2010 | 44.7253 | -124.223 | 73 |
| NPT070_Oct10 | 2010 | 44.686 | -124.161 | 58 |
| NPT078_Oct10 | 2010 | 44.6472 | -124.206 | 66 |
| NPT085_Oct10 | 2010 | 44.6185 | -124.190 | 57 |
| NPT086_Oct10 | 2010 | 44.63 | -124.150 | 49 |
| NPT093_Oct10 | 2010 | 44.6265 | -124.260 | 74 |
| NPT094_Oct10 | 2010 | 44.7203 | -124.206 | 70 |
| NPT102_Oct10 | 2010 | 44.6585 | -124.210 | 68 |
| NPT110_Oct10 | 2010 | 44.6785 | -124.243 | 72 |
| NPT118_Oct10 | 2010 | 44.6745 | -124.225 | 70 |
| NS20A_Jun11 | 2011 | 44.62817 | -124.090 | 18.4 |
| NS20B_Jun11 | 2011 | 44.62817 | -124.090 | 18.2 |
| NS30A_Jun11 | 2011 | 44.62583 | -124.110 | 35.3 |
| NS30B_Jun11 | 2011 | 44.62583 | -124.110 | 36.7 |
| NS40A_Jun11 | 2011 | 44.6215 | -124.120 | 40.3 |
| NS40B_Jun11 | 2011 | 44.62133 | -124.120 | 40.3 |

| Station | Year | Latitude | Longitude | Depth |
|---------------|------|----------|-----------|-------|
| NS50A_Jun11 | 2011 | 44.6265 | -124.130 | 48.6 |
| NS50B_Jun11 | 2011 | 44.62633 | -124.130 | 48.7 |
| NS60A_Jun11 | 2011 | 44.62317 | -124.190 | 57.7 |
| NS60B_Jun11 | 2011 | 44.62067 | -124.190 | 56.5 |
| NS70A_Jun11 | 2011 | 44.624 | -124.240 | 73.8 |
| NS70B_Jun11 | 2011 | 44.622 | -124.240 | 71.5 |
| NSAF012_Oct10 | 2010 | 39.6979 | -123.895 | 118 |
| NSAF016_Oct10 | 2010 | 39.6441 | -123.882 | 115 |
| NSAF024_Oct10 | 2010 | 39.858 | -124.335 | 122 |
| NSAF028_Oct10 | 2010 | 39.8007 | -123.920 | 102 |
| NSAF032_Oct10 | 2010 | 39.5877 | -123.864 | 107 |
| NSAF040_Oct10 | 2010 | 39.842 | -123.969 | 115 |
| NSAF044_Oct10 | 2010 | 39.7632 | -123.914 | 116 |
| NSAF048_Oct10 | 2010 | 39.5948 | -123.882 | 118 |
| NSAF056_Oct10 | 2010 | 39.8499 | -123.976 | 113 |
| NSAF060_Oct10 | 2010 | 39.6791 | -123.879 | 111 |
| NSAF064_Oct10 | 2010 | 39.5177 | -123.909 | 125 |
| NSAF072_Oct10 | 2010 | 39.7913 | -123.943 | 127 |
| NSAF080_Oct10 | 2010 | 39.642 | -123.855 | 95 |
| NSAF088_Oct10 | 2010 | 39.6255 | -123.889 | 120 |
| NSAF096_Oct10 | 2010 | 39.6335 | -123.905 | 127 |
| NSAF100_Oct10 | 2010 | 39.8725 | -124.071 | 122 |
| NSAF104_Oct10 | 2010 | 39.6123 | -123.883 | 98 |
| NSAF108_Oct10 | 2010 | 39.8462 | -123.996 | 122 |
| NSAF112_Oct10 | 2010 | 39.6128 | -123.899 | 125 |
| NSAF116_Oct10 | 2010 | 39.718 | -123.915 | 129 |
| NSAF120_Oct10 | 2010 | 39.48 | -123.923 | 118 |
| PD30_Jun15 | 2015 | 44.591 | -124.115 | 30.5 |
| PD40_Jun15 | 2015 | 44.5923 | -124.121 | 39.7 |
| PD50_Jun15 | 2015 | 44.5937 | -124.160 | 51.8 |
| PD60_Jun15 | 2015 | 44.5937 | -124.206 | 60.6 |
| PD70_Jun15 | 2015 | 44.5902 | -124.233 | 70.1 |
| RP301_Jun11 | 2011 | 43.7325 | -124.215 | 28.4 |
| RP302_Jun11 | 2011 | 43.8182 | -124.192 | 24.3 |
| RP304_Jun11 | 2011 | 43.7663 | -124.212 | 35.1 |
| RP305_Jun11 | 2011 | 43.7883 | -124.209 | 35.9 |
| RP306_Jun11 | 2011 | 43.7407 | -124.216 | 32.4 |
| RP307_Jun11 | 2011 | 43.7352 | -124.228 | 42.8 |
| RP308_Jun11 | 2011 | 43.7913 | -124.210 | 37.8 |
| RP309_Jun11 | 2011 | 43.7625 | -124.218 | 39.4 |
| RP310_Jun11 | 2011 | 43.7965 | -124.231 | 63.1 |

| Station | Year | Latitude | Longitude | Depth |
|-------------|------|----------|-----------|-------|
| RP312_Jun11 | 2011 | 43.7445 | -124.240 | 61.5 |
| RP313_Jun11 | 2011 | 43.7834 | -124.235 | 65.7 |
| RP314_Jun11 | 2011 | 43.7408 | -124.243 | 65 |
| RP315_Jun11 | 2011 | 43.816 | -124.229 | 64.1 |
| RP316_Jun11 | 2011 | 43.7385 | -124.251 | 72.7 |
| RP317_Jun11 | 2011 | 43.766 | -124.244 | 71.7 |
| RP318_Jun11 | 2011 | 43.8003 | -124.242 | 73.7 |
| RP319_Jun11 | 2011 | 43.74 | -124.255 | 79.5 |
| RP320_Jun11 | 2011 | 43.7333 | -124.257 | 79.2 |
| RP321_Jun11 | 2011 | 43.7387 | -124.255 | 77.9 |
| RP326_Jun11 | 2011 | 43.7485 | -124.214 | 32.1 |
| RP336_Jun11 | 2011 | 43.741 | -124.236 | 54.8 |
| RS40_Jun15 | 2015 | 44.5588 | -124.127 | 42.2 |
| RS50_Jun15 | 2015 | 44.5602 | -124.157 | 50.7 |
| RS60_Jun15 | 2015 | 44.5625 | -124.205 | 60.3 |
| RS70_Jun15 | 2015 | 44.5588 | -124.232 | 72.1 |
| SB40_Jun15 | 2015 | 44.5277 | -124.128 | 41.1 |
| SB50_Jun15 | 2015 | 44.526 | -124.165 | 50 |
| SB60_Jun15 | 2015 | 44.526 | -124.205 | 59.4 |
| SB70_Jun15 | 2015 | 44.526 | -124.235 | 70.5 |
| SC001_Aug10 | 2010 | 43.607 | -124.309 | 100 |
| SC005_Aug10 | 2010 | 43.6037 | -124.448 | 133 |
| SC009_Aug10 | 2010 | 43.599 | -124.363 | 112 |
| SC017_Oct10 | 2010 | 43.556 | -124.309 | 91 |
| SC021_Aug10 | 2010 | 43.5773 | -124.443 | 130 |
| SC029_Aug10 | 2010 | 43.6014 | -124.408 | 124 |
| SC033_Aug10 | 2010 | 43.5476 | -124.443 | 126 |
| SC037_Oct10 | 2010 | 43.5478 | -124.331 | 97 |
| SC041_Aug10 | 2010 | 43.5385 | -124.390 | 113 |
| SC065_Aug10 | 2010 | 43.6116 | -124.331 | 106 |
| SC069_Aug10 | 2010 | 43.592 | -124.378 | 117 |
| SC073_Aug10 | 2010 | 43.5854 | -124.419 | 125 |
| SC077_Oct10 | 2010 | 43.5533 | -124.348 | 104 |
| SC097_Aug10 | 2010 | 43.5477 | -124.379 | 112 |
| SC105_Aug10 | 2010 | 43.5857 | -124.375 | 108 |
| SC128_Aug10 | 2010 | 43.5741 | -124.403 | 119 |
| SC134_Aug10 | 2010 | 43.5758 | -124.440 | 129 |
| SC136_Aug10 | 2010 | 43.5828 | -124.353 | 110 |
| SC150_Aug10 | 2010 | 43.6123 | -124.415 | 127 |
| SC401_Jun11 | 2011 | 43.6228 | -124.235 | 24.9 |
| SC402_Jun11 | 2011 | 43.569 | -124.252 | 28.6 |

| Station | Year | Latitude | Longitude | Depth |
|-------------|------|----------|-----------|-------|
| SC403_Jun11 | 2011 | 43.5788 | -124.251 | 31.3 |
| SC404_Jun11 | 2011 | 43.5957 | -124.244 | 29.8 |
| SC405_Jun11 | 2011 | 43.5765 | -124.255 | 35.1 |
| SC406_Jun11 | 2011 | 43.5508 | -124.268 | 40.9 |
| SC407_Jun11 | 2011 | 43.6057 | -124.252 | 33.9 |
| SC408_Jun11 | 2011 | 43.538 | -124.278 | 52.5 |
| SC409_Jun11 | 2011 | 43.5465 | -124.272 | 47.1 |
| SC410_Jun11 | 2011 | 43.5772 | -124.267 | 60.8 |
| SC411_Jun11 | 2011 | 43.602 | -124.260 | 59.2 |
| SC412_Jun11 | 2011 | 43.5725 | -124.267 | 55.9 |
| SC413_Jun11 | 2011 | 43.5953 | -124.255 | 68.6 |
| SC414_Jun11 | 2011 | 43.5507 | -124.282 | 69.9 |
| SC415_Jun11 | 2011 | 43.5805 | -124.269 | 66 |
| SC416_Jun11 | 2011 | 43.5512 | -124.287 | 80.5 |
| SC417_Jun11 | 2011 | 43.5923 | -124.271 | 74.6 |
| SC418_Jun11 | 2011 | 43.608 | -124.270 | 78.4 |
| SC419_Jun11 | 2011 | 43.6058 | -124.283 | 89.5 |
| SC420_Jun11 | 2011 | 43.5472 | -124.297 | 81 |
| SC421_Jun11 | 2011 | 43.5725 | -124.285 | 82.7 |
| SR30_Jun15 | 2015 | 44.4915 | -124.114 | 31.2 |
| SR40_Jun15 | 2015 | 44.492 | -124.125 | 38.3 |
| SR60_Jun15 | 2015 | 44.4943 | -124.210 | 60 |
| SR70_Jun15 | 2015 | 44.494 | -124.251 | 70.1 |
| WFP102016 | 2016 | 43.43728 | -124.711 | 466 |
| WFP112016 | 2016 | 43.4374 | -124.683 | 373 |
| WFP12016 | 2016 | 43.40523 | -124.696 | 408 |
| WFP122016 | 2016 | 43.458 | -124.698 | 450 |
| WFP132016 | 2016 | 43.46337 | -124.633 | 243 |
| WFP142016 | 2016 | 43.43862 | -124.734 | 525 |
| WFP152016 | 2016 | 43.44755 | -124.721 | 510 |
| WFP22016 | 2016 | 43.40605 | -124.71 | 451 |
| WFP32016 | 2016 | 43.4132 | -124.681 | 348 |
| WFP42016 | 2016 | 43.41298 | -124.681 | 315 |
| WFP52016 | 2016 | 43.41452 | -124.727 | 490 |
| WFP62016 | 2016 | 43.41447 | -124.701 | 445 |
| WFP72016 | 2016 | 43.41602 | -124.696 | 406 |
| WFP82016 | 2016 | 43.42633 | -124.700 | 421 |
| WFP92016 | 2016 | 43.436 | -124.725 | 501 |

Table A-2. Abundance of all Annelids collected at the 404 stations considered in Chapter 3.

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|-----------------------|-----------------|-----------------------------|--------------------|
| Clitellata | Rhynchobdellida | Piscicolidae | Piscicolidae sp | 13 |
| Clitellata | Oligochaeta | | Oligochaeta spp | 1 |
| Polychaeta | Echiuroidea | Bonellidae | Bonellia sp | 27 |
| Polychaeta | Echiuroidea | Echiuridae | Echiura spp | 1 |
| Polychaeta | Echiuroidea | Echiuridae | Echiuridae spp | 22 |
| Polychaeta | Echiuroidea | Echiuridae | Echiurus echiurus | 4 |
| Polychaeta | Echiuroidea | Echiuridae | Echiurus echiurus alascanus | 6 |
| Polychaeta | Terebellida | Acrocirridae | Macrochaeta pege | 2 |
| Polychaeta | Terebellida | Ampharetidae | Amage anops | 5 |
| Polychaeta | Terebellida | Ampharetidae | Ampharete acutifrons | 3 |
| Polychaeta | Terebellida | Ampharetidae | Ampharete finmarchica | 9 |
| Polychaeta | Terebellida | Ampharetidae | Ampharete spp | 17 |
| Polychaeta | Terebellida | Ampharetidae | Ampharetidae spp | 10 |
| Polychaeta | Terebellida | Ampharetidae | Amphicteis mucronata | 4 |
| Polychaeta | Terebellida | Ampharetidae | Amphicteis spp | 6 |
| Polychaeta | Terebellida | Ampharetidae | Amphisamytha bioculata | 1 |
| Polychaeta | Terebellida | Ampharetidae | Anobothrus gracilis | 23 |
| Polychaeta | Terebellida | Ampharetidae | Asabellides lineata | 4 |
| Polychaeta | Terebellida | Ampharetidae | Lysippe labiata | 7 |
| Polychaeta | Terebellida | Ampharetidae | Melinna heterodonta | 20 |
| Polychaeta | Terebellida | Ampharetidae | Melinna oculata | 6 |
| Polychaeta | Terebellida | Ampharetidae | Melinna spp | 3 |
| Polychaeta | Terebellida | Ampharetidae | Samytha californiensis | 4 |
| Polychaeta | Amphinomida | Amphinomidae | Amphinomidae sp | 2 |
| Polychaeta | Amphinomida | Amphinomidae | Chloeia pinnata | 150 |
| Polychaeta | Phyllodocida | Aphroditidae | Aphrodita refulgida | 3 |
| Polychaeta | Phyllodocida | Aphroditidae | Aphrodita spp | 1 |
| Polychaeta | Spionida | Apistobanchidae | Apistobanchus tullbergi | 10 |
| Polychaeta | Sedentaria | Capitellidae | Barantolla americana | 1 |
| Polychaeta | Sedentaria | Capitellidae | Capitellidae spp | 92 |
| Polychaeta | Sedentaria | Capitellidae | Decamastus gracilis | 7 |
| Polychaeta | Sedentaria | Capitellidae | Heteromastus filobranhus | 2 |
| Polychaeta | Sedentaria | Capitellidae | Mediomastus californiensis | 248 |
| Polychaeta | Sedentaria | Capitellidae | Notomastus hemipodus | 158 |
| Polychaeta | Sedentaria | Capitellidae | Notomastus latericeus | 152 |
| Polychaeta | Sedentaria | Capitellidae | Notomastus lineatus | 90 |
| Polychaeta | Sedentaria | Capitellidae | Notomastus magnus | 2 |
| Polychaeta | Sedentaria | Capitellidae | Notomastus spp | 114 |
| Polychaeta | Sedentaria | Capitellidae | Notomastus tenuis | 145 |
| Polychaeta | Sedentaria | Chaetopteridae | Chaetopteridae sp | 2 |
| Polychaeta | Sedentaria | Chaetopteridae | Chaetopterus sp | 1 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|------------|----------------|-----------------|---------------------------------|-------------|
| Polychaeta | Sedentaria | Chaetopteridae | Chaetopterus variopedatus cmplx | 1 |
| Polychaeta | Sedentaria | Chaetopteridae | Mesochaetopterus spp | 3 |
| Polychaeta | Sedentaria | Chaetopteridae | Mesochaetopterus taylori | 26 |
| Polychaeta | Sedentaria | Chaetopteridae | Phyllochaetopterus limicolus | 3 |
| Polychaeta | Sedentaria | Chaetopteridae | Phyllochaetopterus prolifica | 1 |
| Polychaeta | Sedentaria | Chaetopteridae | Spiochaetopterus costarum | 618 |
| Polychaeta | Sedentaria | Chaetopteridae | Spiochaetopterus spp | 25 |
| Polychaeta | Terebellida | Cirratulidae | Aphelochaeta spp | 237 |
| Polychaeta | Terebellida | Cirratulidae | Aphelochaeta tigrina | 18 |
| Polychaeta | Terebellida | Cirratulidae | Chaetozone bansei | 124 |
| Polychaeta | Terebellida | Cirratulidae | Chaetozone columbiana | 3 |
| Polychaeta | Terebellida | Cirratulidae | Chaetozone nr setosa | 3 |
| Polychaeta | Terebellida | Cirratulidae | Chaetozone spp | 19 |
| Polychaeta | Terebellida | Cirratulidae | Cirratulidae spp | 5 |
| Polychaeta | Terebellida | Cirratulidae | Kirkegaardia dutchae | 3 |
| Polychaeta | Terebellida | Cirratulidae | Kirkegaardia secunda | 4 |
| Polychaeta | Terebellida | Cirratulidae | Kirkegaardia serratiseta | 2 |
| Polychaeta | Terebellida | Cirratulidae | Kirkegaardia tessellata | 29 |
| Polychaeta | Terebellida | Cirratulidae | Monticellina cryptica | 5 |
| Polychaeta | Terebellida | Cirratulidae | Monticellina serratiseta | 2 |
| Polychaeta | Terebellida | Cirratulidae | Monticellina spp | 3 |
| Polychaeta | Terebellida | Cirratulidae | Monticellina tessellata | 59 |
| Polychaeta | Sedentaria | Cossuridae | Cossura bansei | 1 |
| Polychaeta | Sedentaria | Cossuridae | Cossura candida | 11 |
| Polychaeta | Sedentaria | Cossuridae | Cossura pygodactylata | 1 |
| Polychaeta | Eunicida | Dorvilleidae | Dorvillea annulata | 7 |
| Polychaeta | Eunicida | Dorvilleidae | Protodorvillea gracilis | 8 |
| Polychaeta | Eunicida | Dorvilleidae | Schistomeringos longicornis | 3 |
| Polychaeta | Terebellida | Fauveliopsidae | Fauveliopsis magna | 6 |
| Polychaeta | Terebellida | Flabelligeridae | Brada sachalina | 15 |
| Polychaeta | Terebellida | Flabelligeridae | Brada villosa | 13 |
| Polychaeta | Terebellida | Flabelligeridae | Flabelligera affinis | 1 |
| Polychaeta | Terebellida | Flabelligeridae | Flabelligeridae spp | 1 |
| Polychaeta | Terebellida | Flabelligeridae | Pherusa neopapillata | 5 |
| Polychaeta | Terebellida | Flabelligeridae | Pherusa plumosa | 3 |
| Polychaeta | Terebellida | Flabelligeridae | Piromis hospitis | 1 |
| Polychaeta | Phyllodocida | Glyceridae | Glycera americana | 5 |
| Polychaeta | Phyllodocida | Glyceridae | Glycera macrobranchia | 2 |
| Polychaeta | Phyllodocida | Glyceridae | Glycera nana | 103 |
| Polychaeta | Phyllodocida | Glyceridae | Glycera oxycephala | 117 |
| Polychaeta | Phyllodocida | Glyceridae | Glycera spp | 6 |
| Polychaeta | Phyllodocida | Glyceridae | Glycera tessellata | 1 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|-----------------------|---------------|----------------------------|--------------------|
| Polychaeta | Phyllodocida | Goniadidae | Glycinde armigera | 239 |
| Polychaeta | Phyllodocida | Goniadidae | Glycinde picta | 21 |
| Polychaeta | Phyllodocida | Goniadidae | Glycinde spp | 6 |
| Polychaeta | Phyllodocida | Goniadidae | Goniada brunnea | 15 |
| Polychaeta | Phyllodocida | Goniadidae | Goniada maculata | 57 |
| Polychaeta | Phyllodocida | Goniadidae | Goniada spp | 4 |
| Polychaeta | Phyllodocida | Hesionidae | Heteropodarke heteromorpha | 2 |
| Polychaeta | Phyllodocida | Hesionidae | Ophiodromus pugettensis | 4 |
| Polychaeta | Phyllodocida | Hesionidae | Podarkeopsis glabrus | 7 |
| Polychaeta | Eunicida | Lumbrineridae | Eranno bicirrata | 79 |
| Polychaeta | Eunicida | Lumbrineridae | Eranno lagunae | 24 |
| Polychaeta | Eunicida | Lumbrineridae | Eranno sp | 11 |
| Polychaeta | Eunicida | Lumbrineridae | Lumbrineridae spp | 20 |
| Polychaeta | Eunicida | Lumbrineridae | Lumbrineris californiensis | 9 |
| Polychaeta | Eunicida | Lumbrineridae | Lumbrineris cruzensis | 23 |
| Polychaeta | Eunicida | Lumbrineridae | Lumbrineris japonica | 7 |
| Polychaeta | Eunicida | Lumbrineridae | Lumbrineris latreilli | 15 |
| Polychaeta | Eunicida | Lumbrineridae | Lumbrineris spp | 85 |
| Polychaeta | Eunicida | Lumbrineridae | Ninoe gemmea | 246 |
| Polychaeta | Eunicida | Lumbrineridae | Scoletoma luti | 294 |
| Polychaeta | Eunicida | Lumbrineridae | Scoletoma tetraura | 7 |
| Polychaeta | Eunicida | Lumbrineridae | Scoletoma zonata | 4 |
| Polychaeta | Spionida | Magelonidae | Magelona berkeleyi | 931 |
| Polychaeta | Spionida | Magelonidae | Magelona hartmanae | 109 |
| Polychaeta | Spionida | Magelonidae | Magelona longicornis | 180 |
| Polychaeta | Spionida | Magelonidae | Magelona sacculata | 275 |
| Polychaeta | Spionida | Magelonidae | Magelona spp | 2 |
| Polychaeta | Sedentaria | Maldanidae | Axiiothella rubrocincta | 119 |
| Polychaeta | Capitellida | Maldanidae | Chirimia similis | 69 |
| Polychaeta | Sedentaria | Maldanidae | Clymenura gracilis | 24 |
| Polychaeta | Sedentaria | Maldanidae | Clymenura spp | 8 |
| Polychaeta | Sedentaria | Maldanidae | Euclymene zonalis | 25 |
| Polychaeta | Sedentaria | Maldanidae | Euclymeninae spp | 319 |
| Polychaeta | Sedentaria | Maldanidae | Maldane cristata | 5 |
| Polychaeta | Sedentaria | Maldanidae | Maldane sarsi | 247 |
| Polychaeta | Sedentaria | Maldanidae | Maldanidae spp | 4 |
| Polychaeta | Sedentaria | Maldanidae | Metasychis disparidentatus | 14 |
| Polychaeta | Sedentaria | Maldanidae | Nicomache lumbricalis | 1 |
| Polychaeta | Sedentaria | Maldanidae | Nicomache personata | 1 |
| Polychaeta | Sedentaria | Maldanidae | Notoproctus pacificus | 11 |
| Polychaeta | Sedentaria | Maldanidae | Petaloproctus borealis | 8 |
| Polychaeta | Sedentaria | Maldanidae | Praxillella gracilis | 89 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|------------|----------------|------------|------------------------------|-------------|
| Polychaeta | Sedentaria | Maldanidae | Praxillella pacifica | 13 |
| Polychaeta | Sedentaria | Maldanidae | Praxillella spp | 28 |
| Polychaeta | Sedentaria | Maldanidae | Rhodine bitorquata | 70 |
| Polychaeta | Phyllodocida | Nephtyidae | Bipalponephtys cornuta | 9 |
| Polychaeta | Phyllodocida | Nephtyidae | Nephtys caeca | 4 |
| Polychaeta | Phyllodocida | Nephtyidae | Nephtys caecoides | 217 |
| Polychaeta | Phyllodocida | Nephtyidae | Nephtys ferruginea | 146 |
| Polychaeta | Phyllodocida | Nephtyidae | Nephtys glabra | 5 |
| Polychaeta | Phyllodocida | Nephtyidae | Nephtys punctata | 61 |
| Polychaeta | Phyllodocida | Nephtyidae | Nephtys spp | 233 |
| Polychaeta | Phyllodocida | Nereididae | Cheilonereis cyclurus | 3 |
| Polychaeta | Phyllodocida | Nereididae | Nereididae spp | 1 |
| Polychaeta | Phyllodocida | Nereididae | Nereis pelagica | 2 |
| Polychaeta | Phyllodocida | Nereididae | Nereis procera | 24 |
| Polychaeta | Phyllodocida | Nereididae | Nereis spp | 4 |
| Polychaeta | Phyllodocida | Nereididae | Nereis zonata | 33 |
| Polychaeta | Eunicida | Oenonidae | Drilonereis falcata | 5 |
| Polychaeta | Eunicida | Oenonidae | Drilonereis longa | 7 |
| Polychaeta | Eunicida | Oenonidae | Notocirrus californiensis | 5 |
| Polychaeta | Eunicida | Onuphidae | Diopatra ornata | 43 |
| Polychaeta | Eunicida | Onuphidae | Onuphidae spp | 20 |
| Polychaeta | Eunicida | Onuphidae | Onuphis elegans | 7 |
| Polychaeta | Eunicida | Onuphidae | Onuphis iridescent | 647 |
| Polychaeta | Eunicida | Onuphidae | Onuphis spp | 21 |
| Polychaeta | Eunicida | Onuphidae | Paradiopatra parva | 98 |
| Polychaeta | Sedentaria | Opheliidae | Armandia brevis | 1 |
| Polychaeta | Sedentaria | Opheliidae | Ophelia assimilis | 357 |
| Polychaeta | Sedentaria | Opheliidae | Ophelia pulchella | 16 |
| Polychaeta | Sedentaria | Opheliidae | Ophelina acuminata | 67 |
| Polychaeta | Sedentaria | Opheliidae | Ophelina cylindrica | 1 |
| Polychaeta | Sedentaria | Orbiniidae | Leitoscoloplos pugettensis | 266 |
| Polychaeta | Sedentaria | Orbiniidae | Naineris grubei | 2 |
| Polychaeta | Sedentaria | Orbiniidae | Naineris uncinata | 6 |
| Polychaeta | Sedentaria | Orbiniidae | Phylo felix | 118 |
| Polychaeta | Sedentaria | Orbiniidae | Scoloplos acmeceps | 317 |
| Polychaeta | Sedentaria | Orbiniidae | Scoloplos armiger | 3 |
| Polychaeta | Sabellida | Oweniidae | Galathowenia oculata | 1347 |
| Polychaeta | Sabellida | Oweniidae | Myriochele gracilis | 174 |
| Polychaeta | Sabellida | Oweniidae | Myriochele spp | 1 |
| Polychaeta | Sabellida | Oweniidae | Owenia fusiformis | 88 |
| Polychaeta | Sedentaria | Paraonidae | Aricidea (acmira) catherinae | 4 |
| Polychaeta | Sedentaria | Paraonidae | Aricidea (acmira) cerrutii | 4 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|------------|---------------------------|---------------|-------------------------------|-------------|
| Polychaeta | Sedentaria | Paraonidae | Aricidea (acmira) simplex | 36 |
| Polychaeta | Sedentaria | Paraonidae | Aricidea (aedicira) pacifica | 25 |
| Polychaeta | Sedentaria | Paraonidae | Aricidea (allia) antennata | 8 |
| Polychaeta | Sedentaria | Paraonidae | Aricidea (allia) ramosa | 11 |
| Polychaeta | Sedentaria | Paraonidae | Aricidea spp | 34 |
| Polychaeta | Sedentaria | Paraonidae | Cirrophorus branchiatus | 3 |
| Polychaeta | Sedentaria | Paraonidae | Levinsenia gracilis | 5 |
| Polychaeta | Sedentaria | Paraonidae | Paradoneis spinifera | 1 |
| Polychaeta | Terebellida | Pectinariidae | Pectinaria californiensis | 199 |
| Polychaeta | Terebellida | Pectinariidae | Pectinaria granulata | 13 |
| Polychaeta | Terebellida | Pectinariidae | Pectinaria spp | 15 |
| Polychaeta | Phyllodocida | Pholoidae | Pholoe spp | 39 |
| Polychaeta | Phyllodocida | Phyllodocidae | Eteone leptotes | 1 |
| Polychaeta | Phyllodocida | Phyllodocidae | Eteone spp | 30 |
| Polychaeta | Phyllodocida | Phyllodocidae | Eulalia californiensis | 2 |
| Polychaeta | Phyllodocida | Phyllodocidae | Eumida longicornuta | 2 |
| Polychaeta | Phyllodocida | Phyllodocidae | Hesionura coineaui difficilis | 1 |
| Polychaeta | Phyllodocida | Phyllodocidae | Paranaitis polynoides | 15 |
| Polychaeta | Phyllodocida | Phyllodocidae | Phyllodoce cuspidata | 20 |
| Polychaeta | Phyllodocida | Phyllodocidae | Phyllodoce groenlandica | 12 |
| Polychaeta | Phyllodocida | Phyllodocidae | Phyllodoce hartmanae | 41 |
| Polychaeta | Phyllodocida | Phyllodocidae | Phyllodoce longipes | 1 |
| Polychaeta | Phyllodocida | Phyllodocidae | Phyllodoce spp | 7 |
| Polychaeta | Phyllodocida | Pilargidae | Ancistrosyllis groenlandica | 1 |
| Polychaeta | Phyllodocida | Pilargidae | Hermundura fauveli | 48 |
| Polychaeta | Phyllodocida | Pilargidae | Hermundura ocularis | 9 |
| Polychaeta | Phyllodocida | Pilargidae | Pilargis berkeleyae | 5 |
| Polychaeta | Phyllodocida | Pilargidae | Pilargis maculata | 21 |
| Polychaeta | Phyllodocida | Pilargidae | Sigambra bassi | 2 |
| Polychaeta | Phyllodocida | Pilargidae | Sigambra spp | 1 |
| Polychaeta | Polychaeta incertae sedis | Polygordiidae | Polygordius spp | 9 |
| Polychaeta | Phyllodocida | Polynoidae | Arcteobia anticostiensis | 2 |
| Polychaeta | Phyllodocida | Polynoidae | Bylgides macrolepidus | 7 |
| Polychaeta | Phyllodocida | Polynoidae | Eucranta aniculata | 9 |
| Polychaeta | Phyllodocida | Polynoidae | Gattyana ciliata | 1 |
| Polychaeta | Phyllodocida | Polynoidae | Harmothoe extenuata | 3 |
| Polychaeta | Phyllodocida | Polynoidae | Harmothoe spp | 3 |
| Polychaeta | Phyllodocida | Polynoidae | Hesperonoe complanata | 9 |
| Polychaeta | Phyllodocida | Polynoidae | Hesperonoe laevis | 6 |
| Polychaeta | Phyllodocida | Polynoidae | Lepidasthenia berkeleyae | 13 |
| Polychaeta | Phyllodocida | Polynoidae | Lepidasthenia longicirrata | 10 |
| Polychaeta | Phyllodocida | Polynoidae | Lepidonotus spiculus | 2 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|------------|---------------------------|------------------|-----------------------------|-------------|
| Polychaeta | Phyllodocida | Polynoidae | Lepidonotus squamatus | 5 |
| Polychaeta | Phyllodocida | Polynoidae | Malmgreniella bansei | 21 |
| Polychaeta | Phyllodocida | Polynoidae | Malmgreniella baschi | 2 |
| Polychaeta | Phyllodocida | Polynoidae | Malmgreniella berkeleyorum | 1 |
| Polychaeta | Phyllodocida | Polynoidae | Malmgreniella liei | 1 |
| Polychaeta | Phyllodocida | Polynoidae | Malmgreniella macginitiei | 1 |
| Polychaeta | Phyllodocida | Polynoidae | Malmgreniella sanpedroensis | 46 |
| Polychaeta | Phyllodocida | Polynoidae | Malmgreniella scriptoria | 51 |
| Polychaeta | Phyllodocida | Polynoidae | Malmgreniella spp | 7 |
| Polychaeta | Phyllodocida | Polynoidae | Nemidia microlepidia | 6 |
| Polychaeta | Phyllodocida | Polynoidae | Polynoidae spp | 9 |
| Polychaeta | Phyllodocida | Polynoidae | Tenonia priops | 15 |
| Polychaeta | Sabellida | Sabellidae | Bispira spp | 1 |
| Polychaeta | Sabellida | Sabellidae | Chone magna | 1 |
| Polychaeta | Sabellida | Sabellidae | Chone spp | 5 |
| Polychaeta | Sabellida | Sabellidae | Chone veleronis | 1 |
| Polychaeta | Sabellida | Sabellidae | Dialychone albocincta | 8 |
| Polychaeta | Sabellida | Sabellidae | Dialychone veleronis | 6 |
| Polychaeta | Sabellida | Sabellidae | Euchone analis | 8 |
| Polychaeta | Sabellida | Sabellidae | Euchone spp | 2 |
| Polychaeta | Sabellida | Sabellidae | Myxicola infundibulum | 1 |
| Polychaeta | Sabellida | Sabellidae | Paradialychone ecaudata | 14 |
| Polychaeta | Sabellida | Sabellidae | Parasabella rugosa | 1 |
| Polychaeta | Sabellida | Sabellidae | Pseudopotamilla intermedia | 1 |
| Polychaeta | Sabellida | Sabellidae | Sabellidae spp | 3 |
| Polychaeta | Polychaeta incertae sedis | Saccocirridae | Saccocirrus spp | 2 |
| Polychaeta | Sedentaria | Scalibregmatidae | Scalibregma californicum | 77 |
| Polychaeta | Sedentaria | Scalibregmatidae | Scalibregma inflatum | 8 |
| Polychaeta | Phyllodocida | Sigalionidae | Leanira alba | 3 |
| Polychaeta | Phyllodocida | Sigalionidae | Pholoides asperus | 40 |
| Polychaeta | Phyllodocida | Sigalionidae | Pisione spp | 3 |
| Polychaeta | Phyllodocida | Sigalionidae | Sigalion spinosus | 75 |
| Polychaeta | Phyllodocida | Sigalionidae | Sthenelais berkeleyi | 7 |
| Polychaeta | Phyllodocida | Sigalionidae | Sthenelais verruculosa | 12 |
| Polychaeta | Spionida | Spionidae | Aonides glandulosa | 2 |
| Polychaeta | Spionida | Spionidae | Apoprionospio pygmaea | 1 |
| Polychaeta | Spionida | Spionidae | Boccardia pugettensis | 21 |
| Polychaeta | Spionida | Spionidae | Boccardia sp | 9 |
| Polychaeta | Spionida | Spionidae | Dipolydora brachycephala | 2 |
| Polychaeta | Spionida | Spionidae | Dipolydora cardalia | 5 |
| Polychaeta | Spionida | Spionidae | Dipolydora caulleryi | 2 |
| Polychaeta | Spionida | Spionidae | Dipolydora socialis | 13 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|------------|----------------|--------------|------------------------------|-------------|
| Polychaeta | Spionida | Spionidae | Laonice cirrata | 29 |
| Polychaeta | Spionida | Spionidae | Microspio pigmentata | 68 |
| Polychaeta | Spionida | Spionidae | Paraprionospio alata | 246 |
| Polychaeta | Spionida | Spionidae | Prionospio ehlersi | 8 |
| Polychaeta | Spionida | Spionidae | Prionospio lighti | 16 |
| Polychaeta | Spionida | Spionidae | Prionospio steenstrupi | 209 |
| Polychaeta | Spionida | Spionidae | Pseudopolydora sp | 1 |
| Polychaeta | Spionida | Spionidae | Scolecipis squamata | 48 |
| Polychaeta | Spionida | Spionidae | Scolecipis tridentata | 2 |
| Polychaeta | Spionida | Spionidae | Spio spp | 1 |
| Polychaeta | Spionida | Spionidae | Spio thulini | 38 |
| Polychaeta | Spionida | Spionidae | Spionidae spp | 5 |
| Polychaeta | Spionida | Spionidae | Spiophanes berkeleyorum | 185 |
| Polychaeta | Spionida | Spionidae | Spiophanes norrisi | 300 |
| Polychaeta | Terebellida | Sternaspidae | Sternaspis assimilis | 65 |
| Polychaeta | Terebellida | Sternaspidae | Sternaspis fossor | 324 |
| Polychaeta | Phyllodocida | Syllidae | Exogone lourei | 28 |
| Polychaeta | Phyllodocida | Syllidae | Exogone spp | 33 |
| Polychaeta | Phyllodocida | Syllidae | Geminosyllis ohma | 2 |
| Polychaeta | Phyllodocida | Syllidae | Pionosyllis sp | 1 |
| Polychaeta | Phyllodocida | Syllidae | Proceraea cornuta | 1 |
| Polychaeta | Phyllodocida | Syllidae | Sphaerosyllis californiensis | 42 |
| Polychaeta | Phyllodocida | Syllidae | Syllides longocirratu | 3 |
| Polychaeta | Phyllodocida | Syllidae | Syllis spp | 2 |
| Polychaeta | Phyllodocida | Syllidae | Typosyllis cornuta | 12 |
| Polychaeta | Phyllodocida | Syllidae | Typosyllis heterochaeta | 24 |
| Polychaeta | Phyllodocida | Syllidae | Typosyllis hyperioni | 2 |
| Polychaeta | Phyllodocida | Syllidae | Typosyllis pigmentata | 9 |
| Polychaeta | Phyllodocida | Syllidae | Typosyllis spp | 10 |
| Polychaeta | Terebellida | Terebellidae | Amaeana occidentalis | 45 |
| Polychaeta | Terebellida | Terebellidae | Artacama coniferi | 27 |
| Polychaeta | Terebellida | Terebellidae | Lanassa sp | 1 |
| Polychaeta | Terebellida | Terebellidae | Lanassa venusta | 3 |
| Polychaeta | Terebellida | Terebellidae | Pista agassizi | 3 |
| Polychaeta | Terebellida | Terebellidae | Pista brevibranchiata | 24 |
| Polychaeta | Terebellida | Terebellidae | Pista estevanica | 142 |
| Polychaeta | Terebellida | Terebellidae | Pista moorei | 6 |
| Polychaeta | Terebellida | Terebellidae | Pista spp | 27 |
| Polychaeta | Terebellida | Terebellidae | Pista wui | 107 |
| Polychaeta | Terebellida | Terebellidae | Polycirrus californicus | 5 |
| Polychaeta | Terebellida | Terebellidae | Polycirrus spp | 145 |
| Polychaeta | Terebellida | Terebellidae | Proclea graffi | 9 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|------------|----------------|------------------|--------------------------|-------------|
| Polychaeta | Terebellida | Terebellidae | Proclea graffii | 3 |
| Polychaeta | Terebellida | Terebellidae | Scionella japonica | 2 |
| Polychaeta | Terebellida | Terebellidae | Streblosoma bairdi | 39 |
| Polychaeta | Terebellida | Terebellidae | Thelepus setosus | 3 |
| Polychaeta | Echiuroidea | Thalassematidae | Arhynchite pugettensis | 16 |
| Polychaeta | Sedentaria | Travisiidae | Travisia brevis | 41 |
| Polychaeta | Sedentaria | Travisiidae | Travisia forbesii | 20 |
| Polychaeta | Sedentaria | Travisiidae | Travisia japonica | 8 |
| Polychaeta | Sedentaria | Travisiidae | Travisia pupa | 6 |
| Polychaeta | Terebellida | Trichobranchidae | Artacamella hancocki | 9 |
| Polychaeta | Terebellida | Trichobranchidae | Terebellidae spp | 2 |
| Polychaeta | Terebellida | Trichobranchidae | Terebellides californica | 16 |
| Polychaeta | Terebellida | Trichobranchidae | Terebellides reishi | 29 |
| Polychaeta | Terebellida | Trichobranchidae | Terebellides spp | 21 |
| Polychaeta | Terebellida | Trichobranchidae | Trichobranchus glacialis | 3 |
| Polychaeta | Spionida | Trochochaetidae | Trochochaeta multisetosa | 4 |
| Polychaeta | | | Polychaete spp | 1 |

Table A-3. Abundance of all Crustaceans collected at the 404 stations considered in Chapter 3.

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|-----------------------|-----------------|----------------------------|--------------------|
| Hexanauplia | Calanoida | Calanidae | Calanus spp | 51 |
| Hexanauplia | Calanoida | Metridinidae | Metridia pacifica | 1 |
| Hexanauplia | Calanoida | Pontellidae | Epilabidocera longipedata | 7 |
| Hexanauplia | Cyclopoida | Clausidiidae | Hemicyclops sp | 27 |
| Hexanauplia | Cyclopoida | | Poecilostomatoida sp | 1 |
| Hexanauplia | Sessilia | Balanidae | Balanus crenatus | 1 |
| Hexanauplia | Sessilia | Balanidae | Balanus sp | 1 |
| Malacostraca | Amphipoda | Acidostomatidae | Acidostoma sp | 2 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca agassizi | 41 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca brevisimulata | 5 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca careyi | 364 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca cristata | 29 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca hancocki | 13 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca lobata | 2 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca pugetica | 7 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca spp | 6 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampelisca unsocalae | 10 |
| Malacostraca | Amphipoda | Ampeliscidae | Ampeliscidae sp | 1 |
| Malacostraca | Amphipoda | Ampeliscidae | Byblis millsii | 1 |
| Malacostraca | Amphipoda | Ampeliscidae | Byblis mulleni | 2 |
| Malacostraca | Amphipoda | Ampeliscidae | Byblis spp | 4 |
| Malacostraca | Amphipoda | Aoridae | Aoroides inermis | 20 |
| Malacostraca | Amphipoda | Aoridae | Aoroides sp | 10 |
| Malacostraca | Amphipoda | Aoridae | Aoroides spp | 4 |
| Malacostraca | Amphipoda | Argissidae | Argissa hamatipes | 7 |
| Malacostraca | Amphipoda | Caprellidae | Caprella mendax | 13 |
| Malacostraca | Amphipoda | Caprellidae | Caprella spp | 1 |
| Malacostraca | Amphipoda | Caprellidae | Tritella pilimana | 1 |
| Malacostraca | Amphipoda | Caprellidae | Tritella tenuissima | 17 |
| Malacostraca | Amphipoda | Corophiidae | Cheirimeideia macrocarpa | 13 |
| Malacostraca | Amphipoda | Corophiidae | Cheirimeideia macrodactyla | 16 |
| Malacostraca | Amphipoda | Corophiidae | Cheirimeideia spp | 2 |
| Malacostraca | Amphipoda | Corophiidae | Cheirimeideia zotea | 26 |
| Malacostraca | Amphipoda | Corophiidae | Laticorophium baconi | 4 |
| Malacostraca | Amphipoda | Corophiidae | Protomeideia articulata | 13 |
| Malacostraca | Amphipoda | Corophiidae | Protomeideia prudens | 28 |
| Malacostraca | Amphipoda | Corophiidae | Protomeideia spp | 2 |
| Malacostraca | Amphipoda | Dulichidae | Dulichia sp | 1 |
| Malacostraca | Amphipoda | Eusiridae | Rhachotropis sp | 1 |
| Malacostraca | Amphipoda | Eusiridae | Rhachotropis barnardi | 1 |
| Malacostraca | Amphipoda | Eusiridae | Rhachotropis boreopacifica | 1 |
| Malacostraca | Amphipoda | Haustoriidae | Eohaustorius sawyeri | 181 |
| Malacostraca | Amphipoda | Haustoriidae | Eohaustorius sencillus | 158 |
| Malacostraca | Amphipoda | Hyperiididae | Hyperiididae sp | 5 |
| Malacostraca | Amphipoda | Isaeidae | Isaeidae spp | 79 |
| Malacostraca | Amphipoda | Ischyroceridae | Ischyrocerus spp | 2 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|----------------|-----------------|---------------------------|-------------|
| Malacostraca | Amphipoda | Liljeborgiidae | Idunella sp | 4 |
| Malacostraca | Amphipoda | Liljeborgiidae | Liljeborgia sp | 10 |
| Malacostraca | Amphipoda | Liljeborgiidae | Listriella albina | 3 |
| Malacostraca | Amphipoda | Lysianassidae | Hippomedon coecus | 2 |
| Malacostraca | Amphipoda | Lysianassidae | Hippomedon columbianus | 1 |
| Malacostraca | Amphipoda | Lysianassidae | Hippomedon spp | 1 |
| Malacostraca | Amphipoda | Lysianassidae | Lepidepecreum garthi | 6 |
| Malacostraca | Amphipoda | Lysianassidae | Lysianassidae spp | 11 |
| Malacostraca | Amphipoda | Lysianassidae | Orchomenella decipiens | 1 |
| Malacostraca | Amphipoda | Lysianassidae | Orchomenella pacifica | 18 |
| Malacostraca | Amphipoda | Lysianassidae | Orchomenella pinguis | 115 |
| Malacostraca | Amphipoda | Lysianassidae | Psammonyx longimerus | 4 |
| Malacostraca | Amphipoda | Lysianassidae | Wecomedon wecomus | 9 |
| Malacostraca | Amphipoda | Maeridae | Maera loveni | 1 |
| Malacostraca | Amphipoda | Maeridae | Maera sp | 1 |
| Malacostraca | Amphipoda | Megaluropidae | Gibberosus myersi | 42 |
| Malacostraca | Amphipoda | Melitidae | Desdimelita desdichada | 6 |
| Malacostraca | Amphipoda | Melitidae | Melitidae sp | 5 |
| Malacostraca | Amphipoda | Oedicerotidae | Americhelidium pectinatum | 1 |
| Malacostraca | Amphipoda | Oedicerotidae | Americhelidium shoemakeri | 15 |
| Malacostraca | Amphipoda | Oedicerotidae | Bathymedon covilhani | 1 |
| Malacostraca | Amphipoda | Oedicerotidae | Bathymedon pumilis | 1 |
| Malacostraca | Amphipoda | Oedicerotidae | Hartmanodes hartmanae | 1 |
| Malacostraca | Amphipoda | Oedicerotidae | Monoculodes emarginatus | 3 |
| Malacostraca | Amphipoda | Oedicerotidae | Monoculodes latissimus | 1 |
| Malacostraca | Amphipoda | Oedicerotidae | Oedicerotidae spp | 2 |
| Malacostraca | Amphipoda | Oedicerotidae | Pacifoculodes spinipes | 36 |
| Malacostraca | Amphipoda | Oedicerotidae | Westwoodilla tone | 18 |
| Malacostraca | Amphipoda | Opisidae | Opisa tridentata | 2 |
| Malacostraca | Amphipoda | Pachynidae | Prachynella lodo | 4 |
| Malacostraca | Amphipoda | Pardaliscidae | Nicippe tumida | 7 |
| Malacostraca | Amphipoda | Pardaliscidae | Pardaliscella symmetrica | 2 |
| Malacostraca | Amphipoda | Photidae | Gammaropsis ellisi | 1 |
| Malacostraca | Amphipoda | Photidae | Gammaropsis spp | 7 |
| Malacostraca | Amphipoda | Photidae | Photis brevipes | 81 |
| Malacostraca | Amphipoda | Photidae | Photis chiconola | 1 |
| Malacostraca | Amphipoda | Photidae | Photis macinerneyi | 14 |
| Malacostraca | Amphipoda | Photidae | Photis spp | 21 |
| Malacostraca | Amphipoda | Phoxocephalidae | Foxiphalus golfensis | 2 |
| Malacostraca | Amphipoda | Phoxocephalidae | Foxiphalus similis | 12 |
| Malacostraca | Amphipoda | Phoxocephalidae | Foxiphalus xiximeus | 4 |
| Malacostraca | Amphipoda | Phoxocephalidae | Grandifoxus longirostris | 24 |
| Malacostraca | Amphipoda | Phoxocephalidae | Harpiniopsis emeryi | 7 |
| Malacostraca | Amphipoda | Phoxocephalidae | Harpiniopsis fulgens | 5 |
| Malacostraca | Amphipoda | Phoxocephalidae | Harpiniopsis spp | 8 |
| Malacostraca | Amphipoda | Phoxocephalidae | Heterophoxus affinis | 60 |
| Malacostraca | Amphipoda | Phoxocephalidae | Heterophoxus ellisi | 11 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|----------------|-----------------|--|-------------|
| Malacostraca | Amphipoda | Phoxocephalidae | Heterophoxus frequens | 1 |
| Malacostraca | Amphipoda | Phoxocephalidae | Heterophoxus oculatus | 1 |
| Malacostraca | Amphipoda | Phoxocephalidae | Heterophoxus spp | 121 |
| Malacostraca | Amphipoda | Phoxocephalidae | Majoxiphalus major | 152 |
| Malacostraca | Amphipoda | Phoxocephalidae | Mandibulophoxus mayi | 45 |
| Malacostraca | Amphipoda | Phoxocephalidae | Metaphoxus frequens | 9 |
| Malacostraca | Amphipoda | Phoxocephalidae | Paraphoxus sp | 2 |
| Malacostraca | Amphipoda | Phoxocephalidae | Pseudharpina inexpectata | 1 |
| Malacostraca | Amphipoda | Phoxocephalidae | Rhepoxynius abronius | 10 |
| Malacostraca | Amphipoda | Phoxocephalidae | Rhepoxynius bicuspidatus | 28 |
| Malacostraca | Amphipoda | Phoxocephalidae | Rhepoxynius boreovariatus | 67 |
| Malacostraca | Amphipoda | Phoxocephalidae | Rhepoxynius dabouis | 63 |
| Malacostraca | Amphipoda | Phoxocephalidae | Rhepoxynius fatigans | 214 |
| Malacostraca | Amphipoda | Phoxocephalidae | Rhepoxynius spp | 317 |
| Malacostraca | Amphipoda | Phoxocephalidae | Rhepoxynius variatus | 56 |
| Malacostraca | Amphipoda | Phoxocephalidae | Rhepoxynius vigitegus | 276 |
| Malacostraca | Amphipoda | Pleustidae | Kamptopleustes coquillus | 2 |
| Malacostraca | Amphipoda | Pleustidae | Pleusymtes spp | 4 |
| Malacostraca | Amphipoda | Stenothoidae | Stenothoidae spp | 6 |
| Malacostraca | Amphipoda | Synopiidae | Bruzelia tuberculata | 1 |
| Malacostraca | Amphipoda | Synopiidae | Syrrhoe longifrons | 5 |
| Malacostraca | Amphipoda | Uristidae | Anonyx sp | 1 |
| Malacostraca | Cumacea | Diastylidae | Anchicolurus occidentalis | 33 |
| Malacostraca | Cumacea | Diastylidae | Diastylidae spp | 2 |
| Malacostraca | Cumacea | Diastylidae | Diastylis abboti | 1 |
| Malacostraca | Cumacea | Diastylidae | Diastylis bidentata | 3 |
| Malacostraca | Cumacea | Diastylidae | Diastylis dalli | 1 |
| Malacostraca | Cumacea | Diastylidae | Diastylis paraspiculosa | 7 |
| Malacostraca | Cumacea | Diastylidae | Diastylis pellucida | 9 |
| Malacostraca | Cumacea | Diastylidae | Diastylis quadriplicata | 3 |
| Malacostraca | Cumacea | Diastylidae | Diastylis santamariensis | 13 |
| Malacostraca | Cumacea | Diastylidae | Diastylis spp | 5 |
| Malacostraca | Cumacea | Diastylidae | Diastylopsis dawsoni | 33 |
| Malacostraca | Cumacea | Diastylidae | Diastylopsis tenuis | 3 |
| Malacostraca | Cumacea | Lampropidae | Hemilamprops californicus | 14 |
| Malacostraca | Cumacea | Leuconidae | Eudorella emarginata | 7 |
| Malacostraca | Cumacea | Leuconidae | Eudorella pacifica | 26 |
| Malacostraca | Cumacea | Leuconidae | Eudorellopsis longirostris | 7 |
| Malacostraca | Cumacea | Leuconidae | Leucon spp | 3 |
| Malacostraca | Cumacea | Leuconidae | Leuconidae sp | 3 |
| Malacostraca | Cumacea | Nannastacidae | Campylaspis hartae | 1 |
| Malacostraca | Cumacea | Nannastacidae | Campylaspis papillata | 3 |
| Malacostraca | Cumacea | Nannastacidae | Campylaspis rubromaculata | 1 |
| Malacostraca | Cumacea | Nannastacidae | Campylaspis rufa | 1 |
| Malacostraca | Cumacea | Nannastacidae | Campylaspis spp | 6 |
| Malacostraca | Cumacea | | Cumacea spp | 1 |
| Malacostraca | Decapoda | Axiidae | Calocarides (Acanthaxius) spinulicauda | 2 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|----------------|---------------|------------------------------|-------------|
| Malacostraca | Decapoda | Callinassidae | Neotrypaea californiensis | 18 |
| Malacostraca | Decapoda | Callinassidae | Neotrypaea gigas | 10 |
| Malacostraca | Decapoda | Callinassidae | Neotrypaea spp | 99 |
| Malacostraca | Decapoda | Cancridae | Metacarcinus spp | 8 |
| Malacostraca | Decapoda | Cancridae | Romaleon jordani | 1 |
| Malacostraca | Decapoda | Caridea | Caridea spp | 15 |
| Malacostraca | Decapoda | Crangonidae | Crangon alaskensis | 13 |
| Malacostraca | Decapoda | Crangonidae | Crangon franciscorum | 1 |
| Malacostraca | Decapoda | Crangonidae | Crangon spp | 21 |
| Malacostraca | Decapoda | Crangonidae | Crangon stylirostris | 16 |
| Malacostraca | Decapoda | Crangonidae | Lissocrangon stylirostris | 14 |
| Malacostraca | Decapoda | Crangonidae | Neocrangon communis | 6 |
| Malacostraca | Decapoda | Diogenidae | Paguristes turgidus | 1 |
| Malacostraca | Decapoda | Oregoniidae | Oregonia gracilis | 1 |
| Malacostraca | Decapoda | Paguridae | Pagurus armatus | 15 |
| Malacostraca | Decapoda | Paguridae | Pagurus capillatus | 1 |
| Malacostraca | Decapoda | Paguridae | Pagurus caurinus | 1 |
| Malacostraca | Decapoda | Paguridae | Pagurus dalli | 1 |
| Malacostraca | Decapoda | Paguridae | Pagurus ochotensis | 4 |
| Malacostraca | Decapoda | Paguridae | Pagurus quaylei | 6 |
| Malacostraca | Decapoda | Paguridae | Pagurus spp | 33 |
| Malacostraca | Decapoda | Pandalidae | Pandalus jordani | 3 |
| Malacostraca | Decapoda | Pasiphaeidae | Pasiphaea pacifica | 1 |
| Malacostraca | Decapoda | Pinnotheridae | Pinnixa occidentalis complex | 1041 |
| Malacostraca | Decapoda | Pinnotheridae | Pinnixa spp | 162 |
| Malacostraca | Decapoda | Pinnotheridae | Pinnotheridae sp | 17 |
| Malacostraca | Decapoda | Thoridae | Eualus berkeleyorum | 1 |
| Malacostraca | Decapoda | Thoridae | Spirontocaris lamellicornis | 1 |
| Malacostraca | Decapoda | Thoridae | Spirontocaris snyderi | 2 |
| Malacostraca | Decapoda | Thoridae | Spirontocaris sp | 2 |
| Malacostraca | Euphausiacea | Euphausiidae | Euphausia pacifica | 2 |
| Malacostraca | Euphausiacea | Euphausiidae | Thysanoessa spp | 2 |
| Malacostraca | Isopoda | Aegidae | Rocinela angustata | 2 |
| Malacostraca | Isopoda | Ancinidae | Bathycopea daltonae | 8 |
| Malacostraca | Isopoda | Anthuridae | Haliophasma geminata | 2 |
| Malacostraca | Isopoda | Gnathiidae | Gnathia spp | 1 |
| Malacostraca | Isopoda | Gnathiidae | Gnathia tridens | 1 |
| Malacostraca | Isopoda | Idoteidae | Edotia sublittoralis | 4 |
| Malacostraca | Isopoda | Idoteidae | Synidotea media | 3 |
| Malacostraca | Isopoda | Idoteidae | Synidotea spp | 21 |
| Malacostraca | Leptostraca | Nebaliidae | Nebalia spp | 7 |
| Malacostraca | Mysida | Mysidae | Alienacanthomysis macropsis | 2 |
| Malacostraca | Mysida | Mysidae | Archaeomysis grebnitzkii | 96 |
| Malacostraca | Mysida | Mysidae | Exacanthomysis davisii | 1 |
| Malacostraca | Mysida | Mysidae | Holmesiella anomala | 2 |
| Malacostraca | Mysida | Mysidae | Inusitatomysis insolita | 1 |
| Malacostraca | Mysida | Mysidae | Mysidae sp | 6 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|----------------|------------------------------|----------------------------------|-------------|
| Malacostraca | Mysida | Mysidae | Mysidella americana | 1 |
| Malacostraca | Mysida | Mysidae | Neomysis kadiakensis | 2 |
| Malacostraca | Mysida | Mysidae | Pacifacanthomysis nephrophthalma | 3 |
| Malacostraca | Tanaidacea | Paratanaoidea incertae sedis | Scoloura phillipsi | 3 |
| Malacostraca | Tanaidacea | Tanaellidae | Araphura breviarua | 1 |
| Ostracoda | Myodocopida | Cylindroleberididae | Cylindroleberididae spp | 43 |
| Ostracoda | Myodocopida | Philomedidae | Euphilomedes carcharadonta | 22 |
| Ostracoda | Myodocopida | Philomedidae | Euphilomedes carcharodonta | 262 |
| Ostracoda | Myodocopida | Philomedidae | Euphilomedes producta | 29 |
| Ostracoda | Myodocopida | Philomedidae | Scleroconcha trituberculata | 22 |
| Ostracoda | Myodocopida | Rutidermatidae | Rutiderma lomae | 3 |
| Ostracoda | | | Ostracoda spp | 4 |

Table A-4. Abundance of all Molluscs collected at the 404 stations considered in Chapter 3.

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|-----------------------|---------------|---|--------------------|
| Bivalvia | Adapedonta | Hiatellidae | Hiatella arctica | 14 |
| Bivalvia | Adapedonta | Pharidae | Pharidae sp | 2 |
| Bivalvia | Adapedonta | Pharidae | Siliqua alta | 7 |
| Bivalvia | Adapedonta | Pharidae | Siliqua patula | 24 |
| Bivalvia | Adapedonta | Pharidae | Siliqua spp | 4 |
| Bivalvia | Adapedonta | Solenidae | Solen sicarius | 1 |
| Bivalvia | Cardiida | Cardiidae | Keenaea centifilosa | 6 |
| Bivalvia | Cardiida | Tellinidae | Ameritella carpenteri | 143 |
| Bivalvia | Cardiida | Tellinidae | Ameritella modesta | 60 |
| Bivalvia | Cardiida | Tellinidae | Macoma calcarea | 1 |
| Bivalvia | Cardiida | Tellinidae | Macoma carlottensis | 725 |
| Bivalvia | Cardiida | Tellinidae | Macoma elimata | 223 |
| Bivalvia | Cardiida | Tellinidae | Macoma inquinata | 1 |
| Bivalvia | Cardiida | Tellinidae | Macoma spp | 62 |
| Bivalvia | Cardiida | Tellinidae | Macoma yoldiformis | 1 |
| Bivalvia | Cardiida | Tellinidae | Megangulus bodegensis | 17 |
| Bivalvia | Cardiida | Tellinidae | Tellina nuculoides | 230 |
| Bivalvia | Carditida | Carditidae | Cyclocardia ventricosa | 140 |
| Bivalvia | Galeommatida | Lasaeidae | Kurtiella tumida | 868 |
| Bivalvia | Heterodonta | Cuspidariidae | Cardiomya pectinata | 13 |
| Bivalvia | Heterodonta | Cuspidariidae | Cardiomya planetica | 3 |
| Bivalvia | Heterodonta | Cuspidariidae | Cuspidaria glacialis | 4 |
| Bivalvia | Heterodonta | Cuspidariidae | Cuspidariidae sp | 3 |
| Bivalvia | Heterodonta | Cuspidariidae | Pseudoneaera (Austroneaera) semipellucida | 1 |
| Bivalvia | Heterodonta | Laternulidae | Laternula marilina | 28 |
| Bivalvia | Heterodonta | Lyonsiidae | Lyonsia californica | 3 |
| Bivalvia | Heterodonta | Pandoridae | Pandora bilirata | 20 |
| Bivalvia | Heterodonta | Pandoridae | Pandora filosa | 2 |
| Bivalvia | Heterodonta | Thraciidae | Thracia challisiana | 2 |
| Bivalvia | Heterodonta | Thraciidae | Thracia trapezoides | 6 |
| Bivalvia | Heterodonta | Basterotiidae | Saxicavella pacifica | 25 |
| Bivalvia | Lucinida | Lucinidae | Lucinoma annulata | 15 |
| Bivalvia | Lucinida | Lucinidae | Lucinoma annulatum | 2 |
| Bivalvia | Lucinida | Lucinidae | Parvilucina tenuisculpta | 1 |
| Bivalvia | Lucinida | Thyasiridae | Adontorhina cyclia | 394 |
| Bivalvia | Lucinida | Thyasiridae | Adontorhina sphaerica | 31 |
| Bivalvia | Lucinida | Thyasiridae | Axinopsida serricata | 8806 |
| Bivalvia | Lucinida | Thyasiridae | Mendicula ferruginosa | 41 |
| Bivalvia | Lucinida | Thyasiridae | Thyasira flexuosa | 110 |
| Bivalvia | Myida | Pholadoidea | Pholadoidea sp | 12 |
| Bivalvia | Mytilida | Mytilidae | Modiolus rectus | 5 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|--------------|-----------------|------------------|------------------------------|-------------|
| Bivalvia | Mytilida | Mytilidae | Mytilidae spp | 4 |
| Bivalvia | Mytilida | Mytilidae | Solamen columbianum | 60 |
| Bivalvia | Nuculanida | Nuculanidae | Nuculana conceptionis | 2 |
| Bivalvia | Nuculanida | Nuculanidae | Nuculana fossa | 17 |
| Bivalvia | Nuculanida | Nuculanidae | Nuculana hamata | 23 |
| Bivalvia | Nuculanida | Nuculanidae | Nuculana minuta | 1 |
| Bivalvia | Nuculanida | Nuculanidae | Nuculana spp | 3 |
| Bivalvia | Nuculanida | Yoldiidae | Megayoldia martyria | 22 |
| Bivalvia | Nuculanida | Yoldiidae | Megayoldia thraciaeformis | 2 |
| Bivalvia | Nuculanida | Yoldiidae | Yoldia scissurata | 15 |
| Bivalvia | Nuculanida | Yoldiidae | Yoldia seminuda | 51 |
| Bivalvia | Nuculanida | Yoldiidae | Yoldiella spp | 3 |
| Bivalvia | Nuculanida | Yoldiidae | Yolida scissurata | 14 |
| Bivalvia | Nuculida | Nuculidae | Acila castrensis | 1311 |
| Bivalvia | Nuculida | Nuculidae | Ennucula tenuis | 903 |
| Bivalvia | Pectinida | Pectinidae | Delectopecten vancouverensis | 1 |
| Bivalvia | Solemyida | Nucinellidae | Huxleyia munita | 1171 |
| Bivalvia | Solemyida | Solemyidae | Solemya reidi | 11 |
| Bivalvia | Venerida | Mactridae | Mactridae spp | 1 |
| Bivalvia | Venerida | Veneridae | Compsomyax subdiaphana | 85 |
| Bivalvia | Venerida | Veneridae | Humilaria kennerleyi | 2 |
| Bivalvia | Venerida | Veneridae | Nutricola lordi | 4041 |
| Bivalvia | | | Bivalvia spp | 11 |
| Caudofoveata | Chaetodermatida | Chaetodermatidae | Chaetoderma argenteum | 135 |
| Caudofoveata | Chaetodermatida | Chaetodermatidae | Chaetoderma spp | 28 |
| Gastropoda | Caenogastropoda | Cerithiidae | Liribittium sp | 38 |
| Gastropoda | Caenogastropoda | Epitoniidae | Epitonium hindsii | 1 |
| Gastropoda | Caenogastropoda | Epitoniidae | Epitonium indianorum | 7 |
| Gastropoda | Caenogastropoda | Epitoniidae | Epitonium spp | 15 |
| Gastropoda | Cephalaspidea | Acteocinidae | Acteocina cerealis | 6 |
| Gastropoda | Cephalaspidea | Acteocinidae | Acteocina eximia | 121 |
| Gastropoda | Cephalaspidea | Acteocinidae | Acteocina spp | 160 |
| Gastropoda | Cephalaspidea | Aglajidae | Melanochlamys diomedea | 6 |
| Gastropoda | Cephalaspidea | Cylichnidae | Cylichna attonsa | 547 |
| Gastropoda | Cephalaspidea | Cylichnidae | Cylichna spp | 1 |
| Gastropoda | Cephalaspidea | Diaphanidae | Diaphana californica | 8 |
| Gastropoda | Cephalaspidea | Gastropteridae | Gastropteron pacificum | 9 |
| Gastropoda | Cephalaspidea | Haminoeidae | Haminoea vesicula | 7 |
| Gastropoda | Cephalaspidea | Retusidae | Retusa xystrum | 1 |
| Gastropoda | Cephalaspidea | Rhizoridae | Volvulella cylindrica | 23 |
| Gastropoda | Heterobranchia | Acteonidae | Rictaxis punctocaelatus | 17 |
| Gastropoda | Heterobranchia | Pyramidellidae | Boonea oregonensis | 18 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|------------|-------------------|-------------------|-------------------------------------|-------------|
| Gastropoda | Heterobranchia | Pyramidellidae | Odostomia spp | 187 |
| Gastropoda | Heterobranchia | Pyramidellidae | Turbonilla spp | 116 |
| Gastropoda | Lepetellida | Fissurellidae | Fissurellidae sp | 1 |
| Gastropoda | Lepetellida | Scissurellidae | Anatoma (Scissurella) crispata | 1 |
| Gastropoda | Littorinimorpha | Eulimidae | Polygireulima rutila | 9 |
| Gastropoda | Littorinimorpha | Littorinidae | Lacuna vincta | 2 |
| Gastropoda | Littorinimorpha | Naticidae | Cryptonatica affinis | 9 |
| Gastropoda | Littorinimorpha | Naticidae | Sinum scopulosum | 1 |
| Gastropoda | Littorinimorpha | Rissoidae | Alvania compacta | 50 |
| Gastropoda | Neogastropoda | Borsoniidae | Ophiidermella cancellata | 4 |
| Gastropoda | Neogastropoda | Buccinidae | Ancistrolepis eucosmius | 4 |
| Gastropoda | Neogastropoda | Buccinidae | Buccinidae sp | 2 |
| Gastropoda | Neogastropoda | Buccinidae | Buccinum strigillatum fucanum | 7 |
| Gastropoda | Neogastropoda | Buccinidae | Colus halli | 3 |
| Gastropoda | Neogastropoda | Cancellariidae | Admete gracilior | 2 |
| Gastropoda | Neogastropoda | Cancellariidae | Admete viridula | 16 |
| Gastropoda | Neogastropoda | Columbellidae | Mitrella (Alia/Astyris) aurantiaca | 35 |
| Gastropoda | Neogastropoda | Columbellidae | Mitrella (Alia/Astyris) gausapata | 729 |
| Gastropoda | Neogastropoda | Mangeliidae | Kurtzia arteaga | 47 |
| Gastropoda | Neogastropoda | Mangeliidae | Kurtziella plumbea | 10 |
| Gastropoda | Neogastropoda | Mangeliidae | Oenopota fidicula | 14 |
| Gastropoda | Neogastropoda | Mangeliidae | Oenopota spp | 3 |
| Gastropoda | Neogastropoda | Mangeliidae | Oenopota turricula | 1 |
| Gastropoda | Neogastropoda | Muricidae | Boreotrophon dalli | 1 |
| Gastropoda | Neogastropoda | Muricidae | Boreotrophon orpheus | 5 |
| Gastropoda | Neogastropoda | Muricidae | Scabrotrophon lasius | 2 |
| Gastropoda | Neogastropoda | Nassariidae | Hima mendica | 1 |
| Gastropoda | Neogastropoda | Nassariidae | Nassarius fossatus (Caesia fossata) | 17 |
| Gastropoda | Neogastropoda | Olividae | Callianax baetica | 363 |
| Gastropoda | Neogastropoda | Olividae | Callianax biplicata | 37 |
| Gastropoda | Neogastropoda | Olividae | Callianax pycna | 293 |
| Gastropoda | Neogastropoda | Olividae | Olivella baetica | 24 |
| Gastropoda | Neogastropoda | Pseudomelatomidae | Antiplanes catalinae (voyi) | 5 |
| Gastropoda | Neogastropoda | Pseudomelatomidae | Antiplanes santarosana | 1 |
| Gastropoda | Neogastropoda | Pseudomelatomidae | Antiplanes spp | 3 |
| Gastropoda | Neogastropoda | Ptychatractidae | Exilioidea rectirostris | 1 |
| Gastropoda | Neogastropoda | Turridae | Turridae spp | 5 |
| Gastropoda | Nudibranchia | Arminidae | Armina californica | 1 |
| Gastropoda | Patellogastropoda | Lottiidae | Lottia sp | 2 |
| Gastropoda | Trochida | Colloniidae | Homalopoma radiatum | 9 |
| Gastropoda | Trochida | Margaritidae | Margarites pupillus | 1 |
| Gastropoda | Trochida | Solariellidae | Solariella peramabilis | 13 |

| Class | Subclass/Order | Family | Taxon | Total Abund |
|----------------|-----------------------|------------------|-----------------------|--------------------|
| Gastropoda | Trochida | Solariellidae | Solariella sp | 1 |
| Gastropoda | Trochida | Trochidae | Lirularia lirulata | 8 |
| Gastropoda | Trochida | Trochidae | Trochidae sp | 3 |
| Gastropoda | | | Gastropoda spp | 5 |
| Polyplacophora | Chitonida | Ischnochitonidae | Ischnochiton willetti | 21 |
| Polyplacophora | Chitonida | Ischnochitonidae | Tripoplax trifida | 5 |
| Polyplacophora | Chitonida | Mopaliidae | Mopalia imporcata | 1 |
| Polyplacophora | Chitonida | Mopaliidae | Mopalia sp | 2 |
| Polyplacophora | | | Polyplacophora sp | 1 |
| Scaphopoda | Dentaliida | Dentaliidae | Antalis pretiosum | 45 |
| Scaphopoda | Dentaliida | Dentaliidae | Dentaliidae spp | 4 |
| Scaphopoda | Dentaliida | Rhabdidae | Rhabdus rectius | 562 |
| Scaphopoda | Gadilida | Gadilidae | Gadila aberrans | 105 |
| Scaphopoda | Gadilida | Gadilidae | Gadila tolmiei | 164 |
| Scaphopoda | Gadilida | Pulsellidae | Pulsellidae sp | 84 |
| Scaphopoda | Gadilida | Pulsellidae | Pulsellum salishorum | 266 |
| Scaphopoda | | | Scaphopoda spp | 4 |

Table A-5. Abundance of all other organisms not listed above collected at the 404 stations considered in Chapter 3.

| Phylum | Class | Subclass/Order | Family | Taxon | Total Abund |
|---------------|----------------|-----------------|----------------------|-----------------------------|-------------|
| Brachiopoda | Rhynchonellata | Terebratulida | Laqueidae | Laqueus californianus | 4 |
| Bryozoa | Gymnolaemata | Ctenostomatida | Clavoporidae | Clavopora occidentalis | 1 |
| Chaetognatha | Sagittoidea | Aphragmophora | Sagittidae | Sagitta spp | 4 |
| Chordata | Ascidacea | Phlebobranchia | Corellidae | Chelysoma columbianum | 12 |
| Cnidaria | Anthozoa | Actiniaria | Edwardsiidae | Edwardsia juliae | 3 |
| Cnidaria | Anthozoa | Actiniaria | Edwardsiidae | Edwardsia profunda | 1 |
| Cnidaria | Anthozoa | Actiniaria | Edwardsiidae | Edwardsia spp | 12 |
| Cnidaria | Anthozoa | Actiniaria | Halcampidae | Halcampa crypta | 2 |
| Cnidaria | Anthozoa | Actiniaria | Halcampidae | Halcampa decemtentaculata | 19 |
| Cnidaria | Anthozoa | Actiniaria | Halcampidae | Halcampidae sp | 9 |
| Cnidaria | Anthozoa | Actiniaria | Halcampidae | Halcampoides purpureus | 2 |
| Cnidaria | Anthozoa | Actiniaria | Haloclavidae | Peachia quinquecapitata | 11 |
| Cnidaria | Anthozoa | Actiniaria | Metridiidae | Metridium sp | 12 |
| Cnidaria | Anthozoa | Actiniaria | | Acontaria sp | 1 |
| Cnidaria | Anthozoa | Actiniaria | | Actiniaria sp | 1 |
| Cnidaria | Anthozoa | Actiniaria | | Athenaria sp | 2 |
| Cnidaria | Anthozoa | Pennatulacea | Halopteridae | Halopteris sp | 3 |
| Cnidaria | Anthozoa | Pennatulacea | Pennatulidae | Ptilosarcus gurneyi | 2 |
| Cnidaria | Anthozoa | Pennatulacea | Virgulariidae | Stylatula elongata | 17 |
| Cnidaria | Anthozoa | Pennatulacea | Virgulariidae | Virgularia spp | 2 |
| Cnidaria | Anthozoa | Pennatulacea | Virgulariidae | Virgulariidae spp | 3 |
| Cnidaria | Anthozoa | Spirularia | Cerianthidae | Cerianthidae sp | 6 |
| Cnidaria | Anthozoa | Spirularia | Cerianthidae | Pachycerianthus fimbriatus | 2 |
| Cnidaria | Anthozoa | Spirularia | Cerianthidae | Pachycerianthus sp | 25 |
| Cnidaria | Anthozoa | | | Hexacorallia spp | 1 |
| Cnidaria | Hydrozoa | Anthoathecata | Tubulariidae | Ectopleura sp | 1 |
| Echinodermata | Asteroidea | Paxillosida | Ctenodiscidae | Ctenodiscus crispatus | 3 |
| Echinodermata | Echinoidea | Camarodonta | Strongylocentrotidae | Strongylocentrotus fragilis | 2 |
| Echinodermata | Echinoidea | Clypeasteroidea | Dendrasteridae | Dendraster excentricus | 219 |
| Echinodermata | Echinoidea | Spatangoida | Schizasteridae | Brisaster latifrons | 159 |
| Echinodermata | Holothuroidea | Apodida | Chiridotidae | Chiridota spp | 2 |
| Echinodermata | Holothuroidea | Apodida | Synaptidae | Leptosynapta spp | 8 |
| Echinodermata | Holothuroidea | Dendrochirotida | Cucumariidae | Cucumaria piperata | 1 |
| Echinodermata | Holothuroidea | Dendrochirotida | Cucumariidae | Cucumariidae sp | 1 |
| Echinodermata | Holothuroidea | Dendrochirotida | Phyllophoridae | Pentamera populifera | 1 |
| Echinodermata | Holothuroidea | Dendrochirotida | Phyllophoridae | Pentamera pseudocalcigera | 4 |

| Phylum | Class | Subclass/Order | Family | Taxon | Total Abund |
|---------------|----------------|------------------|-----------------------------|--------------------------|-------------|
| Echinodermata | Holothuroidea | Dendrochirotida | Phyllophoridae | Pentamera rigida | 2 |
| Echinodermata | Holothuroidea | Dendrochirotida | Phyllophoridae | Pentamera spp | 13 |
| Echinodermata | Holothuroidea | Molpadida | Caudinidae | Paracaudina chilensis | 27 |
| Echinodermata | Holothuroidea | Molpadida | Molpadiidae | Molpadia intermedia | 2 |
| Echinodermata | Ophiuroidea | Ophiurida | Amphiuridae | Amphiodia occidentalis | 41 |
| Echinodermata | Ophiuroidea | Ophiurida | Amphiuridae | Amphiodia periercta | 2 |
| Echinodermata | Ophiuroidea | Ophiurida | Amphiuridae | Amphiodia spp | 1 |
| Echinodermata | Ophiuroidea | Ophiurida | Amphiuridae | Amphiodia urtica | 364 |
| Echinodermata | Ophiuroidea | Ophiurida | Amphiuridae | Amphioplus macraspis | 133 |
| Echinodermata | Ophiuroidea | Ophiurida | Amphiuridae | Amphioplus strongyloplax | 230 |
| Echinodermata | Ophiuroidea | Ophiurida | Amphiuridae | Amphipholis pugetana | 2 |
| Echinodermata | Ophiuroidea | Ophiurida | Amphiuridae | Amphiuridae spp | 20 |
| Echinodermata | Ophiuroidea | Ophiurida | Ophiactidae | Ophiopholis bakeri | 3 |
| Echinodermata | Ophiuroidea | Ophiurida | Ophiuridae | Ophiura lutkeni | 68 |
| Echinodermata | Ophiuroidea | Ophiurida | Ophiuridae | Ophiura spp | 12 |
| Echinodermata | Ophiuroidea | | | Ophiuroidea spp | 10 |
| Entoprocta | | Solitaria | Barentsiidae | Barentsia parva | 1 |
| Foraminifera | | Foraminifera sp | Biserial type 1 | | 2 |
| Foraminifera | | Foraminifera sp | Biserial type 2 | | 1 |
| Foraminifera | | Foraminifera sp | Planispiral evolute type 1 | | 34 |
| Foraminifera | | Foraminifera sp | Planispiral involute type 1 | | 12 |
| Foraminifera | | Foraminifera sp | Planispiral involute type 2 | | 41 |
| Foraminifera | | Foraminifera sp | Star type 1 | | 1 |
| Foraminifera | | Foraminifera sp | Streptospiral type 1 | | 1 |
| Foraminifera | | Foraminifera sp | Streptospiral type 2 | | 1 |
| Foraminifera | | Foraminifera sp | Triserial type 1 | | 250 |
| Foraminifera | | Foraminifera sp | Triserial type 2 | | 17 |
| Foraminifera | | Foraminifera sp | Trochospiral type 1 | | 24 |
| Foraminifera | | Foraminifera sp | Trochospiral type 2 | | 7 |
| Foraminifera | | Foraminifera sp | Uniserial type 1 | | 43 |
| Foraminifera | | Foraminifera sp | Uniserial type 2 | | 52 |
| Foraminifera | | Foraminifera sp | Uniserial type 3 | | 7 |
| Foraminifera | | Foraminifera spp | | | 3 |
| Hemichordata | Enteropneusta | Enteropneusta | Harrimaniidae | Saccoglossus sp | 1 |
| Hemichordata | Enteropneusta | Enteropneusta | Ptychoderidae | Glossobalanus sp | 5 |
| Nematoda | | | | Nematoda spp | 71 |
| Nemertea | Enopla | Monostilifera | Amphiporidae | Amphiporus spp | 4 |
| Nemertea | Enopla | Monostilifera | Emplectonematidae | Paranemertes californica | 3 |
| Nemertea | Enopla | Monostilifera | Tetrastemmatidae | Tetrastemma spp | 10 |
| Nemertea | Hoplonemertea | | | Hoplonemertea spp | 33 |
| Nemertea | Palaeonemertea | Carinomidae | | Carinoma mutabilis | 216 |

| Phylum | Class | Subclass/Order | Family | Taxon | Total Abund |
|-----------------|----------------|----------------|---------------|--------------------------|-------------|
| Nemertea | Palaeonemertea | Tubulanidae | | Tubulanus polymorphus | 51 |
| Nemertea | Palaeonemertea | Tubulanidae | | Tubulanus spp | 19 |
| Nemertea | Pilidiophora | Heteronemertea | Lineidae | Cerebratulus marginatus | 1 |
| Nemertea | Pilidiophora | Heteronemertea | Lineidae | Cerebratulus montgomeryi | 2 |
| Nemertea | Pilidiophora | Heteronemertea | Lineidae | Cerebratulus spp | 33 |
| Nemertea | Pilidiophora | Heteronemertea | Lineidae | Lineidae spp | 19 |
| Nemertea | Pilidiophora | Heteronemertea | Lineidae | Lineus bilineatus | 19 |
| Nemertea | Pilidiophora | Heteronemertea | Lineidae | Lineus sp | 4 |
| Nemertea | Pilidiophora | Heteronemertea | Lineidae | Micrura spp | 75 |
| Nemertea | | | | Nemertea spp | 3 |
| Phoronida | | | Phoronidae | Phoronidae sp | 118 |
| Phoronida | | | Phoronidae | Phoronis spp | 101 |
| Platyhelminthes | Rhabditophora | Polycladida | Leptoplanidae | Leptoplanidae sp | 6 |
| Porifera | Hexactinellid | | | Hexactinellid sp | 9 |
| Porifera | | | | Porifera spp | 5 |
| Retaria | Radiolaria | | | Radiolarian spp | 65 |
| Sipuncula | Sipunculidea | Golfingiida | Golfingiidae | Golfingia spp | 1 |
| Sipuncula | Sipunculidea | Golfingiida | Golfingiidae | Golfingiidae sp | 18 |
| Sipuncula | Sipunculidea | Golfingiida | Golfingiidae | Nephasoma diaphanes | 69 |
| Sipuncula | Sipunculidea | Golfingiida | Golfingiidae | Nephasoma spp | 11 |
| Sipuncula | Sipunculidea | Golfingiida | Golfingiidae | Thysanocardia nigra | 33 |
| Sipuncula | Sipunculidea | | | Phascolosoma agassizii | 2 |
| Sipuncula | | | | Sipuncula spp | 1 |
| Sipuncula | | | | Sipunculida sp | 1 |

Table A-6. All combinations of variables considered for the LINKTREE analysis.

Rows are sort by trees with the fewest number of splits at the top. The most parsimonious tree used all environmental factors with majority coverage (see Table 1 in Chapter 3). An equivalent tree was determined using only latitude, depth, median grain size, and total organic carbon (TOC). Since many sampling programs do not include analysis of TOC, and a tree with only two additional splits could be constructed without the use of that additional variable, we chose latitude, depth, and median grain size as the most parsimonious tree with the fewest variables (highlighted).

| # Factors | Variables | Breaks to |
|-----------|--|-----------|
| all | all | BQ |
| 4 | latitude, depth, medianGS, TOC | BQ |
| 4 | latitude, depth, medianGS, UpYear | BR |
| 4 | latitude, depth, medianGS, pH | BR |
| 4 | latitude, depth, medianGS, temp | BR |
| 3 | latitude, depth, medianGS | BS |
| 4 | latitude, depth, medianGS, UpMon | BT |
| 5 | latitude, depth, medianGS, TOC, UpPrev | BV |
| 4 | latitude, depth, medianGS, sal | BW |
| 4 | latitude, depth, medianGS, DO | BW |
| 4 | latitude, depth, fines, UpMon | BX |
| 4 | latitude, depth, medianGS, UpPrev | BX |
| 4 | latitude, depth, fines, UpYear | BX |
| 5 | latitude, depth, medianGS, fines, upPrev | BY |
| 1 | depth | BY |
| 4 | latitude, depth, fines, UpPrev | BY |
| 4 | latitude, depth, medianGS, fines | BZ |
| 3 | latitude, depth, fines | BZ |
| 4 | latitude, depth, fines, temp | BZ |
| 4 | latitude, depth, fines, pH | BZ |
| 3 | latitude, depth, salinity | CA |
| 4 | latitude, depth, fines, DO | CB |
| 4 | latitude, depth, fines, sal | CB |
| 3 | depth, medianGS, upYear | CC |
| 3 | latitude, depth, pH | CC |
| 3 | depth, medianGS, UpMon | CC |
| 3 | depth, medianGS, UpYear | CC |
| 1 | fines | CD |
| 1 | latitude | CD |
| 2 | latitude, depth | CD |
| 3 | latitude, depth, temp | CE |
| 3 | latitude, depth, TOC | CE |
| 3 | latitude, depth, DO | CF |
| 3 | latitude, medianGS, DO | CG |
| 3 | depth, medianGS, upPrev | CI |
| 3 | depth, medianGS, temp | CJ |
| 3 | depth, medianGS, DO | CJ |

| # Factors | Variables | Breaks to |
|-----------|----------------------------------|-----------|
| 5 | depth, fines, medianGS, temp, pH | CM |
| 3 | latitude, medianGS, salinity | CM |
| 3 | latitude, medianGS, pH | CP |
| 3 | latitude, medianGS, temp | CP |
| 3 | depth, medianGS, pH | CQ |
| 3 | depth, medianGS, sal | CQ |
| 3 | depth, medianGS, UpYear | CR |
| 2 | latitude, medianGS | CS |
| 3 | depth, medianGS, fines | CU |
| 2 | depth, medianGS | CW |
| 3 | depth, medianGS, temp | CY |
| 2 | latitude, fines | CZ |
| 2 | depth, fines | DB |
| 3 | median grain size | DF |

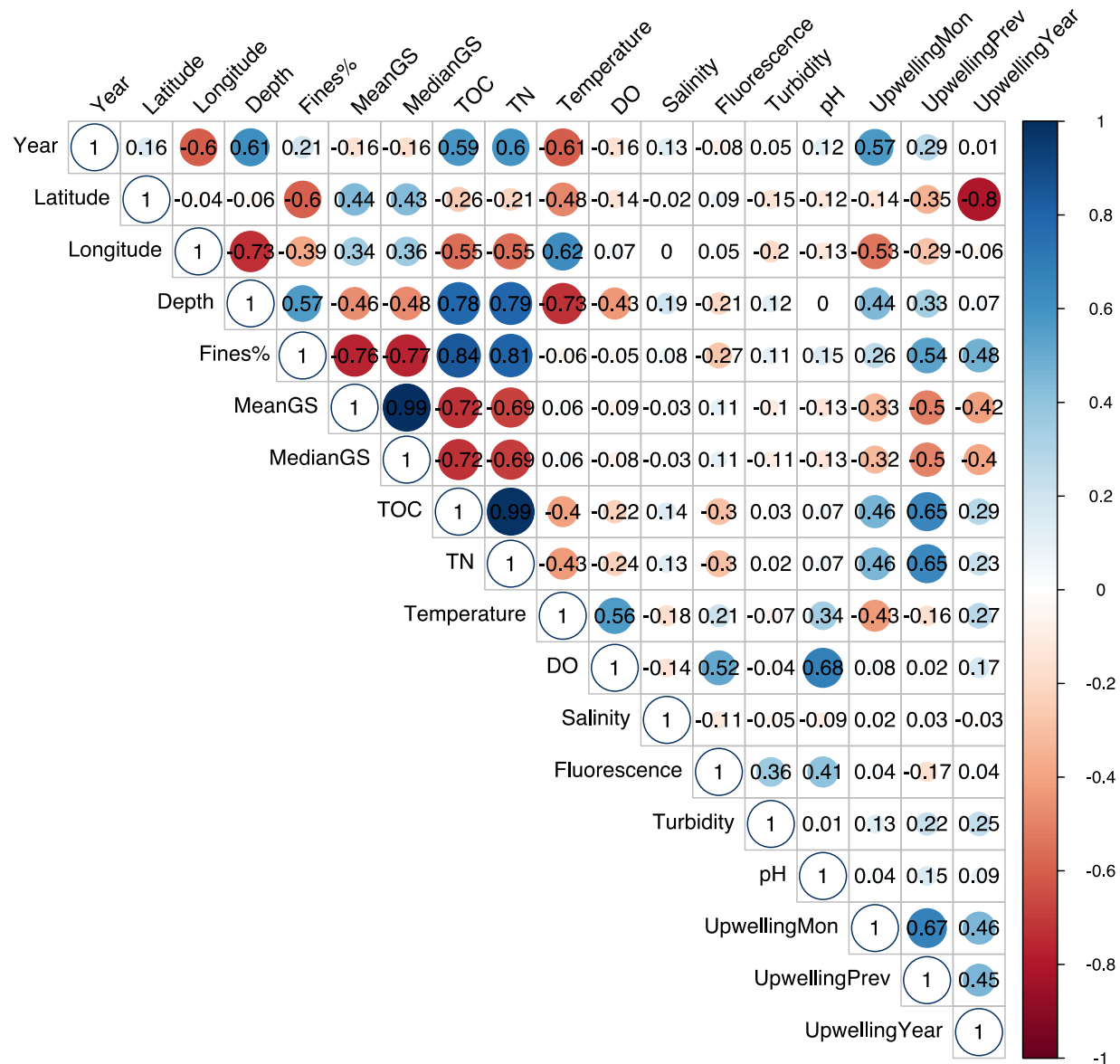


Figure A-1. Correlations among all the environmental variables collected in the study.

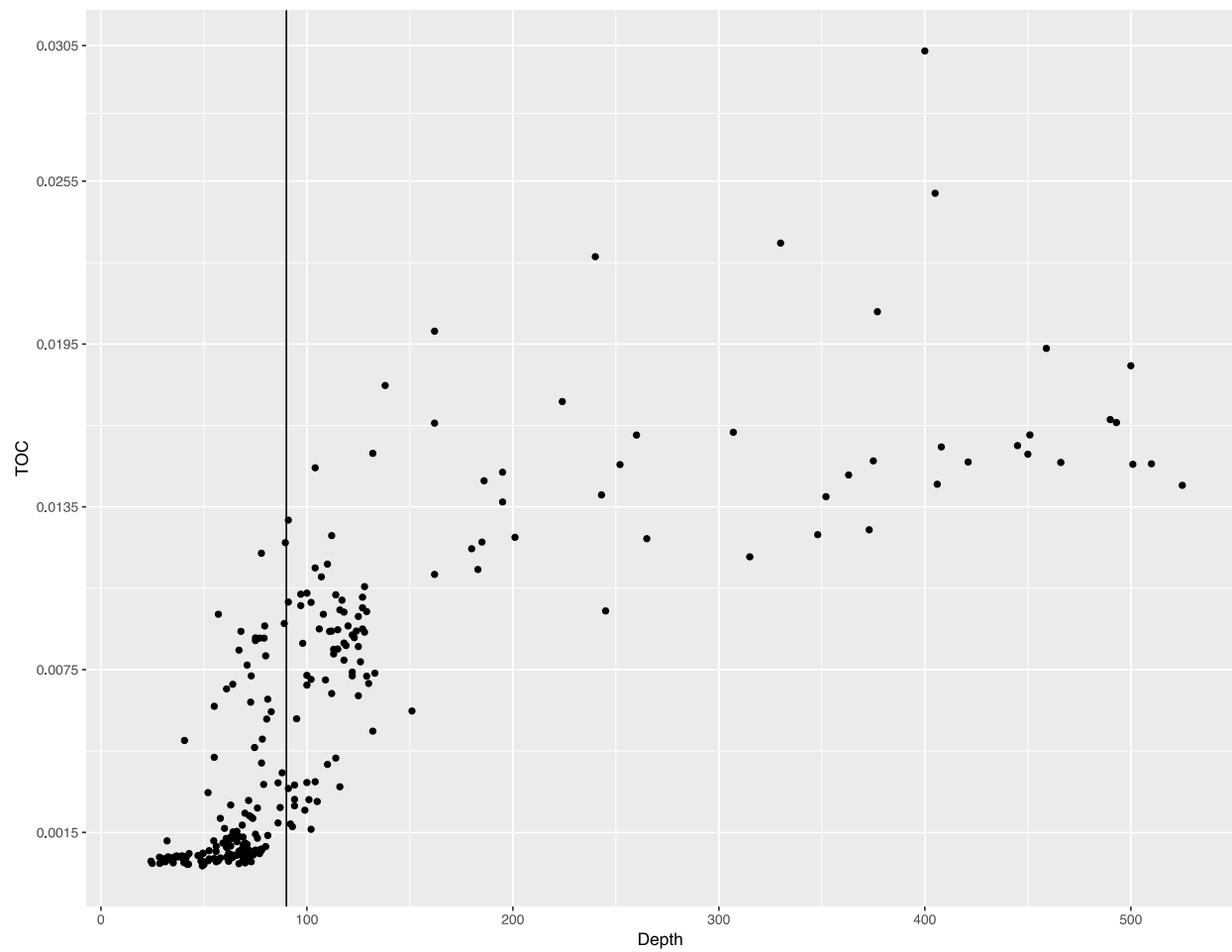


Figure A-2. Total Organic Carbon (TOC) versus depth for the 256 stations (of 378 analyzed) for which we had TOC data.



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