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Characterization of Benthic Conditions and Organisms on the Oregon South Coast

A Rapid Evaluation of Habitat Characteristics and Benthic Organisms at the Proposed Reedsport Wave Park

Prepared by
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On behalf of Oregon Wave Energy Trust

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Oregon Wave Energy Trust (OWET) is a nonprofit public-private partnership funded by the Oregon Innovation Council. Its mission is to support the responsible development of wave energy in Oregon. OWET emphasizes an inclusive, collaborative model to ensure that Oregon maintains its competitive advantage and maximizes the economic development and environmental potential of this emerging industry. Our work includes stakeholder outreach and education, policy development, environmental assessment, applied research and market development.

Characterization of Benthic Conditions and Organisms on the Oregon South Coast in areas targeted for Wave Energy Development

Principle Investigator: Sarah Henkel

This project was a single assessment of the benthic habitat characteristics and organisms near the future Ocean Power Technologies Demonstration facility near Reedsport, OR, and a reference location. The goal of this project was to assess sediment characteristics, infaunal invertebrates, epifaunal invertebrates, and fish at the future installation site, inshore of the target site, and at a reference site. Specifically, CTD casts, box cores, and beam trawl collections were conducted at the sited in summer 2011. In summary, all assemblages sampled had distributions strongly driven by depth. Other factors contributing to the variability among sampling stations were potentially due to differences in temperature and dissolved oxygen, which co-vary with depth. In the following document we report in detail on the spatial variability of the habitat features and biological assemblages. Finally, we make recommendations for plans for future monitoring at these or similar sites.

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BACKGROUND

Through support from OWET, we (OSU-NNMREC) successfully sampled benthic infaunal invertebrates via box core as well as groundfish and epibenthic invertebrates via beam trawl in an area near the future NNMREC Ocean Test Facility off Newport, OR. This sampling included analysis of the physical and organic properties of the sediment and water column. Sampling was conducted from spring 2010 to fall 2011, enabling investigation of potential seasonal changes in community composition and organism abundance. That project was supported by OWET in an attempt to facilitate the siting of the NNMREC test facility for industry and research use and to guide future efforts in site characterization and monitoring by the industry. While the sampling conducted at Newport can lead to guidance about the scale of sampling needed to characterize that site and monitor for changes, it does not address questions of spatial variability throughout Oregon's territorial sea.

Within Federal waters, we have conducted a study, sponsored by BOEM, to characterize benthic habitats and invertebrates via box core sampling from northern California to Washington. Results from the BOEM study indicate that the make-up of the benthic communities is driven largely by depth and grain size. The south coast area near Reedsport and Coos Bay differ strongly from the Newport area in both respects. The shelf is much narrower on the south coast, thus the depth transition is much greater (depths of > 90 m are reached while still in the territorial sea as opposed to ~ 50 m off Newport), and the median grain size of the sediment is much smaller (60 μm off Lakeside vs. 273 μm off Newport). These data indicate that the south coast may be a substantially different habitat from the Newport area, supporting different biological communities.

This project was proposed to fill a gap in spatial sampling along Oregon. Infauna in the depth and latitude range that OPT is proposing to develop wave energy capture facilities has not been sampled. Through support from OWET, HT Harvey and Associates sampled the Reedsport area using a 'skate trawl' (Terrill et al. 2010); however, this is a substantially larger trawl than used in the Newport test facility area and did not capture the juvenile flatfish – a life history stage of great interest and concern. The project presented here extended the BOEM-sponsored sampling done off Lakeside, OR, into state waters and sampled the future OPT demonstration site. Through support from OWET for this project, we provide a baseline evaluation of benthic invertebrates and fishes within and inshore of the future development site as well as have a full swath of inshore to offshore sampling in the region between Reedsport and Coos Bay, which may be used as a reference area as either site is developed in the future.

INTRODUCTION

Reedsport Site

According to documents submitted to FERC, the OPT Demonstration array will be approximately 2.5 miles offshore of Gardiner, Oregon in 50 – 69 m (165 – 225 ft) of water. The project boundary will encompass an area of 800 m x 800 m (0.25 mi^2).

The actual footprint of the constructed array is expected to be 300 m by 400 m (1,000' by 1,300') or approximately 0.12 km^2 (30 acres) in the northwest corner of the project area, where depths range from 62 to 69 meters (204' to 225'). Approximately 1.7% of the seafloor within the buoy array will be converted from sedimentary habitat to hard bottom with the installation of the 16 anchors. A full project build-out with the same anchoring scheme is expected to be similar to the 1.7% proportion.

Sedimentary (soft bottom) habitat is the predominant habitat on the continental shelf and slope throughout the Pacific Northwest. Although these sandy or muddy habitats are sometimes considered an ocean 'desert', they are dynamic and full of life. Organisms living in and on the sediment have to contend with significant changes to their habitat as a result of wave action and ocean currents, making them generally resilient to disturbance. This habitat encompasses two main community types: infaunal (living in the sediment) and epifaunal (living on top of the sediment). Infaunal invertebrates modify the sediment and structure the habitat, making them key species despite their individual small sizes. 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 infaunal soft-bottom organisms.

While sedimentary habitats from the territorial sea to the edges of offshore rocky banks in the Pacific Northwest are most likely to be developed for offshore renewable energy, this portion of the seafloor is the least characterized. Many studies have been conducted in southern California (Fauchald and Jones 1977, 1979, SAIC 1986, Hyland et al. 1991, Allen et al. 2007), but studies from well-characterized southern California sites are not necessarily transferrable to this region.

Sampling Sedimentary Habitat and Species

In order to collect baseline information about sediment dynamics that may occur in the vicinity of wave energy capture installation, seasonal and inter-annual dynamics in the composition and distribution of the local sediment should be determined so that potential effects can be evaluated in the context of natural variability. Techniques that traditionally have been used to study and classify the benthic environment include sediment-profile cameras, side-scan sonar, sediment grabs and cores, acoustic sub-bottom profiling, and acoustic backscatter (Rhoads, Muromoto, and Ward 1994). Sediment collection and grain size analysis varying distances and directions from the project location can be used to determine if a project has an effect on sediment dynamics.

To evaluate potential effects on benthic invertebrates and fishes in the project area, information about their distribution, habitat associations, and food habits should be collected, and the degree of temporal and spatial variability in species or assemblages of interest needs to be characterized before project-related changes can be evaluated. Fishes and invertebrates may be observed using various visual survey methods or collected using trawls or grabs. These three methods are briefly reviewed in the final report submitted to OWET of the sampling conducted at the Newport site.

METHODS

Site selection

We selected two study locations based on other, related activities in the area, as described in the Background section above. We selected a study area that encompassed the future OPT Demonstration site (RP; 'Reedsport'), and we selected a study area to the south (SC; 'South Comparison'), connected to the OCS site that is part of our BOEM sampling (Figure 1). Within each study area, we established 21 box core stations using a stratified random sampling design, known as a Generalized Random Tessellation Stratified (GRTS; Stevens & Olsen 2004) that distributed the sampling stations partitioned such that the number of stations within a 10 m depth bin was scaled based on the area of that bin within the site. After randomly generating the box core stations, 9 of those stations were selected as trawl locations such that there were three trawl stations at ~ 30 m depth, three at ~50 m, and three at ~70 m.

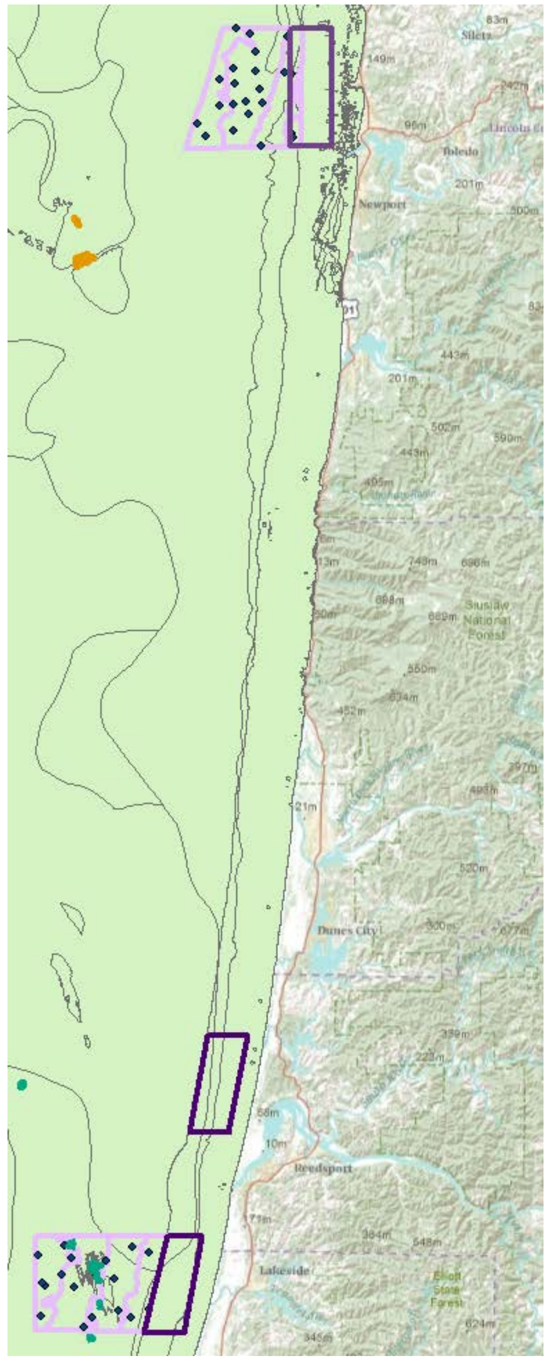

Figure 1: Sampling locations for this south coast study relative to other sites. Offshore pink polygons are sites surveyed for BOEM; blue dots within are grab stations. Inshore purple polygons are sites sampled via OWET funding (off Newport at the Ocean Test Facility site) and those for this project (in the south).

Box Coring

Infaunal invertebrates and sediment for grain size and total organic carbon samples were obtained using a modified Gray-O'Hare 0.1 m^2 box core (Figure 2). The Reedsport location was sampled on June 29 and 30; the South Comparison site was sampled on June 30, 2011. One grab was taken at each of the 21 stations. From each box core, a sub-sample of sediment was taken from the undisturbed top layer of the collected sample. A second sub-sample of sediment was taken from the middle of the sample. The remaining sediment was sieved onboard through a 1.0 mm screen. Collected organisms were preserved in 5 % buffered formalin. Upon return to the laboratory, rose Bengal was added to stain the samples. After 48 h samples were transferred to 70 % ethanol. Benthic infauna were sorted into major taxonomic groups laboratory staff. All groups except crustaceans and polychaetes were identified by laboratory staff using a stereomicroscope and, when necessary, a compound scope. Contracted 'taxonomic experts' identified the crustaceans and polychaetes. We used the same individuals contracted for the Newport sampling and the 2003 EPA-NCA project to ensure consistency in identification and to facilitate comparison with those surveys.

Grain sizes of the sediment were analyzed using a Beckman Coulter Laser Diffraction Particle Size Analyzer (LD-PSA) to determine percent sand and percent silt/clay. Samples also were analyzed for percent total organic carbon.

Trawling

For collection of epifaunal invertebrates and fishes, a beam trawl was used. The beam trawl is 2 meters wide by 70 centimeters high with a 3-millimeter (mm) mesh liner the entire length of the net and a tickler chain (Figure 3). The South Comparison site was sampled on July 2, and Reedsport site was sampled on July 3, 2011. Tows were conducted for 5 minutes because of the large numbers of ctenophores forced us to reduce the tow time to 5 minutes), and a constant speed of ~1.5 knots was attempted. A meter wheel on the sled of the trawl provided actual measures of the distance the trawl was on the bottom.

Upon bringing the collection on board, fish and small epifaunal invertebrates were sorted into major groups and promptly euthanized and frozen. Larger invertebrates such as crabs and sea stars were identified, sexed if appropriate, measured, and released. Upon return to the laboratory, fish and collected invertebrates were sorted by species and counted. All fish lengths and weights were measured.

Water column sampling

At each station-visit vertical water-column profiles of conductivity, temperature, dissolved oxygen, pH, turbidity, and depth were obtained with a Sea-Bird CTD.

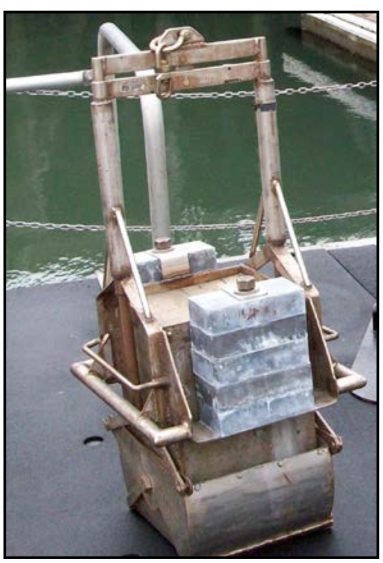

Figure 2: Box corer used for collecting infaunal invertebrates.

Figure 3: Beam trawl used for collecting epifaunal invertebrates and groundfish.

Data Analysis

Environmental Variability: To investigate the physical variability among sampling stations, principal components analysis (PCA) was conducted on the 'environmental' variables associated with each station: water depth, temperature, dissolved oxygen, pH, turbidity, salinity, median grain size and % silt/clay. PCA is one of the most commonly used multivariate statistical techniques used to reveal patterns in data, especially among objects (e.g. stations) that cannot be found by analyzing each variable separately (Quinn & Keough 2002). Biplots were generated with axes representing the dominant principal components (reduced variables), points representing the stations, and vectors, representing the physical variables, drawn from the origin. The direction of the vector indicates that the value of the variable increases in that direction and the length of the vector indicates the rate of increase – long vectors are more gradual increases, short vectors are faster increases (Quinn & Keough 2002).

Box Core and Trawl Assemblages: For species assemblage analyses (conducted separately for box core invertebrates, trawl invertebrates, and trawl fishes), taxa for which there was just one individual collected for the entire dataset were removed so as not to skew the data based on rare species. Data were then square root transformed for subsequent multivariate analyses.

Cluster analysis was conducted on the transformed density datasets for each 'assemblage' (infaunal invertebrates from box cores, epifaunal invertebrates from trawls, and fish from trawls) in order to produce groups of similar stations based on the species abundances. The SIMPROF routine was run in Primer 6 (Clarke 1993). This routine conducts a series of permutation tests to determine if clusters in the dendrogram have statistically significant structure. Samples within a cluster that could not be significantly differentiated are considered to be a genuine group. The SIMPER procedure in Primer was then used to identify the species contributing most to similarities within clusters and differences between clusters.

Multidimensional Scaling (MDS) was used to analyze the transformed density data to examine species composition and proportions across stations. MDS is an ordination technique where a small number of axes are selected prior to analysis and data are fitted to those dimensions, but no axes are hidden from variation (Holland 2008). Data were analyzed using the MDS function in Primer 6 (Clarke 1993). Data are displayed in the MDS plots such that samples that form a genuine cluster, as determined using the SIMPROF routine, have the same symbol on the plot. Following MDS analysis of the organism data, the BEST function in Primer was used. The BEST function is based on the BIO-ENV procedure, which uses all the available environmental variables to find the combination that corresponds best to the patterns in the biological data. In order to fully investigate the relationship among all physical variables and species distributions, for analysis of the trawl catches, sediment data from corresponding box core grabs were used.

RESULTS

Box Coring

Physical Characteristics

Box core stations ranged from 24 to 90 m deep. The median grain size of the sampling stations over the course of the study ranged from 58 µm to 227 µm. Larger median grain sizes were found at shallower stations while smaller grain sizes were found at the deeper stations. Specifically, all the grabs with <2 % silt/clay (defined as grains 62.5 µm or smaller) were shallower than 62 m. Stations from 55 m to 90 m contained 2 – 53 % silt/clay. Percent total organic carbon (TOC) in the collected sediment ranged from 0.036 % to 1.218 % and was inversely related to grain size. The best fit between the variables was an exponential relationship with an R^2 value of 0.71.

Most bottom water property values did not vary between the two sampling locations. However, there were significant differences in pH and nearly significant differences in dissolved oxygen. Overall temperatures ranged from 7.35 °C to 9.84 °C. Salinity ranged from 33.14 to 33.91. Dissolved oxygen values ranged from 1.04 ml/L to 6.17 ml/L with the South Comparison (SC) site having generally higher DO. The South Comparison (SC) site also had significantly higher pH values than the Reedsport site with 7.79 at SC and 7.70 at RP and a total range of 7.58 to 8.14. Turbidity ranged from 0.61 to 0.70 units.

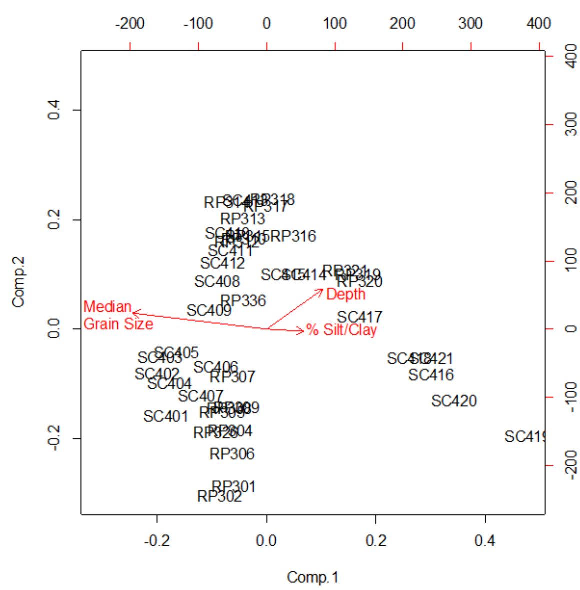

Figure 4: Principle Components Analysis of physical attributes of box core samples.

Analysis of the variation in physical attributes of the box core stations using Principle Components indicated that the first axis accounted for 91.8% of the variation among sampling stations. Component 1 aligned with the Median Grain Size and % silt/clay vectors (which are inversely correlated; Figure 4). The Depth vector integrated Components 1 and 2. Together Components 1 & 2 explained 99.3% of the variance in physical characteristics of the samples.

Infaunal Invertebrates

A total of 166 total invertebrate taxa were identified from the box cores collected near Reedsport, OR. Analysis of infauna based on the density of collected species indicated that similar communities formed primarily based on station depth (Figure 5). Most of the stations at less than 50 m depth from both RP and SC clustered together (Groups i, h, and f). Group g consisted of stations from both sites that were 54 - 70 m deep; Groups a, b, and c consisted of stations from both sites that were 70 - 80 m deep; and Groups d & e consisted of stations greater than 80 m deep (which occurred only at SC). The BEST function indicated that the highest resemblance between the biological and physical ordinations of the stations was achieved when just two of the environmental variables were used: water depth and temperature. This resulted in a correlation of 0.849. This procedure was bootstrapped 499 times with a resultant significance level of 0.02.

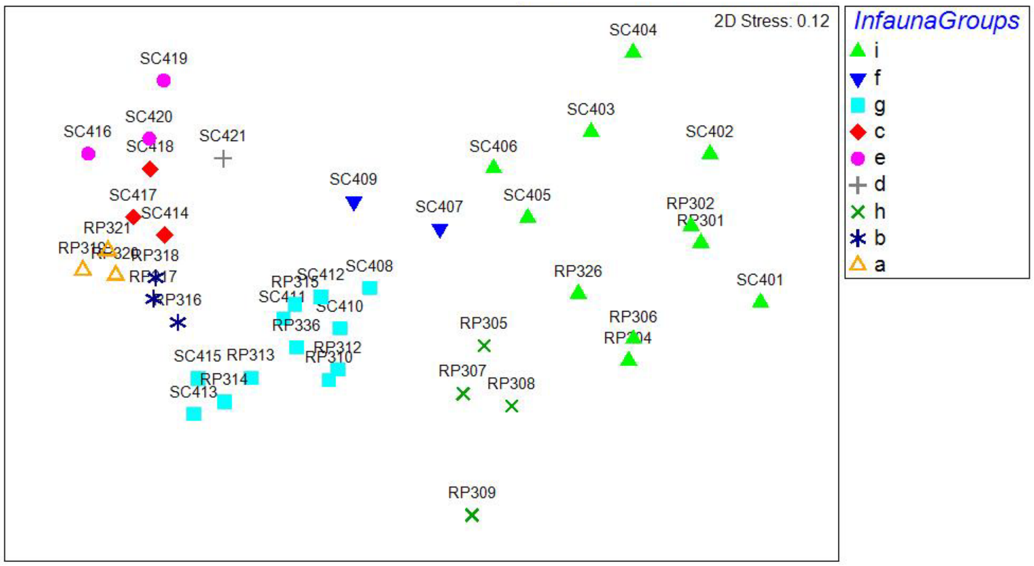

Figure 5: Multi-dimensional Scaling plot of similarity in infaunal invertebrate assemblages among trawls. Data were square root transformed. Significant clusters were determined used Bray Curtis similarity. Stations with the same symbol are statistically indistinguishable.

Trawling

Physical characteristics

Trawl stations ranged from 32 to 74 m deep. There were no significant differences in any of the bottom water characteristics between sites at the trawl locations. Temperatures ranged from 7.48 °C to 8.7 °C. Salinity ranged from 33.41 to 33.87. Dissolved oxygen was less variable during the trawl sampling than during the box core sampling; values ranged from a low of 1.86 ml/L to a high of 3.76 ml/L. The range of pH values was also narrower during the trawl sampling, with a low of 7.65 and a high of 7.79. The turbidity varied greatly during the trawl sampling, ranging from 0.49 to 2.99 units.

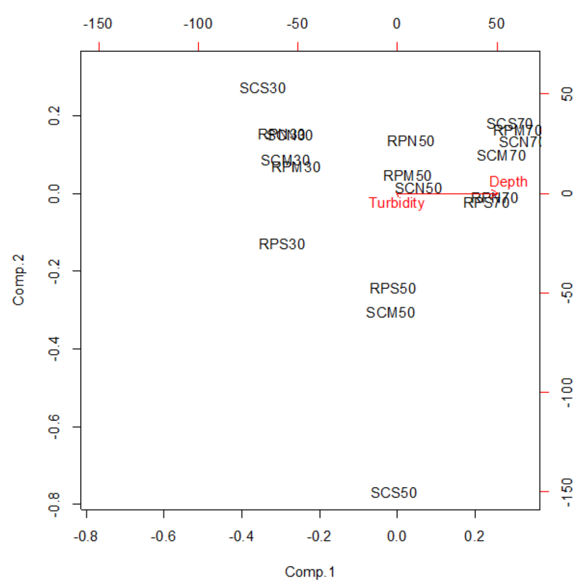

Figure 6: Principle Components analysis of water properties of tow stations

Analysis of the variation in the water

quality attributes (no sediment samples were taken on the trawl trips) of the trawl sampling visits using Principle Components indicated that the first axis accounted for 99.8 % of the variation. Component 1 aligned with the Depth vector (Figure 6). Turbidity aligned with Component 2 (which accounted for just 0.18 % of the variation).

Collected fish

In the 18 tows across the two sites, 24 species of fish were collected (Table 1). There were two distinct groups of fish assemblages (Figure 7). The 30 m stations from both locations clustered together and were characterized by high abundances of butter sole. The 50 m and 70 m stations from both sites clustered together and were characterized by high abundances of Pacific sanddabs along with the presence of Dover sole and rex sole, which were absent at the shallower stations. Overall, greater numbers of fish species were found at stations ~ 50 – 70 m deep than at stations approximately 30 m deep. Fish were also three times as abundant at the deeper stations than at the 30 m stations.

Table 1: Fish species collected via beam trawl near Reedsport, OR.

Species	Total #	% of Total
Pacific sanddab	319	28.7%
butter sole	216	19.4%
English sole	199	17.9%
rex sole	126	11.3%
sanddab sp.	56	5.0%
speckled sanddab	29	2.6%
Dover sole	27	2.4%
larval poacher	22	2.0%
pygmy poacher	18	1.6%
sand sole	15	1.3%
unidentified	14	1.3%
Pacific staghorn	13	1.2%
warty poacher	11	1.0%
roughback sculpin	7	0.6%
slim sculpin	7	0.6%
blackbelly eelpout	6	0.5%
ribbon snailfish	6	0.5%
sole sp.	6	0.5%
poacher sp.	4	0.4%
snailfish sp.	4	0.4%
slender sole	3	0.3%
flathead sole	2	0.2%
big skate	2	0.2%
rockfish sp.	1	0.1%

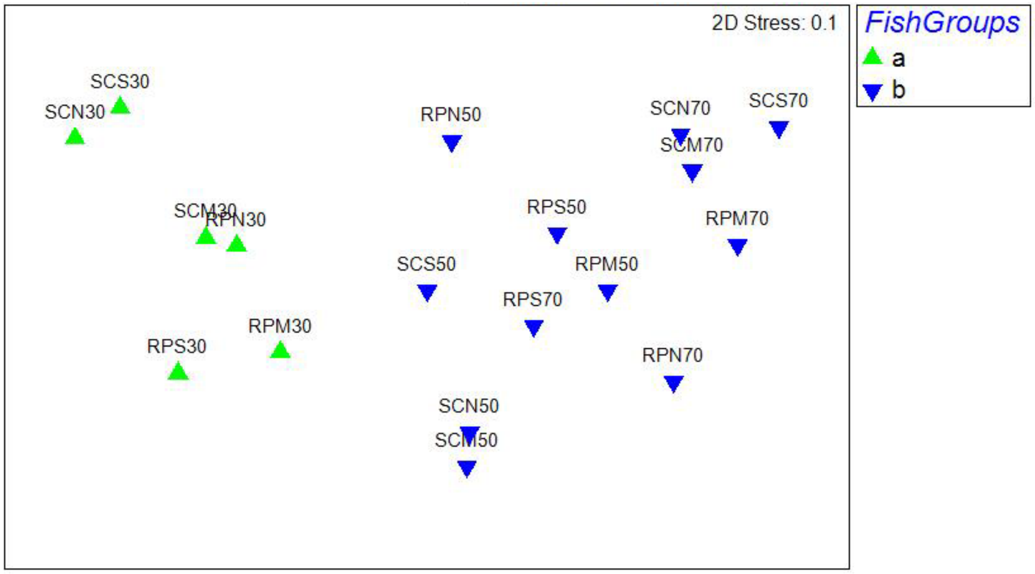

Figure 7: Multi-dimensional Scaling plot of similarity in fish assemblages among trawls. Data were square root transformed. Significant clusters were determined used Bray Curtis similarity. Stations with the same symbol are statistically indistinguishable.

The BEST function indicated that the highest resemblance between the ordination of the stations based on the biological variables and the ordination of the stations based on the environmental variables was achieved when just water depth was used in the analysis. This resulted in a rho value (correlation) of 0.779. The next best correlation (0.773) included dissolved oxygen. This procedure was bootstrapped 499 times with a resultant significance level of 0.02.

Collected epifaunal invertebrates

A total of 40 epifaunal invertebrate taxa were collected via trawl. Epifauna formed 4 significant clusters, based largely on station depth (Figure 8). Samples from 30 m depth at Reedsport and one SC station clustered together while the other two 30 m stations from SC formed a separate cluster. The rest of the deeper stations formed a third group except for one SC station at 70 m, which was unique. Epifaunal invertebrate species numbers were similar between the two groups, and organism abundance was more than three times higher at the 30 m stations than the deeper stations. The BEST function indicated a correlation of 0.690 between the biological and physical ordinations of the stations was achieved when only water depth was used in the analysis. The next best correlation (0.664) included dissolved oxygen. This procedure was bootstrapped 499 times with a resultant significance level of 0.02.

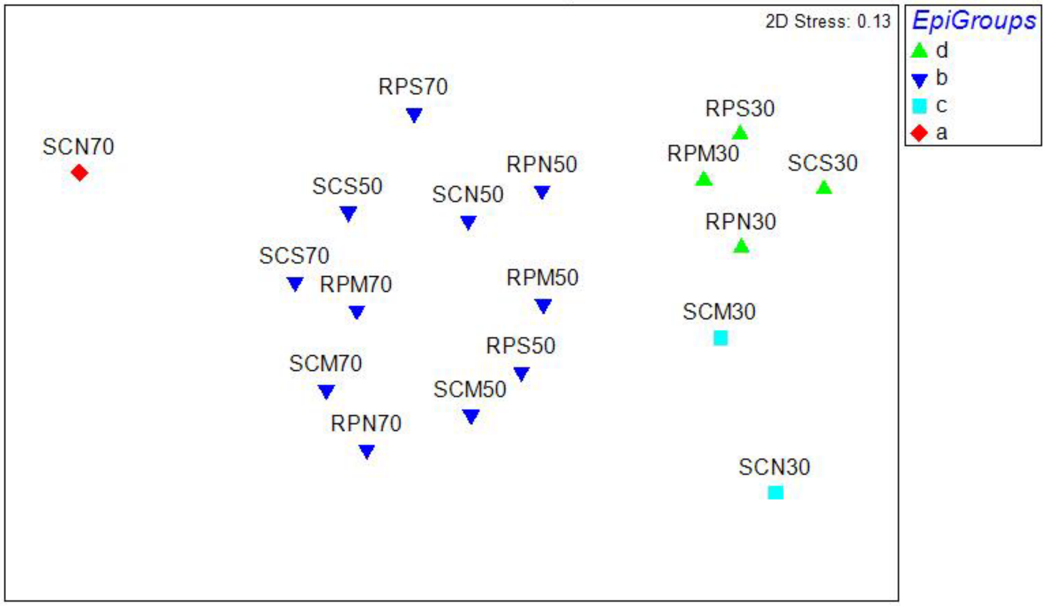

Figure 8: Multi-dimensional Scaling plot of similarity in epifaunal invertebrate assemblages among trawls. Data were square root transformed. Significant clusters were determined used Bray Curtis similarity. Stations with the same symbol are statistically indistinguishable.

DISCUSSION

Sediment and Infaunal Invertebrates

Both sediment characteristics and infaunal invertebrate assemblages varied with depth at these sites in south-central Oregon. While there was a break in sediment characteristics in the 50 to 60 m depth range, infaunal invertebrate species fell into finer depth bins, based on depth and presumably linked to temperature. Stations less than 40 m deep formed a unique cluster and were closely related to those stations less than 55 m deep. As sampling was conducted at deeper depths, the collected species formed assemblages associated with narrower depth bins. Thus, the sampling conducted by this study likely characterized the infaunal invertebrates potentially impacted by the planned OPT installation at in 62 – 69 m water, as 70 % of our effort was shallower than 70 m. However, if future installations are planned for deeper waters, additional sampling should be conducted to more fully characterize the assemblages of species found there.

Fish and Epifaunal Invertebrates

Water depth was the major driver of fish and epifaunal invertebrate assemblages found at the two locations in south-central Oregon. Because of strong seasonal (and sometimes inter-annual) differences in species abundances in our sampling off Newport, Oregon, full characterization of fish and epifaunal invertebrates of interest at the site should be conducted across multiple seasons. Effects monitoring should also be conducted across seasons. Minimally, one should ensure that before and after effects monitoring is done in the same season across years, so that natural seasonal variation does not confound the observations and conclusions. As for infaunal invertebrates, if future installations are planned for deeper waters, additional sampling should be conducted to more fully characterize the assemblages of species found there, since there was a strong depth component to species distributions and abundances in the range we sampled for this project. Understanding baseline differences in species distributions and abundances prior to installation is essential to evaluating possible project effects.

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