## Technical Summary

**STUDY TITLE:** SURVEY OF BENTHIC COMMUNITIES NEAR POTENTIAL RENEWABLE ENERGY SITES OFFSHORE THE PACIFIC NORTHWEST

**REPORT TITLE:** BENTHIC HABITAT CHARACTERIZATION OFFSHORE THE PACIFIC NORTHWEST
VOLUME 1: Evaluation of Continental Shelf Geology
VOLUME 2: Evaluation of Continental Shelf Benthic Communities

CONTRACT NUMBER: M10AC20002

SPONSORING OCS REGION: PACIFIC

APPLICABLE PLANNING AREAS: WASHINGTON-OREGON, NORTHERN CALIFORNIA

FISCAL YEARS OF PROJECT FUNDING: 2010 – 2015

COMPLETION DATE OF REPORT: NOVEMBER 24, 2014

COSTS: FY 2010 $1,598,846
FY 2011 $0
FY 2012 $0
FY 2013 $0
FY 2014 $0
FY 2015 $0

CUMULATIVE PROJECT COST: $1,598,846

PROJECT MANAGER: SARAH K. HENKEL

AFFILIATION (OF PROJECT MANAGER): HATFIELD MARINE SCIENCE CENTER, OREGON STATE UNIVERSITY

ADDRESS: 2030 S.E. MARINE SCIENCE DR., NEWPORT, OR, 97365

PRINCIPAL INVESTIGATORS*: SARAH K. HENKEL AND CHRIS GOLDFINGER

KEY WORDS: Bayesian, benthic, box core, grain size, habitat suitability, macro-invertebrate, mega-invertebrate, multibeam, northern California, Oregon, ROV, seafloor, surficial geologic habitat, Washington

**BACKGROUND:** While the oceans of western North America hold great potential for the development of both marine hydrokinetic and floating wind renewable energy technologies, concerns have been raised about effects on seafloor-associated (benthic) organisms by the installation of devices and mooring systems. To assess potential effects of development on benthic resources, it is necessary to gather a baseline understanding of the distributions of benthic organisms and how they relate to the physical environment (habitat). However, little is known about species-habitat relationships and community processes on the outer continental shelf. The first step in evaluating benthic species-habitat associations is to understand the benthic habitat, which for this project is defined as the depth and surficial substrate (or lithology). Historically, there have been few surveys in the Pacific Northwest. In 1995-1998, the

STRATAFORM project, initiated by the Office of Naval Research, resulted in maps and sediment analysis of the continental slope and shelf between Trinidad Head and Cape Mendocino, California, and other efforts by Oregon State University (OSU) scientists have mapped a number of the rocky banks offshore Oregon and Washington. More recently, Oregon and California have undertaken a large effort to map considerable proportions of their state waters. Similar to historical mapping efforts, invertebrate surveys have been patchy. While there has been some documentation of invertebrate bycatch from the trawl fishery, little is known about mega-invertebrate assemblages on this part of the continental shelf, with a few surveys conducted over the past two decades. Sedimentary (soft bottom) seafloor is the predominant habitat on the continental shelf and it is likely to be the habitat targeted for offshore renewable energy development; however, only one extensive study of benthic macrofauna has been conducted on the shelf in the region: a 2003 US Environmental Protection Agency (EPA) National Coastal Assessment.

**OBJECTIVES:** The purpose of this project is to provide a regional understanding of the physical properties of the seafloor and the distribution and location of invertebrates for Federal waters in the Pacific Northwest. The first objective was to build upon existing mapping datasets by collecting new data from key locations and integrating these results into a suite of data products designed to improve our understanding of seabed habitats at both local and regional scales. The second major objective was to survey benthic invertebrates in the region and distinguish communities associated with particular habitat characteristics. We focused on two main groups of invertebrates: mega-invertebrates (surveyed using a Remotely Operated Vehicle (ROV)) and macro-invertebrates (larger than 1 mm, collected using a box-corer). Finally, we aimed to develop models to predict habitat suitability for individual invertebrate species. By assembling this information for the first time in this region, this project provides predictive capabilities of where benthic habitats and invertebrate species/communities of interest may occur to inform decision-making regarding siting of facilities.

**DESCRIPTION:** The Active Tectonics and Seafloor Mapping Lab at OSU mapped the seafloor at five sites located 4.8 to 19 km (3 to 12 mi) offshore during the summers of 2010 and 2011. Bathymetry was mapped using high-resolution multibeam sonar, accurate to within a few centimeters resolution, and seabed hardness and texture were interpreted from multibeam backscatter data. Seabed grab samples were acquired from soft-bottom areas and analyzed using a laser diffraction particle size analyzer to identify relationships between grain size, bathymetry and backscatter data. Mapping products include local-scale habitat maps, an updated and extended regional Surficial Geologic Habitat map, data density and quality maps and a predictive rock outcrop map. The Benthic Ecology Lab at OSU visited three sites with rocky reef habitat using an ROV: Grays Bank, Washington, and Siltcoos and Bandon-Arago, Oregon, during the summers of 2011 and 2012. Substrate type (on and off the reefs) was quantified and observed invertebrates living on or attached to the sediments (mega-invertebrates) were identified from the resulting footage. To sample macrofauna living in soft-bottoms, during summer 2010, 118 macrofaunal and sediment samples were collected at the six originally proposed sites using a 0.1 $m^2$ box-corer. Two additional sites were sampled during the summer of 2012 to fill in latitudinal and habitat gaps. Sediment samples were sieved using 1 mm mesh and all macrofaunal organisms were identified and counted after a sub-sample of sediment was removed for particle size analysis. Bayesian networks were developed to statistically infer suitable habitat for seven species of soft-sediment-associated benthic macrofauna along on the continental shelf of the Pacific Northwest. Models were learned from benthic macrofauna sampling data collected from the eight sites along the Pacific Northwest continental shelf. Netica® software was implemented for the design and analysis of statistical models. The final products are static Habitat Suitability Probability maps communicating areas along the shelf that are likely good habitat for species of interest. We also developed maps communicating error or uncertainty associated with each Habitat Suitability Probability map.

**SIGNIFICANT CONCLUSIONS:** The multi-faceted approach to narrowing the information gap undertaken by this project yielded measureable gains in baseline data coverage in the study area. We added value to the new mapping data by developing seabed classifications at project survey sites as well as incorporating data from external sources into the classification. A key accomplishment of the project has been carrying the new mapping through to the regional synthesis data sets, the Version 4.0 Surficial Geologic Habitat Map for Washington, Oregon, and northern California and the probability of outcrop model ensuring that the most up-to-date seabed habitat information is available for marine renewable energy planning. While these integrations were not intended as comprehensive region-wide data collection and mapping efforts, they have provided key datasets that can be used to assess data distribution, thematic habitat map quality, likelihood of rock outcrop, and surficial sedimentary character. In terms of mega-faunal invertebrates, we identified at least four habitat types based on associated observed invertebrates (outlined in results below). These are somewhat different than geological classifications and should be considered in future surveys as distinct seafloor habitats. All four main habitat types were associated with mega-invertebrates that provided structure and complexity to the seafloor environment. Some taxa groups, such as gorgonians and sponges, which are long-lived and slow growing, were found not just on rocky reefs but also were characteristic of the areas with smaller rocks around the reef. Likewise, distinctions between macrofaunal invertebrate assemblages did not fully align with traditional sediment classifications. Areas comprised of very high percentages of sand (> 87%) contained multiple significantly different assemblages, differentiated based on particle size. Conversely, areas comprised of greater than 15% mud (regardless of whether it was 20% or 75% mud) were quite similar with no further differentiation associated with grain size. Within sediment types, depth-related changes were observed, with distinctions in assemblages occurring at approximately 10 m depth intervals. A benthic macrofauna model framework for invertebrates living within marine sediment that is both adaptable to new species and updateable was developed. Evaluation of many different model parameters and structure found a common suite of explanatory variables: regional variables (Distance to Shore, Depth, Latitude and Mean Grain Size) that are used to then predict *in situ* variables (Percent Silt, Percent Sand, TOC and TN). Experience maps are a novel product that communicates the percentage of data informing probabilities in the model. These maps help to communicate regional confidence in predictions arising from sampling effort.

**STUDY RESULTS:** The individual mapping components each provide an important update for the regional knowledge base. Multibeam bathymetry and backscatter data collection funded under this project at local-scale study sites corresponds to an approximately 5% increase in mapping coverage over the continental shelf study region (8 – 130 m depth from southern Washington to northern California). When including and accounting for the coverage that was made possible by leveraging external projects such as the OOI sites survey and the NOAA Ocean Explorer NSAF study, the new data coverage estimate is closer to 7%. Seabed imagery was classified for seabed habitat type for each of the six project study sites and seven additional backlog sites to create 13 new local seabed habitat maps. The completion of 13 site-specific habitat maps as well as the consolidation of 37 new externally developed sources of mapping data, largely collected through the Oregon and California State Waters Mapping Programs and identified in the EFH review, laid the groundwork for making significant updates to continental shelf habitats of the regional Surficial Geologic Habitat (SGH) map for Oregon and Washington, resulting in the new Version 4.0 habitat map. In addition to newly mapped areas of continental shelf and slope, the Version 4.0 SGH map also underwent significant modifications/updates to its underlying attributes. The “mixed” seabed induration modifier (second character of SGH Prefix) usage was corrected and the SGH primary and secondary lithology codes were redefined to clear up ambiguities making the distinction between homogeneous sediment mixtures and heterogeneous habitat patches more clearly defined. We adopt the recommended definition of SGH_Pref1 and SGH_Pref2 presented in the review and have incorporated the two newly identified map sources for Oregon. The Version 3.0 data quality maps for the SGH were updated resulting in a complete set of Version 4 data quality map products. The update extended the bathymetry density and sediment sample layers south into California waters in order to reflect the usage

of new regional bathymetry and sample data for regional SGH mapping in this region where physiographic canyon and channel systems were modified and sediment type was added. To evaluate the overall probability of rock outcrop, we incorporated six mapping components into an expert Bayesian model constructed using Netica®. The environmental data was sampled at a 200 m x 200 m spaced grid interval and predictions were made for over 2.5 million prediction points. A final Probability of Rock Outcrop map was assembled from the model output. Inverse Distance Weighted modeling was used to develop maps of grain size and percent sand composition on the continental shelf from 20 m to 130 m.

For the mega-invertebrate surveys, a total of 28 different substratum patch types were identified across the ROV stations. The fewest different substratum patch types were observed and analyzed at Siltcoos Reef, intermediate patch type diversity was observed and analyzed at Grays Bank, and the greatest numbers of substratum patch types were observed and analyzed at Bandon-Arago. A total of 91 taxa representing eight phyla were identified. We identified at least four habitat types for mega-invertebrate assemblages: (1) Pure Mud dominated by sea whips and burrowing brittle stars; (2) Mixed Mud-Rock (which may be further divided based on size of mixed-in rocks) characterized by various species in low density; (3) Consolidated Rocks characterized by high diversity and density of sessile and motile mega-invertebrates (at deeper depths there may be some distinction between flat and ridge rocks); and (4) Rubble Rocks showing less diversity and density than the consolidated rocks, probably due to the disturbance generated by the unconsolidated rocks. The two rocky habitats might not be as distinct at deeper depths where reefs might have their own local assemblages due to the predominance of locally induced conditions and deep species recruiting. Future studies should be designed to obtain thorough video coverage of transition areas between consolidated rock and mud habitats to discern whether different sizes of rocks mixed in with mud support distinct mega-invertebrate assemblages.

In the macrofauna collections polychaetes (Annelida) and bivalves (Mollusca) dominated the assemblages at each site. The site with the highest average Shannon-Weiner diversity was Nehalem and the lowest average diversity was found at the Newport site. The greatest ranges in number of species among stations as well as in H' diversity among stations were found at Grays Bank and Bandon-Arago; this was expected as these sites encompassed the greatest variety of sediment types (including gravel). Based on invertebrate species abundances, gravelly stations clustered together, regardless of site, and some sandy stations clustered across sites. Overall the subset of measured environmental variables that correlated best with the distribution of stations based on the macrofaunal invertebrate assemblages included depth, % sand, % gravel and median grain size with a correlation of 0.709. Further analysis indicated high gravel and moderate gravel assemblages very distinct from the rest of the groupings. Next, all stations (n = 70 across 5 sites) that were less than 84% sand (> 16% silt) formed a significantly similar group, which was not further subdivided, indicating that silty habitats support similar macrofaunal assemblages regardless of latitude or depth. Within stations that had > 87% sand, stations were further split on the basis of depth, median grain size, and finally a differentiation between 99.2 and 100% sand.

We developed Habitat Suitability Probability models for seven species of interest in the next chapter: *Axinopsida serricata, Ennucula tenuis, Astyris gausapata, Callianax pycna, Magelona berkeleyi, Onuphis iridescens,* and *Sternaspis fossor*. Some of these species were chosen because they represent ones that might be expected to change distributions based on sediment changes due to wave energy converter (WEC) installations. Others were chosen because of other characteristics about their distributions in order to demonstrate the utility of the tool across a spectrum of species. Model outputs for these seven species were then 'field validated' using data collected in the region later in the course of the study. Regions of rock, cobble and gravel were masked from the final predictive maps as the model was developed only for soft sediment habitats. However, preliminary models for the hard bottom glass sponge dictyonine species group are under development using the Probability of Outcrop map along with "Ridges" identified from the Version 4 Surficial Geologic Habitat map.

**STUDY PRODUCT(S):**

| | |
|---|---|
| **Report** | S.K. Henkel, C. Goldfinger, C. Romsos, K. Politano, L.G. Hemery, and A. Havron. 2014. Benthic Habitat Characterization offshore the Pacific Northwest. Bureau of Ocean Energy Management, OCS Study BOEM 2014-662. |
| **Theses** | |
| Lockett | A Bayesian approach to habitat suitability prediction (http://ir.library.oregonstate.edu/xmlui/handle/1957/28788) |
| Lee | Patterns of benthic macroinvertebrate communities and habitat associations in temperate continental shelf waters of the Pacific Northwest (http://ir.library.oregonstate.edu/xmlui/handle/1957/29185) |
| Labou | Physical factors affecting the spatial distribution of infaunal bivalve assemblages and species along the continental shelf of the Pacific Northwest (http://ir.library.oregonstate.edu/xmlui/handle/1957/42751) |
| Havron | The application of Bayesian networks towards benthic fauna habitat suitability modeling along the US west coast (In Prep.) |
| **Websites** | |
| Report: | http://www.boem.gov/Pacific-Completed-Studies/; http://www.boem.gov/2014-662-v2/; http://www.boem.gov/2014-662-v1/ |
| Geoportal: | http://bhc.coas.oregonstate.edu/geoportal |
| Data Download: | http://bhc.coas.oregonstate.edu/boem_data |
| Web Data Viewer: | http://bhc.coas.oregonstate.edu/benthic |
| Web Map Services: | http://bhc.coas.oregonstate.edu/arcgis/rest/services/2014_BOEM |

**Databases**

Arc GIS Personal Geodatabase of all GIS Data Products (DVD distribution)
MS Access Database of ROV video observations (substrata and organisms)
.csv files of all physical data and invertebrate counts from box core collections
(All invertebrate and associated data have been submitted to the NODC under accession number 0122659; http://data.nodc.noaa.gov/accession/0122659.)

**ArcCatalog Connection**

GIS Servers, Add ArcGIS Server, Use GIS Services, http://bhc.coas.oregonstate.edu/arcgis/services

## Listing of raster imagery filenames in the BOEM.gdb by site (row) and imagery type (column)

| BOEM.gdb (ESRI File Geodatabase) | | | | |
|---|---|---|---|---|
| Bathymetry and Derivative Raster Datasets | | | | |
| SITE | Backscatter | Bathymetry | Color Shaded-Relief | Grey Shaded-Relief |
| Grays Bank, WA | graysbank_8m_bs | graysbank_8m_bthy | graysbank_8m_colorshd | graysbank_8m_hllshd |
| Nehalem, OR | Nehalem_50cm_bs | Nehalem_8m_bthy | Nehalem_8m_colorshd | Nehalem_8m_hllshd |
| Newport, OR | Newport_1m_bs | Newport_8m_bthy | Newport_8m_colorshd | Newport_8m_hllshd |
| Silt Coos, OR | siltcoos_1m_bs | siltcoos_4m_bthy | siltcoos_4m_colorshd | siltcoos_4m_hllshd |
| Eureka, CA | eureka_18m_bs | eureka_18m_bthy | eureka_18m_hllshd | NA |
| NSAF, CA | nsaf_4m_bs | nsaf_8m_bthy | nsaf_8m_colorshd | nsaf_8m_hllshd |
| WA Inshore | wa_inshore_1m_bs | wa_inshore_2m_bthy | wa_inshore_2m_colorshd | wa_inshore_2m_hllshd |
| WA Sponge Reef | wa_sponge_2m_bs | wa_sponge_8m_bthy | wa_sponge_8m_colorshd | wa_sponge_8m_hllshd |
| Cape Falcon | capefalcon_1m_bs | capefalcon_4m_bthy | capefalcon_4m_colorshd | capefalcon_4m_hllshd |
| Stonewall Bank | Stonewall_2m_bs | Stonewall_2m_bthy | Stonewall_2m_colorshd | Stonewall_2m_hllshd |
| Coquille Bank | coquille_10m_bs | coquille_15m_bthy | coquille_15m_colorshd | coquille_15m_hllshd |
| H12130 | NA | h12130_4m_bthy | h12130_4m_colorshd | h12130_4m_hllshd |
| H12131 | NA | h12131_4m_bthy | h12131_4m_colorshd | h12131_4m_hllshd |

## Listing and description of all vector format features in the BOEM.gdb ESRI file geodatabase.

| BOEM.gdb (ESRI File Geodatabase) | | |
|---|---|---|
| FeatureClass | Feature Dataset | Description |
| Contour | CapeFalconContours | 5 meter interval bathymetry countour |
| | CoquilleBankContours | 5 meter interval bathymetry countour |
| | EurekaContours | 5 meter interval bathymetry countour |
| | GraysBankContours | 5 meter interval bathymetry countour |
| | H12130Contours | 5 meter interval bathymetry countour |
| | H12131Contours | 5 meter interval bathymetry countour |
| | NehalemContours | 5 meter interval bathymetry countour |
| | NewportContours | 5 meter interval bathymetry countour |
| | NSAFContours | 5 meter interval bathymetry countour |
| | SiltCoosContours | 5 meter interval bathymetry countour |
| | SpongeReefContours | 5 meter interval bathymetry countour |
| | WAInshoreContrours | 5 meter interval bathymetry countour |
| | PercentSandContours | 10% interval contour |
| | MeanGrainsizeContours | 1 phi unit interval contour |
| DataOutlines | BOEMSites | Site outlines for study sites |
| | EFH_SubRegion_Strata | Regional strata from 2012 EFH Review Synthesis |
| | ExistingSites | Site outlines for habitat maps developed through other work |
| | NonBOEMSites | Site outlines for "backlog" sites |
| IsocoreOutcropStability | Isocore | Map of minimum isocore sediment thickness |
| | SeismicLinesForIsopach | Tracklines used to develop Isocore map |
| | SeismicPredictedRock | Map of areas where rock may occur along seismic survey lines |
| | SlopeStabiltityPredictedRock | Map of areas where unstable slopes may cause rock outcrop |
| SeabedClassification | CapeFalconFaultHabitat | Local-scale habitat map |
| | CoquilleBankHabitat | Local-scale habitat map |
| | EurekaHabitat | Local-scale habitat map |
| | GraysBankHabitat | Local-scale habitat map |
| | H12130Habitat | Local-scale habitat map |
| | H12131Habitat | Local-scale habitat map |
| | NehalemHabitat | Local-scale habitat map |
| | NewportHabitat | Local-scale habitat map |
| | NSAFHabitat | Local-scale habitat map |
| | SiltCoosHabitat | Local-scale habitat map |
| | SpongeReefHabitat | Local-scale habitat map |
| | StonewallBankHabitat | Local-scale habitat map |
| | WA_OR_NCA_V4_0_SGH | Regional -scale habitat map |
| | WA_InshoreHabitat | Local-scale habitat map |
| SeabedSamples | BOEM_Shipek_Grab_Samples | Shipek Grab Samples (and textural data) for BOEM sites |
| | ORSWMP_Shipek_Grab_Samples | Shipek Grab Samples (and textural data) from the ORSWMP |
| | BOEM_Box_Cores_Sed | Box Core Samples (with textural data) for BOEM sites |
| | BOEM_Box_Cores_Bio | Box Core Samples (infauna and sed. data) for BOEM sites |
| | EPA_Box_CORES | Box Core Samples (infauna and sed. data) for EPA sites |
| Submersible | NOAA_Sled_Transects_2010 | Tracklines for NOAA Sled deployments |
| | OSUWE2011_HabSegments | Habitat segments for 2011 ROV depolyments |
| | OSUWE2011_Trackline | Tracklines for ROV deployments 2011 |
| | OSUWE2012_HabSegments | Habitat segments for 2012 ROV depolyments |
| | OSUWE2012_Trackline | Tracklines for ROV deployments 2012 |

**Listing and descriptions of regional raster datasets in the BOEM.gdb**

| BOEM.gdb (ESRI File Geodatabase) | |
|---|---|
| Regional Raster Datasets | Description |
| MeanGrainsize | Modeled mean grainsize |
| PercentSand | Modeled % Sand composition |
| OutcropModel | Modeled rocky outcrop liklihood |
| V3_SGH_Map_Quality | Previous Regional Data Quality Map |
| V4_SGH_Map_Quality | Version 4.0 Data Quality map |
| V4_Data_Quality_Updates | Mapping quaity overlay |
| V4bathydensity | Ranked bathymetry data density |
| V4sampdensity | Ranked sample data density |
| V4ssdensity | Ranked sidescan data density |
| V4seisdensity | Ranked seismic data density |
| waornca_100m_colorshd | Color shaded-relief image of the region |
| WestCoastSlope100m | bathymetric slope map of the region |

**Publications**

Hemery, LG and Henkel, SK. (*Revised version submitted*) Patterns of benthic mega-invertebrate communities and habitat associations in Pacific Northwest continental shelf waters. Biodiversity and Conservation.

Labou, SG and Henkel, SK. (*In revision*) Factors related to distinct infaunal bivalve assemblages differ in sand versus silt shelf habitats. Marine Environmental Research.

**Presentations**

Goldfinger:

1. Ocean Sciences Meeting: Hawaii – Predicting Benthic Invertebrate Distribution: GIS-Linked Bayesian Belief Networks for Marine Spatial Planning. February 2014

Henkel:

1. Environmental Interactions of Marine Renewables: Stornoway, Scotland – Estimating distribution of sedimentary benthic habitats and species on the eastern Pacific shelf and detecting effects of device deployment. May 1, 2014
2. Benthic Ecology Meeting: Jacksonville, FL – Classifying Benthic Habitats is Complex: but that's Not what Epifaunal Invertebrates Like about It. March 2014
3. Western Society of Naturalists Meeting: Oxnard, CA – Identifying Invertebrate Assemblages on the PNW Shelf for Habitat Mapping and Environmental Assessment. (Poster) November 2013
4. Oregon Marine Renewable Energy Environmental Science Conference: Corvallis, Oregon – Linking Habitat and Benthic Invertebrate Species Distributions in Areas of Potential Renewable Energy Development. November 2012
5. Oregon Institute of Marine Biology Fall Seminar Series: Charleston, OR – Diversity and Dynamics of Benthic Invertebrates on the Oregon and Washington Shelf. November 2012
6. Benthic Ecology Meeting: Norfolk, Virginia – Spatial Heterogeneity of Pacific Northwest Infauna Increases with Grain Size. March 2012
7. Western Society of Naturalists: Vancouver, Washington – Spatial and Temporal Patterns in the Distribution of Infaunal Invertebrates. November 2011

8. Heceta Head Coastal Conference: Florence, Oregon – Assessment of Benthic Habitats and Communities in Areas Targeted for Offshore Wave Energy Development. October 2011
9. American Fisheries Society: Seattle, Washington – Assessment of Benthic Habitats and Communities in Areas Targeted for Offshore Wave Energy Development. September 2011
10. Benthic Ecology Meeting: Mobile, Alabama – Benthic Assemblages at Sites Proposed for Wave Energy Testing. March 2011

Gilbane

1. Western Society of Naturalists Meeting: Oxnard, CA – The Role of Collaboration in Conducting a Regional Benthic Assessment. November 2013
2. Oregon Marine Renewable Energy Environmental Science Conference: Corvallis, Oregon – Gorgonians as a potential indicator for assessing sea floor condition in marine spatial planning. November 2012

Havron

1. International Marine Conservation Congress: Glasgow, Scotland – Bayesian Inference of Benthic Infauna Habitat Suitability along the U.S. West Coast. August 2014

Hemery:

1. North American Echinoderm Conference: FL – Ecological niche and species distribution modeling of sea stars along the Pacific Northwest coast. June 2014

Labou:

1. Western Society of Naturalists Meeting: Oxnard, CA – Physical Factors Affecting the Distribution of Infaunal Bivalve Assemblages along the Continental Shelf of the Pacific Northwest November 2013
2. Heceta Head Coastal Conference: Florence, OR – Mapping spatial and temporal variation of bivalves. (Poster) October 2012.

Lee:

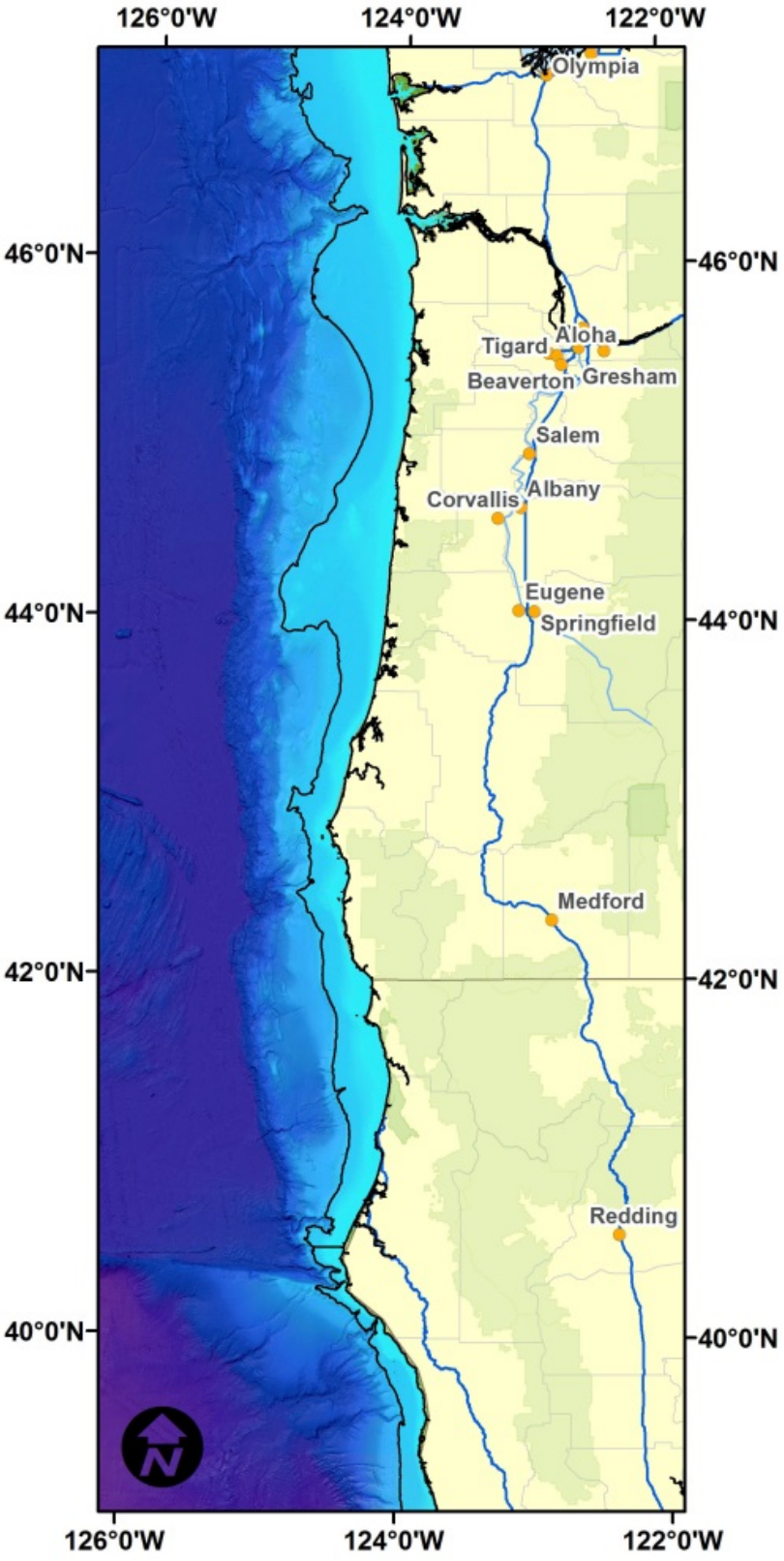
1. Ocean Sciences Meeting, Salt Lake City, Utah – Finding Appropriate Abiotic Parameters to Evaluate Benthic Macroinvertebrate Assemblages in Temperate Continental Shelf Waters. (Poster) February 2012
2. Western Society of Naturalists: Vancouver, Washington – Variances of Asteroid Echinoderms Densities across Substrata, Depth, and Temperature. November 2011

Lockett:

1. Western Groundfish Conference: Seattle, WA – Predicting Benthic Invertebrate Distribution: GIS-linked Bayesian Belief Networks for Marine Spatial Planning. (Poster) February 2012

**Media**

Beaver Nation Video on Sarah Henkel and baseline sampling for wave energy:
http://sites.oregonstate.edu/beaver-nation/everywhere/coast/#henkel


126°0'W
124°0'W
122°0'W
46°0'N
44°0'N
42°0'N
40°0'N
Olympia
Aloha
Tigard
Beaverton
Gresham
Salem
Albany
Corvallis
Eugene
Springfield
Medford
Redding

**Study Area**