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Benthic assemblages of mega epifauna on the Oregon continental margin

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ABSTRACT

Environmental assessment studies are usually required by a country's administration before issuing permits for any industrial activities. One of the goals of such environmental assessment studies is to highlight species assemblages and habitat composition that could make the targeted area unique. A section of the Oregon continental slope that had not been previously explored was targeted for the deployment of floating wind turbines. We carried out an underwater video survey, using a towed camera sled, to describe its benthic assemblages. Organisms were identified to the lowest taxonomic level possible and assemblages described related to the nature of the seafloor and the depth. We highlighted six invertebrate assemblages and three fish assemblages. For the invertebrates within flat soft sediments areas we defined three different assemblages based on primarily depth: a broad mid-depth (98–315 m) assemblage dominated by red octopus, sea pens and pink shrimps; a narrower mid-depth (250–270 m) assemblage dominated by box crabs and various other invertebrates; and a deeper (310–600 m) assemblage dominated by sea urchins, sea anemones, various snails and zoroasterid sea stars. The invertebrates on mixed sediments also were divided into three different assemblages: a shallow (~100 m deep) assemblage dominated by plumose sea anemones, broad mid-depth (170–370 m) assemblage dominated by sea cucumbers and various other invertebrates; and, again, a narrower mid-depth (230–270 m) assemblage, dominated by crinoids and encrusting invertebrates. For the fish, we identified a rockfish assemblage on coarse mixed sediments at 170–370 m and another fish assemblage on smaller mixed sediments within that depth range (250–370 m) dominated by thornyheads, poachers and flatfishes; and we identified a wide depth-range (98–600 m) fish assemblage on flat soft sediments dominated by flatfishes, eelpouts and thornyheads. Three of these assemblages (the two broad fish assemblages and the deep flat soft sediments invertebrate assemblage) seem to represent deeper examples of assemblages already known on the Oregon continental shelf, especially on soft sediments, while the assemblages in the pockmarks habitat (the narrower depth ranges) might be unique to the area. This diversity of assemblages in a relatively small section of the Oregon continental upper slope and shelf shows the importance of environmental assessment studies in helping limit future impacts of industrial activities on benthic communities.

1. Introduction

In many countries where developments of marine industrial activities are considered, such as offshore drilling, marine renewable energy, fisheries and aquaculture, environmental assessment studies are required before issuing permits (e.g. Blanchard and Feder, 2014, European Commission, 2010, Lissner et al., 1985). Many of these studies aim at characterizing the nature of the seafloor, the properties of the water column, the species making up the different assemblages of organisms, and the general ecological state of the different components of the ecosystem in the targeted area. Environmental assessment studies are thus great sources of data to improve our basic knowledge of poorly known organisms and ecosystems (e.g. Amon et al., 2016, Hemery and Henkel, 2016).

U.S. federal and state governments are preparing for the development of offshore renewable energy to slow down the rise of atmospheric carbon dioxide due to fossil fuel consumption, (e.g., Oregon Executive Order No 08-07, 2008). The Pacific Northwest has high potential for both offshore wave (Bedard et al., 2005) and wind (Thresher and Musial, 2010) development. A section of the seafloor offshore Coos Bay, Oregon, was selected for the potential deployment of floating wind turbines; before the Bureau of Ocean Energy Management (BOEM) allows lease sales of the seafloor, however, a seafloor habitat assessment needed to be completed in the area of interest. Although several benthic assemblage and habitat studies based on underwater video images have already been carried out at a few places on the Oregon and Washington

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continental shelf (Hannah et al., 2010, 2013; Hemery and Henkel, 2015, 2016; Hixon and Tissot, 2007; Stein et al., 1992; Strom, 2006; Tissot et al., 2007), and Essential Fish Habitat has been modeled off Oregon using available data (Pacific Fishery Management Council, 2012), the proposed wind energy area had not been previously surveyed. The aim of the present study was to describe the benthic megafauna assemblages (sessile and motile, fishes and invertebrates) offshore Coos Bay, Oregon, as part of a multidisciplinary exploration mapping effort to produce a Coastal and Marine Ecological Classification Standard (CMECS) map of an area targeted for the deployment of offshore wind turbines (Cochrane et al., 2017). Video images were acquired with a towed camera sled for ground-truth of the seafloor in order to ground truth map interpretations (Cochrane et al., 2017). This material was used to highlight similarities and differences with assemblages described in previous studies, and to better understand the variety and characteristics of benthic assemblages on the northeastern Pacific continental margin (slope and shelf). We identified organisms to the lowest taxonomic level possible and described assemblages related to the composition of the seafloor and the depth. This study enables better insight into the deep-water benthic organisms and their habitats in a data-poor area of this continental margin and provides new information about the distribution of the observed taxa along the continental margin in order to help manage the impacts of human activities on the biodiversity.

2. Material and methods

2.1. Study site

In September 2014, we conducted seafloor surveys over a 140-km^2 area primarily 15 miles offshore Coos Bay, Oregon, on the upper slope (200–600 m) with one additional observation on the shelf (100 m). In the study area, the near-surface geologic units consist of recent sediment overlying Quaternary bedrock (Clarke et al., 1985) with two slope classes present in the area: flat areas with a slope of 0–5° and sloping areas with a slope of 5–30° (Cochrane et al., 2017). Noticeable features of the seabed comprise a series of pockmarks between the 200 and 300 m isobaths, a landslide starting at about 300 m deep, and a rocky ridge which highest point reaches about 300 m as well (Fig. 1). General patterns and processes of circulation over this portion of the shelf and slope are described in Hickey (1989) and Landry et al. (1989) and annual averages of near-bottom temperature, salinity, eastward and northward horizontal current components from a regional ocean circulation model over a larger area are presented in Hemery et al. (2016); however no hydrographic parameters were measured for this survey.

2.2. Visual inspection and mapping

We used a tethered instrument package called the Benthic OBservation Sled, or “BOB Sled”, developed by the USGS Pacific Coastal and Marine Science Center in Santa Cruz, California (Anderson et al., 2007; Cochrane et al., 2015), to record underwater videos for the double purpose of supervising the interpretation of multibeam echo sounder (MBES) data for geology and benthic habitats (Cochrane et al., 2017) and of surveying epifauna to determine assemblages and habitats associations.

The BOB sled (136 cm long, 44 cm wide, and 52 cm high) was equipped with two color high definition (HD) video cameras: one facing downward and perpendicular to the dorsal surface of the sled, and the other facing forward, slightly angled from the dorsal surface. The light was provided by three DeepSea Power & Light SeaLite LED lights: two on the front of the sled directed downward and one on the tail directed 15 degrees forward of vertical. The position and orientation of the lights were chosen to provide even illumination of the view area of the two video cameras at a 1-m height. The sled was also equipped with sizing lasers for each camera (10 cm apart), a Subsea electronics housing and an altimeter. Downward-facing HD videos were used to identify substratum patches and organisms, and outward-facing HD videos were only used to help difficult identifications, providing a different angle. Due to bad visibility, all footage viewed by the downward-facing camera was considered “on-transect” if the sled's height above the seafloor was low enough to allow identification ($\approx$ 1 m).

Upon completion of the MBES survey, 17 dives were conducted using the BOB Sled with the intent to survey the diversity of geologic features (revealed by different shades of grey on the MBES map; Fig. 1) and variability of depth covered by the project area, in order to get as much representative information on the seafloor as possible (Fig. 1, Table 1; Cochrane et al., 2015). The BOB Sled was towed behind the USGS R/V *Parke Snavely* at a speed under 1 knot. When possible, the sled was kept at less than a meter above the bottom by keeping the supporting cable tight and winching the sled up or down, in order to provide images of good quality to identify and enumerate the benthic organisms. The position of the boat at the surface was used as a proxy of the latitude and longitude of the sled when on the bottom. The absolute geographic position of the sled on the seabed was not required for the present analysis.

2.3. Substratum patch area and species density

The area covered by each substratum patch was calculated from the distance covered by the boat at the sea surface. The R/V *Parke Snavely* is an 11-m boat and swell conditions off the Oregon coast caused boat motion that affected the camera altitude significantly. For the analysis, the transect width was averaged to a fixed width (1.15 m) corresponding to the width of the view of the seafloor when the sled was at about 1-m high. The substratum patch area was calculated by multiplying the distance covered by the boat and the transect width. The density of each organism taxon per substratum patch was then calculated as the number of each organism taxon divided by the segment area.

2.4. Video analyses

Video analysis generally followed guidelines established by Tissot (2008). Each video was watched by a single viewer following a five-step analysis procedure: (1) initial identification of all fish and mega-invertebrates larger than 5 cm (epifauna and endofauna taxa showing recognizable body parts above the sediment); (2) substratum identification; (3) sessile mega-invertebrate enumeration; (4) motile mega-invertebrate enumeration; and (5) fish enumeration. Some stations with a denser invertebrate coverage necessitated one to three additional viewings. Each observation entry (i.e. beginning / end of a substratum patch and occurrences of fish and invertebrates) was accompanied with a time code that was used to determine in which substratum patch a particular organism was found.

2.4.1. Substratum classification

A different substratum segment was recorded each time the video sled would cover a different substratum type or would be off-transect. Segments of similar substratum type separated by less than a minute were defined as patches, and the start and end times of each substratum patch were recorded.

Substratum was classified based on seven grain-size classes estimated from the video footage using the lasers to differentiate pebble from cobble from boulder and, for consolidated rocks, on relief angle (Stein et al., 1992; Tissot, 2008). Substratum composition was coded with two letters, first letter indicates dominating substratum (50–80% of the seafloor) and the second letter indicates substratum covering the remaining 20–50%. The substratum categories used were: R for ridge rock (angle > 30°), F for flat rock (angle < 30°), B for boulder, C for cobble, P for pebble, G for gravel, and M for mud (not distinguished from sand). If a patch comprised over 80% of a single substratum type,

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