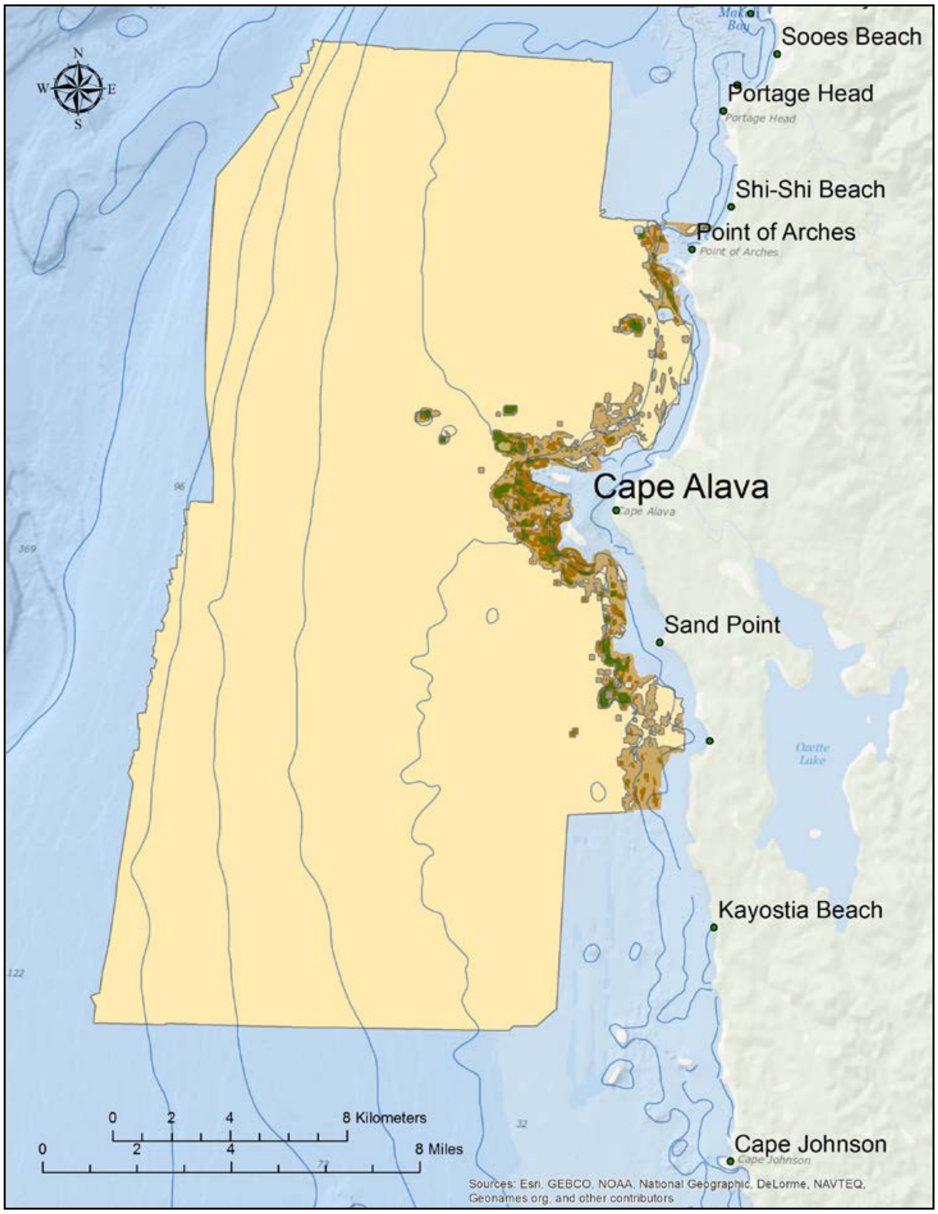
Seafloor Habitat Classification of Cape Alava



2010 NOAA Ship Fairweather Survey

HMPR-125-2010-01

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NOAA Olympic Coast National Marine Sanctuary, 2013

NOAA SHIP FAIRWEATHER

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Introduction

Olympic Coast National Marine Sanctuary (OCNMS) spans 8,259 km^2 (3,189 square miles) of the continental shelf and deep canyons off the coast of Washington State. The sanctuary protects a productive upwelling zone – home to rich marine mammal and seabird communities, diverse populations of kelp and algae, thriving invertebrate populations, and an extensive groundfish population. OCNMS continues to invest resources in seafloor mapping to build a knowledge-base that supports resource management by the sanctuary, its tribal trustees, and its Washington State partner.

The *West Coast Governors' Agreement on Ocean Health* (Gregoire et al., 2006) and *Washington's Ocean Action Plan* (Hennessey, 2006) have called for the partnership of California, Oregon and Washington to support improved coastal and ocean health. The tri-state research and monitoring program for the entire West Coast includes mapping the seafloor bathymetry and habitat of all state tidelands out to three miles by 2020. Products derived from this mapping would include improved navigational information, provide safety guidelines for mariners, inform seafloor characterization and classification, and create baseline data about the nearshore critical habitats that support vital marine life.

NOAA is the primary agency that conducts seafloor mapping off Washington's coast. By focusing the NOAA Ship *Fairweather* survey on the unmapped Cape Alava area, OCNMS increased the area of mapped state water inside the sanctuary to nearly 44%. It also increased the mapped area of the sanctuary to 28%. It linked existing surveys from the NOAA Ship *Rainier* (Intelmann et al., 2006), hydrographic coastal LIDAR surveys (Intelmann, 2006), and several side scan surveys (Intelmann and Cochrane, 2006) to facilitate the development of a seamless atlas of seafloor shelf and canyon habitats. More than 180 sites were ground truthed using ROV, video, underwater camera, and sediment sampling to validate this hydrographic survey and guide the habitat characterization. For state, federal, and tribal marine waters, this survey provides more quantitative and qualitative information about the seafloor than any other single survey since the OCNMS mapping program began in 2000.

The intention of the survey was to capture both hydrographic data for charting and benthic habitat characteristics for resource protection. As a result, several different types of reports were generated. A Descriptive Report (DR) for each of the five survey sub-areas (sheets) was generated by the Chief of Party (Neander, 2010a). Data processing details, unique findings, or dangers to navigation are noted in these reports. Additional technical information on acquisition and processing procedures used for hydrographic projects on the *Fairweather* are available in the Data Acquisition and Processing Report (DAPR) (Neander, 2010b). Finally, *Seafloor Habitat Characterization of Cape Alava from 2010 NOAA Ship*

Fairweather Survey addresses benthic habitat characteristics to assist marine resource managers in understanding nearshore conditions.

Survey Area

OCNMS surveyed 557.1 km^2 (215.1 mi^2) in an area off Cape Alava, Washington that stretches from Point of Arches in the north to Sea Lion Rock in the south. The survey depths ranged from 10 meters at the rocky shoreline to 120 meters at the western extent of the survey. The unique rocky coastline of Cape Alava is classified as Quaternary glacial drift, a lithified silt, sand and gravel that is constantly eroded by the force of the Pacific. While there are many rocky environments like this throughout Puget Sound in Washington, there are few on the outer coast, making this a valuable marine habitat for seabirds and marine mammals, invertebrates, and groundfish. However, this area is unprotected from the extremes of Pacific tide, surf and storm. The Cape Alava rocky coast provides significant challenges to any vessel moving among the small rocky islands, and few survey vessels have worked in this area. The most recent bathymetry surveys were conducted in the early 1900's and scant information exists on the extent or nature of the seafloor sediments.

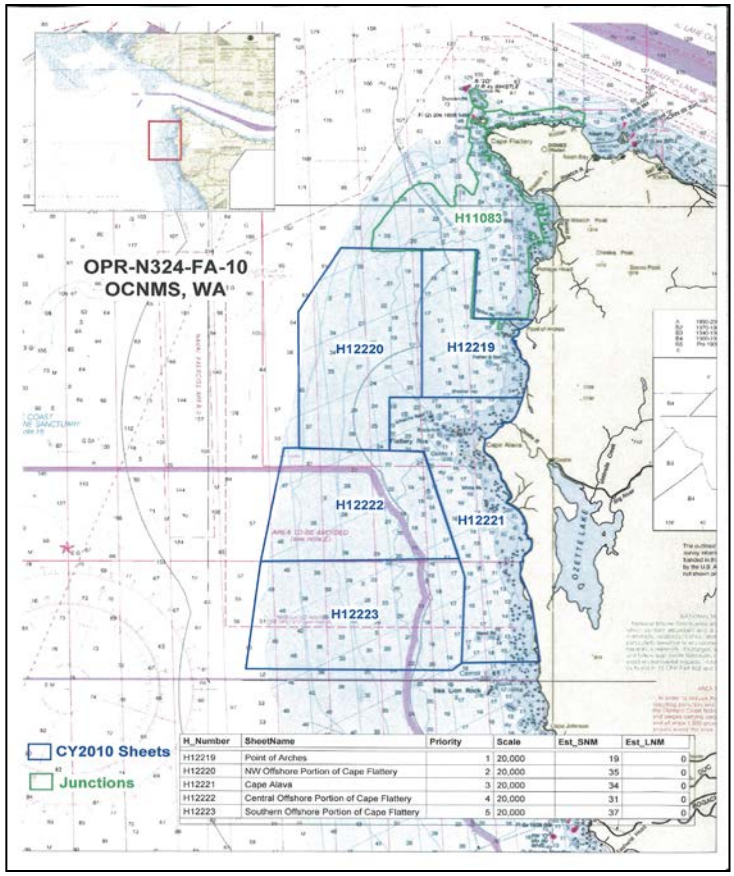

Figure 1: The five areas (sheets) surveyed off Cape Alava in 2010 were selected because of their valuable coastal ecosystems and their need for updated navigational information. In addition, mapping within state waters contributed to Washington State's Marine Spatial Planning Initiative.

This survey area was selected because the *Fairweather* could deploy its smaller 29 ft launches with hull-mounted multibeam echosounders in the rocky areas of mapping sheets H12219 and H12221 (Neander, 2010a) to collect bathymetry measurements for updated navigational information and backscatter data for sediment analysis and classification. This area was also selected because it complimented the needs of Washington State and the West Coast Governors' Agreement on Ocean Health (Gregoire et al., 2006) to provide high-resolution bathymetric, topographic, and seafloor habitat information within state waters for Marine Spatial Planning.

Data Acquisition and Processing

The *Fairweather* is equipped with Reson 7111 and Reson SeaBat 8160 hull mounted multibeam echosounders (MBES). Each of the *Fairweather's* four survey launches was equipped with a hull-mounted Reson 7125 SV dual frequency (200, 400kHz) MBES, although only the 400 KhZ frequency was used during the OCNMS survey due to the shallow depths of the survey. All MBES units were 'snippet' enabled to support the collection of backscatter data used for seafloor characterization.

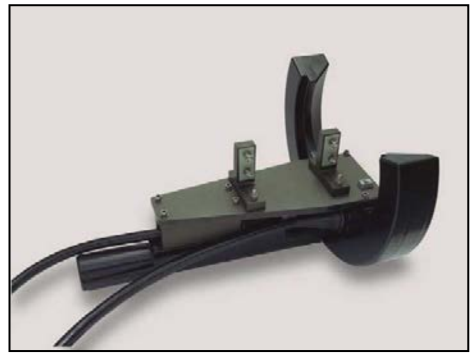

Figure 2: Reson SeaBat 8160 MBES

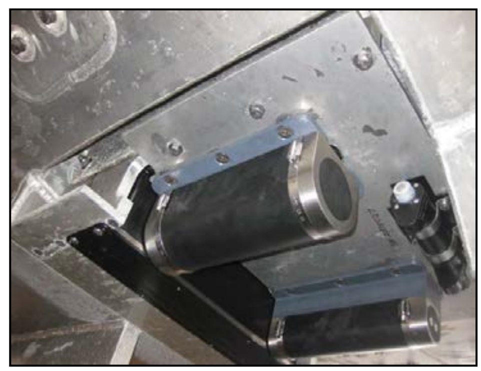

Figure 3: Hull-mounted Reson 7125 SV MBES

Hydrographic survey data were processed in CARIS HIPS^{TM} (Hydrographic Information Processing System) by physical scientists onboard the *Fairweather* following the standards outlined in the DAPR. Bathymetry and backscatter data were delivered to OCNMS for the development of a benthic habitat characterization and classification scheme.

OCNMS first created backscatter mosaics in CARIS Geocoder. The mosaics were moved to ArcGIS 10.2 as rasters. Subsequent analysis of geomorphology – slope, relief, habitat complexity – were assessed in GIS.

Ground Truthing

In July, 2012 the R/V Tatoosh collected sediment samples and seafloor video from 31 sites within the area mapped by the *Fairweather* in 2010. Ground truthing is necessary to validate the imagery provided by sonar and to determine the texture of the seafloor for habitat characterization. OCNMS has developed a ground truthing method that uses a Smith-MacIntyre sediment grab with an attached, self-contained underwater video camera. This combination provides a hands-on sample of seafloor sediment with a video of the area around the sample to provide visual context to complement the grain size analysis.

From each Smith-MacIntyre grab we save 500-1000 g seafloor material, dry it in the laboratory, and sieve it to levels of coarseness from cobble to clay based on the Wentworth grain size scale (Wentworth, 1922). This provides a textural foundation for habitat characterization. For example, we know from the sonar reflectance that 95% of the area mapped was mostly flat and soft. Sediment samples from this survey, and additional data from 180 earlier ground truthing sites, validate that 205.3 mi^2 of the shelf are soft sediment – coarse sand to fine silt. The remaining 5% of the area is coastal rocky substrate. On rocks, the video was instrumental in providing data on reef habitat characteristics valuable for classification. From the underwater video we can verify the presence of anemones, worms, amphipods, isopods, crabs, bivalves, squat lobsters, brittle stars, and many other benthic invertebrates. The outside measurement of the glass cover is 8.5 cm, allowing us to measure the rocks and living organisms. Only 14% of the 210 ground truth sites for this survey have underwater video validation since the technology is a new innovation by OCNMS.

Figure 4: Smith-MacIntyre sediment grab with attached video camera being deployed off the R/V Tatoosh.

Figure 5: Video clip from a rocky subtidal ground truthing site shows a purple urchin on a boulder with algae.

Figure 6: A sea star clings to the exposed side of a small boulder at approximately 40 meters depth.

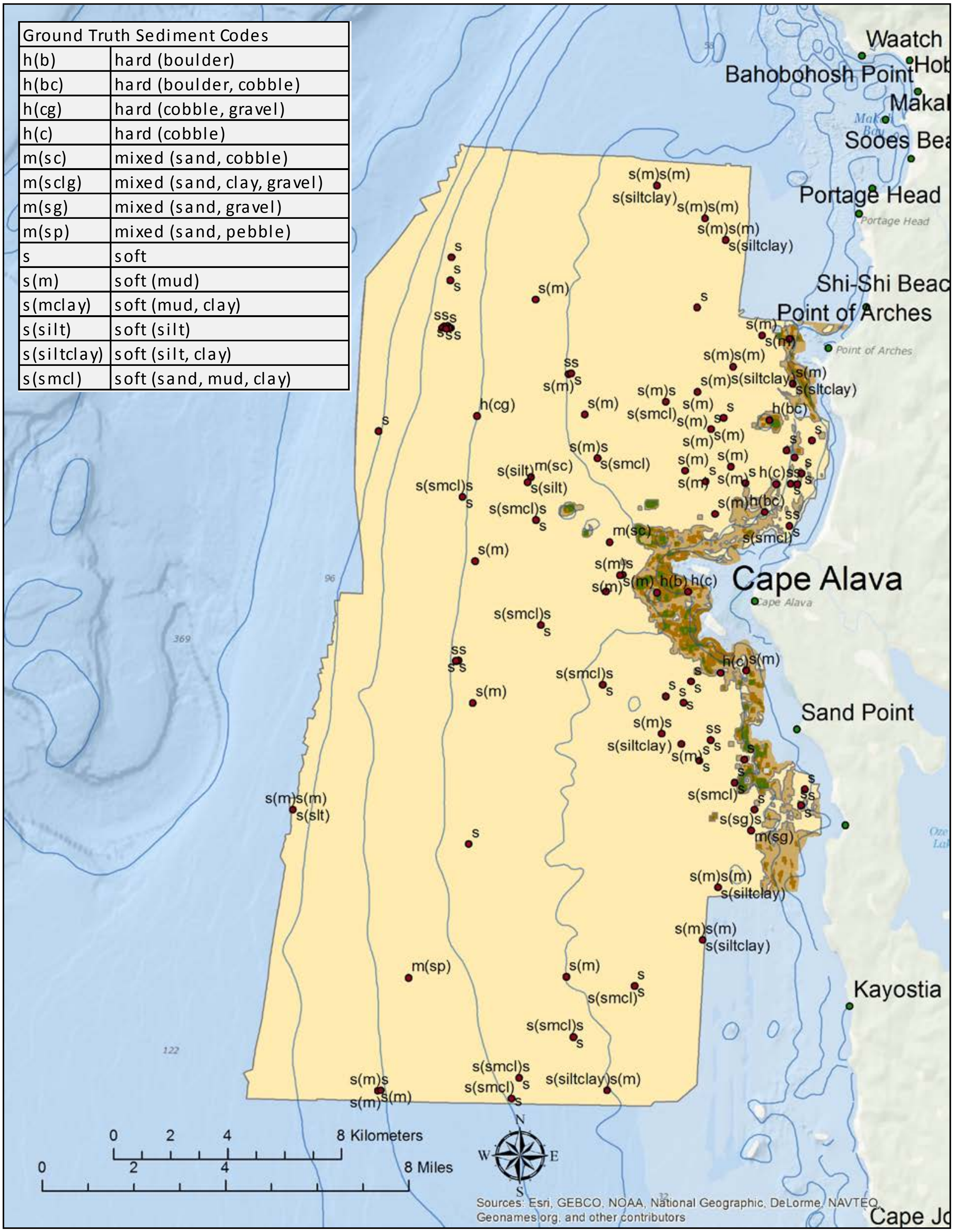

Figure 7: Habitat complexity map with location of 210 ground truthing sites.

Habitat Classification

OCNMS uses a marine classification scheme (Greene et al., 1999) that structures seafloor habitat information at mega-, meso-, and micro- spatial scales and includes bathymetry, induration, seafloor slope, seafloor complexity, and presence of benthic biology in a geospatial context. A variety of sensors and data collection tools are employed to meet the specifications of each data scale. Megahabitats — 10s of kilometers in size — are 'mapped' by the multibeam sonar products of bathymetry and backscatter. Meso- and macro- and microhabitats — meters to kilometers in size — are best characterized by a combination of remote sensors and localized ground truthing tools such as sediment grabs, seafloor video and still shots, cores, and rock samples.

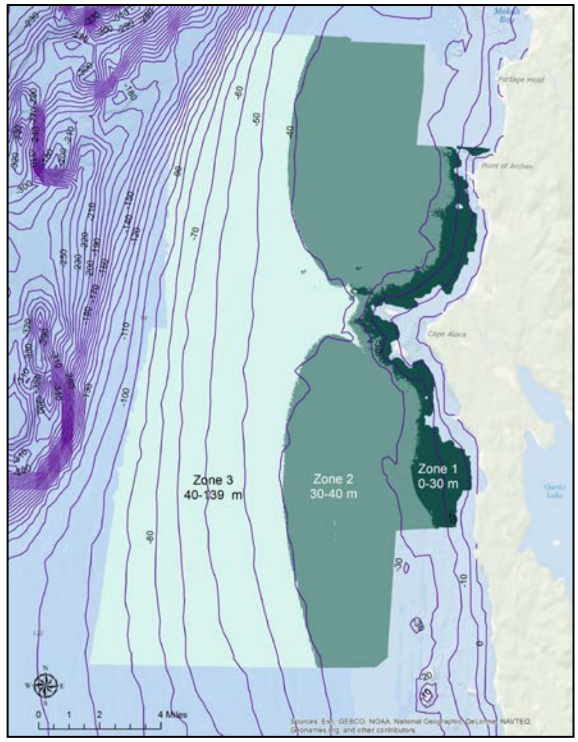

Figure 8: Bathymetric contours outline three depth zones corresponding to the rocky shoreline (dark green), the shallow flats (medium green), and the broad sloping shelf (light green).

Depth, Slope, and Seafloor Complexity

This survey was conducted on the shelf, southeast of the Juan de Fuca Canyon in depths from the shoreline to 139 meters in three primary zones. A rocky shoreline zone exists from 0-30 meters depth; it meets the soft shelf with a hard transition between the rock and sand habitat types. From Cape Alava north and south, a second depth zone arcs out six miles from shore, north to Portage Head and south to Carroll Island, maintaining a nearly flat 30-40 meter depth. A third broad zone stretches four to ten miles further out from shore, to 139 meters depth near an interface with the canyon.

From bathymetry, derivative products of slope and seafloor complexity (terrain ruggedness) were calculated by a set of geospatial tools called Benthic Terrain Modeler (BTM) (Wright et al., 2012). Slope was calculated in degrees at 8 m resolution. Bathymetric zones 2 and 3 slope less than 1° toward the Juan de Fuca Canyon in the northwest. Zone 1, the crenulated nearshore rocky reef, slopes 1°-30°, and a few peaks of rock near islands slope more steeply from 30°-60°. Seafloor complexity is generally the ratio of surface area to linear area when combined with slope. Using BTM in GIS software, terrain ruggedness is a more complex calculation using slope and aspect (Sappington et al., 2007) in neighborhood statistics which evaluate the characteristics of each 8 meter cell based on variations in the cells around it. Ruggedness is then reported as resultant standard deviation units of very low complexity (-1) to very high complexity (3+) (Greene et al., 1999). The soft sediments comprising 95% of the shelf (Zones 2 and 3) were low complexity (0-1). The rocky reefs in Zone 1 were a combination of 3.1% moderate complexity (1-2), 1.4% high complexity (2-3), and .5% very high complexity.

Ideally, multibeam sonar produces a backscatter reflectance which can provide an indication of sediment induration, the metric for substrate hardness. Induration is an important seafloor characteristic as a determinant in species habitat usage. For example, deep sea corals, sponges, nearshore kelp, and many groundfish and rockfish species are dependent on hard substrate. The *Fairweather* survey emphasized the collection of bathymetry for hydrographic charting over backscatter for habitat mapping, a technical detail related to sonar settings that resulted in less than optimum resolution backscatter data. The lack of high quality backscatter data marginalized the ability to determine hard versus mixed or soft sediment types. In areas where the rock-to-sand interface had a hard transition, the backscatter plus ground truthing made habitat classification clear. But other areas such as transitions between mixed gravel sizes or subtle changes between mud, silt and clay were impossible to classify without good backscatter data.

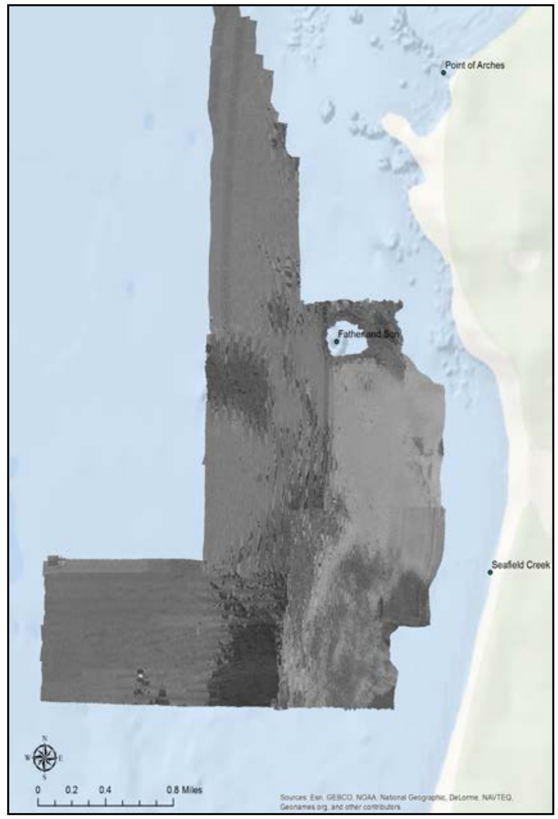

Figure 9: Backscatter data (8m resolution) show low (light grey), medium (medium grey), and high (black) reflectance at rocky reefs around Father and Son Rock. Backscatter data were marginal quality due to prioritization of bathymetry data collection for hydrographic charting.

The following process converted the raster layers to features in ArcGIS: the complexity data were hand digitized in one of five categories; seafloor induration was assigned one of three classes; the slope data were assigned one of five levels based on the relationship with complexity; the meso-macrohabitat was assigned one of two categories; modifiers and descriptors were assigned appropriately, given the information in the ground truthing.

Table 1: Summary Habitat Classification Table (based on classification by Greene et al.) This table shows the breakdown of habitat characteristics in each of the classification categories.

1. **Megahabitat**: Based on depths > or < 200 meter; canyon flank (F) > 200 meters or shelf (S) < 200 meters	F: Flank S: Shelf	None 195.6 mi^2	
2. **Seafloor Induration:** Substrate hardness in categories of hard, mixed hard/soft, or soft.	Hard (h) 26.9 km^2 (10.4 mi^2)	Mixed hard/soft (m) 33.4 km^2 (12.9 mi^2)	Soft (s) 446.3 km^2 (172.3 mi^2)
3. **Meso/Macrohabitat:** Seafloor features ranging from 1m to 1 km.	(f): Flats (d): Deformed, tilted and folded bedrock	446.3 km^2 (172.3 mi^2) 60.3km2 (23.3 mi^2)	
4. **Modifiers** Texture or lithography of seafloor.	(u): Unconsolidated sediment (c): Consolidated sediment (g): Granite	404 km^2 (156.1 mi^2) 82.3 km^2 (31.8 mi^2) 19.9km2 (7.7 mi^2)	
5. **Seafloor Slope** Calculated from bathymetry at 8m resolution.	1: Less than 1° slope: 2: Between 1° - 30° slope:	446.3 km^2 (172.3 mi^2) 60.3km^2 (23.3 mi^2)	
6. **Seafloor Complexity** Calculated from bathymetry, slope and aspect at 8m resolution.	A: Very Low Complexity B: Low Complexity C: Moderate Complexity D: High Complexity E: Very High Complexity	None 481.3 km^2 (185.8 mi^2) 15.8 km^2 (6.1 mi^2) 7.0 km^2 (2.7 mi^2) 2.5 km^2 (0.9 mi^2)	
7. **Macro- Microhabitats** Fine-scale habitats described within survey bounds.	(b) boulder (c) cobble (d) deformed, faulted, folded (e) exposed bedrock	(g) gravel (m) mud, silt, clay (p) pebbles (s) sand	
8. **Biologic attributes** Ground truth notes include this benthic biology.	[a] algae [b] bryozoans [d] detritus [e] echinoderms	[f] fish [n] anemones [o] other sessile organisms [w] worms, worm tubes	

Conclusion

The Cape Alava survey contributed high quality multibeam sonar data and habitat classification to a substantial area of previously unmapped seafloor in OCNMS. It also demonstrated the importance of establishing technical protocols for collecting sonar data that provides quality bathymetry and backscatter reflectance. The survey also provided the first opportunity to test the utility of the underwater video camera for adding visual context to ground truthed locations. It is the first survey in OCNMS that will include a habitat classification plus five Descriptive Reports and a Data Acquisition and Processing Report from the Office of Coast Survey.

Citations

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