A Streamlined and Standardized Benthic Habitat Mapping Approach for Marine and Hydrokinetic Site Environmental Assessments

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Problem Statement

Marine renewable energy facilities have the potential to impact seabed habitat so there is a need to effectively and rapidly assess benthic conditions in the permitting and long-term monitoring of these sites. Many types of bottom sampling methods have been used to measure sediment physical (e.g., grain size) and biological (e.g., macrofauna taxonomy) conditions at marine and hydrokinetic (MHK) energy sites. These approaches often lack standardization, provide limited spatial coverage, and are expensive and time-consuming. Because benthic environments involve a complex interplay of physical and biologic processes on a wide range of spatial and temporal scales, this nascent industry needs a standardized tool set that provides more complete spatial coverage, is time- and cost-effective, and can be communicated universally.

Project Concept

We have combined two seafloor mapping techniques to efficiently map benthic habitat conditions. **Multibeam echosounder (MBES) surveys** provide detailed bathymetry and backscatter mosaics. **Sediment profile and plan view imaging (SPI/PV)** rapidly provides dense ground truth data on seabed physical and biological features. This combination was used to produce high-resolution maps for a 7 km^2 seafloor area surveyed near Dungeness Spit, Washington (Figure 1).

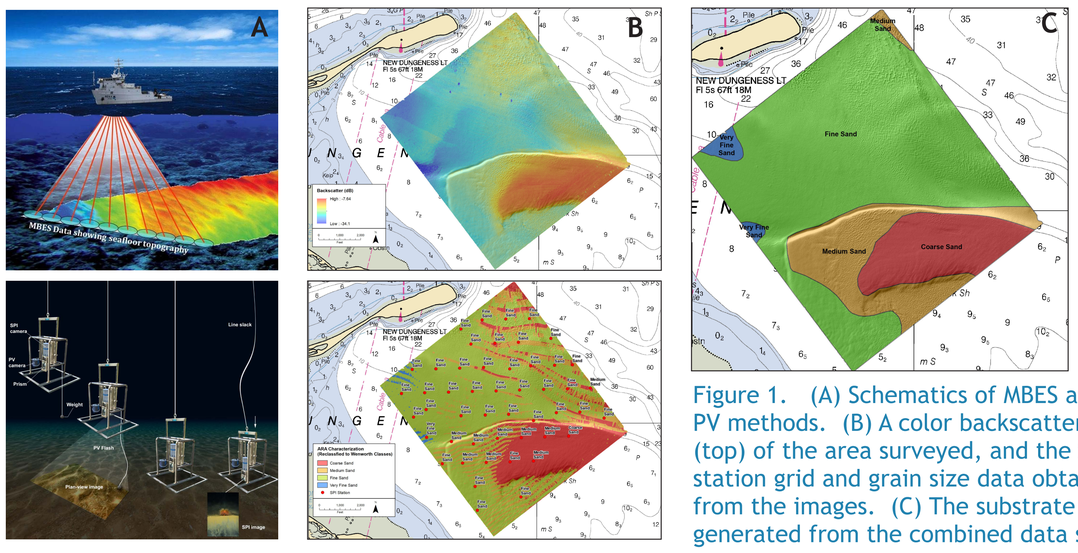

Figure 1. (A) Schematics of MBES and SPI/PV methods. (B) A color backscatter map (top) of the area surveyed, and the SPI/PV station grid and grain size data obtained from the images. (C) The substrate map generated from the combined data sets.

Imaged Features and Interpretation

Key features can be identified and measured in SPI images (Figure 2). These include:

- Sediment type (grain size major mode throughout the image)
- Prism penetration depth
- Boundary roughness
- Apparent redox potential discontinuity (aRPD) depth
- Number, depth, and type of biogenic structures

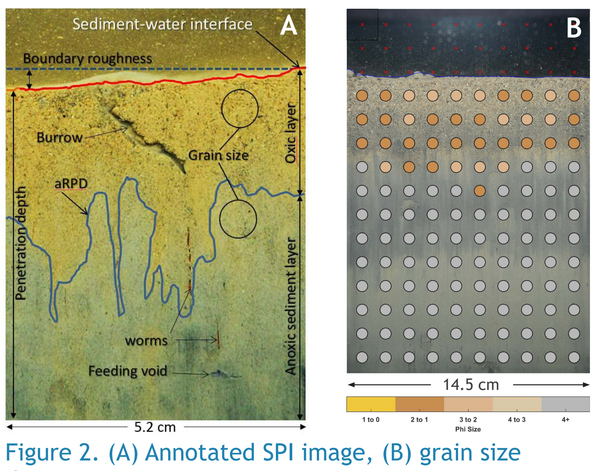

Figure 2. (A) Annotated SPI image, (B) grain size designations.

Plan view images provide a top-down view of the seabed and can show the presence of bedforms, shell lag deposits, submerged aquatic vegetation, and hard bottom substrates. Figure 3 shows rippled sands in a plan view image and a geoform component map of the site based on the bathymetry data.

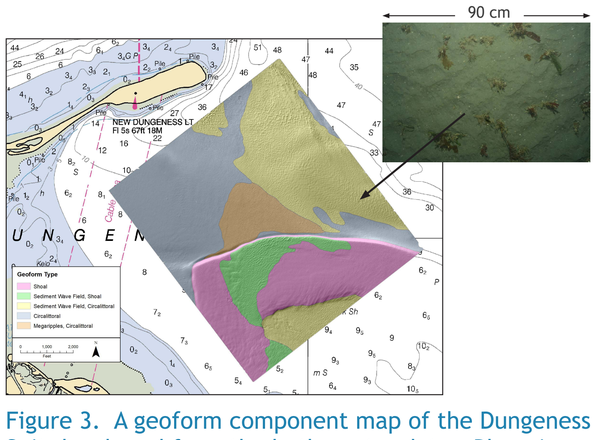

Figure 3. A geoform component map of the Dungeness Spit developed from the bathymetry data. Plan view images help confirm/interpret the bathymetric data.

Benthic Habitat Mapping

We are using the Coastal and Marine Ecological Classification Standard, or CMECS (FGDC 2012), as a mapping framework. Various combinations of the bathymetry and backscatter and SPI/PV data inform the geoform, substrate, and biotic CMECS components (Figure 4).

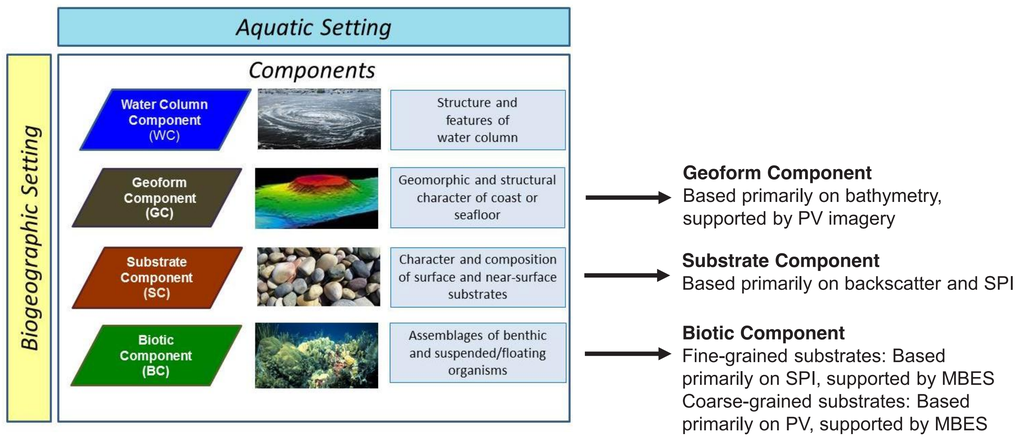

Figure 4. CMECS settings and components. Geoform, substrate, and biotic components can be mapped with combinations of MBES and SPI/PV results.

Grain size is readily obtained from SPI images (Figure 2). Map C in Figure 1 is the substrate component mosaic based on backscatter textures ground truthed with SPI grain size designations. Other standard SPI metrics may be used to define and delineate the benthic conditions. Total prism penetration, a function of substrate bearing capacity, and aRPD depth, a function of surface sediment biogenic mixing, are illustrated and mapped in Figure 5. Both show strong west to east gradients that reflect the benthic energy regimes.

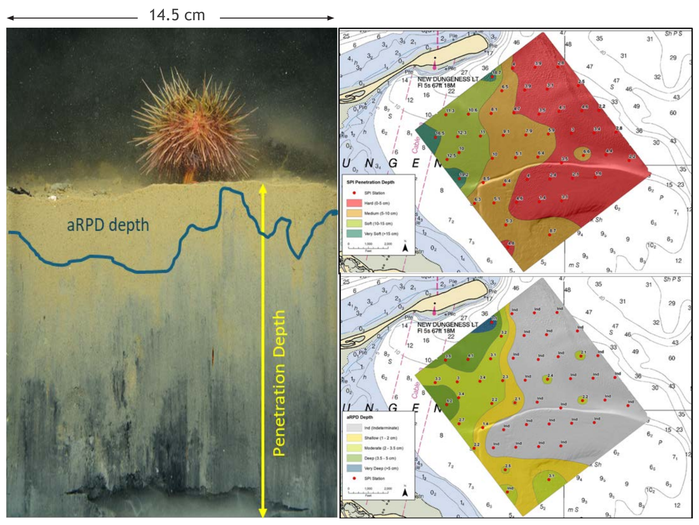

Figure 5. Prism penetration and aRPD depth (left) and maps of these parameters for the near Dungeness Spit (right).

Automated SPI Image Analysis

A key innovation of this project has been the development of a computer-assisted image processing system that standardizes the SPI data generation process. A unique combination of machine- and deep-learning techniques for grain-size classification, sediment–water interface delineation, and object detection (e.g., infauna and feeding voids) is described in Sackmann et al. (2018). An automated SPI image analysis system provides a standardized and cost-effective approach for image processing.

Conclusion

Combining MBES with SPI/PV camera technology provides a first tier approach to rapidly documenting seabed physical and biological conditions in high resolution at MHK sites. When coupled with computer automated data extraction from the imagery, this approach provides a standardized and cost-effective method to establish and monitor benthic habitat conditions over time.

References

FGDC. 2012. Coastal and Marine Ecological Classification Standard (CMECS). FGDC-STD-018-2012. Federal Geographic Data Committee. June.

Sackmann, B., E. Revelas, and C. Jones. 2018. Standardized and Cost-Effective Benthic Habitat Mapping Tools for Marine and Hydrokinetic Site Environmental Assessments. Poster presented at METS 2018, Washington, DC.

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