# Linking Surficial Geomorphology with Vertical Structure in High and Low Energy Marine Environments

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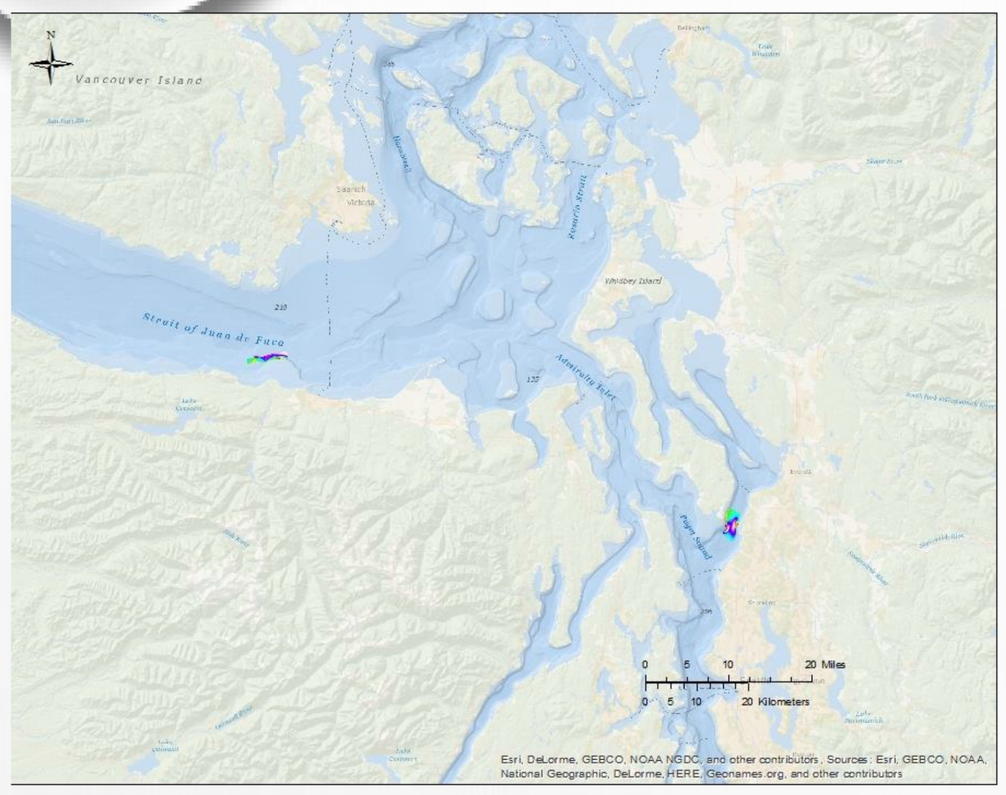

Figure 1. Location map displaying the two study sites used, with the Elwha site in the Strait of Juan de Fuca and the South Possession Sound site within the Puget Sound, Washington, USA.

## Introduction

The inland waters of the Puget Sound, Washington, USA, and Georgia Basin, British Columba, Canada, is a complex system of high energy river inputs to lower energy large basins with direct connection to the open ocean through the Straits of Juan de Fuca. High energy systems acting as transport mechanisms for coarse sediment interact with low energy regions with transport deposition of finer sediments to create the vertical stratigraphy of the seafloor. In regions of high energy the seafloor expression is dominated by a rougher seafloor with more geomorphic features of coarser material, while low energy regions are expressed in a seafloor of uniform lamination. This research investigates the link between the surface expression of seafloor roughness and the underlying vertical structure of sediment deposition. Using a high resolution bathymetric surface derived from multibeam sonar synchronized with low frequency sub-bottom acoustic profiles, the depth of acoustic penetration is correlated with a focal calculation of seafloor roughness. Areas of lower acoustic impedance have a larger range in penetration, with lower ranges of penetration persisting in areas of high acoustic impedance. High acoustic impedance is indicative of harder sediments, such as sand, and low acoustic impedance indicates softer sediments, such as mud. The research is a comparative study between a high energy system adjacent to the mouth of the Elwha River and the low energy protected region of South Possession Sound. The research illustrates the strong link between seafloor geomorphology and the terrestrial sources of sediment input and mitigation of sediment transport energy.

## Methods

Three parallel transect lines of comparable lengths were surveyed on November 15, 2015 aboard the R/V Thomas G. Thompson using synchronized multibeam sonar (Simrad EM302, Kongsberg SIS) and Knudsen 3260 "chirp" sub-bottom profiler at the two study location representing the high energy Elwha River and low energy South Possession Sound. Data from the multibeam sonar was post-processed in CARIS Hips and Sips 9.0 to create bathymetric surfaces of the surveyed sites and to identify surficial expression of geomorphic features correlating to high or low energy systems. The post-processing software, SonarWiz (ver. 3x) was used on the chirp data to clip and remove survey turn data. These lines were then imported as shapefiles in ArcGIS, along with the bathymetric surfaces created in CARIS. In ArcGIS, several functions were run in order to create elevation profiles along the transect lines and to determine seafloor roughness.

Knudsen Post Survey was used to view and differentiate between various stratigraphic layers, determine the range of penetration, and the type of seafloor based on impendence. As some of the data was offset, the chirp data was run through a Matlab script to realign these offsets with one another.

## Conclusion

The survey lines of the high energy environment of the Elwha study area exhibit similar ranges of rigosity, yet dissimilar composition in impedance with the low energy environment of the South Possession Sound. This study suggests that surficial morphology masks vertical structure of both high and low energy systems, illustrating the need for synchronized surveys of both multibeam and sub-bottom sonars.

### Acknowledgements

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## High Energy Environment

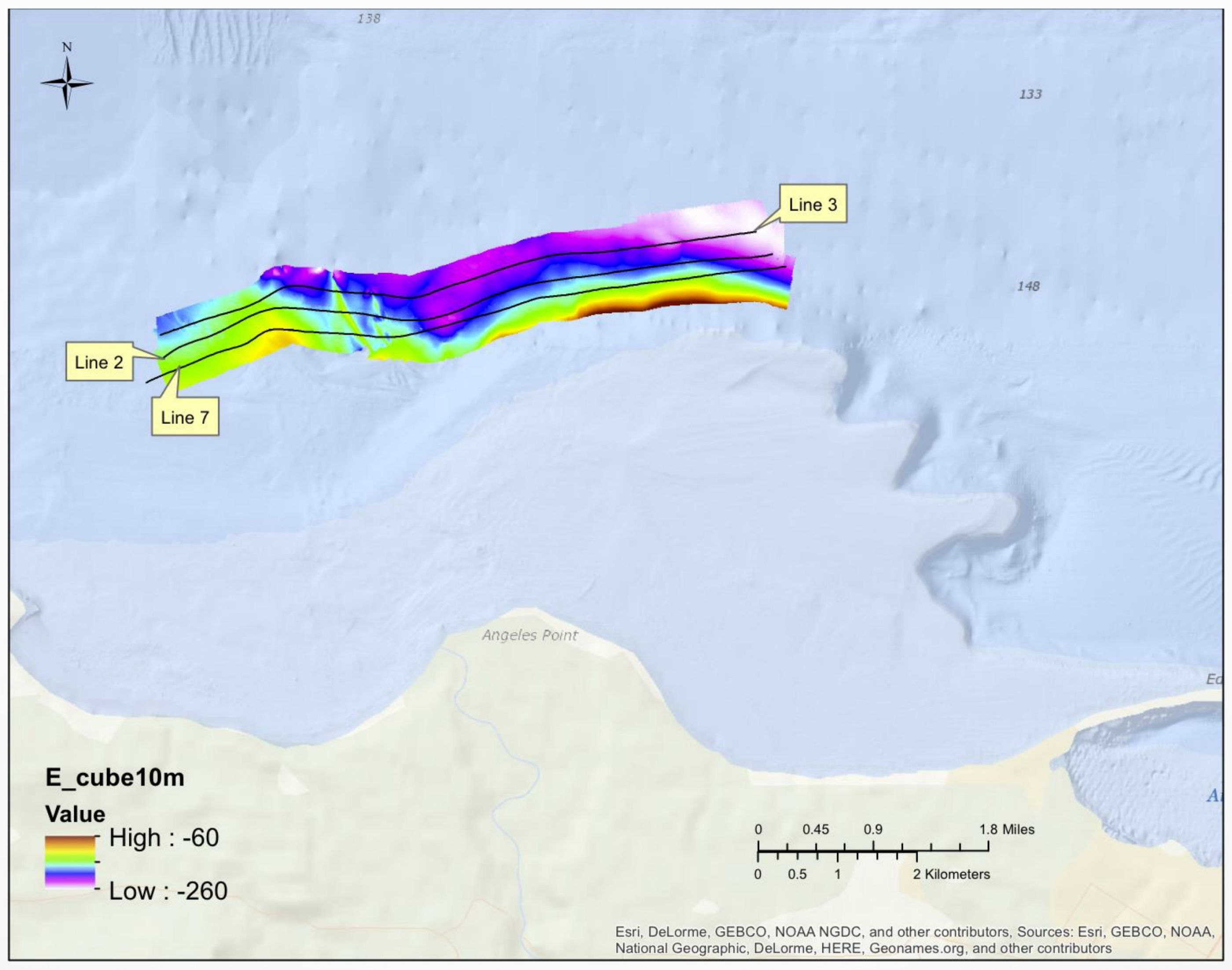


Figure 2. Elwha River study site with the three lines used for analysis.

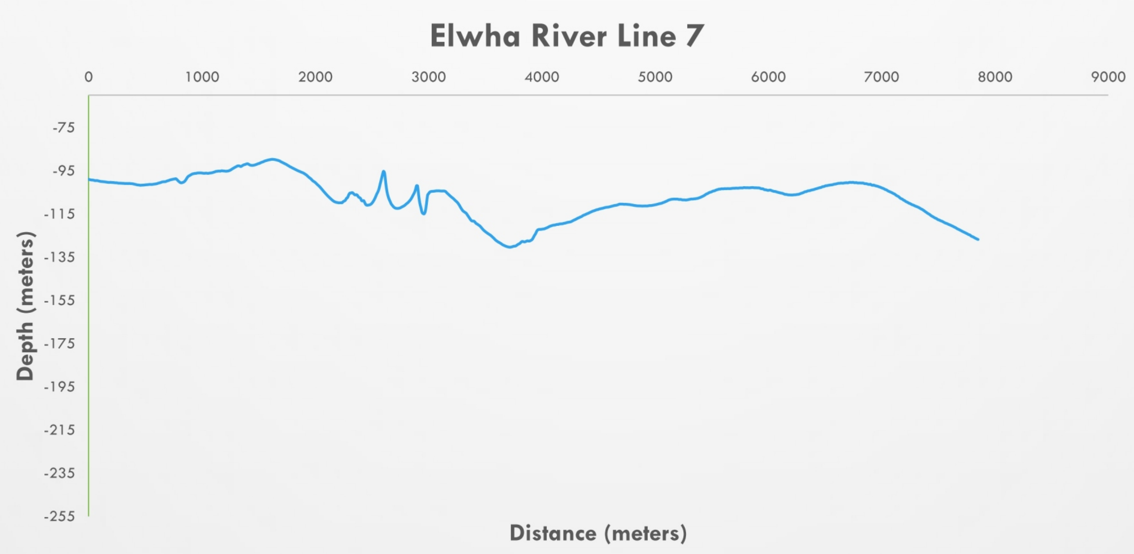


Figure 4. Elevation profile, in meters, of Line 7 from the multibeam bathymetric surface created in CARIS, at the Elwha River study area.

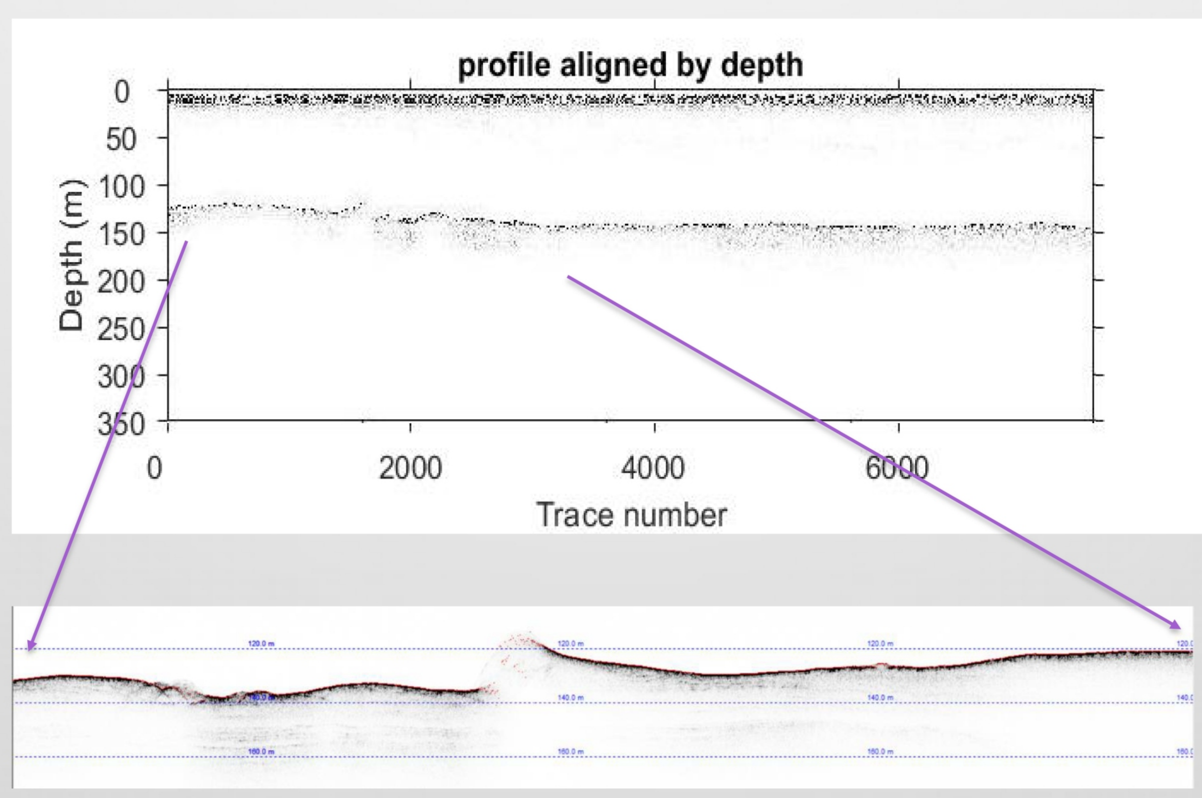


Figure 6. Elevation profile, in meters, of Line 7 at the Elwha River study area, created in Matlab to realign depth offsets within the chirp data. The callout below the full profile, is a section of the chirp line displayed in Knudsen Post-Survey to better display the vertical structure.

| Line | Min | Max | Mean | Std Dev | Range |
|---|---|---|---|---|---|
| 2 | -4.35 | 7.95 | -0.02 | 0.50 | 12.30 |
| 3 | -5.03 | 4.36 | -0.02 | 0.38 | 9.39 |
| 7 | -4.37 | 3.84 | -0.01 | 0.49 | 8.21 |

Table 1. Statistics for seafloor rigosity along each survey line in Elwha study area. All values are in meters.

| Line | 0m | 1-5m | 6-10m | 11-15m | 16-20m |
|---|---|---|---|---|---|
| 2 | 90% | 0% | 10% | 0% | 0% |
| 3 | 95% | 5% | 0% | 0% | 0% |
| 7 | 95% | 0% | 0% | 0% | 5% |

Table 3. Range of impedance observed between surface and last return in meter ranges at the Elwha study area.

## Low Energy Environment

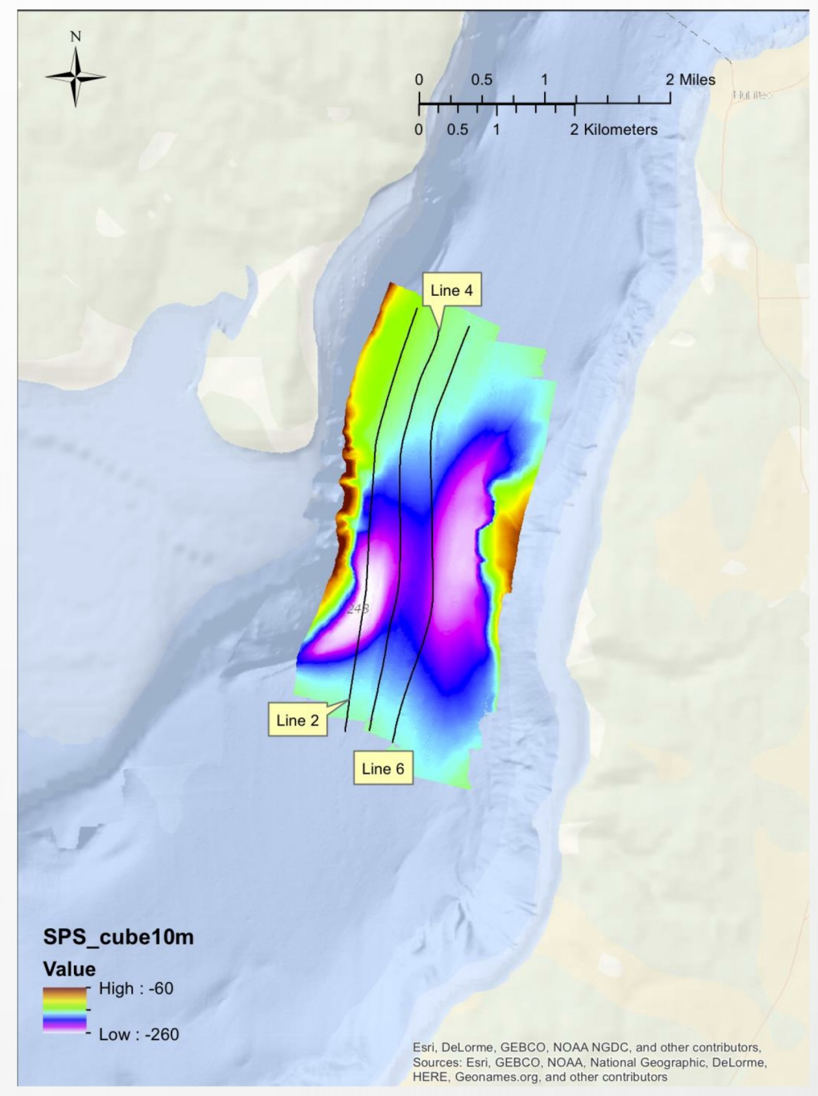


Figure 3. South Possession Sound study site with the three lines used for analysis.

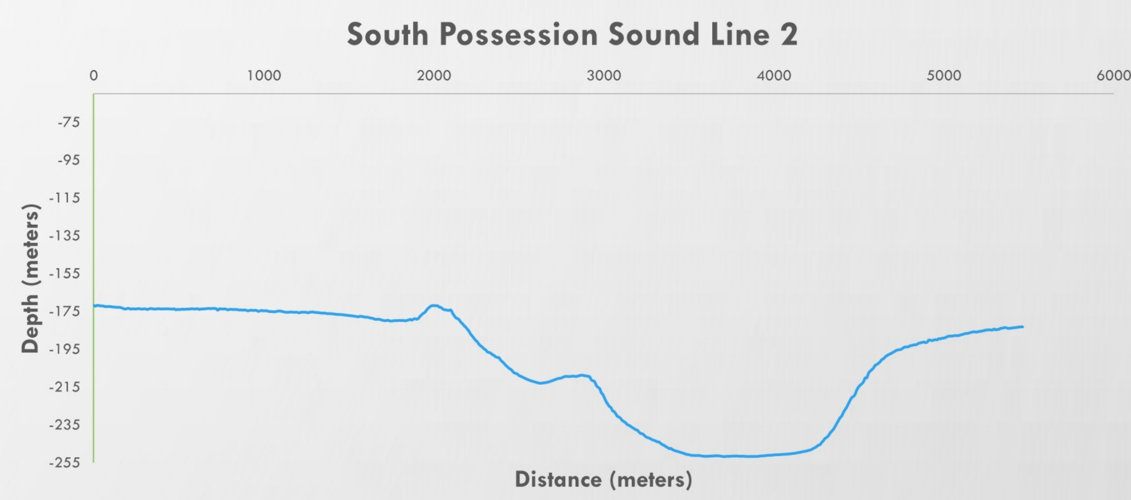


Figure 5. Elevation profile, in meters, of Line 2 from the multibeam bathymetric surface created in CARIS, at the South Possession Sound study area.

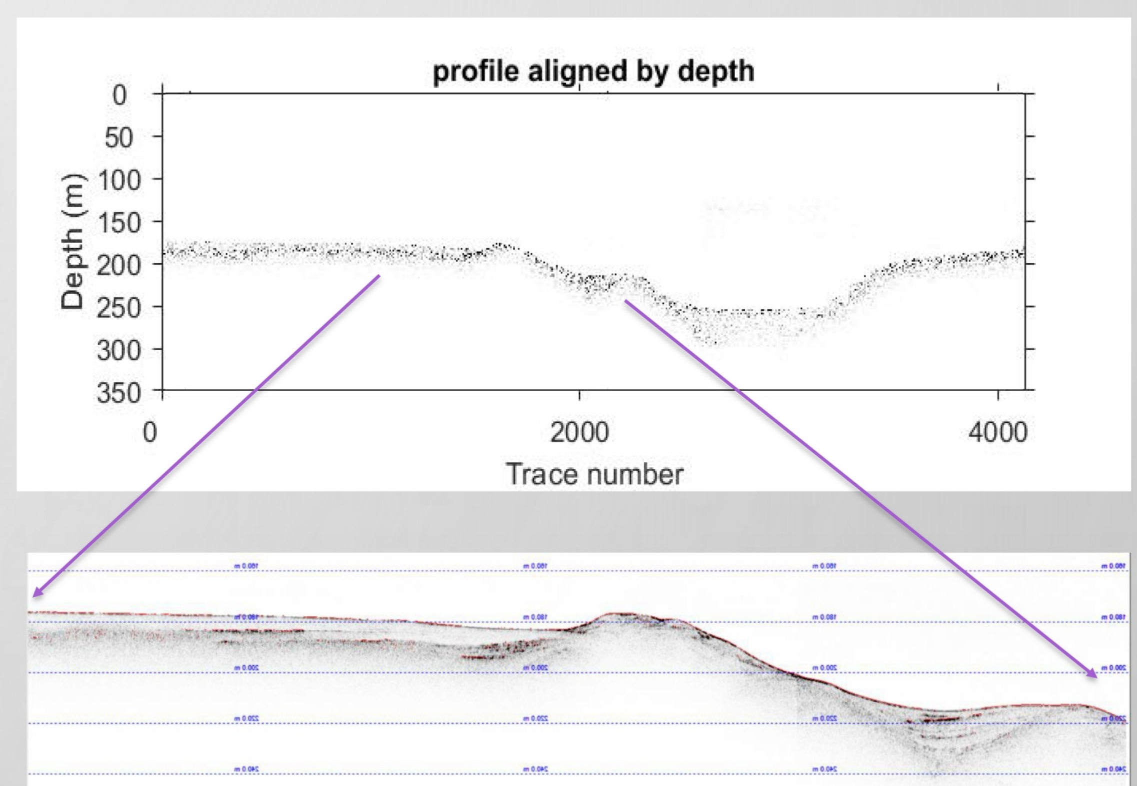


Figure 7. Elevation profile, in meters, of Line 2 at the South Possession Sound study area, created in Matlab to realign depth offsets within the chirp data. The callout below the full profile, is a section of the chirp line displayed in Knudsen Post-Survey to better display the vertical structure.

| Line | Min | Max | Mean | Std Dev | Range |
|---|---|---|---|---|---|
| 2 | -3.22 | 4.88 | -0.10 | 0.55 | 8.10 |
| 4 | -7.38 | 4.87 | -0.10 | 0.78 | 12.25 |
| 6 | -3.79 | 3.90 | 0.06 | 0.95 | 7.66 |

Table 2. Statistics for seafloor rigosity along each survey line in South Possession Sound. All values are in meters.

| Line | 0m | 1-5m | 6-10m | 11-15m | 16-20m |
|---|---|---|---|---|---|
| 2 | 17% | 33% | 17% | 0% | 33% |
| 4 | 33% | 33% | 33% | 0% | 0% |
| 6 | 0% | 0% | 50% | 25% | 0% |

Table 4. Range of impedance observed between surface and last return in meter ranges at the South Possession Sound study area.