Identification and Characterization of Atlantic Halibut (Hippoglossus hippoglossus) Habitats with Bathymetric Data Supplemented with Seafloor Video Observations

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Abstract

The utilization of first-order information about seafloor morphology, derived from multibeam sonar data, has become common in the investigation of deep-sea benthic habitats. When combined with complementary datasets, these data can be used to study deep-sea coral ecosystems and predict environments that are favorable for fish spawning, larval nurseries, and juvenile fish habitats. The identification and protection of these environments is critical where biodiversity is vulnerable or unique in order to rehabilitate or maintain ecological communities and encourage higher fecundity. In August of 2019, the expedition Deep Connections: Exploring Atlantic Canyons and Seamounts was conducted to explore understudied deep-sea environments aboard the NOAA Ship Okeanos Explorer off the coast of the United States and Canada (EX1905L1 and EX1905L2). This expedition included multibeam mapping and seafloor exploration with a Remotely Operated Vehicle (ROV). Observations from ROV dives include several fish species including multiple sightings of Atlantic halibut (Hippoglossus hippoglossus), which is considered endangered on the International Union for Conservation of Nature Red List of Threatened Species. Identifying and classifying the habitats where Atlantic halibut is observed would facilitate future endeavors of protection or rehabilitation. Spawning events are known to coincide with areas of increased seafloor slope associated with high energy systems such as canyons. Utilizing multibeam data included in the Global Multi-Resolution Topography (GMRT) Synthesis, we characterize canyons at the edges of George's and Brown's Banks based on morphology, roughness, and seafloor slope and aspect. We combine these data with observations of Atlantic halibut from ROV video to seek correlations that can be used to identify potential habitats. This information can be used to guide further exploration and characterization of the seafloor to better understand the spatial extent of Atlantic halibut habitat in the region.

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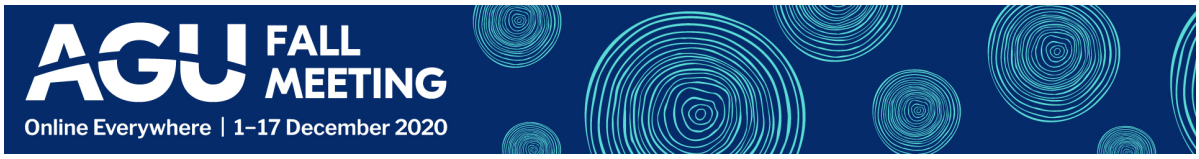


MAPPING OUR WATERS

Having a complete image of the seafloor is imperative to understanding ocean processes, protecting sensitive habitats, and unifying global knowledge to create a sustainable future (Fig.1).

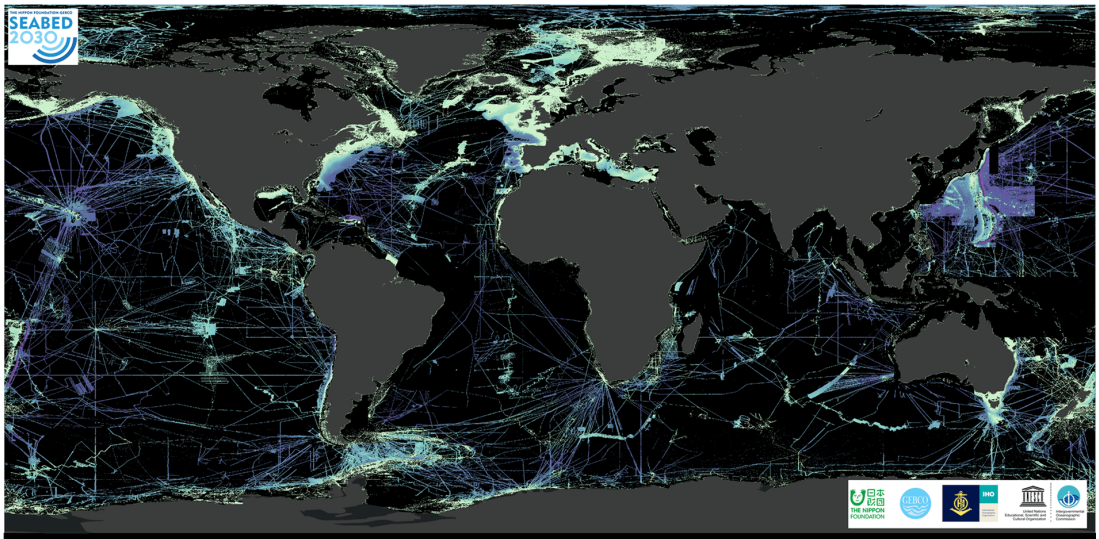


Figure 1. Seabed2030 grid with areas highlighted in black accounting for roughly 80% unmapped.

NOAA's Office of Exploration and Research has conducted several expeditions in support of mapping and initiatives such including **Atlantic Seafloor Partnership for Integrated Research and Exploration (ASPIRE)**, aims to extend bathymetric mapping coverage in the U.S. EEZ and international waters.

The **Deep Connections: Exploring Atlantic Canyons and Seamounts mission** (August 6, 2019 to September 15, 2019) contributed directly to the ASPIRE campaign, conducting 12 telepresence enabled, remotely operated vehicle (ROV) dives off the Northeast coast of North America aboard the NOAA ship **Okeanos Explorer** (EX1905L2, Fig. 2).

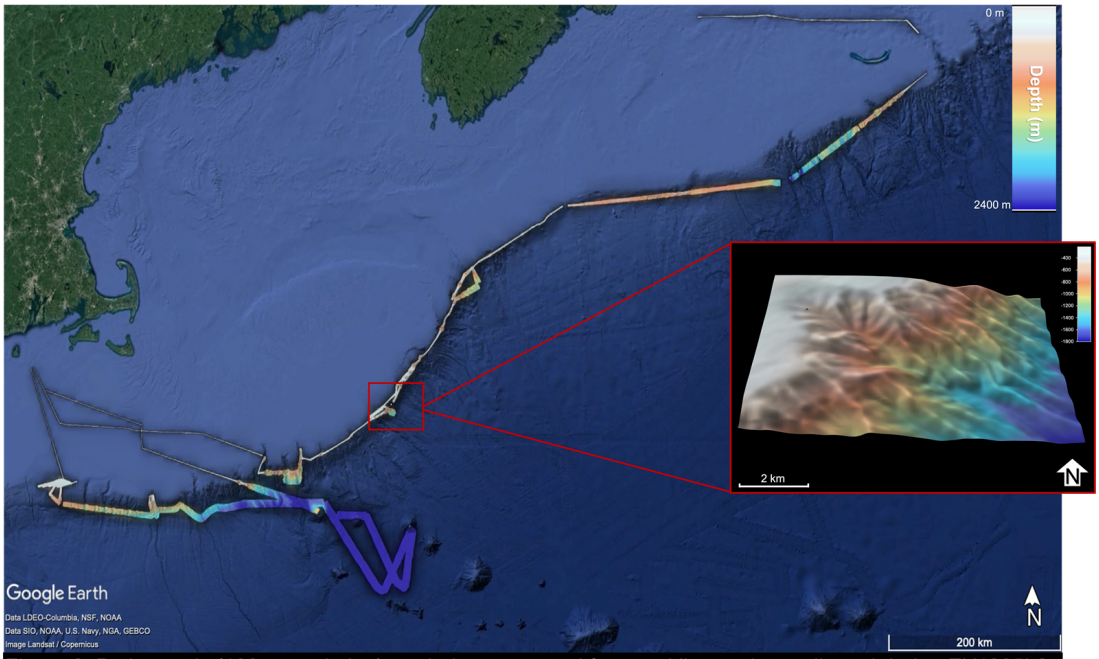
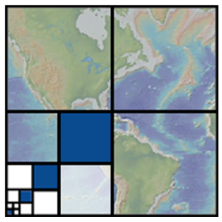


Figure 2. Bathymetric (100m resolution) rendering generated from multibeam data collected during EX1905L2 along the U.S. northwestern continental shelf edge. Inset map depicts 100m bathymetric grid generated from GMRT Synthesis of DIVE 05 site, which was absent in EX1905L2 products.

Study sites were chosen in order to explore understudied deep-sea (>250 m) environments as well as further development of habitat suitability and geohazard models. This area is of particular concern due to the canyons being potential critical

habitat to multiple species due to the slopes hosting a high density of deepsea coral and sponge communities (NOAA, 2019). As with all NOAA OER expeditions, data acquired during EX1905L2 were made publicly available and serve as a resource for studies.



ENDANGERED COMMUNITIES

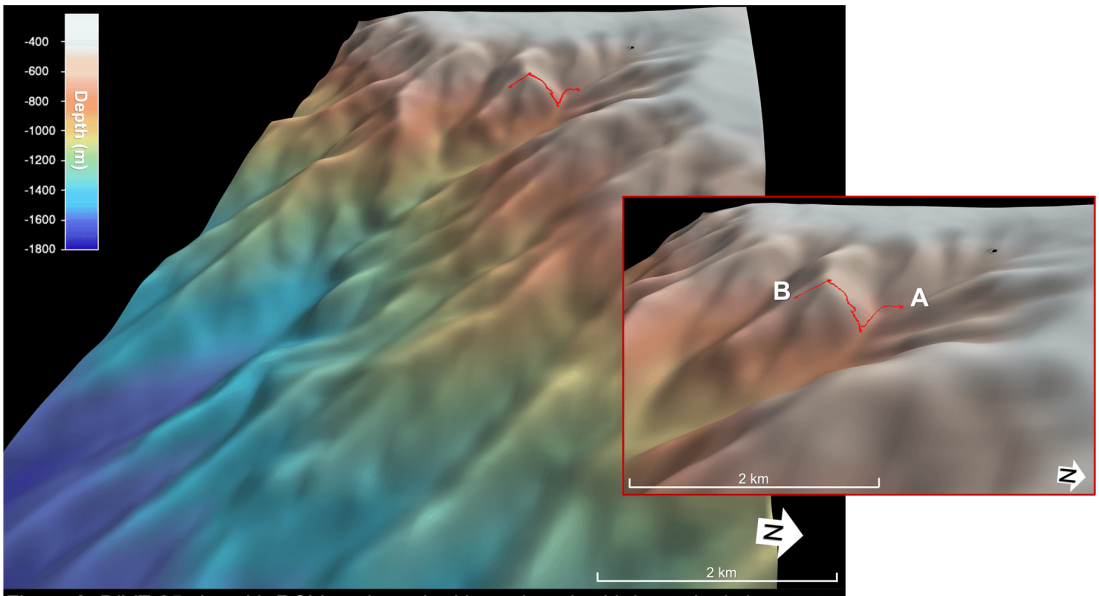


Figure 3. DIVE 05 site with ROV track marked by red track with inset depicting start (A) and stop (B) points.

During Dive 05, the ROV was deployed in an unnamed canyon located ~300 km offshore at 758 m depth (Fig. 3), revealed observations of the endangered species *Hippoglossus hippoglossus*, commonly known as Atlantic halibut (Fig. 4).

Figure 4. Atlantic halibut observed at 732m in the unnamed canyon during EX1905L2 Dive 05 measured more than 1m.

Due to overfishing since 1996 the International Union for Conservation of Nature Red List of Threatened Species (IUCN) has classified the Atlantic halibut as endangered (Sobel, J., 1996) and NOAA has classified *H. hippoglossus* as species of concern (Cargnelli, et al. 1999). While a female fish can reach up to 4.7 m and live over 40 years, the average size caught is 80-89 cm (Cargnelli, et al. 1999). This is concerning because sexual maturity for females is defined as 9 years of age, sizing 119 cm (Trzcinski, M. K., & Bowen, W. D. 2016) indicating the catches are of mainly individuals which are not yet sexually mature (Fig. 5).

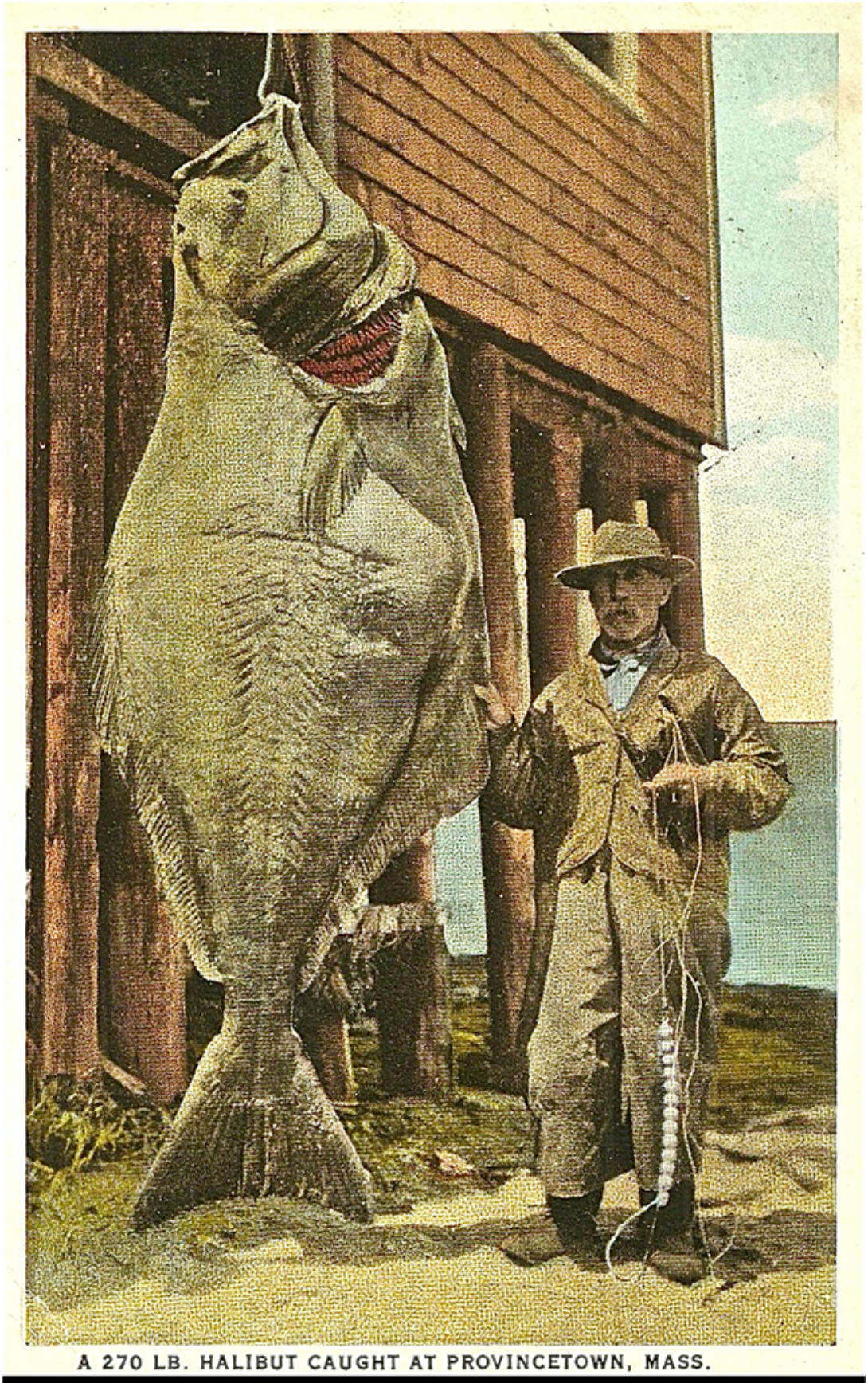


Figure 5. Atlantic halibut caught in the region in 1910.

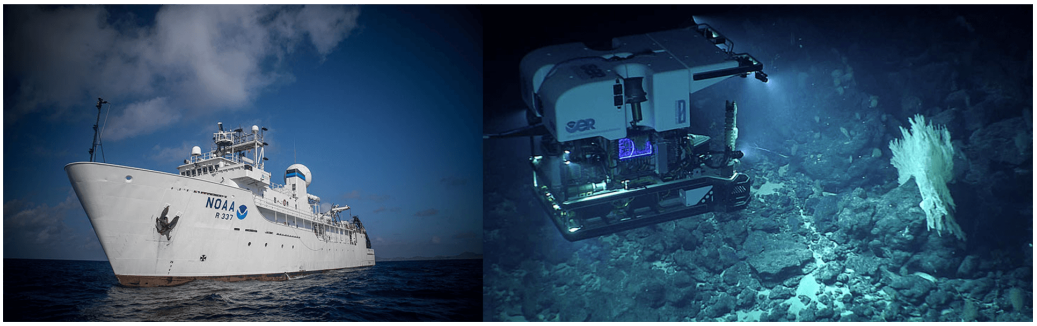
Studies of the Atlantic halibut stock conducted by Northeast Fisheries Science Center have struggled with catching specimens to sample from, only averaging 6-12 individuals/yr in the past decade (Dawicki, 2019). This indicates the 3 observations of individuals in Dive 05 to be fairly significant.

Spawning is believed to occur on the slopes of the continental shelf and on the offshore banks, over rough or rocky bottom (Collins 1887, McCracken 1958; Nickerson 1978; Neilson et al. 1993, as quoted in Cargnelli, et al 1999). The negatively buoyant eggs remain on the seafloor until hatching where upon the larvae maintain a pelagic lifestyle near to the ocean surface until metamorphosis (Cargnelli, et al 1999).

The study aims to utilize first-order information about seafloor morphology, derived from multibeam sonar data collected during EX1905L2, to identify potential habitat for the Atlantic halibut and spawning grounds. A secondary goal for the study is to illustrate how seafloor mapping has the potential to facilitate many of the sustainable development goals of the United Nations Decade for Ocean Science.

METHODS

- Data were collected as part of Deep Connections: Exploring Atlantic Canyons and Seamounts using a Kongsberg EM302 multibeam sonar echosounder aboard the **R/V Okeanos Explorer**. The survey took place from 08/06/19-09/15/19 and was led by NOAA Office of Ocean Exploration and Research.



- First-order observations from Dive 05 were obtained collected utilizing ROV Deep Discoverer and camera platform Seirios.

- Sonar data were post-processed and analyzed utilizing MB-System and GeoMapApp.

- Slope, aspect, and 3D visualization were generated using QPS Fledermaus.

- Extant maps and data layers from Northeast Ocean Data Explorer of current systems, temperature, and geomorphology were collected for comparison (Fig. 6).

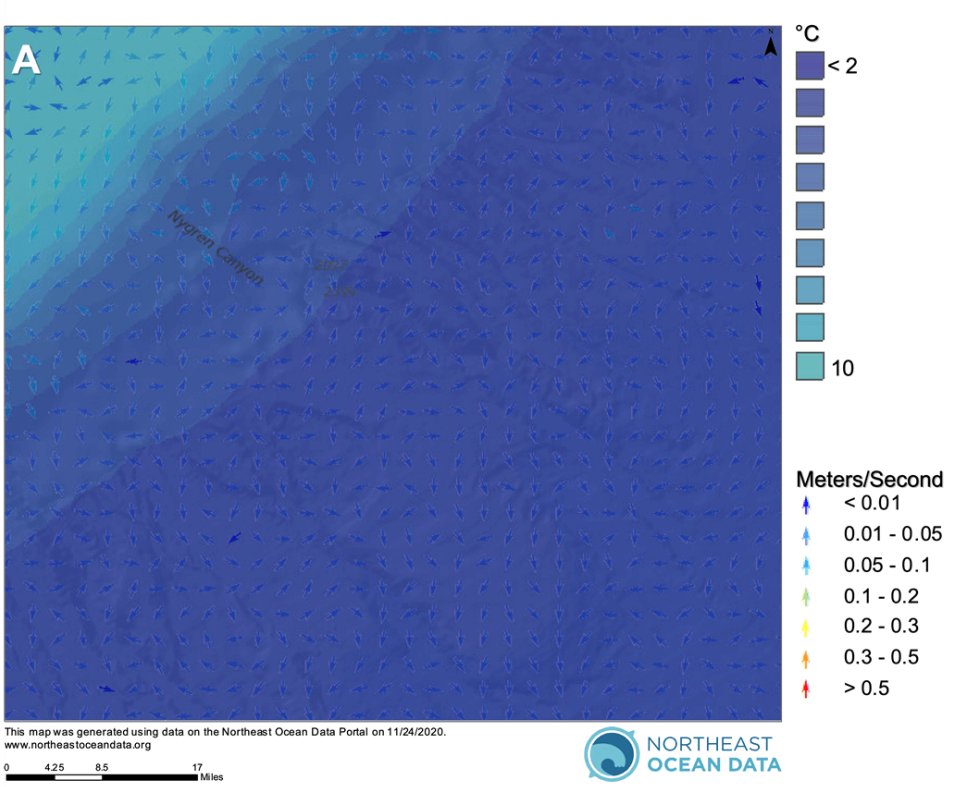
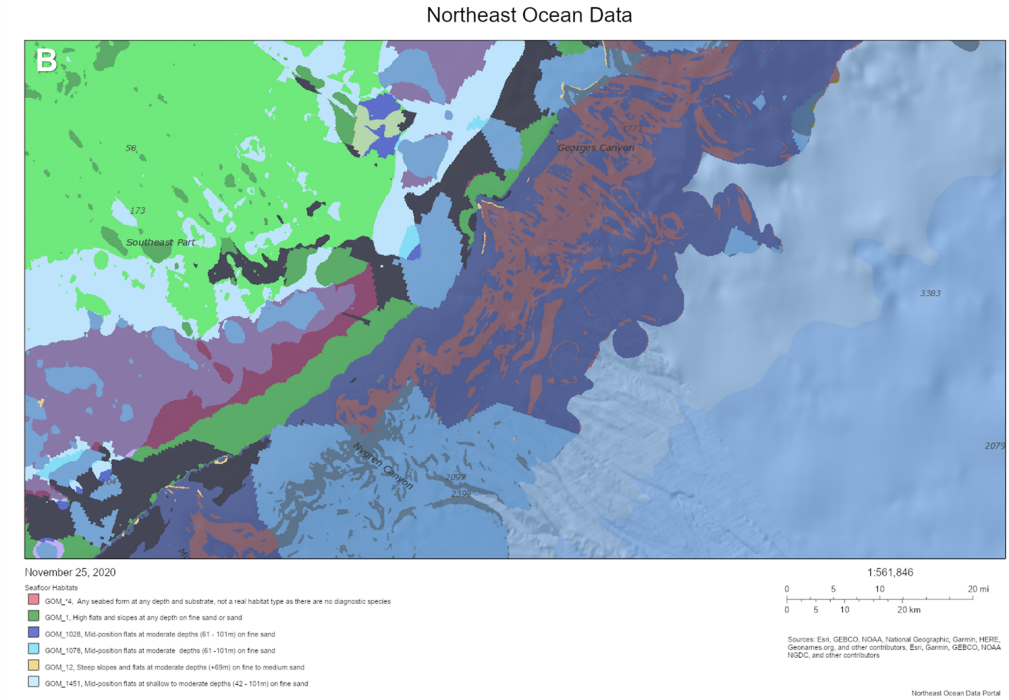


Figure 6. Extant oceanographic data provided through the Northeast Ocean Data map portal of deep-water current systems and temperature (A, Above) and seabed habitat (B, Below) of the New England canyons .



- All data layers were processed using ArcMap Benthic Terrain Modeler (BTM) (Walbridge et al., 2018) and *H. Hippoglossus* observations projected onto the surface to identify if unique geomorphologic data correlated the observations.

RESULTS

- *H. hippoglossus* observations from NOAA Deep Discoverer on DIVE 05 were at depths, 732m, 570m, and 546m. Locations of these sightings were derived from the ROV track lat/long and projected onto the bathymetric surface. Canyon zones directly surrounding DIVE 05 were chosen for habitat investigation due to their proximity of the halibut observations and the presence of similar geomorphology. (Fig. 8A)

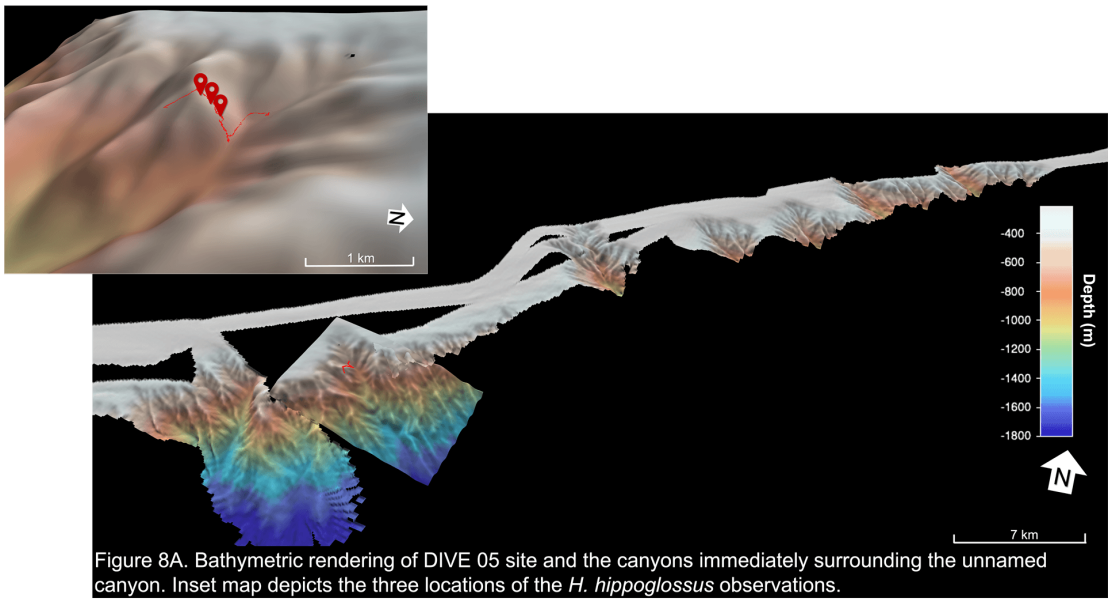


Figure 8A. Bathymetric rendering of DIVE 05 site and the canyons immediately surrounding the unnamed canyon. Inset map depicts the three locations of the *H. hippoglossus* observations.

- Slope derived from the data and draped on the bathymetric surface revealing the halibut were observed as the canyon began to crest. (Fig. 8B)

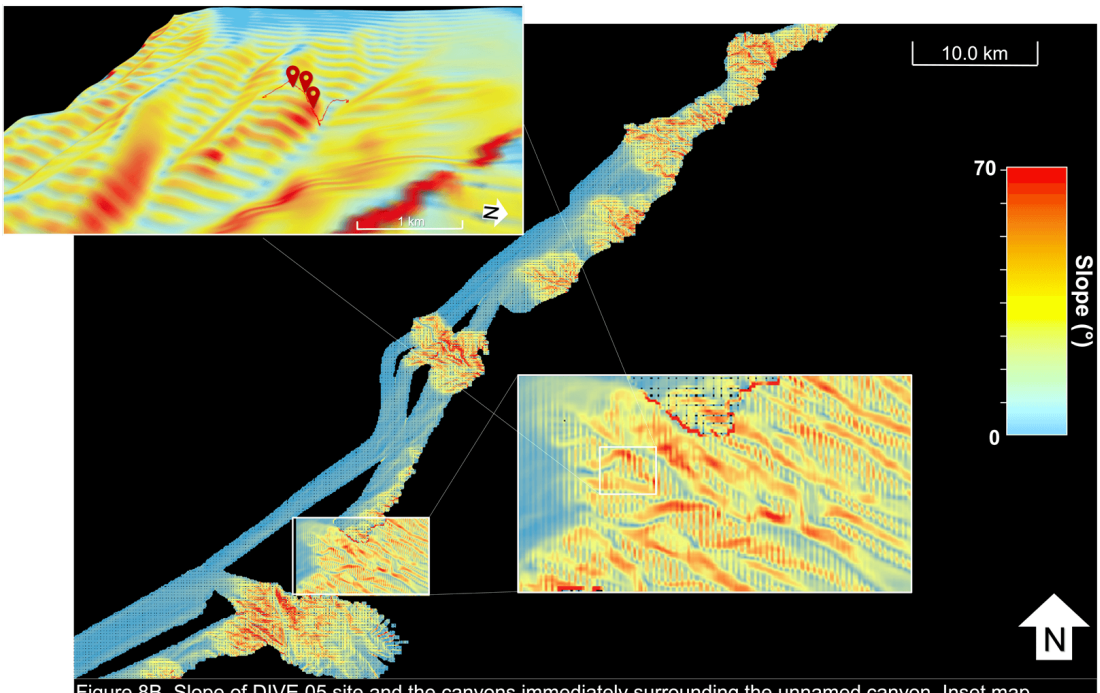


Figure 8B. Slope of DIVE 05 site and the canyons immediately surrounding the unnamed canyon. Inset map depicts slope draped on bathymetric surface the three locations of *H. hippoglossus* observations.

- Aspect of the region, dervided from the data, illustrates the H. hippoglossus observations were seen on a North facing slope (Fig. 8C)

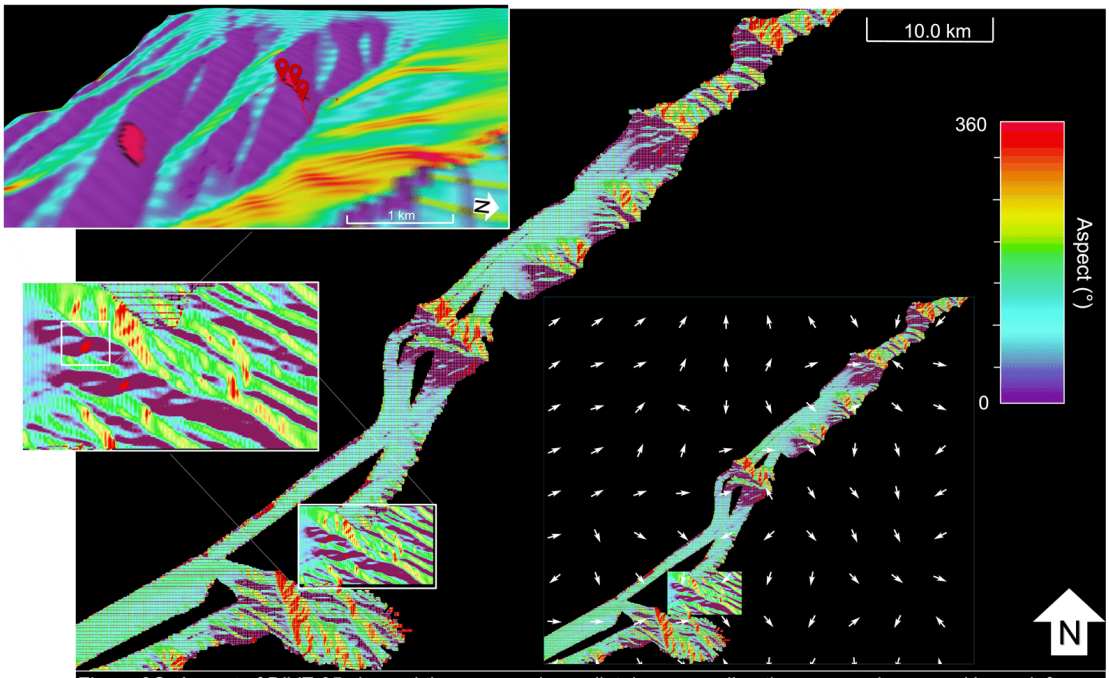


Figure 8C. Aspect of DIVE 05 site and the canyons immediately surrounding the unnamed canyon. Upper, left, inset map depicts aspect draped on bathymetric surface of the three locations of *H. hippoglossus* observations. Lower, right overlays the bottom current direction on top of the aspect layer.

- Rugosity was derived from the slope and aspect data and draped on the bathymetric surface revealing the halibut were observed to be present in areas of higher rugosity. (Fig. 8D)

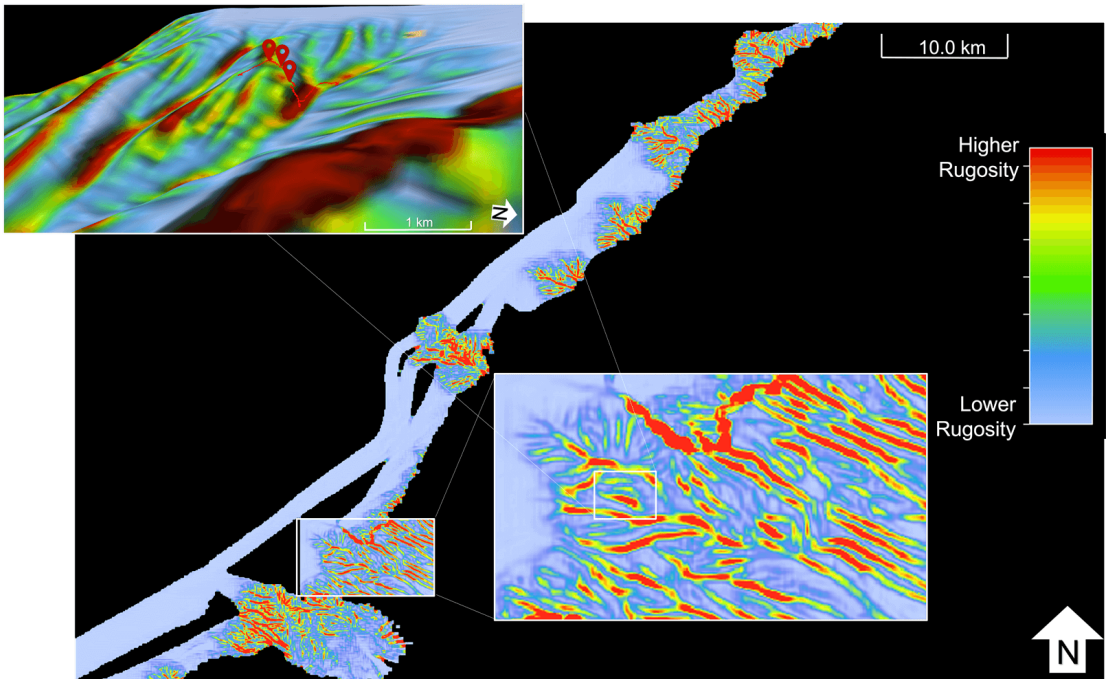


Figure 8D. Terrain rugosity of DIVE 05 site and the canyons immediately surrounding the unnamed canyon. Inset map depicts rugosity draped on bathymetric surface of the three locations of *H. hippoglossus* observations.

- All layers of, bathymetry, slope, aspect, and rugosity were fed into the Benthic Terrain Modeler, generating a classified map of the region, observations occurring at the Canyon crest and upper slopes. (Fig.8E)

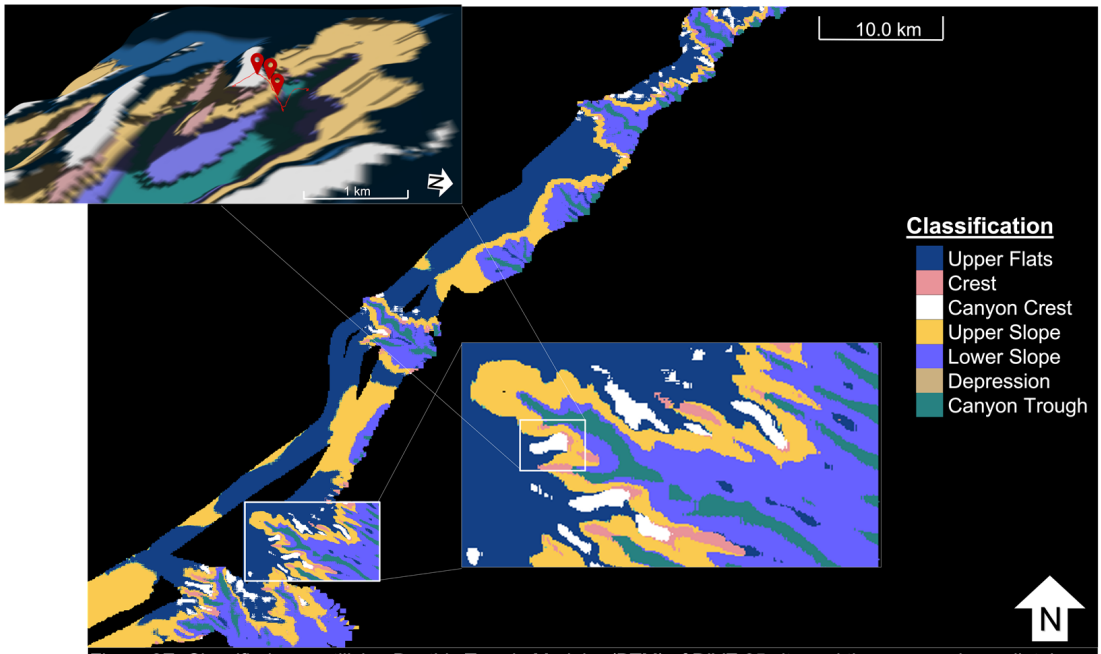


Figure 8E. Classified map utilizing Benthic Terrain Modeler (BTM) of DIVE 05 site and the canyons immediately surrounding the unnamed canyon. Inset map depicts BTM surface draped on bathymetric surface the three locations of the *H. hippoglossus* observations.

HYPOTHESIZED HALIBUT HABITAT

Through combined processing of multibeam derived data layers utilizing the Benthic Terrain Modeler, The New England canyons in this area display distinct zones of canyon trough (Fig 9), lower slope, upper slope, and canyon crest.

Figure 9. Surface generated in the benthic terrain modeler draped over EX1905L2 and DIVE 05 bathymetric surfaces. Canyons and channels are highlighted in blue.

Analysis of multibeam derived data layers, ROV video footage, and extant maps of regional oceanographic conditions, allows for a map of hypothesized *H. hippoglossus* habitat can be generated (Fig. 10).

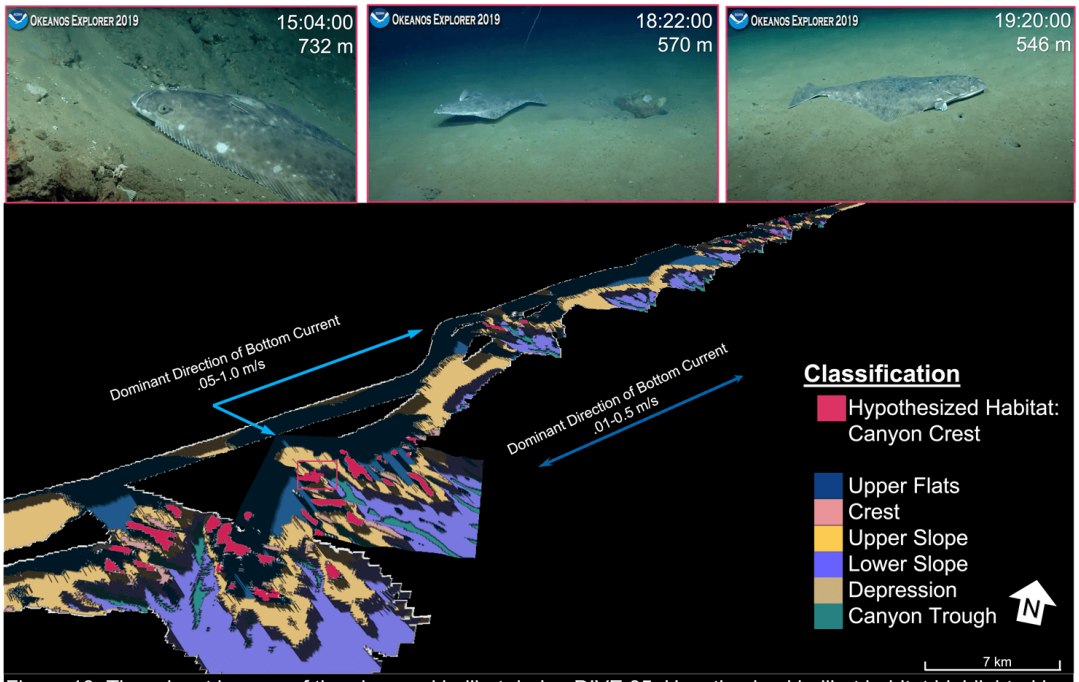


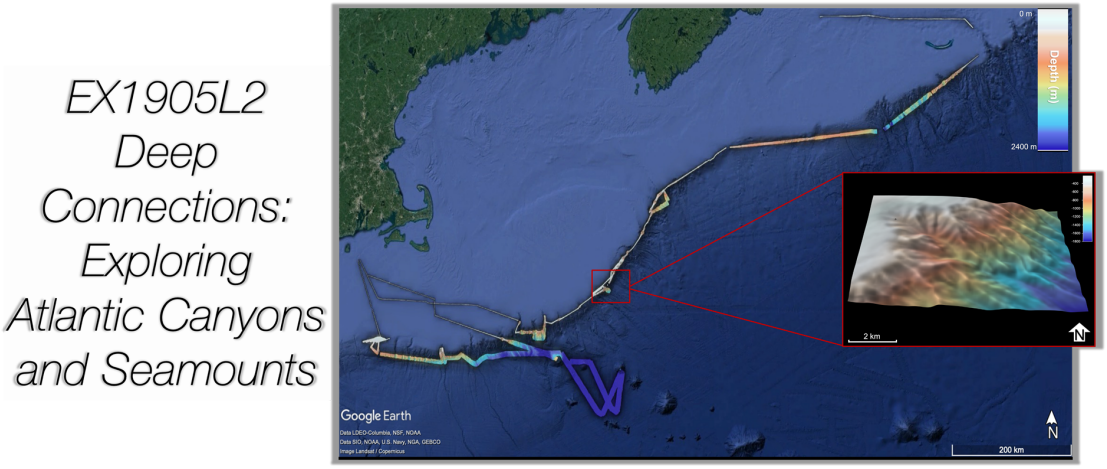
Figure 10. Three inset images of the observed halibut during DIVE 05. Hypothesized halibut habitat highlighted in areas were higher canyon crests present along with faster off shelf currents. Currents were observed to be higher at the edge of the shelf typically in a north northwesterly direction whereas, off-shelf, they were slower and a dominant direction could not be determined.

The sightings of *H. hippogolssus* occurred on or in the regions neighboring canyon crests (highlighted in red in Figure 10). This geomorphology is consistent with spawning regions (high slope, flow, and rugosity) but because halibut were observed on these crests outside of their spawning months, their presence could suggest they inhabit the New England

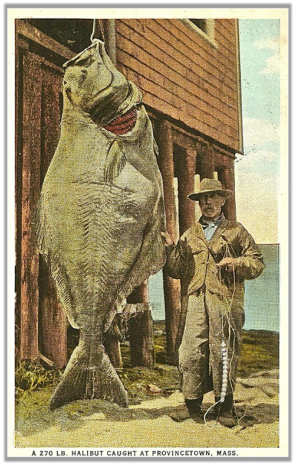
canyons outside of spawning.

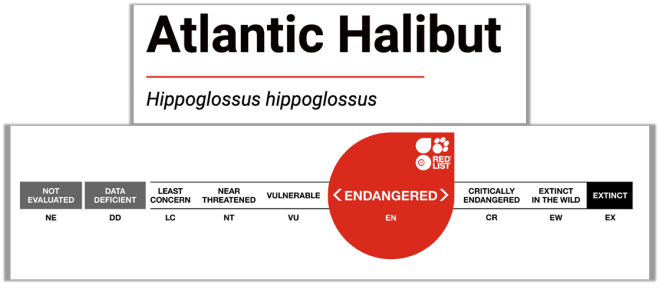
Observations of individuals which were more than 1 m indicates a potential mature, thus higher fecund, population. Because of the endangered status of the species, protecting habitats that host mature individuals could facilitate bolstering the stock and preserving the New England population.

Combining regional mapping efforts with global data products this study was able to hypothesize critical habitat, illustrating the dynamic quality of seafloor mapping data to multiple fields of science.



"A female Atlantic halibut can reach up to 4.7 m and live over 40 years…"





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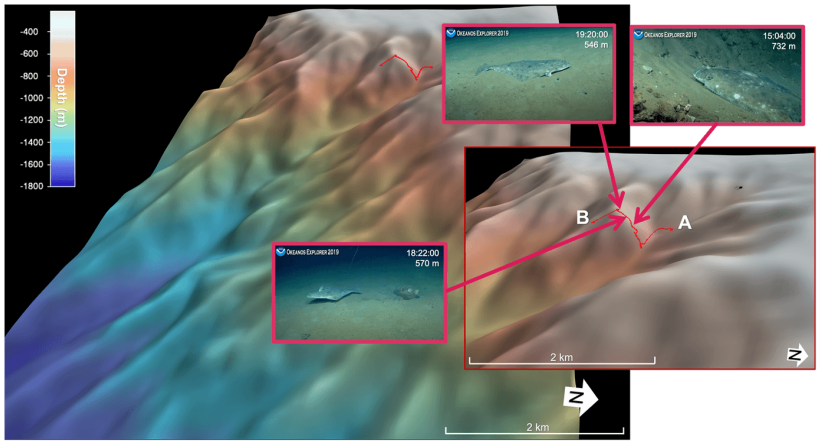

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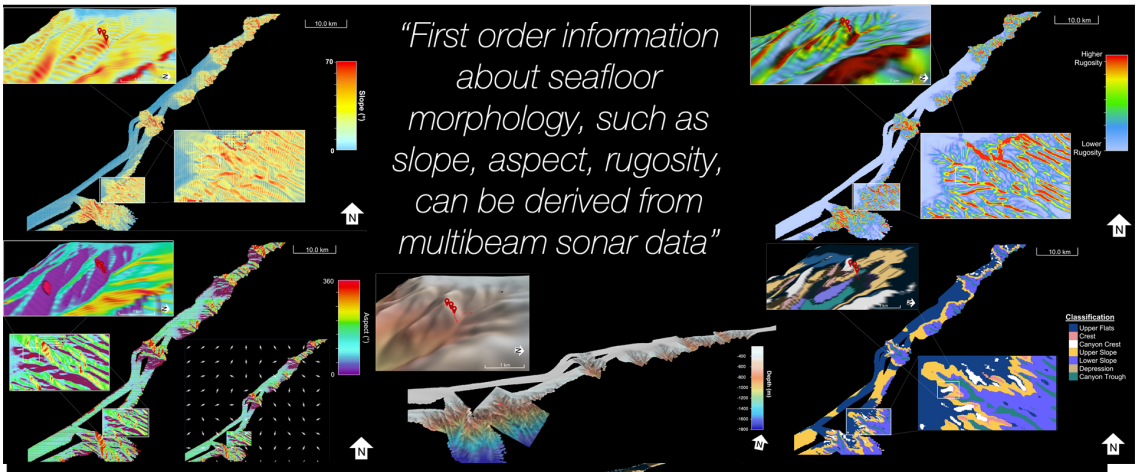
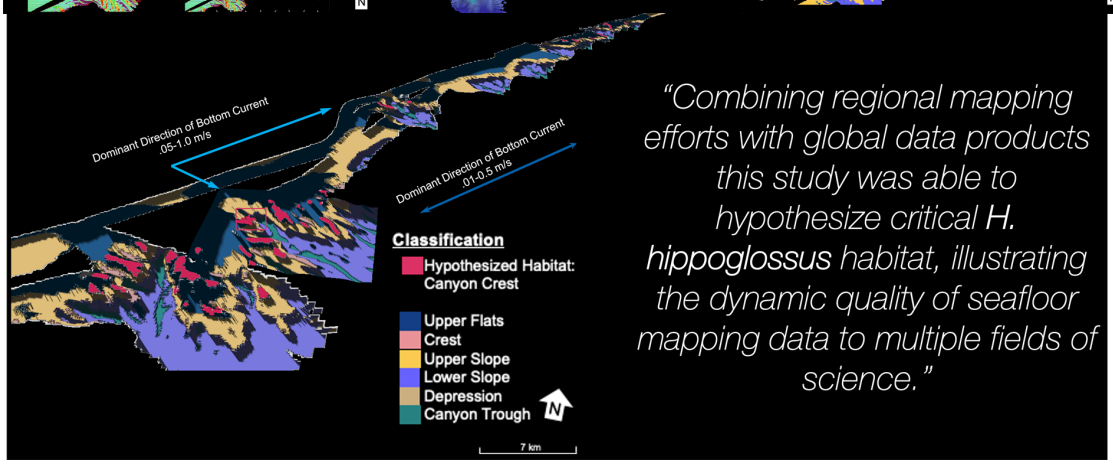


"First order information about seafloor morphology, such as slope, aspect, rugosity, can be derived from multibeam sonar data"



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ABSTRACT

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REFERENCES

Cargnelli, L. M., Griesbach, S. J., & Morse, W. W. (1999). Essential fish habitat source document. Atlantic halibut, Hippoglossus hippoglossus, life history and habitat characteristics.

Dawicki, Shelley. (2019, Nov. 27) Learning More About a Big Fish: Atlantic Halibut Team Goes ‘Under the Hood.’ NOAA Fisheries.

NOAA: Office Ocean Exploration and Research. (2019, October 21). Expedition Summary: Deep Connections 2019: Exploring Atlantic Canyons and Seamounts of the United States and Canada. United States Department of Commerce.

Sobel, J. (1996). "Hippoglossus hippoglossus". IUCN Red List of Threatened Species. 1996: e.T10097A3162182. doi:10.2305/IUCN.UK.1996.RLTS.T10097A3162182.en

Trzcinski, M. K., & Bowen, W. D. (2016). The recovery of Atlantic halibut: a large, long-lived, and exploited marine predator. ICES Journal of Marine Science, 73(4), 1104-1114.

Walbridge, S.; Slocum, N.; Pobuda, M.; Wright, D.J. Unified Geomorphological Analysis Workflows with Benthic Terrain Modeler. Geosciences 2018, 8, 94. doi:10.3390/geosciences8030094