Contact Information

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Willing to Attend Workshop? Either Cindy, or I, or both will attend
Target Name: Exploration of Western North Atlantic Shelf-Break Ecoregions and the Laurentian Fan
Geographic Area(s) of Interest within the North Atlantic Ocean: Northern shelf break ecoregions and the Laurentian Fan
Relevant Subject Area(s) Biology, Geology, Chemistry, Habitat Mapping

Description of Region and Topic Recommended for Exploration

REGION: Northern shelf-break ecoregions. Based on published databases of biophysical proxies (temperature, pH, particulate organic carbon flux, dissolved oxygen, sediment granulometry) and K-neighborhood clustering methods (spatial autocorrelation), the shelf break extending from Cape Hatteras to the Gulf of Maine is predicted to include 5 ecoregions (Fig 1), with additional ecoregions accumulating to the north (i.e., beyond the geographic scope of the effort that generated Fig 1). **TOPIC: Shelf-break biogeography.** Seeps and the surrounding seafloor environment provide targets for testing whether the ecoregions identified using biophysical proxies are reflected in measurable differences in the benthic faunas. Mapping of water column acoustic anomalies associated with methane release from seeps could be strategically focused within unexplored northern ecoregions, ideally extending as far north as the Laurentian Fan (Fig 2), where there is a seep that has not been visited since 1986.

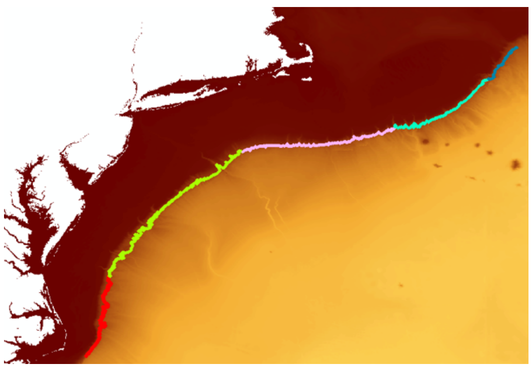

Figure 1. Color-coded ecoregions of the NW Atlantic shelf break (Van Dover laboratory).

The Laurentian Fan – North Atlantic –centered on 43°33'N, 55°37'W, 3878 m. On 18 November 1929, a magnitude 7.2 earthquake occurred in the region of the Eastern Valley of the Laurentian Fan south of Newfoundland. This earthquake generated a turbidity current that sequentially destroyed submarine telegraph cables across the Atlantic and repaved the floor of the Eastern Valley creating fields of giant, transverse, gravel-wave bedforms. Exploration of this remarkable seabed geomorphology with the submersible *Alvin* in 1986 led to the totally unexpected discovery of dense biological communities (vesicomyid and thyasirid clams, gastropods, pogonophoran tubes, galatheids, and unidentified branched organisms; Mayer et al. 1988) located on the crests of gravel waves and presumed to be associated with a methane cold-seep system (Figure 2). These communities may represent one of the largest cold-seep systems ever discovered.

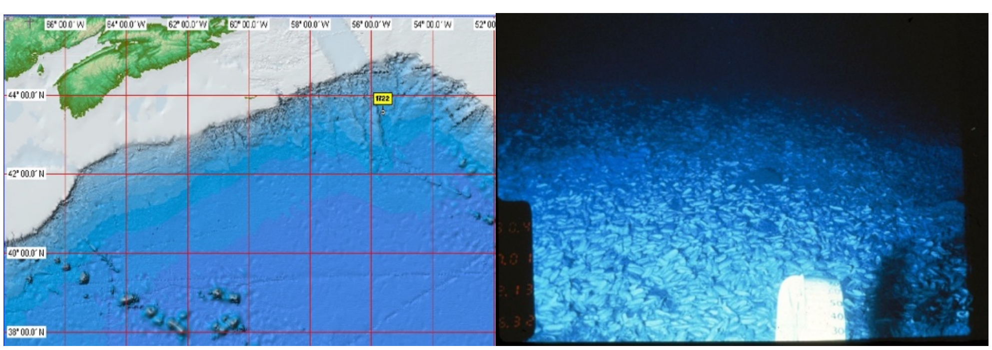

Figure 2. Left - Location of large chemosynthetic communities on the Laurentian Fan (yellow); right – example of clam communities seen from Alvin.

Brief Summary of Current State of Knowledge: Shelf-Break Ecoregions. Skarke et al. (2014) identified more than 500 seeps along the US Atlantic margin and set the stage for follow-on characterization of shelf-break seep ecosystems (e.g., Bourque et al. 2016). Global data sets of biophysical proxies enable spatial analyses that explore potential eco- and biogeographic regions and that can be used strategically to identify priority areas for exploration and characterization of seafloor ecosystems (Watling et al. 2013, Dunn et al. 2018). Detailed analysis of seep faunas extending from Cape Hatteras to Cape Cod documents shifts in community characteristics consistent with an ecoregion structure (P Turner, Duke PhD dissertation, in progress).

Brief Summary of Current State of Knowledge: The Laurentia Fan. The classic work of Heezen and Ewing (1952) that demonstrated the existence of deep-sea turbidity currents triggered by the 1929 Grand Banks earthquake, this region of the Laurentian Fan has been subject to a number of geological studies focused on the impact of the turbidity current. The discovery chemosynthetic communities in 1986 was accidental and unexpected. Faunal and biophysical characteristics seemingly places these communities in a different biogeographic/ecoregion from those of the Skarke et al. seeps on the US Atlantic coast shelf break and those recently discovered off Svalbard (Astrom et al. 2016).

Rationale for Future Exploration: Shelf-Break Ecoregions and the Laurentian Fan. Extending the exploration and characterization of seep sites further north than the Skarke et al. (2014) observations will open a new frontier for developing an understanding of the distribution of seep and other seabed faunas relative to biophysical proxies. The *Okeanos Explorer*'s ROV and mapping systems enable localization and characterization of study sites and faunas within a detailed morphologic context. The relationship of communities to the shelf break, and, in the case of the Laurentian Fan, to canyon walls, gravel waves, and turbidity-current deposits, will provide insight into the nature of the methane sources. Sampling and analysis of the fauna will also address the extent of population connectivity between the Laurentian Fan seep fauna and other seeps in the North Atlantic. This will allow Laurentian Fan invertebrates to be placed within a global biogeographic context and provide a basis for the understanding of the relationship of benthic populations to ecoregions defined by biophysical proxies, and to local and regional seafloor processes and fluid flow. Stable isotope analyses of animal tissues will help to resolve whether there is a deep source of thermogenic methane at Laurentian Fan seeps. Finally, because the seafloor was stripped clear by the Laurentian Fan turbidity current in 1929, the 1929 event established a "time zero" benchmark against which the development of the seep community can be assessed (Mayer et al. 1988). A re-visit to the sites visited by ALVIN in 1986 will document changes in the community 33 years after the first dives and nearly a century after the initiating event. The proposed expedition will address fundamental biological and geological questions including the nature of chemosynthetic communities, how they are established, and how they are sustained, and will image and sample environments that are beautiful and exotic -- a key to engaging the public.

Potential Partnerships ATLAS, SponGES, Canada Healthy Oceans Network, Geological Survey Canada (esp. David Mosher, David Piper, Alexandre Normandeau), University Kiel (esp. Sebastian Krastel), InDeep

References **Astrom EKL** et al. (2016) Arctic cold seeps in marine methane hydrate environments: Impacts on shelf macrobenthic community structure offshore Svalbard. Mar Ecol Prog Ser 552:1–18. **Bourque JR** et al. (2016) Macrofaunal communities associated with chemosynthetic habitats from the U.S. Atlantic margin: A comparison among depth and habitat types. Deep Res Part II Top Stud Oceanogr 137:42–55. **Dunn DC** et al. (2018) A strategy for the conservation of biodiversity on mid-ocean ridges from deep-sea mining. :1–16. **Heezen, B.**, W. M., Ewing, (1952), Turbidity currents and submarine slumps, and the Grand Banks earthquake, Amer. Journ. of Science, v. 250, p. 849-873. **Mayer LA** et al. (1988) Dense biological communities at 3850 m on the Laurentian Fan and their relationship to the deposits of the 1929 Grand Banks earthquake. Deep-Sea Research A 35:1235-1246. **Skarke A** et al., (2014) Widespread methane leakage from the sea floor on the northern US Atlantic margin. Nat Geosci:1–5. **Watling L** et al. (2013) A proposed biogeography of the deep ocean floor. Prog Oceanogr 111:91–112.