



New insights to biogeographic patterns among cold-water coral-dominated benthic communities across the Drake Passage

Steven R. Auscavitch, Rhian G. Waller

Darling Marine Center, School of Marine Sciences, University of Maine, Walpole, ME



Background

- Deep-sea benthic habitats in the Southern Ocean are among some of the most remote and least studied in the world's ocean.
- The Drake Passage has been thought throughout history to be a biogeographic discontinuity isolating sub-polar and polar species.
- Cold-water corals have been observed to be extremely abundant and dominant community members in many seafloor habitats, particularly on seamounts in the area (Waller et al. 2011)
- We sought to better understand the distribution and community structure of coral assemblages as well as associated megafauna in the region by conducting benthic surveys.

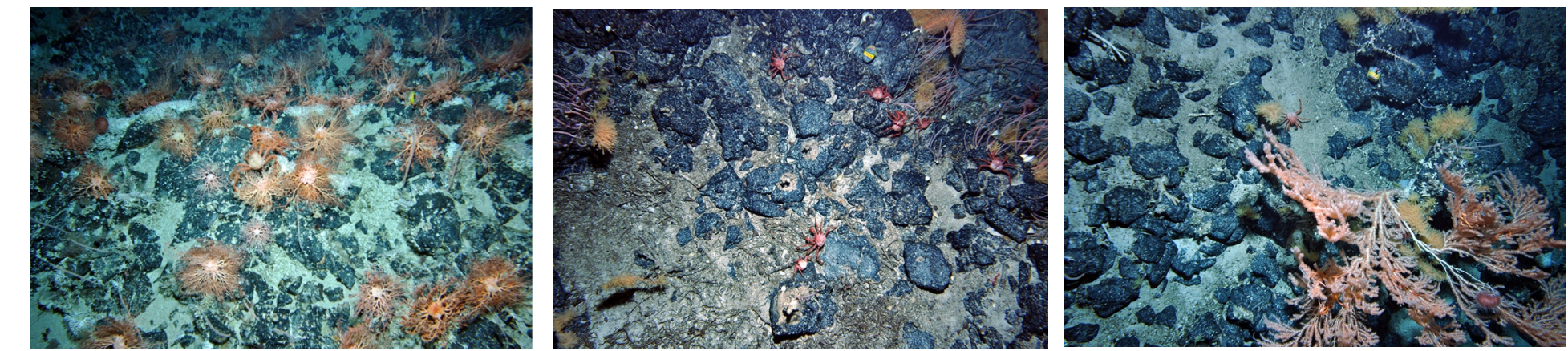


Figure 1: Cold-water coral habitats on Sars Seamount (Central Drake Passage). Locally abundant *Gorgonocephalus chilensis* among stylasterids and whip morphology primnoids (Left); Lithodid crabs among primnoids including stony coral rubble; (Center) Large branching bamboo coral *Jasonis* sp. and small, yellow *Thouarella* sp. (Right).

- Cold-water coral communities were specifically targeted to determine whether assemblage structure differed among seamounts and those within adjacent shelf waters.
- We hypothesized that intermediate benthic communities can provide insight to better define latitudinal and meridional biogeographic patterns at depth, as well as identify potential connective deep-sea stepping-stones across prominent oceanographic boundaries.

Local Oceanography Drives Patterns in Biodiversity

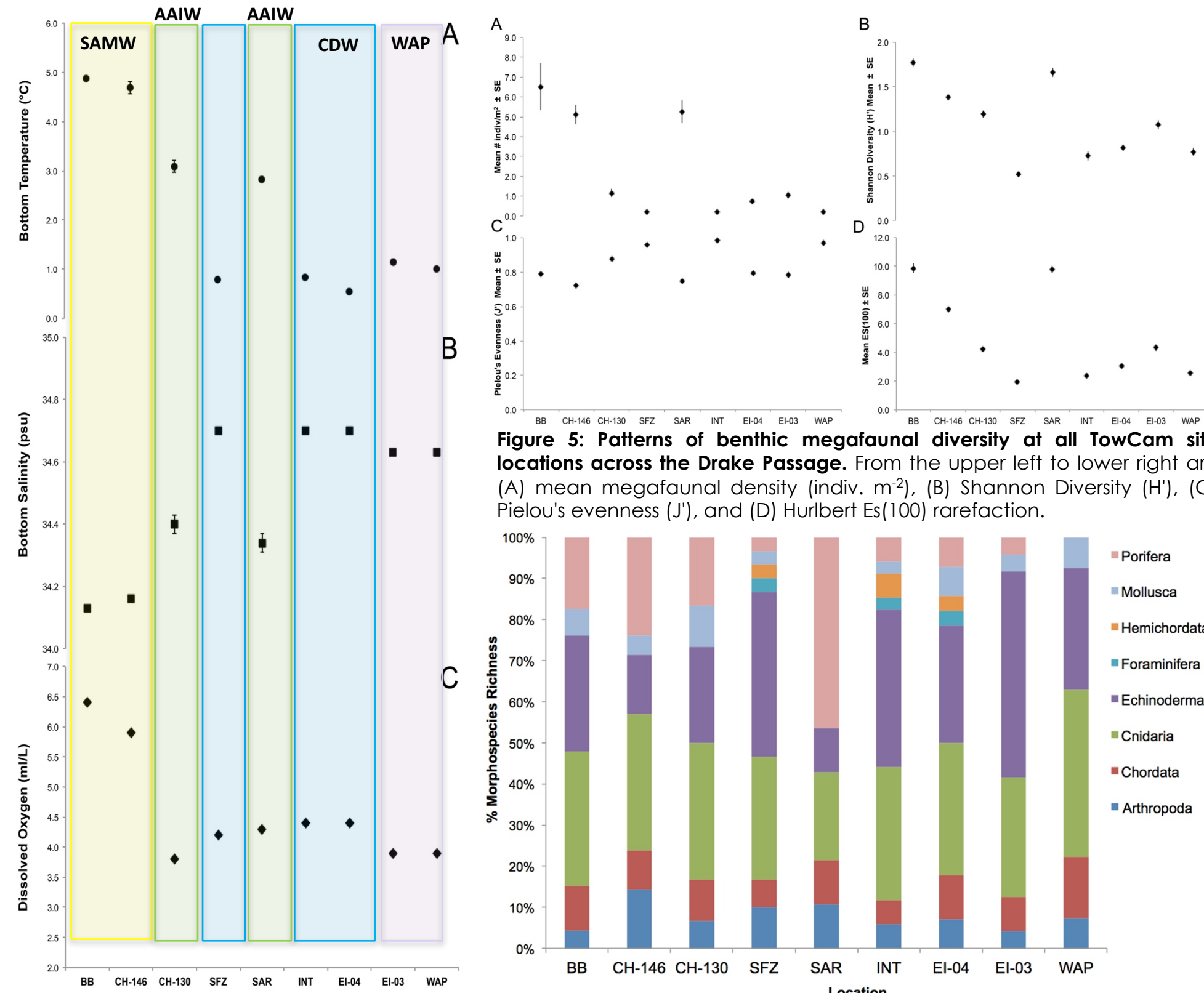


Figure 4: Water column environmental properties of the Drake Passage. A) Temperature (°C), B) Salinity, and C) dissolved oxygen (µMol/L).

Figure 6: Seafloor community composition by phyla at all sites. Data are shown as percent total species richness. Data are displayed latitudinally from North (left) to South (right).

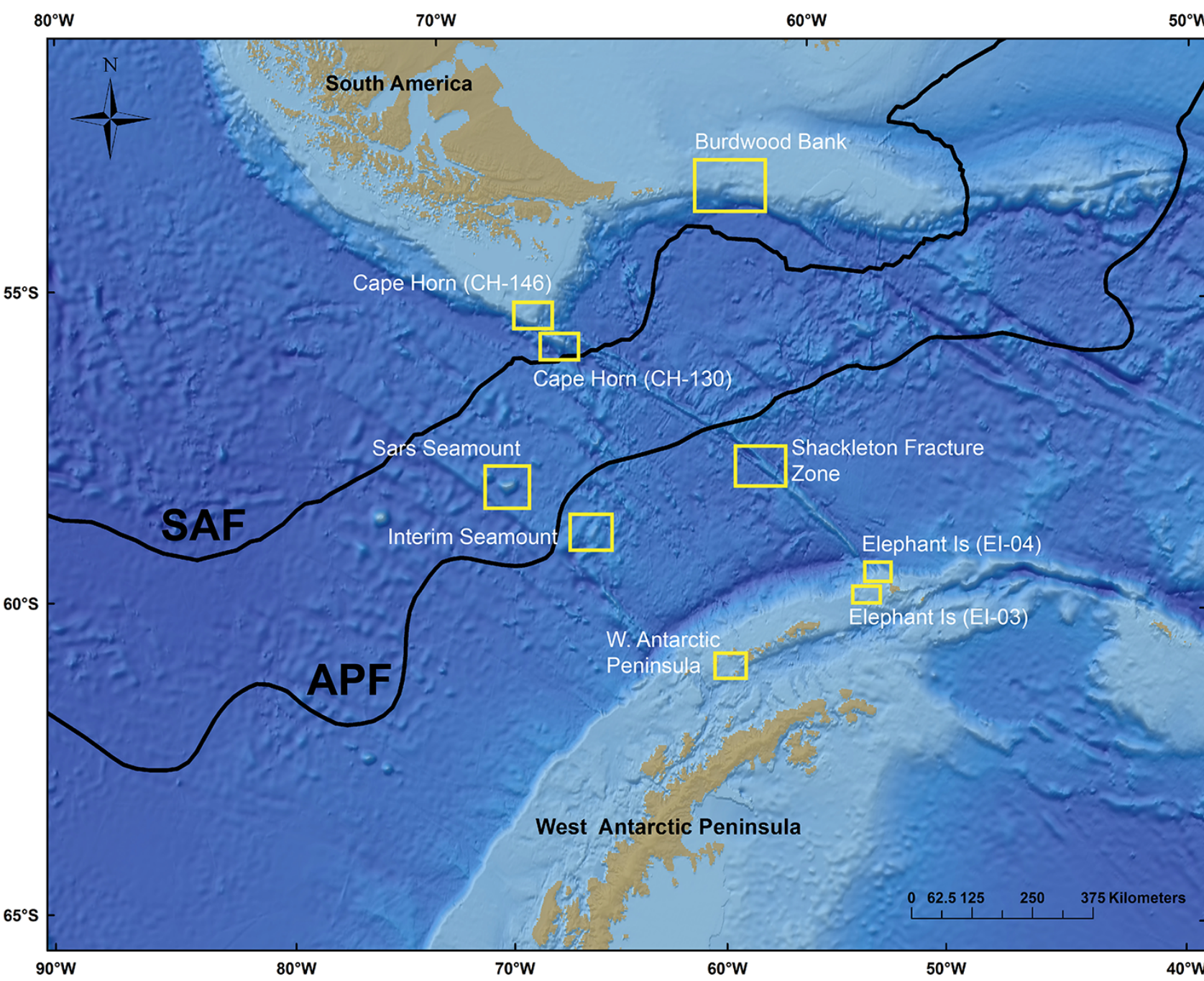
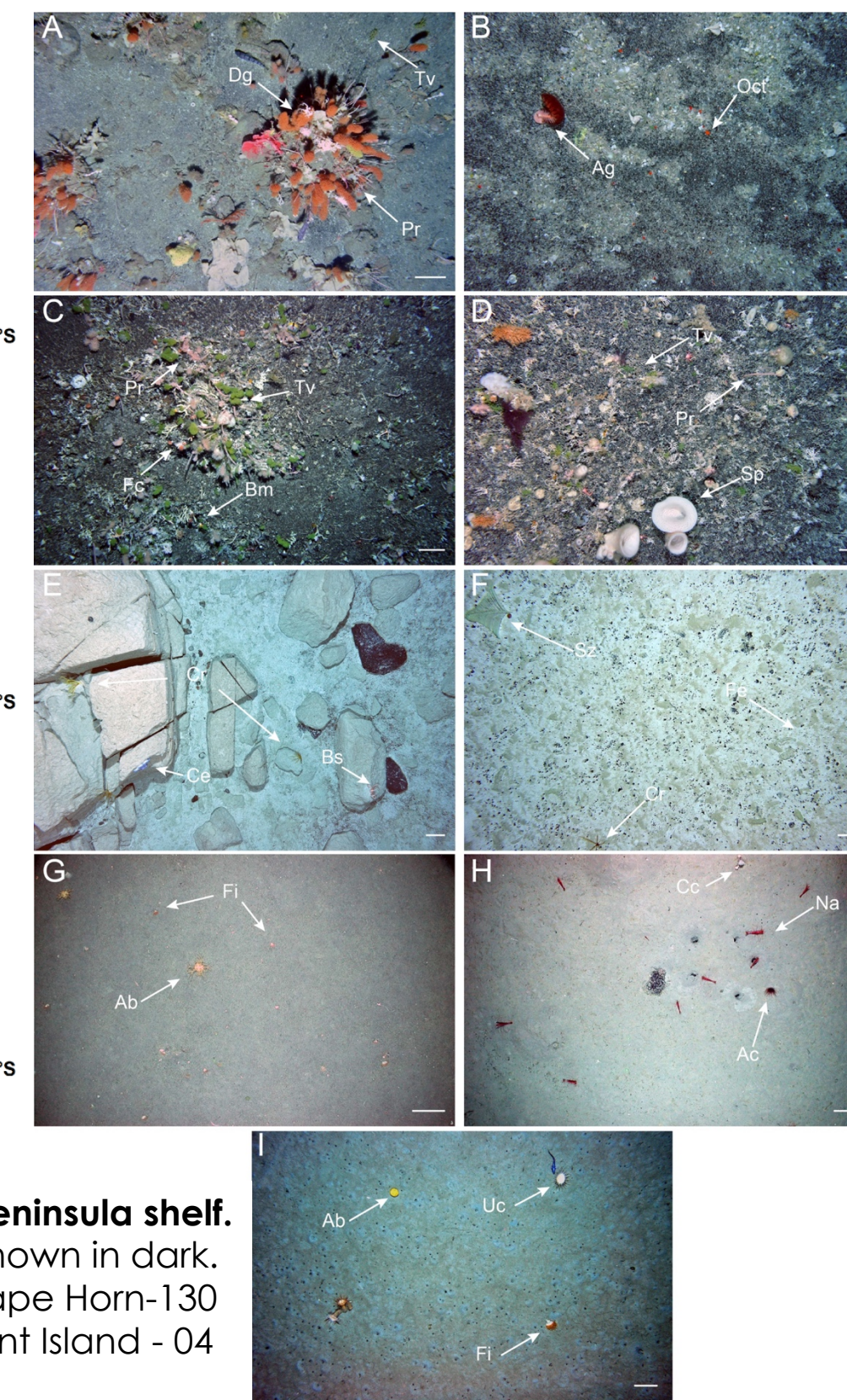


Figure 2: Locations of sites surveyed in the Drake Passage and Western Antarctic Peninsula shelf. Year-mean tracks of the Sub-Antarctic (SAF) and Antarctic Polar Fronts (APF) are shown in dark. Seafloor images are located as follows: Burdwood Bank (A), Cape Horn-146 (B), Cape Horn-130 (C), Sars Seamount (D), Shackleton Fracture Zone (E), Interim Seamount (F), Elephant Island - 04 (G), Elephant Island - 03 (H), W. Antarctic Peninsula (I).



Methodology

- During a series of cruises to the Drake Passage in 2008 and 2011, deep benthic environments were surveyed using a high-resolution towed camera platform allowing bottom images to be taken at a fixed altitude (3-5m) above the seafloor.
- For further species identification, representative biological samples were obtained using targeted trawls at each site.
- In our analysis, megafauna (here defined by the resolution of the camera as organisms greater than a few centimeters in size) were identified and enumerated within photo frames. Towed camera photos were examined at one-minute intervals along transects to avoid image overlap.
- In all, 7712 m² of seafloor were examined across N=590 images. Mean photo area covered was 11.6 m² (± 3.9 m²) in area with approximately 100-200 photos per site.



Figure 3: Seafloor images from deep-sea environments across the Drake Passage. (A) Burdwood Bank (325m) coral gardens composed of primarily primnoid octocorals *Digitogorgia* sp. (*Dg*), *Thouarella viridis* (*Tv*), and several other spp. of primnoid whips (*Pr*). (B) Cape Horn-146, 442m. Sparse megafauna composed of encrusting cnidarians *Anthophilium grandiflorum* (*Ag*) and small stoloniferous octocoral spp. (*Oct*). Numerous battlebrush coral morphologies were also present. (C) Cape Horn-130, 967m. Dense clusters of primnoids and cup corals *Balanophyllia malouenesis* (*Bm*), *Flabellum curvatum* (*Fc*). (D) Sars Seamount peak (503m) with numerous sponges (*Sp*), primnoid octocorals, and occasional small galatheid crabs. (E) Rocky outcrop along the western boundary of the Shackleton Fracture Zone (2252m). Megafauna include crinoid spp. (*Cr*), brisingid stars (*Bs*), and cephalopod mollusks (*Ce*). (F) Deep Interim Seamount (3058m) communities included antipatharian corals, *Schizopathes* sp. (*Sz*) and crinoids (*Cr*). Large fecal casts (*Fe*) from abundant enteropneusts and holothurians were also common. (G) A shallower (400m) Elephant Island (EI-03) soft-bottom community with numerous coral representatives including the prominent *Flabellum impensum* (*Fi*) and *Anthomastus bathyproctus* (*Ab*). (H) Characteristic image of the deeper (1905m) Elephant Island (EI-04) location dominated by aggregations of *Notocrangon antarcticus* (*Na*), occasional attached cup corals (*Cc*) and anemones (*Ac*). Burrows of various sizes were abundant across the seafloor. (I) W. Antarctic Peninsula shelf, 584m. Similar to soft-sediment habitats near Elephant Island, this site was dominated by cnidaria including *A. bathyproctus* (*Ab*), *Urticina* sp. (*Uc*), *F. impensum*. In this location *A. bathyproctus* individuals were only observed with retracted polyps. Scale bars are equivalent to approximately 22cm.

Results

Figure 7: Multivariate analysis of benthic communities. (A) Dendrogram of a cluster analysis for TowCam sampling locations based on species abundance. SIMPROF test results are shown with solid lines indicating significant groupings. (B) Non-metric multidimensional scaling (nMDS) plot of site-pooled species abundance based on a Bray-Curtis similarity index.

- SIMPROF analysis indicated 3 significant similarity clusters.
- These assemblages were found to strongly correspond with changes in major overlying water mass properties associated with Antarctic Intermediate Water, Circumpolar Deep Waters, and Antarctic shelf waters.

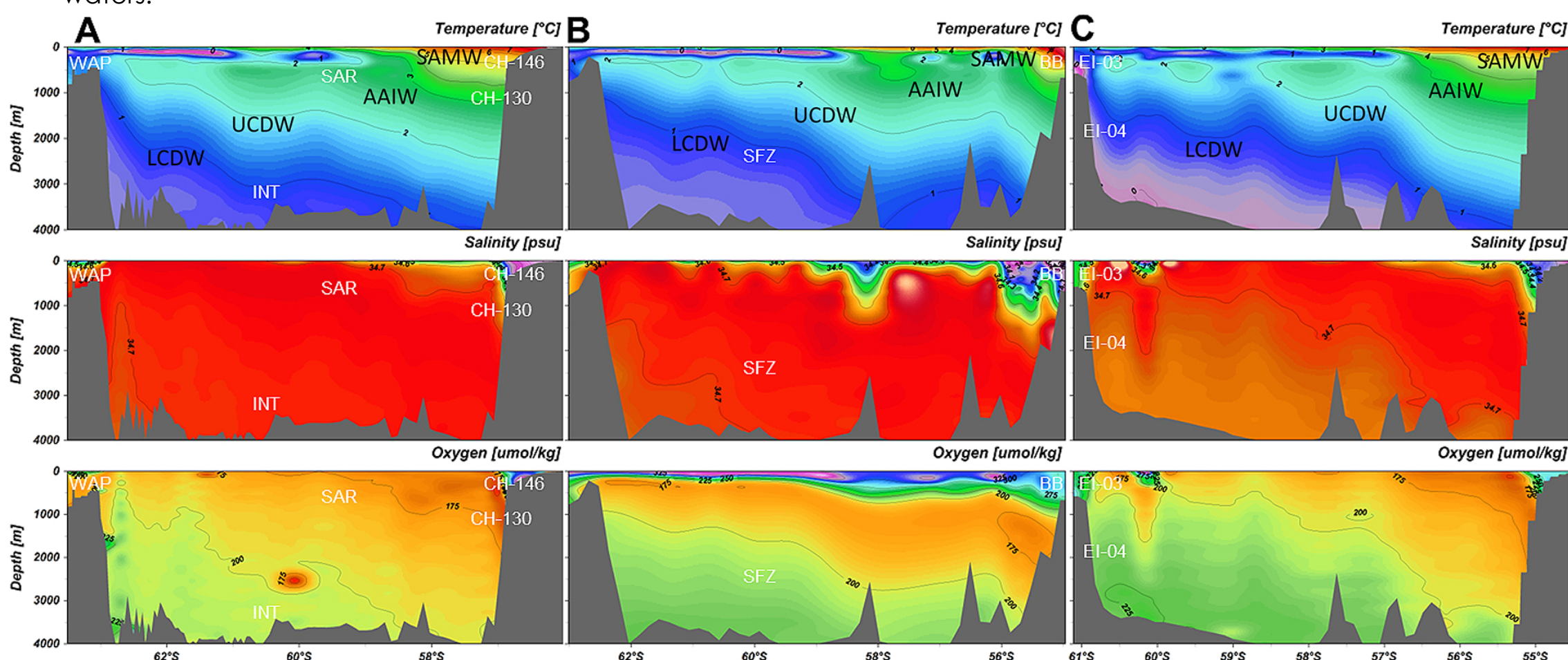
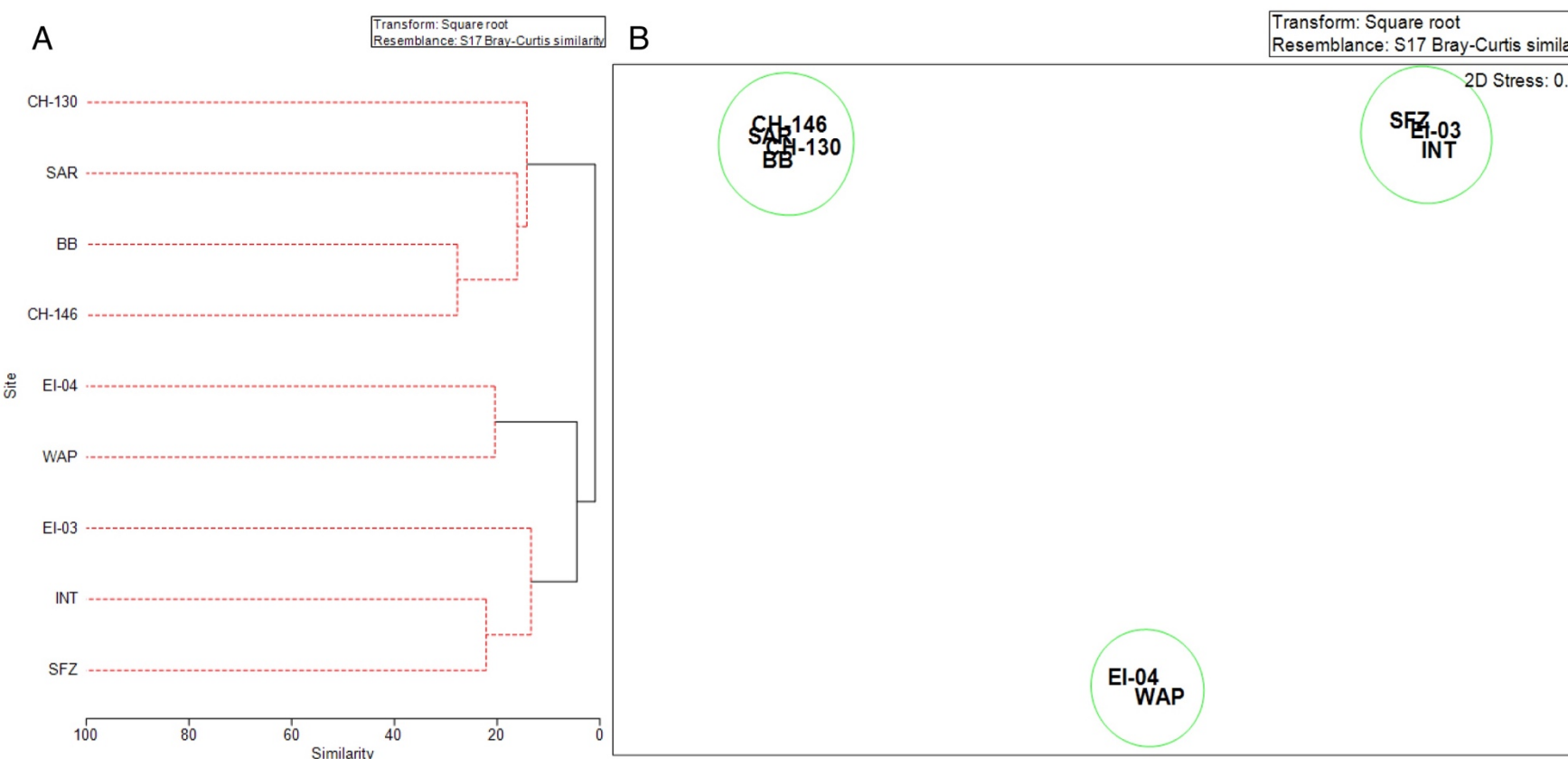


Figure 8: Latitudinal cross-section water column profiles of the Drake Passage region at (A) 63-68°W, (B) 62-65°W, and (C) 54-58°W. TowCam sampling approximate locations are overlaid in white text. Water masses are labeled in black text. Bottle data were acquired from the CLIVAR (Climate Variability and Predictability) CCHDO (Carbon Hydrographic Data Office) repository. Profiles were constructed with Ocean Data View (ODV) software.

Conclusions

- Drake Passage benthic communities shallower than ~1000m are largely dominated by cold-water coral and other anthozoan faunas.
- Cold-water corals and coral gardens were observed to provide structural relief in most habitats on the northern margin. Sars Seamount also hosts the most diverse sponge assemblage in this area.
- Drake Passage bathyal communities are can be divided into 3 biogeographically similar areas which correspond to major overlying Southern Ocean water masses: Antarctic Intermediate Water, Circumpolar Deep-water, and Antarctic Shelf waters.
- Seamounts in the Drake Passage remain very poorly surveyed and hold clues to the likelihood of stepping stones or filters across the narrowest gap between continental land masses in the Southern Ocean

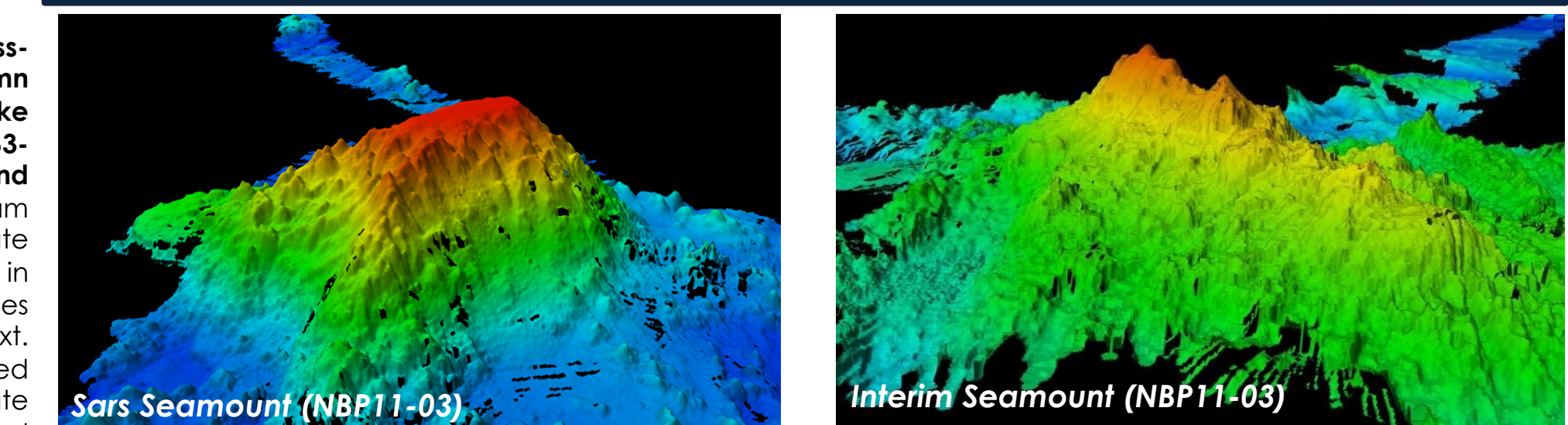


Figure 9: Multibeam bathymetry of Sars and Interim Seamounts in the central Drake Passage. The peak of Sars Seamount lies at 490m while Interim rises only to 725m.

References: Brandt, A., et al. (2007). *Nature*, 447(7142), 307-311.; Waller, R. G. et al. (2011). *PLoS one*, 6(1), e16153; Margolin, A. R. et al. (2014). *Deep Sea Research Part II: Topical Studies in Oceanography*, 99, 237-248.; Wollast, L. et al. (2013). *Progress in Oceanography*, 111, 91-112.

Acknowledgements: We would like to thank the efforts of the science party and crew of the R/V Nathaniel B. Palmer on NBP11-03 and NBP08-05. Also, a special thanks to K. Scanlon and S. Hoy (USGS) for helping to prepare seafloor mapping products, as well as D. Villeneuve (Bowdoin College) for processing seafloor imagery. Valuable taxonomic assistance was provided by L. Alcock, K. Eckelbarger, L. Grange, E. Rodriguez, M. Taylor, and L. Watling.

