Topographic Control on Macrobenthic Community Structure in the Northeastern Chukchi Sea

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Background

Water circulation and the dynamics of circulation patterns influence the deposition of particulate organic carbon which is food for sediment-dwelling (benthic) fauna. Indirect effects of physical characteristics and their interactions with biological communities can result in unexpected spatial patterns in benthic fauna. Topographic control of water circulation is one pathway for indirect effects on benthic communities from landscape-level physical variations.

Benthic communities were sampled during the 2011 Chukchi Sea Environmental Studies Program (CSESP) in four strata encompassing Burger, Klondike, Statoil, and Hanna Shoal (Fig. 1). Sediment-dwelling macrofauna (small organisms retained on a 1.0-mm mesh sieve) were collected with a 0.1 m^{-2} double van Veen grab.

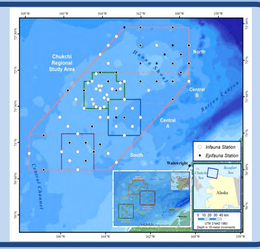

Figure 1. Map of sampling locations in the 2011 CSESP. Inset is the 2008 – 2010 sampling locations. Four strata are used for benthic ecology: South, Central A, Central B, and North.

The Physical Environment:

Water circulation drives carbon availability

- Percent mud was greatest in the Central A and B strata (Fig. 1; fines accumulate in areas with weaker currents), and
- Total organic carbon was greatest in Burger (Central A).

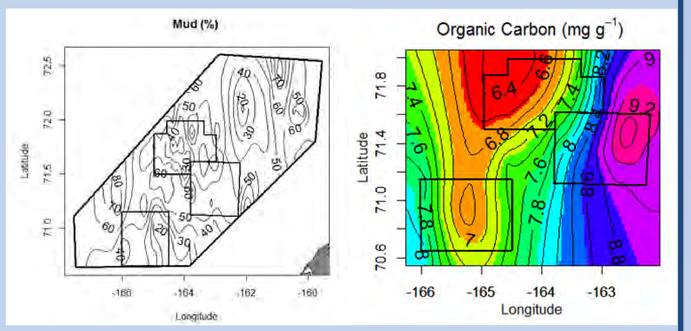

Figure 3. Spatial models of percent mud for 2011 and organic carbon for 2008-2010 (2011 data not yet available).

- Macrofaunal density increased with greater depth and organic carbon for data from 2008-2010 (Fig. 4).

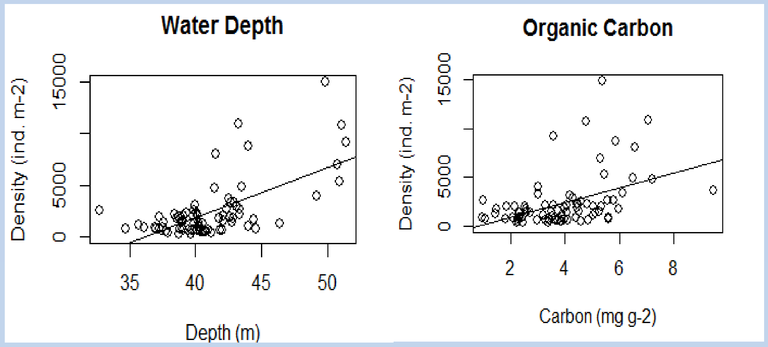

Figure 4. Linear regressions of macrofaunal density against water depth and organic carbon.

Topographic Control of Water Circulation

- High points (shoals) force water to move around them:
  - Northward-flowing water (Current A) circulates around the top of Hanna Shoal and then to Barrow Canyon (Current B).
  - A portion of the water flows to the west around the south flank of Hanna Shoal (Current C).
  - That water meets water flowing east from the Central Channel (Current A) and bends back to the east (Current D).
- Low points (troughs) can be stagnant:
  - Winter water remains longer in the deeper areas of Burger (Weingartner et al., in submission).

General region of convergence and slower currents

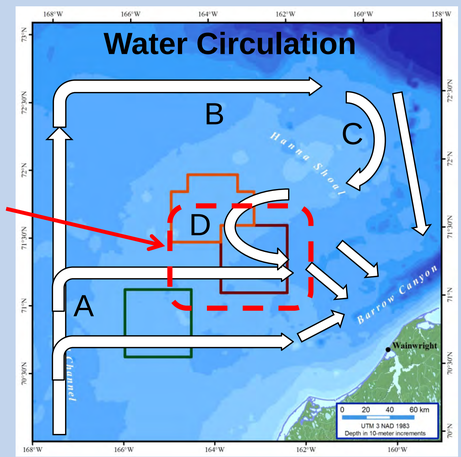

Figure 2. Water circulation around Hanna Shoal from Weingartner et al. (2005) and Spall (2007).

The trough and convergence of currents over Burger slows water movements (Spall, 2007; Weingartner et al., in submission).

Biological Patterns:

Organic carbon availability drives benthic communities

- Macrofaunal density and biomass peaked in or near Burger in the Central A stratum (Fig. 5).
- The density and biomass of bivalves peaked in the Central A and B strata, just to the northeast of Burger (Fig. 6).

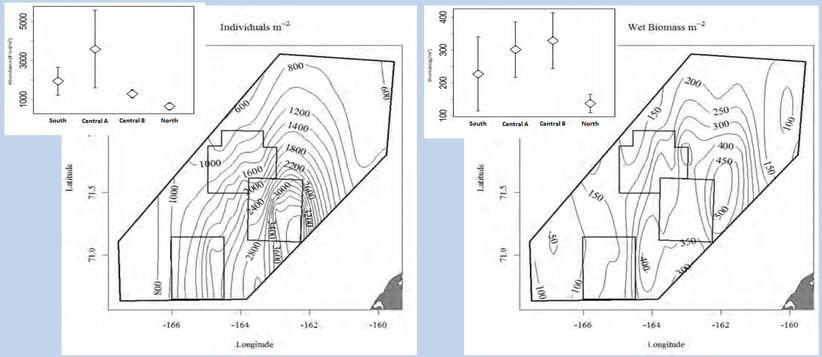

Figure 5. Spatial models of macrofaunal density and biomass for the CSESP 2011 study area.

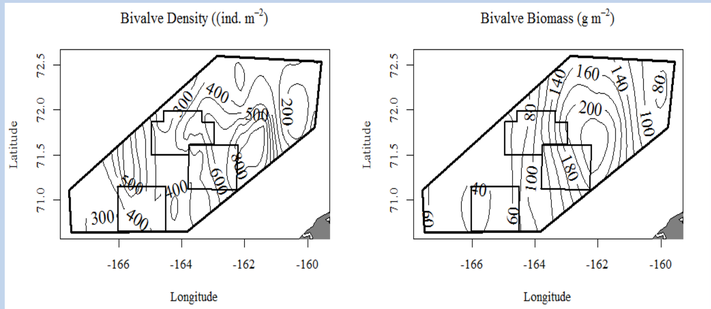

Figure 6. Spatial models of bivalve density and biomass for the CSESP 2011 study area.

Conclusion: Topography is a strong, indirect control on benthic communities

- Environmental characteristics are related to topography:
  - The Central stratum includes a submerged watershed forming in Burger and draining towards Barrow Canyon,
  - Physical oceanography demonstrates that winter-water flushes more slowly (is more stagnant) in the deeper area in Burger,
  - The convergence of topographic-driven, water currents over Burger slows water movements, and
  - Concentrations of organic carbon in sediments are higher in Burger.
- Biological community trends are associated with environmental characteristics which are influenced by topographic-driven variations in water circulation:
  - Macrofaunal and bivalve density and biomass were generally higher in and near Burger in Central A where currents are slower and more organic carbon is deposited (Figs. 2, 5, and 6).
  - The positive relationships of water depth and percent organic carbon with macrofaunal density reflect indirect effects of topography (Hanna Shoal and the trough at Burger) on water circulation.

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