Evidence for the Assimilation of Benthic Microalgae in the Chukchi Sea Food Web

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Background

The COMIDA-CAB project (Chukchi Sea Offshore Monitoring in Drilling Area-Chemistry and Benthos) began the summer of 2009 to establish baseline data within lease areas of the Chukchi Sea. The focus of our sampling effort was the rich benthic shelf community that exists in the Chukchi Sea. One of our research objectives included identifying the trophic structure of the shelf community and to examine how ultimate sources of carbon are assimilated throughout the food web. Here, we examine the trophic structure of the Chukchi Sea and provide further evidence that benthic microalgal communities associated with the shallow arctic sea shelves may be used by infauna and epifauna as an important carbon source. Food web studies in lower latitudes show the incorporation of benthic microalgal carbon in consumers (Abrantes and Sheaves, 2009), but its contribution to Chukchi Sea benthic consumers has not been well documented.

Methods

Benthic sampling was conducted in the summer of 2009 aboard the R/*V Alpha Helix* and 2010 aboard the R/V *Moana Wave* (Figure 1). Epibenthic trawls and van Veen grabs (0.1m^2) were used to collect biota and sediments. After organisms were identified to lowest taxonomic level possible, they were preserved for later stable isotopic analyses at University of Texas Marine Science Institute and University of Alaska at Fairbanks. Acetone extractions of chlorophyll *a* were measured fluorometrically. Colorimetric analysis was used to determine sediment porewater ammonium concentrations. Our benthic microalgal end-member $\delta^{13}C$ value was obtained by collecting the algal cells living on the surface of the sand dollar *Echinarachnius parma*. DeNiro and Epstein (1978, 1981) show that ^{15}N increases 3-4‰ per trophic level, compared to about 1‰ for ^{13}C. Organisms dependent on one carbon end-member would fall on a $\delta^{13}C$: $\delta^{15}N$ bi-plot with a slope of ~3.

Results and Discussion

A linear regression of the current isotope database show a low correlation coefficient (r^2=0.323), which demonstrates multiple carbon sources with differing $\delta^{13}C$ signatures are assimilated by benthic consumers (Figure 2). Consumers with high fidelity to a carbon source will fall along an enrichment line (slope=3, DeNiro and Epstein 1978, 1981) from their associated profiles of POM. In addition to POM, benthic chlorophyll *a* concentrations in bottom sediments can be appreciable (Figure 3). $\delta^{13}C$ values reveal that POM becomes more ^{13}C-enriched with depth (Figure 4). Bottom currents may suspend benthic microalgae in the near-bottom water column that may be assimilated by suspension/filter feeders as well as surface deposit feeders. Taxonomic group mean stable carbon and nitrogen isotopic values show that some organisms demonstrate considerable fidelity to a particular carbon source, while others indiscriminately feed on any available food (Figure 5). Organisms in yellow have similar $\delta^{13}C$ values to phytoplankton and are likely exclusive consumers of that carbon source. Blue indicates lower trophic level organisms with $\delta^{13}C$ values much more enriched than phytoplankton. These likely consume a ^{13}C-enriched primary producer (e.g. benthic microalgae). Organisms denoted in green fall between these values and likely consume both phytoplankton and benthic microalgae. Teal colored symbols represent ^{13}C enriched third trophic level organisms. These omnivorous scavengers likely consume organisms that assimilate benthic microalgae and benthic microalgae itself. Lastly, the highest trophic level organisms (in purple) have multiple ultimate carbon sources from consuming various organisms at lower trophic levels.

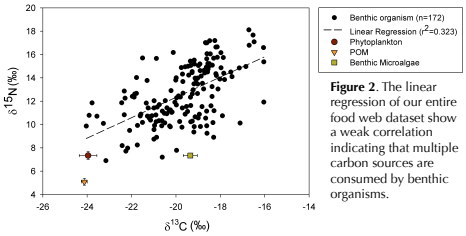

Figure 2. The linear regression of our entire food web dataset show a weak correlation indicating that multiple carbon sources are consumed by benthic organisms.

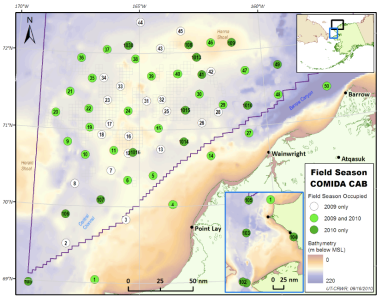

Figure 1. Map of COMIDA stations in 2009 and 2010.

Main Questions:

What major carbon sources are assimilated by the benthic fauna of the Chukchi Sea shelf community?

Can we identify trophic guilds based on stable isotopic analyses?

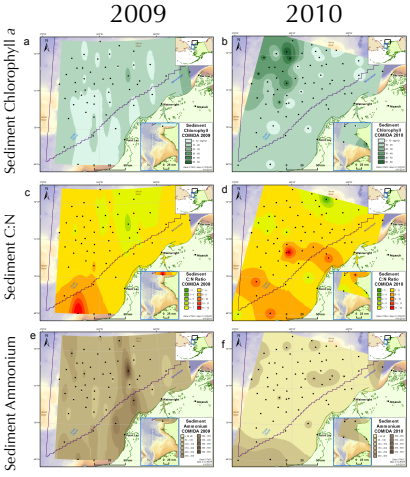

Figure 3. Chlorophyll *a* concentrations in surface sediments (**a,b**) describe the standing stock of photosynthetic cells at the time of sampling. Considerable variation exists both spatially and temporally. C:N ratios of sediments (**c,d**) describe the organic matter in the sediments and is related to ungrazed primary production. The sediment porewater ammonium concentrations (**e,f**) are also variable through space and time. Ammonium is a by-product of aerobic decomposition within the sediments and may fuel production of benthic microalgae.

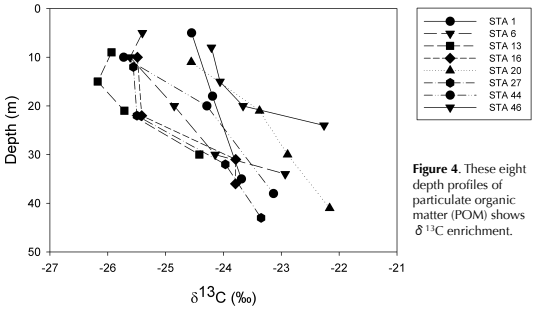

Figure 4. These eight depth profiles of particulate organic matter (POM) shows $\delta^{13}C$ enrichment.

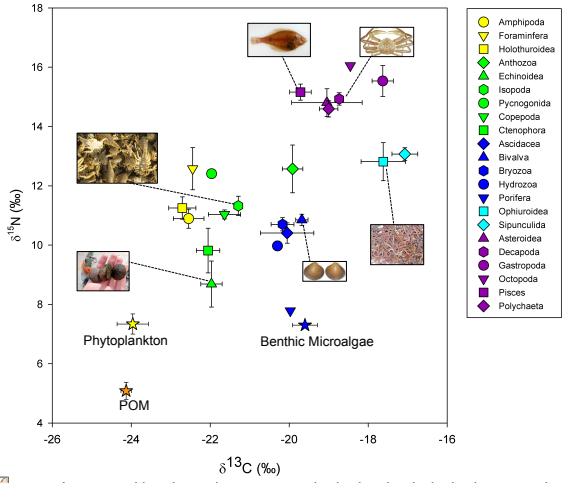

Figure 5. A stable carbon and nitrogen isotope bi-plot describes the food web structure of the Chukchi Sea. Data points (mean±SE) are taxonomic group sorted by similar trophic position and assimilation of carbon sources. The yellow star is the phytoplankton end-member, the orange star is the POM end-member, and the blue star is the benthic microalgae end-member. See Results and Discussion for description of color scheme.

Conclusions and Future Work

The Chukchi Sea benthic food web clearly assimilates multiple carbon sources. In some cases, organisms preferentially feed on one carbon source, while others are indiscriminate feeders. A more enriched carbon source is mixing with surface POM at near-bottom depths and is available for consumption by lower trophic level organisms. Porewater nutrients (Figure 3e,f) may provide a readily available nitrogen source for benthic primary producers that are ubiquitous throughout the Chukchi Sea shelf in various concentrations. Enriched $\delta^{13}C$ values of lower trophic level organisms compared to phytoplankton also indicate that a ^{13}C-enriched carbon source is available to Chukchi Sea consumers. Further sampling will help delineate the range of $\delta^{13}C$ and $\delta^{15}N$ values for benthic microalgae across the temporal and spatial scales of the Chukchi Sea.

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