Temporal patterns in benthic food web structure in the southern Chukchi Sea

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Introduction

The Chukchi Sea shelf supports high benthic biomass due to strong pelagic-benthic coupling of highly productive surface waters with the seafloor. Key water masses differ in their associated nutrient and productivity regimes and can influence spatial patterns of benthic food webs in the southern Chukchi Sea (1). Long-lived Arctic benthic consumers integrate short-term variability, and therefore, reflect persistent oceanographic conditions. It is currently unknown how stable these differences are manifested in food web structure on decadal time scales. Climate warming may affect these water masses and the degree of benthic-pelagic coupling, with possible effects on benthic food web structure. Under the auspices of the Russian-American Long-term Census of the Arctic (RUSALCA), the present ongoing study investigates benthic food web structure on the Chukchi Shelf over three sampling years: 2004, 2009, and 2012.

Questions

Do particulate organic matter food sources differ consistently among water masses over time?

Are patterns in benthic food web structure under different water masses consistent over time?

Methods

- Pelagic particulate organic matter (POM) and benthic invertebrate and fish tissue samples (typically n=3 each) were collected from the same eight stations in the southern Chukchi Sea during RUSALCA cruises in 2004, 2009, and 2012 (Figure 1).
- Lipids were chemically removed from samples in 2009 and 2012 samples, and 2004 stable isotope values were arithmetically corrected for lipid content.
- Carbonate was removed with 1N HCl.
- Stable carbon and nitrogen isotope ratios of these samples were measured at the Alaska Stable Isotope Facility.
- Trophic level of a taxon averaged per water mass was calculated as: TL = ($\delta^{15}N_{consumer}$ – $\delta^{15}N_{PPOM}$)/3.4 + 1 (3.4 used as average fractionation factor per TL (2))

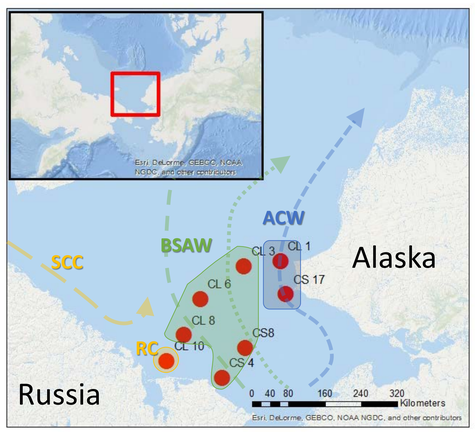

Figure 1. *Study area with stations grouped by water masses. From west to east: The Russian Coast (RC, gold) is intermittently influenced by the Siberian Coastal Current (SCC). The central Chukchi shelf region is under the influence of the Bering Shelf Anadyr Water (BSAW, green). Stations along the Alaska coast are influenced by the Alaska Coastal Water (ACW, blue).*

Results

POM $\delta^{13}C$ values were slightly higher in BSAW than in other two water masses, although these differences were not statistically significant because of high variability. In 2009, the coastal areas were highly variable, while in 2004 and 2012 the BSAW was highly variable. The generally lower (more negative) $\delta^{13}C$ values in RC and ACW may be indicative of a greater proportion of terrestrial production mixed into the POM food source compared with BSAW (more marine production).

Figure 2. *$\delta^{13}C$ values (mean ± SD) for pelagic POM in three water masses and across three sampling years.*

There was a greater and temporally consistent ^{15}N enrichment step between the POM source and benthic consumers in RC and ACW compared with BSAW, except for RC in 2009. This points to a missing trophic link in the benthic food web in RC and ACW.

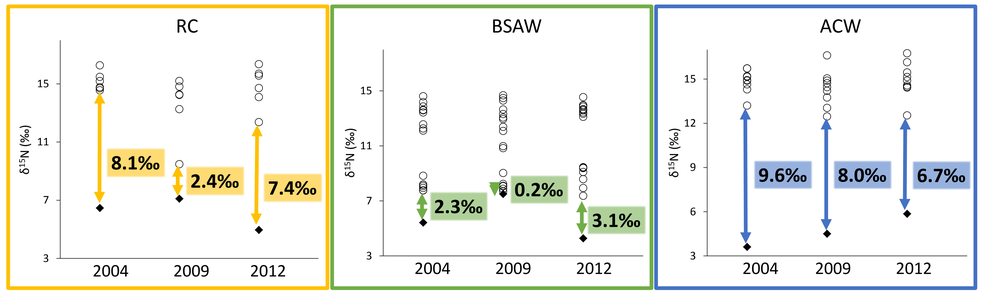

Figure 3. *$\delta^{15}N$ values for POM (black diamonds) and for benthic invertebrates and fishes (circles) across sampling years in the three water masses. Taxa are the same within each water mass across years but differ among water masses.*

Overall trophic level patterns were relatively similar within each water mass and differed consistently among water masses: Consumer taxa in ACW consistently occupied higher TL than those in the other two water masses. Between BSAW and RC, a higher proportion of taxa fed at low TL (2 and 3) at BSAW than at RC.

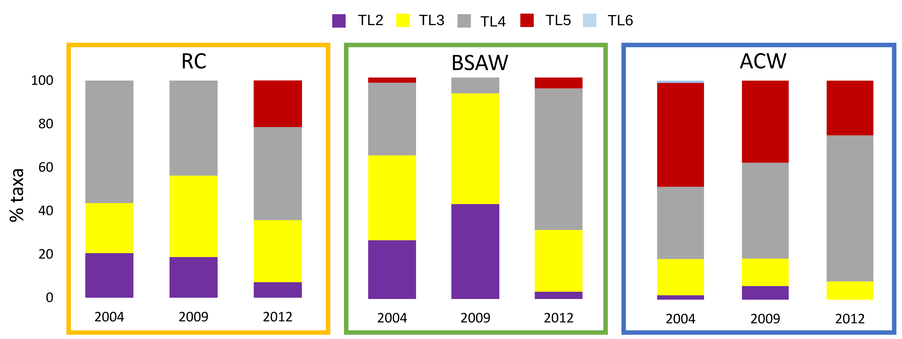

Figure 4. *Food web structure displayed as the proportional distribution of number of taxa across trophic levels (TL) in each water mass across three sampling years.*

Discussion & Conclusion

- The high variability of the POM sources within and among the three water masses likely reflects the high short-term variability in hydrographic properties. In general, however, the slightly lower $\delta^{13}C$ values in the coastal water masses (ACW and RC, Figure 2) may indicate terrestrial matter coming from river inflow.
- Relatively stable food web structure over time suggests that the benthic consumers integrated the high POM variability and reflected the average hydrographic conditions in the area. These benthic food webs should then also be good indicators of potential ecosystem shifts in energy flow on the southern Chukchi shelf, as deriving from long-term climatic changes.
- The differences in ^{15}N enrichment between POM and consumers in the different water masses suggest the missing link may be a microbial step, or consumers not represented in this study. If it is a microbial link, it seems to have a greater influence on coastal water masses with higher terrestrial carbon input. This concurs with higher microbial activity known for the ACW than BSAW, where a smaller portion of the primary production is processed by the microbial loop (3). Climate warming may increase terrestrial matter influx into the southern Chukchi Sea and may also lead to higher microbial activity (4), which may alter benthic food web structure.

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Literature Cited

1. Iken K, Bluhm B, Dunton K (2010) Benthic food-web structure under differing water mass properties in the southern Chukchi Sea. Deep-Sea Res Pt II 57: 71-85
2. Vander Zanden M, Rasmussen JB (2001) Variation in δ15N and δ13C trophic fractionation: implications for aquatic food web studies. Limnol Oceanogr 46(8): 2061-2066
3. Steward GF, Smith DC, Azam F (1999) Abundance and production of bacteria and viruses in the Bering and Chukchi Seas. Mar Ecol Prog Ser 131:287-300
4. Kirchman DL, Morán XAG, Ducklow H (2009) Microbial growth in the polar oceans—role of temperature and potential impact of climate change. Nature Rev Microbiol 7(6): 451-459