Chukchi Sea epibenthic community composition and food web structure

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Objectives

We investigated the epibenthic community and food web structure in the Chukchi Sea during the Russian-American Long-Term Census of the Arctic (RUSALCA) cruise on board the Russian vessel "Professor Khromov", Aug 8-25, 2004. The goals were twofold: (1) to create present-day baseline data of the **epibenthic megafauna** community composition, abundance and biomass, and (2) to provide stable isotope-based **food web structure** information. The underlying hypothesis for both objectives was that community and food web structure are temporally integrating reflectors of oceanographic conditions in different water masses of the study area and can, therefore, serve as observing systems for potential future change in bottom-up processes due to changing climate conditions.

Background

Epibenthic megafauna comprises the larger seafloor animals living on top rather than within the sediment. This fauna is usually caught in trawls and/or recorded on underwater-imagery. Within the framework of RUSALCA, we consider it critical to study the epibenthic megafauna for five main reasons: (i) Many Arctic epibenthic species are long-lived (years to decades) and are, therefore, indicators of oceanographic conditions integrating over seasonal and other short-term 'noise'; (ii) epibenthic megafauna includes species of potential commercial and subsistence use (e.g., crabs, urchins, fishes), hence the study region may become of interest for commercial exploitation if ice-cover and thickness continue to decrease due to climate change; (iii) to complete the RUSALCA census of marine life to assist in the international effort to establish what lives in our oceans now as a baseline for future comparisons; (iv) benthic filter-feeding and deposit-feeding organisms are important in linking water column to benthic production, creating an imprint of the transient oceanographic conditions; and (v) this larger size-class of the benthos accounts for a quarter or more of benthic community remineralization (release of nutrients from degrading organic matter into the water column) on Eurasian Arctic shelves (e.g., Piepenburg 2000, Ambrose et al. 2001). Compared to infaunal collections (see Grebmeier et al. and Sirenko & Gagaev summaries), published studies of epibenthic megafauna in the Chukchi Sea are significantly less comprehensive in time and space. They include a set of ROV stations in the northeastern Chukchi Sea (Ambrose et al. 2001), a trawl-based assessment in Kotzebue Sound and the southern US Chukchi (Feder et al. 2005; collections in 1976 and 1998), and an unpublished (and apparently partially unprocessed) set of trawls taken during the 1993 BERPAC cruise.

Food web structure gives information about the pathways of carbon and energy flow in a system, specifically how tightly different realms (e.g., pelagic-benthic coupling) are connected. Generally, the RUSALCA study area has been found to house areas of extremely tight benthic-pelagic coupling resulting in high benthic biomass and large stocks of benthic-feeding mammals and birds (Grebmeier and Barry 1991). Stable isotopes show a stepwise enrichment between prey and consumer during assimilation processes, thus allowing identification of relative trophic positions among members of a food web. Stable isotope-based food web studies in the western Arctic, which can be compared with and complement our RUSALCA investigations, are ongoing in the eastern part of the Chukchi Sea (Dunton et al., unpublished), in the adjacent Canada Basin (Iken et al. 2005, and unpublished) and south of St. Lawrence Island (Lovvorn et al. 2005).

Results

Epibenthic community structure

To assess epibenthic community structure, we studied trawl hauls from 17 stations, two from Bering Strait, nine from southern Chukchi Sea and six from the Herald Canyon area. Catches from beam trawl hauls and, when those were unavailable, from benthic dredge or Otter trawl were sorted by species or highest taxonomic level identifiable in the field. Organisms were counted and wet weight was determined by species or taxon group. Voucher specimens were preserved in formaldehyde solution and later transferred to isopropanol. Taxonomic identifications were kindly assisted by Sirenko and Gagaev (ZIN, RAS), Coyle and Foster (UAF), and Mah and Fautin (SI). On occasion, when a single species dominated the epibenthic community, we analyzed size frequency distribution of the species. Trawl haul biomass and abundances were normalized to catch per unit effort (1000 m^{-2} trawled area).

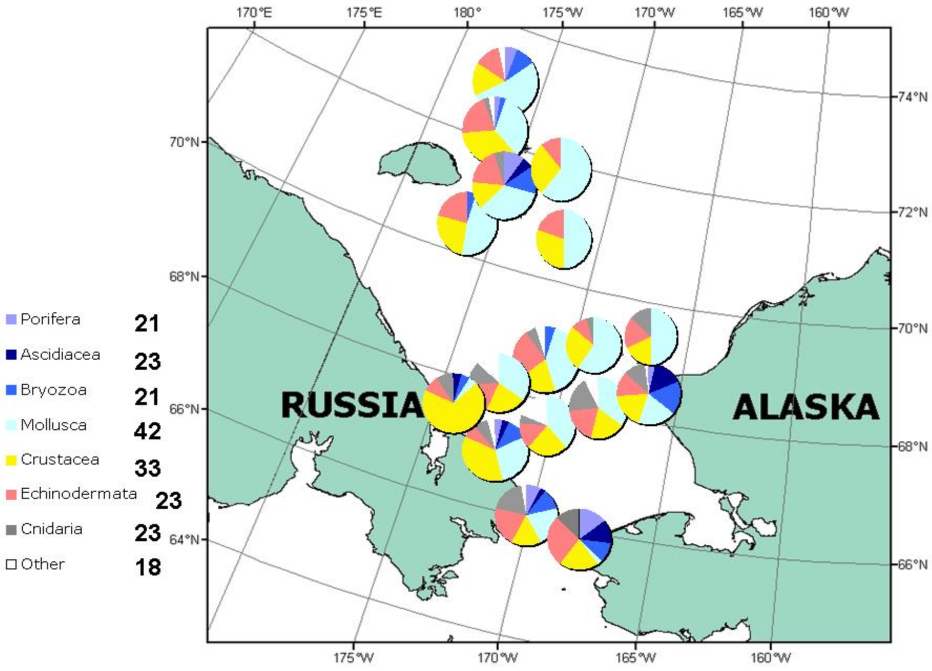

Figure 1: Epibenthic community composition at RUSALCA 2004 stations. The number behind the taxonomic group names indicate species richness.

Epibenthic species richness varied considerable between stations with 18 to 53 species per station. Mollusks and crustaceans were major contributors to overall species richness of the region with 42 and 33 species, respectively, followed by echinoderms, cnidarians and ascidians (23 species each), bryozoans (21 species) and sponges (18 species) (Figure 1). Total species richness for the RUSALCA area was around 180 species (preliminary number until all species identifications confirmed by taxonomic specialists). Locations with hard substrate housed more epifaunal species than soft bottom stations. Boris Sirenko identified four epifaunal species as being recent northern range extensions (see summary by Sirenko and Gagaev), which he attributes to climate warming. Gross abundance and biomass estimates ranged from 800-40,000 individuals 1000 m^{-2} and 1.6-69 kg wet weight 1000 m^{-2}, respectively (1). Interestingly, biomass was highest on the Alaska Coastal Current side and at some of the Herald Canyon stations. This trend is opposite to patterns observed for infauna (see summaries by Sirenko & Gagaev and by Grebmeier & Cooper). At several stations, biomass and abundance were dominated by a single or few species, mainly echinoderms, namely the brittle star *Ophiura sarsi*, the sea urchin *Strongylocentrotus* sp., the sea star *Ctenodiscus crispatus* and the sea cucumber *Myriotrochus rinkii*. The dominance of echinoderms was also recorded in previous studies in the northeastern Chukchi (Ambrose et al. 2001), Kotzebue Sound (Feder et al. 2005), Norton Sound (Hamazaki et al. 2005) and on Eurasian Arctic shelves (Bluhm et al. 1998, Piepenburg 2000). *Chionoecetes opilio*, a commercially harvested species in the Bering Sea, occurred in considerable numbers at several stations, but all specimens were sub-legal size. It is yet unclear if all individuals were young crabs or if environmental conditions restrain growth in this species in its northern range. Multi-dimensional scaling techniques, based on species relative abundances and biomass, were applied to depict similarities between the sampled stations. Stations grouped primarily by substrate type (hard versus soft bottom) (Figure 2). Hard bottom occurred in Bering Strait, along the Siberian and Alaskan coast and in the center of Herald Valley; typical hard bottom fauna included bryozoans, ascidians and sponges. Characteristics of the main water masses appeared to have less influence on epibenthic community composition

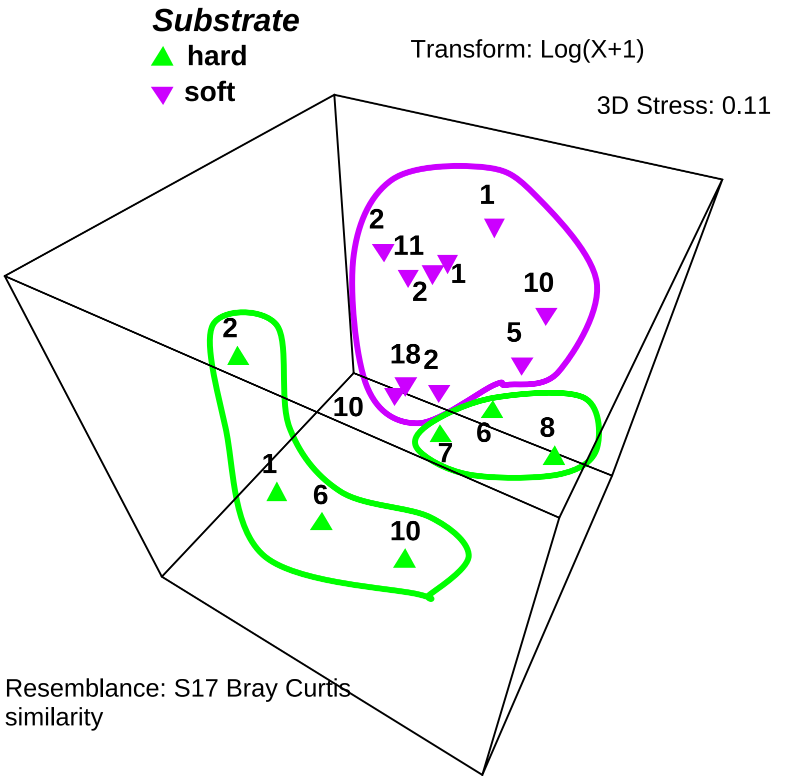

Figure 2: Similarity of RUSALCA 2004 epibenthic megafauna stations depicted in a multi-dimensional scaling plot based on complete species-stations matrix.

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(1) Note that trawl assessments of abundance and biomass are estimated based on trawl time and trawled area, which cannot always be determined accurately. As such these estimates have a certain degree of inaccuracy and resulting values are termed ‘gross’ abundance and biomass.

although a more thorough analysis with a complete oceanographic dataset has yet to be performed. Based on the presence of some Arctic species, the Herald Canyon stations mostly grouped together, although they were relatively similar to the southern Chukchi Sea soft bottom stations in multi-dimensional space. As a preliminary conclusion, we suggest that major changes in current regime, and therefore sea floor substrate structure, should be reflected in epifaunal composition, especially in the ratio of filter-feeding versus deposit-feeding taxa.

Food web structure

Epibenthic trawl, Van Veen grab, and CTD rosette water samples from 14 stations were processed for stable carbon and nitrogen isotope analysis to elucidate food web structure. Plankton samples were available only sporadically. A total of 62 water samples, 40 surface sediment samples, 143 plankton samples and 2165 tissue samples of infaunal and epibenthic organisms were collected. Specimens were dissected to remove gut contents where possible and to isolate muscle or body wall tissues (long-lived tissue). For small species, several complete individuals were pooled to obtain sufficient mass. Samples were dried at 60 degrees ºC, acid-fumed or soaked in HCL to remove inorganic carbonates and ground sub-samples were measured using continuous-flow isotope ratio mass spectrometry (IRMS) at the Alaska Stable Isotope Facility (Iken et al. 2001, 2005).

Particulate organic matter (POM) was considered the major base of the food web and showed isotopically distinct trends in the southern Chukchi Sea region. POM from western stations under nutrient rich Anadyr Water (AW) influence were enriched in $\delta^{13}C$ (average -21‰) compared to stations on the eastern side under nutrient poor Alaska Coastal Current (ACC) influence (average -24‰). Station 27 on the Siberian coast was clearly under freshwater influence

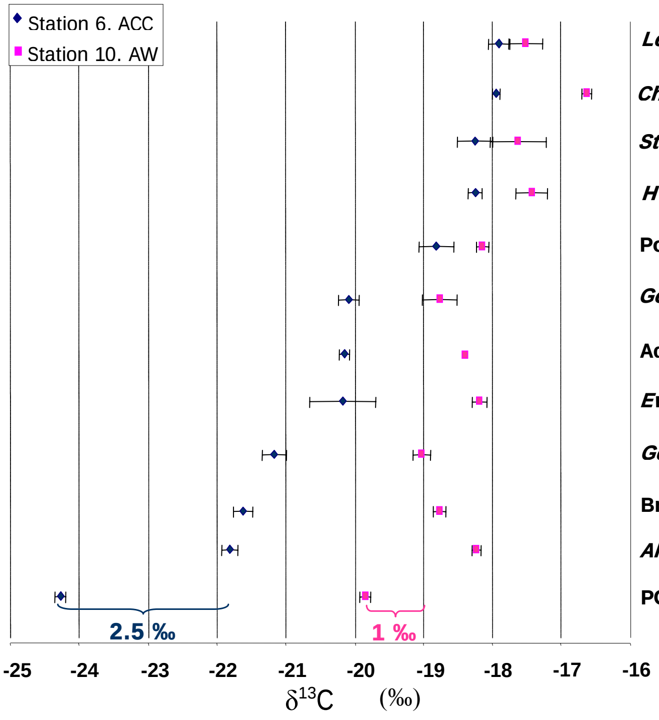

Figure 3: Benthic food web structure ($\delta^{13}C$) at stations six and ten as described by stable isotope signatures

(coastal river drainage) as reflected in the depleted $\delta^{13}C$ signature (average -24.5‰). POM values for the Harald Canyon area are not available because of IRMS instrument failure during these measurements. Coupling between POM and benthic consumers was tighter at stations under AW conditions than at ACC locations as indicated by the short isotopic distance between POM and consumers (Figure 3). Benthic fauna in the western Chukchi Sea AW conditions was tightly linked to pelagic primary production while benthic organisms in ACC locations were separated from the POM food source by 1-2 trophic levels (TL). This resulted in comparatively longer overall food webs at ACC locations (3-4 TL for the fauna sampled) than at AW locations (2-3 TL). This difference seems to indicate that benthic organisms under AW influence receive fresher, less reworked food while those under ACC influence receive more refractory material. We suggest that more extensive reworking and recycling of POM in the pelagic food web may be responsible for this difference which results in the same species feeding on a higher trophic level in ACC relative to AW conditions (Figure 4). Food web structures in Herald Canyon were not noticeably different between inside and outside the canyon and food web length seemed to be more similar to the trophic structures found in the southeastern Chukchi Sea (ACC conditions). Our results suggest that stable isotope composition of POM and benthic fauna at different locations mirror local water mass characteristics, and therefore are useful indicators of ecosystem functioning. A change in water mass characteristics (e.g., productivity) would likely be reflected in food web structure of the benthic community.

Conclusions and recommendations for future study

Based on our results, epifauna community structure can serve as an indicator for substrate distribution in combination with current patterns while stable isotopic signatures are indicative of the different water mass characteristics of the Bering/Chukchi Seas. We conclude that the combination of a basic community census combined with the process-oriented biogeochemical food-web analysis may be an ideal combination to identify potential changes in the western Arctic.

We recommend repeating the sampling scheme presented here on a regular basis every 3-

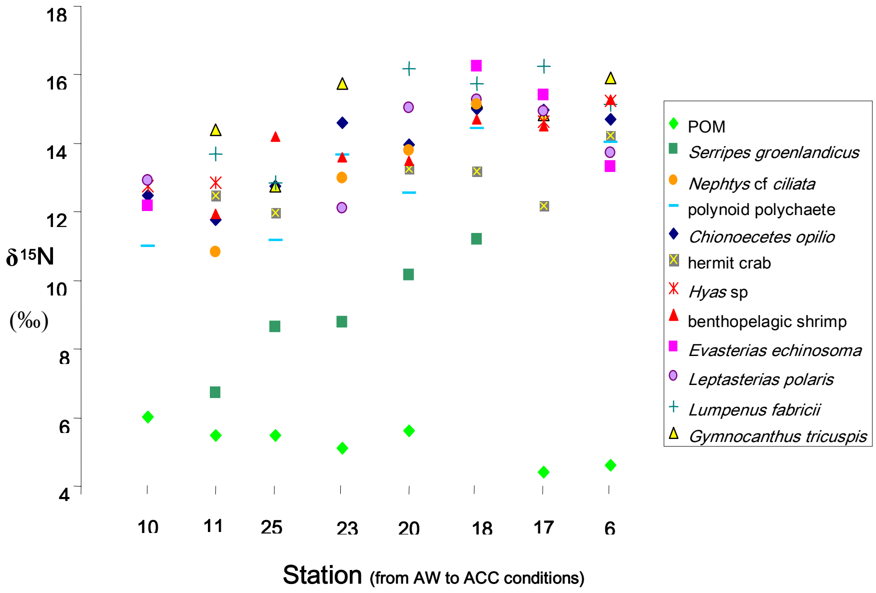

Figure 4: Increase in trophic level (indicated through $\delta^{15}N$ signatures) of benthic species along a gradient from nutrient rich AW to nutrient poor ACC during RUSALCA 2004 expedition.

4 years. For improvements, we suggest including a few stations located in the East Siberian Coastal Current regime since climate change may strengthen or weaken this intermittent current system. If time allows, increased coverage towards the shelf break would be desirable to delineate the present gradient from Pacific and boreal to Arctic species and to follow the carbon transport towards the basin. We also suggest including systematically a set of pelagic species into the food web analysis and focus benthic food-web sampling to a number of representative indicator species. This would allow more detailed tracing of pelagic-benthic coupling.

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