Ecologic and Biogeographic Insights from Ostracoda Distributions in the Chukchi Sea from 2009 through 2017

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Abstract

Chukchi Sea benthic ostracode assemblages collected during a research cruise aboard the USCGC Healy in 2017 are compared to collections from past years, primarily 2009 and 2010, with a goal of understanding recent species changes related to temperature, total organic carbon (TOC) and sediment grain size. The study area includes the continental shelf region influenced by the Alaska Coastal Current and the northward extension of the Bering Sea Shelf waters that flow through Bering Strait. Significant temporal (decadal, interannual) and spatial variability in the proportions of dominant species in the assemblage were observed, including an increase in subarctic species, particularly, *Normanicythere leioderma,* which is typically dominant in the Bering Sea, but which showed a notable range expansion in 2017 into the Chukchi Sea (20% of the 2017 Chukchi Sea assemblage). Secondary subarctic species with increasing abundance include *Schizocythere ikeyai* (8%) and *Munseyella kiklukhensis* (7%). A corresponding decline in dominance of *Paracyprideis pseudopunctillata* (4%), a common Arctic species in Chukchi, Beaufort and Laptev Sea assemblages, is another significant change. Continued monitoring of temperature-sensitive ostracode species in the Bering and Chukchi Seas is planned to provide additional information on annual and decadal variability in species dominance.

Introduction

The Arctic Ocean is currently undergoing broad climate-related transformations that are affecting biological systems. Changes in sea-ice cover, hydrography and circulation significantly influence biological productivity and benthic marine species abundance, composition and distribution. Due to limited yearly and seasonal sampling of chemical, physical and biological parameters, and studies of how those variables interact with each other, our understanding of the ecological impacts of climate change is limited. Sampling of Distributed Biological Observatory (DBO) latitudinal transect lines in the Pacific-Arctic, including the Bering and Chukchi Seas, is documenting the biogeographic boundaries of Pacific versus Arctic species with an overarching goal of a more holistic understanding of the Pan-Arctic ecosystem (Grebmeier et al. 2010). This study examines a component of that ecosystem: the meiobenthic community of ostracodes and the primary factors that influence their ecology and biogeography in response to a changing Bering and Chukchi Sea marine environments.

Materials and Methods

Sediment samples were collected aboard the USCGC Healy during a 2017 DBO cruise to the Bering and Chukchi Seas. The top few centimeters of Van Veen grabs or multicores were analyzed and ostracodes were picked from the washed >125 µm sediment size fraction. Most samples contained carapaces with preserved appendages, which means specimens were alive at or near the time of collection. Using the phi scale to calculate grain size, the percent of coarse or sand sediment fraction for each sample was determined by combining the proportions of sediments with phi values of 0 (very coarse sand) to 4 (very fine sand). Silt or mud samples were considered to be those with ≥5 phi values.

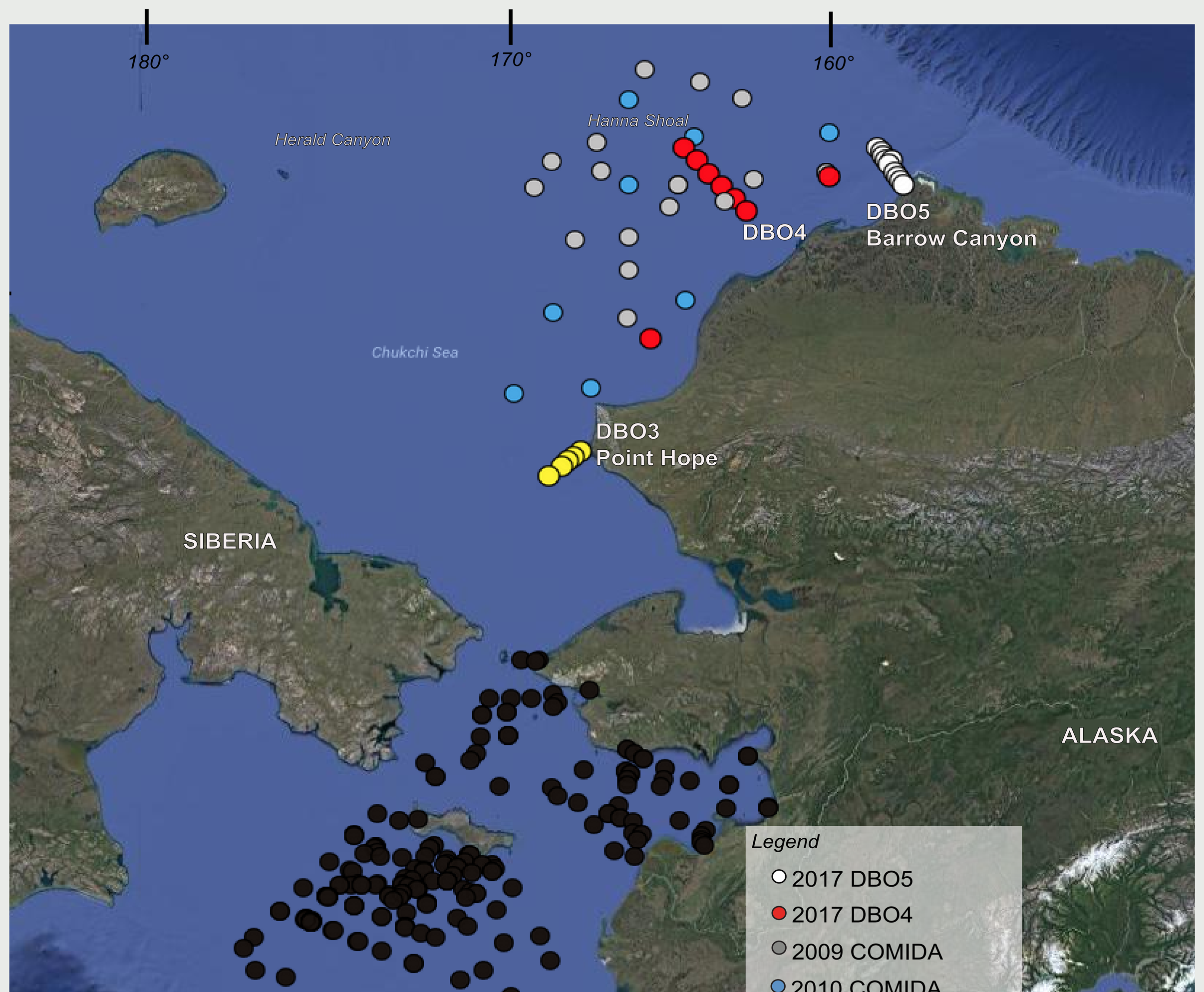

Figure 1.
Location of sampling stations along DBO lines 3, 4 and 5 collected during U.S. Coast Guard Cutter Healy 2017, leg 2, (HLY1702) cruise and other samples collected in previous years in the Chukchi Sea near Hanna Shoal, color coded by year and in the Bering Sea near St. Lawrence Island, color coded by year group.

Acknowledgements

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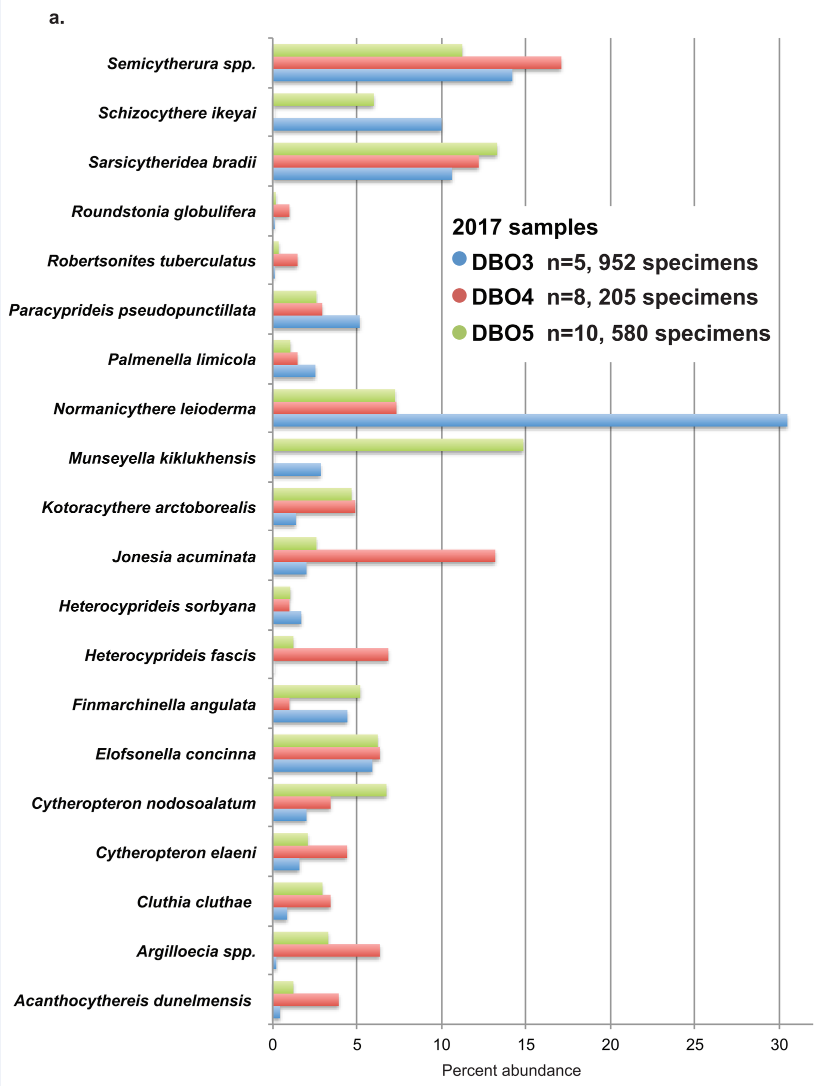


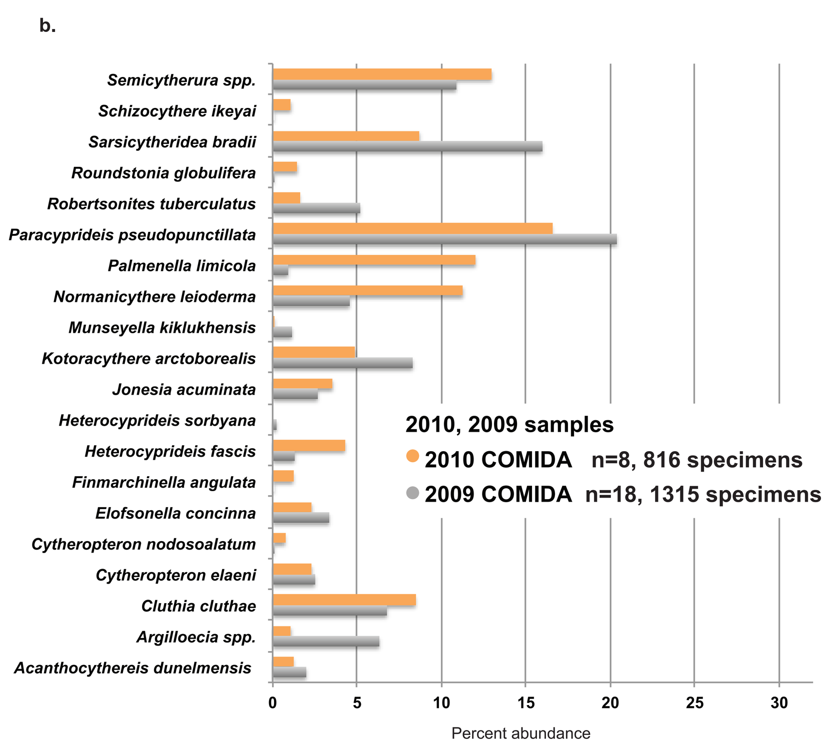


Figure 2. Bar charts of the dominant species in 2017 along DBO transects 3, 4, and 5 (2a) and in 2009 and 2010 (2b). *N. leioderma* is the most abundant species in 2017 Chukchi Sea samples whereas in 2009 and 2010, *P. pseudopunctillata* dominated the Chukchi Sea (Hanna Shoal region).

Results and Discussion

Chukchi Sea Ostracode Biofacies

- A total of 38 species were identified from 23 surface samples collected during the 2017 DBO expedition to the Bering and Chukchi Seas (Fig. 1). These ostracode species (1737 specimens) represent a diverse mixture of species typical of Arctic and sub-Arctic continental shelves including the Beaufort Sea, Siberian Seas and Bering Sea.
- The dominant taxa in 2017 Chukchi Sea samples (Figs. 2a) are *Normanicythere leioderma* (20%), *Semicytherura* spp., (13%) and *Sarsicytheridea bradii* (12%), with secondary species *Schizocythere ikeyai* (8%) and *Munseyella kiklukhensis* (7%).
- Samples in 2010 and 2009 (Figs. 2b) show different dominant species, *Paracyprideis pseudopunctillata* (17%, 20% respectively), *Semicytherura* spp. (13%, 11%), *S. bradii* (9%, 16%), with secondary species *Palmenella limacola* (12%, 2%), *N. leioderma* (11%, 5%), *Kotoracythere arctoborealis* (5%, 8%), and *Cluthia cluthae* (8%, 7%).
- 2017 sampling shows that *P. pseudopunctillata* is no longer dominant, comprising only 4% of the DBO 3, 4, 5 assemblages compared to 17%, 20%, respectively, for the 2010 and 2009 sampling.
- Compared to 2017 samples, *M. kiklukhensis* was very rare in both 2010 and 2009 assemblages (0.12%, 1%), as was *S. ikeyai* (1%, 0%). Both are subarctic species. Using the Arctic Ostracode Database (AOD) of 1300 modern surface samples throughout the Arctic and subarctic to assess water depth and distribution, *M. kiklukhensis* is most commonly found in estuarine inlets, with highest abundances in Hudson Bay, North Star Bay (Greenland), Norton Sound and Chaunskaya Gulf (Eastern Siberian Sea) in bottom water temperatures varying from -0.5 to 6.6 °C and salinities varying from 25.6 to 33. *S. ikeyai* is uncommon in the Arctic Ocean, as it has been recorded on the Chukchi Sea shelf in only 20 samples with abundances of 5 or more specimens, in bottom water temperatures (BWT) typically >2 °C to 8.5 °C and salinity ranging between 31 to 33.3. The higher frequencies of both species in 2017 may also be related to proximity of DBO sampling lines 3 and 5 to coastal regions compared to DBO line 4 samples, which were located farther offshore.

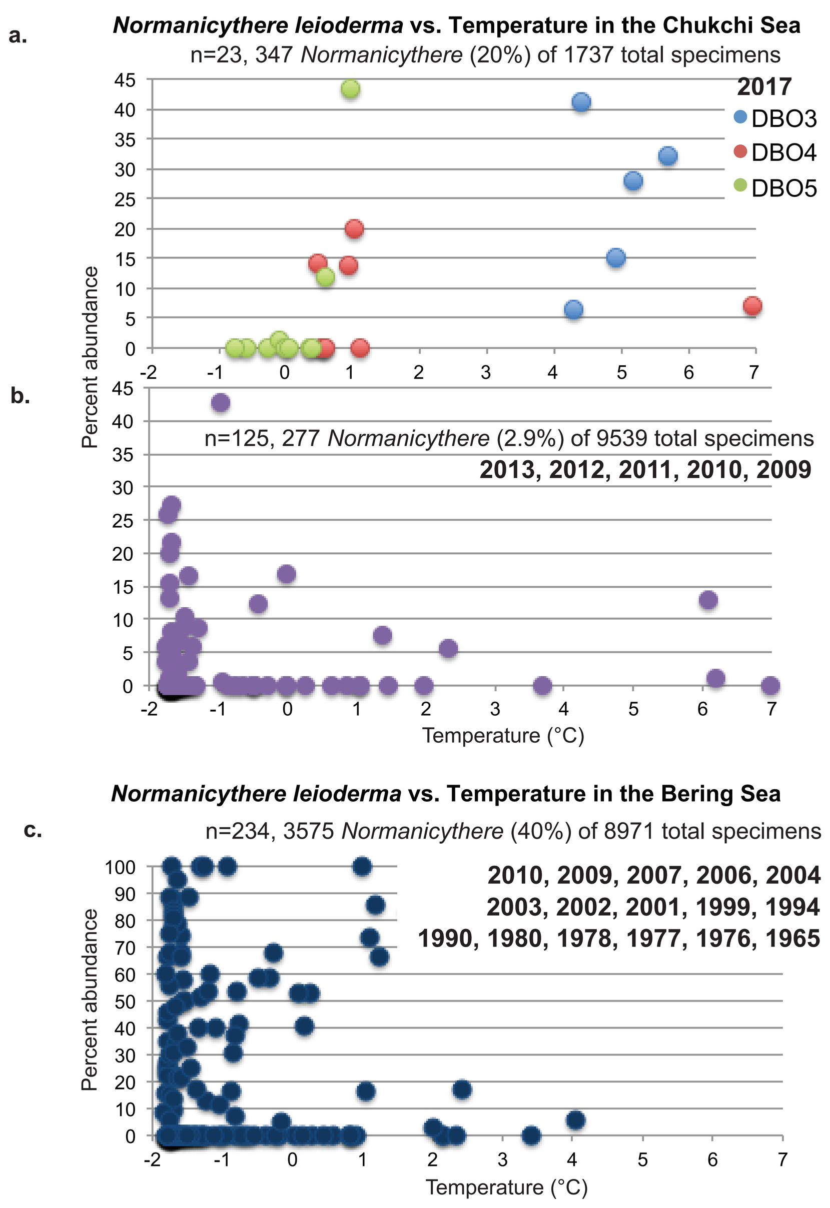


Figure 3. *N. leioderma* abundance vs. temperature in Chukchi Sea (a,b) and in Bering Sea (c) samples.

- *N. leioderma* is present in larger proportions in 2017 Chukchi Sea samples (20%) than in 2013-2009 samples (2.9%; Fig. 3a,b). This may be an example of a subarctic species migrating to a more favorable habitat in the Chukchi, perhaps reflecting higher BWTs. Advective northward-flowing currents from the Bering can allow migration of species into the Chukchi Sea (Carmack & Wassmann 2006, Grebmeier et al. 2006).
- *N. leioderma* is the dominant species in Bering Sea samples (40% of assemblage based on 234 samples collected during a range of years; Gemery et al., 2013; Fig. 3c), and is a cold-water species, living in subarctic to Arctic regions with bottom water temperatures of -1.7°C to 7°C.

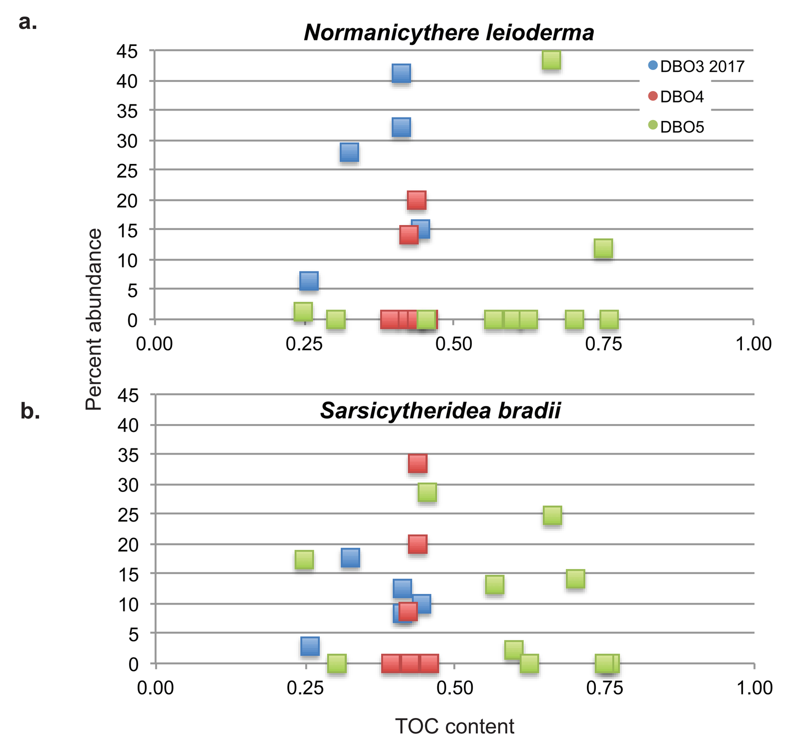
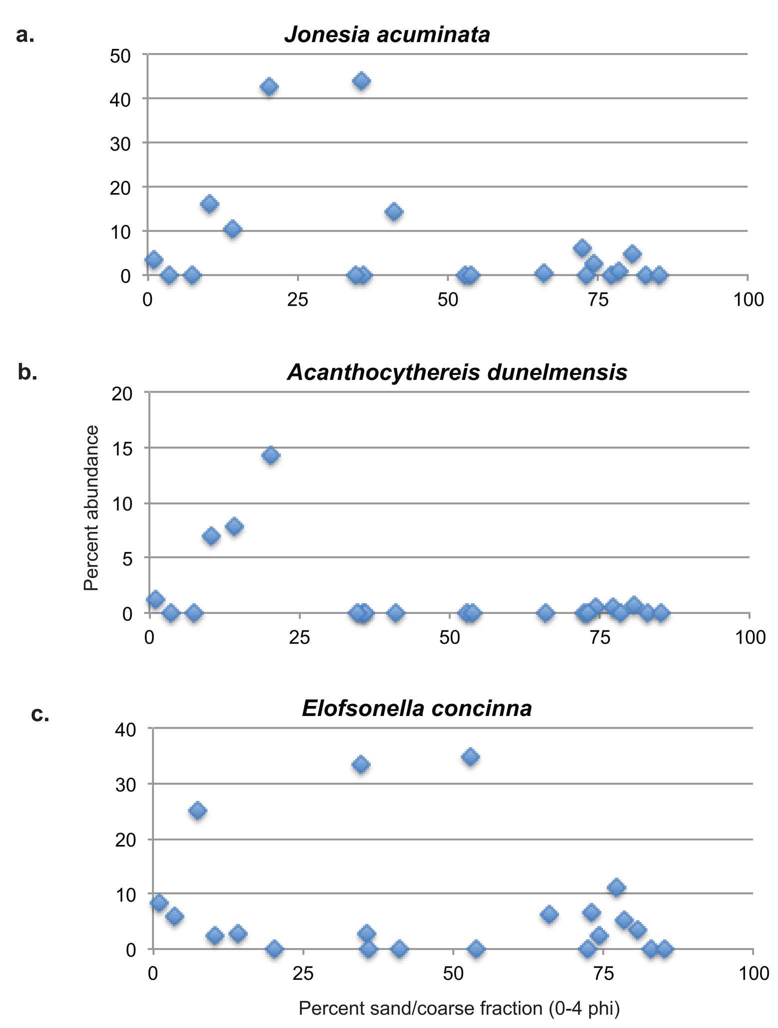


Figure 4. Selected plots of species abundance (*N. leioderma* [a] and *S. bradii* [b]) vs. total organic carbon (TOC).

- Settling phytoplankton and algae may be a food source for foraging ostracodes, and food availability is a top-level factor that drives species survival and reproduction.
Because the total organic carbon (TOC) content of sediments is associated with the amount of detritus in the surface sediments (potential food source), we compared all dominant ostracode species abundance to TOC, but found no relationship for the 2017-DBO dataset. Figure 4 shows two examples, *N. leioderma* and *S. bradii.*

Figure 5. Comparison of species abundance (*Jonesia acuminata* [a] and *Acanthocythereis dunelmensis* [b] and *Elofsonella concinna* [c]) and seafloor sediment composition, i.e. percent of sand or coarse sediment showing that sea floor sediment grain size influences the assemblage of benthic ostracodes. (Grain size consists of mud [≥5 phi fraction], sand [combined 1–4 phi fraction], and gravel [<0 phi]).



- Another environmental factor that can potentially affect ostracode species composition is the seafloor sediment type. Most Arctic ostracodes species live in a range of sandy to muddy sediments, however a few species, *Jonesia acuminata* and *Acanthocythereis dunelmensis*, show a preference for mud or silt (≥5 phi; Fig 5a, b). The carapace of *J. acuminata* is slender and smooth, a shape that facilitates burrowing into soft sediments. The carapace of *A. dunelmensis* is heavily calcified and ornamented, which suggests this species is an epifaunal species that can live on mud or sand. These findings suggest that sediment grain size might influence spatial patterns of certain species (Fig. 5a,b,c).

Conclusions

- **There are no sharp faunal boundaries within the Chukchi Sea study area, however there are year-to year differences in proportions of dominant species.**
- **Several subarctic species were relatively abundant in the Chukchi Sea 2017-DBO samples compared to those from prior years. Continued monitoring should establish whether this pattern continues.**
- **Although we found no relationship between dominant ostracode species abundance and TOC in the 2017-DBO dataset, food availability might be a factor influencing species abundances, and we will test this in future studies.**
- **Sediment grain size influences spatial patterns of certain ostracode species.**