Contribution of sea ice algae to various benthic feeding types on the Chukchi Sea shelf

Tanja Schollmeier (tschollmeier@alaska.edu), Katrin Iken, Matthew J. Wooller, Alexandra C. M. Oliveira
University of Alaska Fairbanks, Fairbanks, Alaska

Introduction

Arctic waters have two main sources of primary production: sea ice algae (iPOM) and phytoplankton (pPOM). The ongoing reduction of seasonal sea ice coverage in the Chukchi Sea due to climate warming could shift the contribution of primary production increasingly or entirely towards pPOM. The loss of iPOM, a high energy food source that occurs early in the year and supports a large benthic community, could have detrimental impacts on benthic organisms. This impact could be different depending on the feeding type of the organisms.

Stable carbon isotopes can be a useful biomarker to trace these two sources of production through marine food webs. Sea ice algae typically are enriched in ^{13}C compared to phytoplankton (Søreide et al. 2006). This isotopic enrichment can also be found in individual biochemical components of the ice algal production, such as fatty acids (Wang et al. 2014). The fatty acids biomarkers of interest here are the 16:1(n-7), 16:4(n-1) and 20:5(n-3). Here we use fatty-acid specific stable isotopes to trace iPOM in various benthic feeding types on the Chukchi Sea.

Question

How does ice algal consumption differ for different benthic feeding types?

Methods

- Benthic invertebrates were collected in the Chukchi Sea in 2012 with van Veen grabs and Plumb Staff Beam Trawls.
- Snow crabs and various clam species were divided into four feeding types (Fig. 1)
- Fatty acids (FA) 16:1(n-7), 16:4(n-1) and 20:5(n-3) were extracted from invertebrate samples in an accelerated solvent extraction (ASE) system
- These FA were converted into fatty acid methyl esters (FAME) and analyzed using gas chromatography and continuous-flow isotope ratio mass spectrometry at the Alaska Stable Isotope Facility
- Stations were arranged by the date at which ice concentration averaged over 7 days was ≤30%, according to Alaska Ocean Observing System (AOOS) sea ice data
  - ➢ Our assumption is that longer ice coverage indicates more ice algal production and therefore greater ice algal contribution to the benthos.

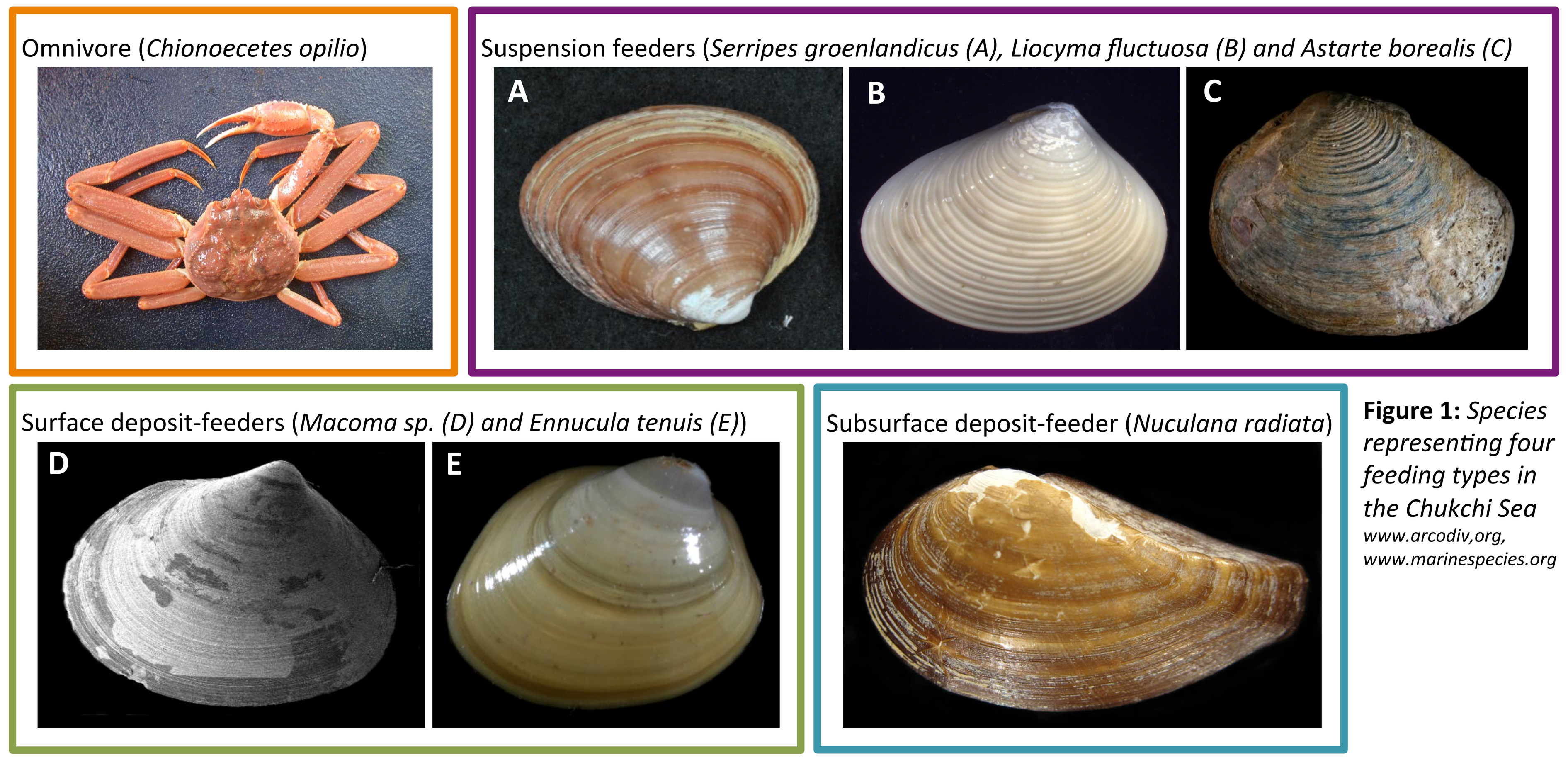

Figure 1: *Species representing four feeding types in the Chukchi Sea*
www.arcodiv,org, www.marinespecies.org

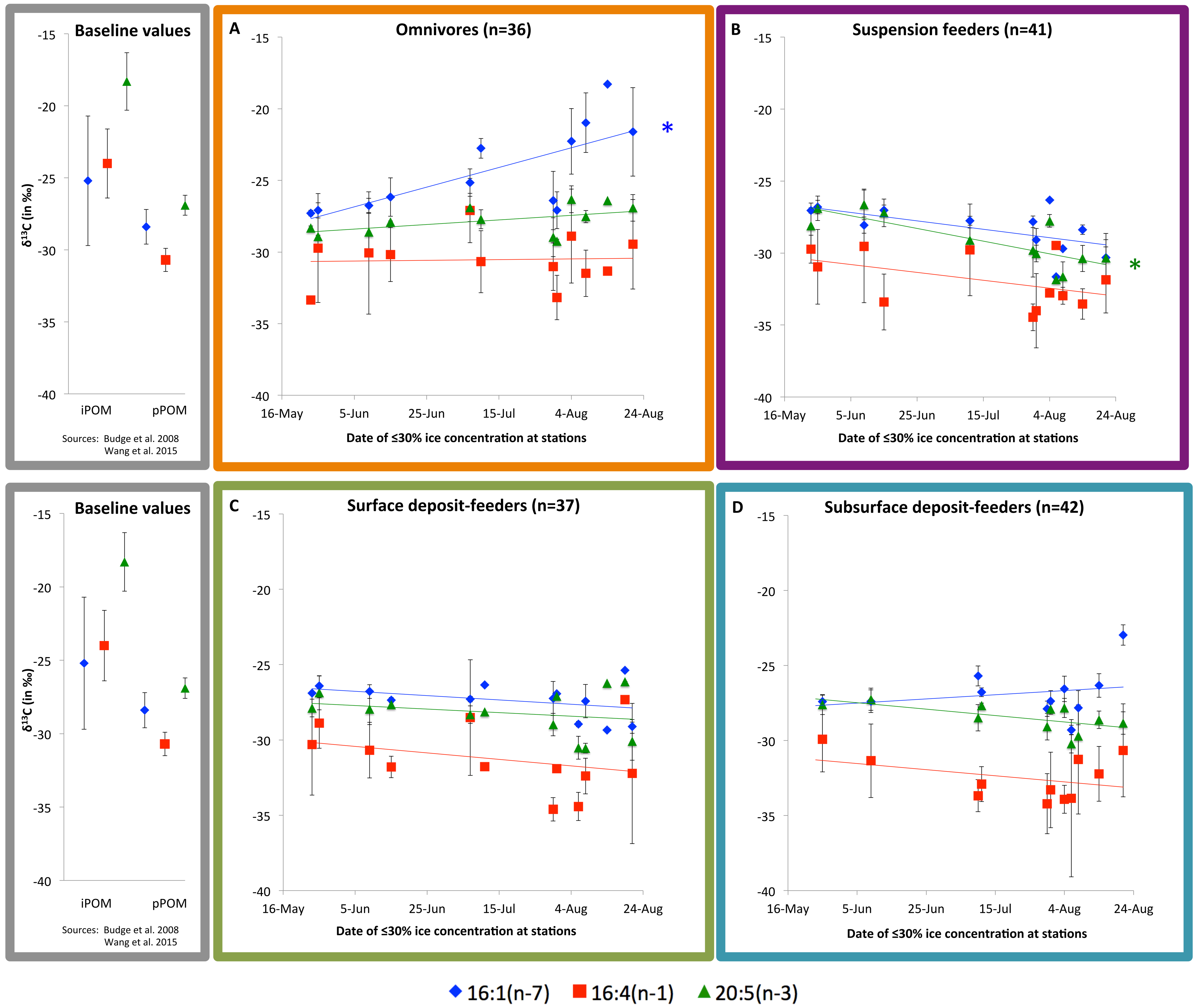

Figure 2: *Literature values of the three fatty acids in iPOM and pPOM (grey panels). Stable carbon isotope values (mean ± SD) of FA 16:1(n-7), 16:4(n-1) and 20:5(n-3) in omnivores (A), suspension feeders (B), surface deposit-feeders (C) and subsurface deposit-feeders (D) at stations with varying length of ice coverage (measured as date of 30% ice cover on x-axis given as day-month in 2012). Statistical significance of the trend line slopes is indicated by *.*

Results

- Large variations in FA $\delta^{13}C$ were found among individuals within all feeding types.
- At locations with shorter ice coverage/ early ice retreat, most feeding types had relatively similar $\delta^{13}C$ values of all three FA, which typically were intermediate between known $\delta^{13}C$ values for FA from iPOM and pPOM (Fig. 2, grey panels).
- We observed a significant increase in $\delta^{13}C$ of 16:1(n-7) in omnivores ($p=0.019$), which overlapped with $\delta^{13}C$ ranges known for this FA deriving from iPOM. The other two FA in omnivores did not have any clear trends to separate between iPOM and pPOM sources.
- In all other feeding types, FA $\delta^{13}C$ values remained within the known ranges for the pPOM source.
- These results indicate that iPOM (Fig. 3) may not be a significant food source for many benthic consumers, except for higher trophic level omnivores. However, literature values of $\delta^{13}C$ in FA should be regarded with caution because of high annual variability.

Figure 3: *Sea ice showing iPOM present on the underside*

Conclusions

1. It is curious that not all FA showed the same trends within a given feeding type and subsequent analyses are needed to determine which FA are the most reliable ice algal biomarkers.
2. The positive link between omnivores and some ice algal FA as opposed to other feeders may come from feeding on intermediary consumers that feed on ice algae, which would not be observed in these other feeding types.
3. Where specific trophic links exist between iPOM and some feeding types, most notably omnivores, it may depend on the ability of prey taxa to opportunistically use other food sources (i.e., pPOM) in changing sea ice conditions to determine if these changes will have an effect on these higher trophic level omnivores.

Acknowledgements

We would like to thank all researchers and crew members of the RUSALCA, COMIDA and Arctic EIS cruises in 2012 for their help with sample collection. The project is funded through North Pacific Research Board project #1227, with additional support for travel and to TA from the UAF graduate school and the Robert Byrd Award.

Literature Cited

Budge SM, Wooller MJ, Springer AM, Iverson SJ, McRoy CP, Divoky GJ. 2008. Tracing carbon flow in an arctic marine food web using fatty acid-stable isotope analysis. Oecologia 157: 117-129

Søreide JE, Hop H, Carroll ML, Falk-Petersen S, Hegseth EN. 2006. Seasonal food web structures and sympagic-pelagic coupling in the European Arctic revealed by stable isotopes and a two-food source food web model. Progress in Oceanography 71: 59-87

Wang SW, Budge SM, Gradinger RR, Iken K, Wooller MJ. 2014. Fatty acid stable isotope characteristics of sea ice and pelagic particulate organic matter in the Bering Sea: tools for estimating sea ice algal contribution to Arctic food web production. Oecologia 174: 699-712

Wang SW, Budge SB, Iken K, Gradinger RR, Springer AM, Wooller MJ. 2015. Importance of sympagic production to Bering Sea zooplankton as revealed from fatty acid-carbon stable isotope analyses. Mar Ecol Prog Ser: 518: 31-50