SPATIAL PATTERNS IN SEDIMENT OXYGEN DEMAND ON THE EASTERN BEAUFORT SHELF: EFFECTS OF PELAGIC PROCESSES AND BENTHIC COMMUNITY STRUCTURE

Paul E Renaud[1,2], Nathalie Morata[1], and Jackie Bowie[3]

1 Department of Marine Sciences; University of Connecticut; Groton, CT USA
2 Akvaplan-niva; Polar Environmental Center; N-9296 Tromsø Norway
3 Biology Department; Bates College; Lewiston, ME USA

ABSTRACT

Arctic shelves have been generally shown to exhibit tight linkages between water-column processes and benthic community structure and function. The eastern Beaufort shelf has not been studied in this respect, and physical and biological gradients produced by the Cape Bathurst Polynya, the Mackenzie River, and a seasonally ice-covered shelf offer an unique opportunity to determine which processes are most important in determining the strength of pelagic-benthic coupling. We measured sediment physical and chemical parameters, along with oxygen demand by macrofauna, meio-/micro- fauna, and epibenthic megafauna, across these gradients, and discuss how spatial patterns in oxygen demand may be related to physical drivers. This understanding is critical as ongoing climate change is likely to alter river flow, ice cover, and productivity regimes on Arctic shelves, and, in this way, influence carbon cycling pathways mediated by the benthos.

INTRODUCTION

Benthic pelagic coupling on Arctic shelves can be particularly tight. A higher percentage of biological production reaches the sea floor and is cycled by the benthos in the Arctic than at lower latitudes. In areas where benthic production is not sufficient, benthic community structure and function is tightly linked to production in overlying pelagic zone and vertical flux. Moreover ice algae may be a significant carbon source for these benthic systems.

The response from benthic communities to deposition of phytodetritus can be very rapid. Part of the organic matter input is stored in the biomass, another part is respired, and another is buried. A high percentage of fixed carbon is buried in Arctic shelf sediments.

RESEARCH QUESTIONS

- How does sediment oxygen demand (SOD) on the Beaufort shelf compare with rates in more productive Arctic areas?
- What are the impacts of spatial heterogeneity (biological and physical gradients) on SOD?
- What determines abundance and biomass of epibenthic fauna?
- How is benthic community oxygen demand partitioned on the Beaufort shelf?

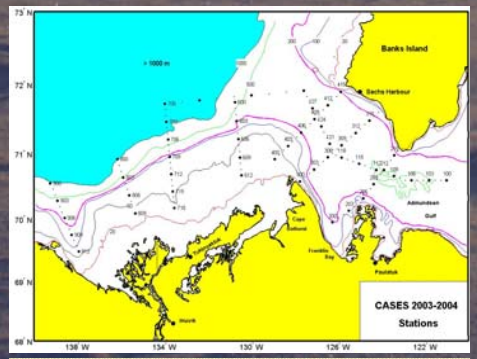


Figure 1. Map of the southern Beaufort Sea with position of the various stations studied.

MATERIALS AND METHODS

Partitioning of benthic oxygen demand

Sub samples are taken from a box corer (Figure 2 and 3)

Figure 2: Picture of the box corer deployment

Figure 3: Picture of the sub sampling cores in the box corer

Incubations are realised for:

- Epibenthic megafauna and Macrofauna (Figure 4)
- Macrofauna-free sediment (meiofauna, protozoans, bacteria, chemical oxidation) (also called minivials, Figure 5)

Figure 4: Picture of epibenthic mega-fauna and macrofauna incubation

Figure 2: Picture of minivial incubation

Epibenthic megafauna density

A bottom camera (Figure 6) is deployed in order to take picture of the epibenthic fauna (Figure 7).

Figure 6: Deployment of the bottom camera

Figure 7: Picture of sea floor at station 206 showing high density of brittle stars

RESULTS and DISCUSSION

Sediment oxygen demand, sediment pigment content and depth

Sediment oxygen demand (SOD) is correlated with benthic pigment concentration (Figure 8). This indicates a tight benthic-pelagic coupling on the Beaufort Shelf. Rates (2-8 mmol $O_2/m^2/d$) are similar to those measured on other Arctic shelves (see the table on the right side).

Sedimentary pigments negatively correlated with depth but SOD is not dependant of depth (Figure 9 and 10).

Partitioning

Rates of epibenthic fauna respiration and biomass are depth dependent (Figure 11), suggesting the potential importance of sediment stability, production supply and bottom currents.

Epibenthic fauna have a variable contribution to benthic community oxygen consumption (0.1% to over 40%). Minivial respiration can represent more than 50% of the total oxygen consumption (Figure 12 13).

Figure 8

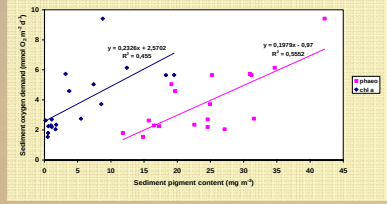


Figure 9

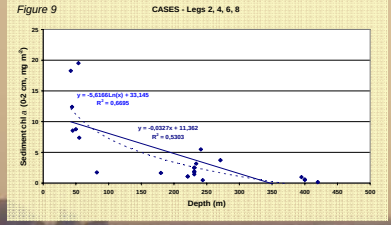


Figure 10

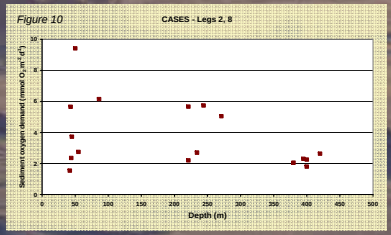


Figure 11

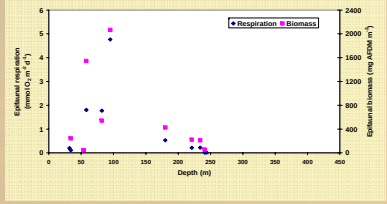


Figure 12

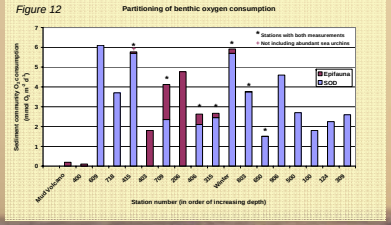
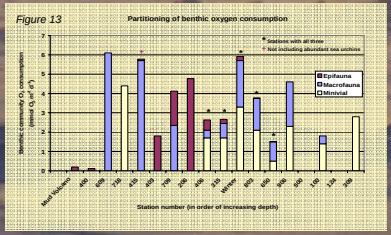


Figure 13



Partitioning oxygen demand

Location	Depth	% Macrofauna	% Epifauna	Reference
Chukchi Sea	29-213m		0-26	Ambrose et al. 2001
North Water Polynya	250-570m	0-70 (spring) 70-80 (summer)		Grant et al. 2002
Chukchi Sea	30-280m	Up to 61		Grebmeier and McRoy 1989
Goban Spur	208-4470m	15-57	0-0.1	Heip et al. 2001
Bay of Biscay	2100m	13	2	Mahaut et al. 1995
Barents Sea	< 200m > 200m	14-75 (avg 17) 5-75 (avg 21)	20-94 (avg 21) 2-4 (avg 3)	Piepenburg et al. 1995
Beaufort Sea	**38-440m**	**33-50***	**0.1-41**	***Present study***

* Macrofaunal contributor underestimated by using our technics

CONCLUSION

- Sediment oxygen demand on the Beaufort shelf is comparable to other sites across the Arctic
- SOD strongly correlated with sediment pigment content, but not depth
- Epifaunal abundance and biomass show strong depth dependence
- Macrofauna are responsible for a large but variable percentage of SOD
- Epifauna can account for more than half the total benthic community oxygen demand
- Role of locally abundant epibenthic amphipods not estimated in this study, but expected to be high

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