Biological Implications of Arctic Change

Jackie M. Grebmeier and Lee W. Cooper

Marine Biogeochemistry and Ecology Group, Department of Ecology and Evolutionary Biology, 10515 Research Drive, Bldg A, Suite 100, The University of Tennessee, Knoxville, Tennessee, 37932, USA

Introduction

The detection of biological change in the Arctic marine environment can be expected to coincide with recent patterns of high-latitude environmental change, including a seasonal reduction in the extent and duration of sea ice, increased seawater temperature, and changing hydrographic conditions (e.g. Serreze *et al.,* 2003; Overland and Stabeno, 2004). The shallow, productive features of the Bering Strait region in the Ameriasian Arctic may accentuate its role as a sentinel indicator of global change effects (Grebmeier and Dunton, 2000). Ecosystem change on the shallow shelves of the northern Bering and Chukchi seas are intimately connected to systems further to the north (Figure 1). Current studies undertaken as part of the Bering Strait Environmental Observatory (BSEO; http://arctic.bio.utk.edu/AEO/index.html) are occupying time series sites in the northern Bering and Chukchi seas to evaluate basic hydrographic and biological parameters. The Western Arctic Shelf-Basin Interactions (SBI; http://sbi.utk.edu) project is also investigating the production, transformation and fate of carbon at the shelf-slope interface in the northern Chukchi and Beaufort seas in the context of Arctic environmental change.

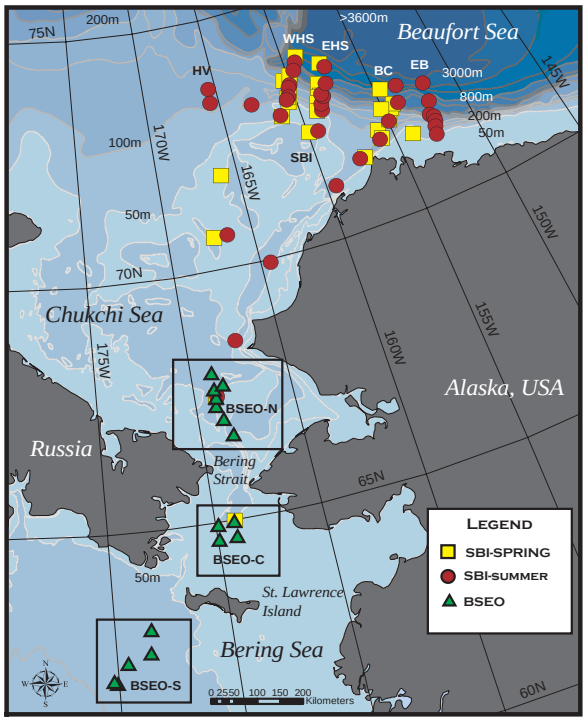

Figure 1. Location of time series oceanographic data for the Bering Strait region maintained by the Bering Strait Environmental Observatory (BSEO) and the western Arctic Shelf-Basin Interactions (SBI) study area. The BSEO sites are designated as BSEO-S (south of St. Lawrence Island), BSEO-C (Chirikov Basin) and BSEO-N (north of Bering Strait). The SBI transects are HV (Herald Valley), WHS (West Hanna Shoal), EHS (East Hanna Shoal), BC (Barrow Canyon) and EB (East Barrow).

Recent studies show that the northern Bering Sea is shifting towards an earlier spring transition between ice-covered and ice-free conditions, with coinciding changes in both primary and secondary trophic level production (Stabeno and Overland, 2001). These changes could have dramatic impacts for higher-trophic level fauna, including some species such as benthic-feeding walrus, bearded seals, gray whales and diving sea-ducks that are of cultural and subsistence significance to Arctic Native residents. Studies in the northern Bering and

Chukchi seas over the last two decades provide many indications of ecosystem change. The tight pelagic-benthic coupling observed between seasonal water column carbon production processes and underlying short- and long-term benthic carbon transformation processes provide a "footprint" in the sediments of persistent ecosystem events and subsequent time-series changes. Pelagic-benthic coupling can be studied via underlying sediment processes on various time scales. Sediment metabolism can be an indicator of weekly-to-seasonal carbon depositional processes, while benthic faunal populations can act as multi-year, long-term integrators of a variety of marine processes.

Methods

Biological time series sites south of St. Lawrence Island (BSEO-S), in the middle of Chirikov Basin to the north of St. Lawrence Island (BSEO-C), in Bering Strait, and just north of Bering Strait in the southern Chukchi Sea (BSEO-N) have been occupied since the late 1980's and in some cases, earlier (Figure 1). Hydrographic measurements of seawater temperature and salinity, along with nutrients and chlorophyll content, were made at these sites using CTD/rosette systems. Hydrographic analyses, benthic population structure, sediment tracer analyses, biomass and sediment oxygen uptake rates that were measured during these studies have been documented elsewhere (e.g., Grebmeier and Cooper, 1995; Cooper *et al.*, 1997; Cooper *et al*., 2002). Similar methods were utilized during the SBI studies from 2002-2004 (Figure 1).

Results and Discussion

An overall decline in both sediment oxygen uptake (an indicator of carbon supply to the sediments) and overall benthic standing stock from the 1980's to the present has occurred in the Bering Strait region, with probable impacts upon higher trophic organisms that are dependent upon benthic prey. For example, declining bivalve populations south of St. Lawrence Island suggest that the decline in the bivalve prey source could be playing a role in population declines for the spectacled eider (Lovvorn *et al.*, 2003). Other studies indicate that a change in hydrographic forcing and nutrient supply is limiting primary production in the region (Figure 2; Grebmeier and Dunton, 2000; Grebmeier *et al.,* in prep). In addition, recent

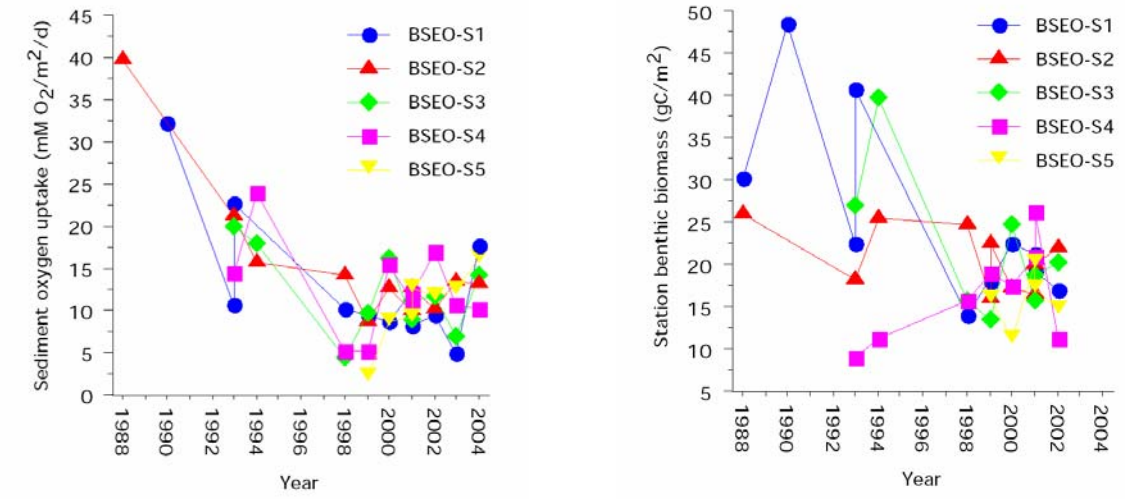

Figure 2. Time series measurements of total sediment oxygen uptake (an indicator of carbon supply to the benthos) and benthic biomass in the region southwest of St. Lawrence Island in the northern Bering Sea (BSEO-S).

studies of gray whale feeding areas and benthic time series measurements data in the Chirikov Basin also indicate a decline in the benthic amphipod prey biomass in the region over the last decade, with indications that gray whales are feeding predominantly north of Bering Strait (Moore *et al.,* 2003). Recent data also indicate gray whales are feeding in new areas along their migration path to obtain food without reaching historical feeding areas in the Bering and Chukchi Seas (Grebmeier *et al.*, unpubl. data).

Thus, biological populations are exhibiting ecosystem change on the shallow shelves of the northern Bering and Chukchi seas, and this ecosystem is intimately connected to the larger Arctic systems further to the north. Current studies as part of the SBI project at the shelf-slope interface in the northern Chukchi and Beaufort Seas are downstream of these productive shallow western Arctic shelves. In these recent studies (2002-2004) sediment oxygen uptake, nutrient flux and benthic faunal populations were highest on the Chukchi shelf, with rates decreasing in the Beaufort Seas as well as from the shelf to deep basin in all transect lines (Grebmeier and Cooper, 2004, submitted). Sediment nutrient exchange indicates high levels of silicate and ammonium effluxing from the sediments in the Chukchi and Beaufort shelves and being transported into the deep basin at the level of the Pacific-influenced Arctic upper halocline. In addition, Barrow Canyon is a key exchange site for both particulate and dissolved carbon. Any change in hydrographic forcing and benthic processes on the productive northern Bering and Chukchi shelves will directly impact carbon and nutrient export from the shelf regions to the deep basin. These current and planned shelf-basin studies are providing key baseline data for research planning efforts on Arctic environmental change (see Arctic Ocean Sciences Board; http:www.aosb.org), International Conference on Arctic Research Planning II (http://www.icarp.dk/), and planning for the International Polar Year (http://www.ipy.org/).

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