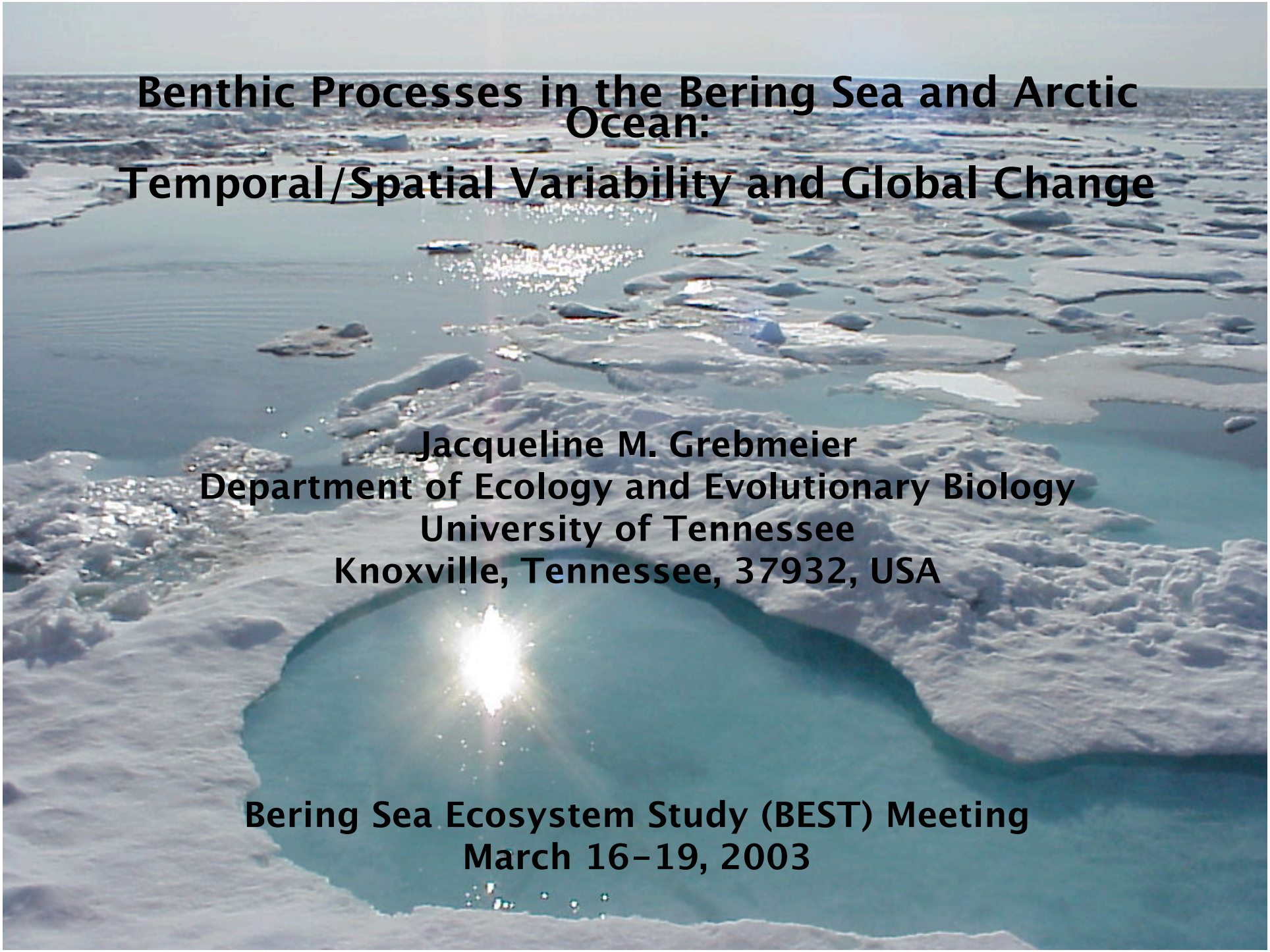


Benthic Processes in the Bering Sea and Arctic Ocean:
Temporal/Spatial Variability and Global Change

Jacqueline M. Grebmeier
Department of Ecology and Evolutionary Biology
University of Tennessee
Knoxville, Tennessee, 37932, USA

Bering Sea Ecosystem Study (BEST) Meeting
March 16-19, 2003

INTRODUCTION

- high latitude ecosystems sensitive to climate change
- polar benthic fauna: long-lived, slow growing, tend high biomass
- short food chains, such that changes in lower trophic levels can cascade more efficiently to higher trophic organisms (e.g., seals, whales, walruses, seabirds and ultimately man)
- changes in the timing, extent, composition and location of annual production (both primary and secondary trophic levels) important in pelagic-benthic coupling
- potential impacts of change have broad-reaching implications for long-term ecosystem structure

BENTHIC PROCESSES

- Influenced by:
  - ¬ water temperature and salinity
  - ¬ extent and duration of sea ice
  - ¬ water column production and grazing
  - ¬ net carbon flux to the sediments
  - ¬ sediment grain size
  - ¬ predator–prey relationships

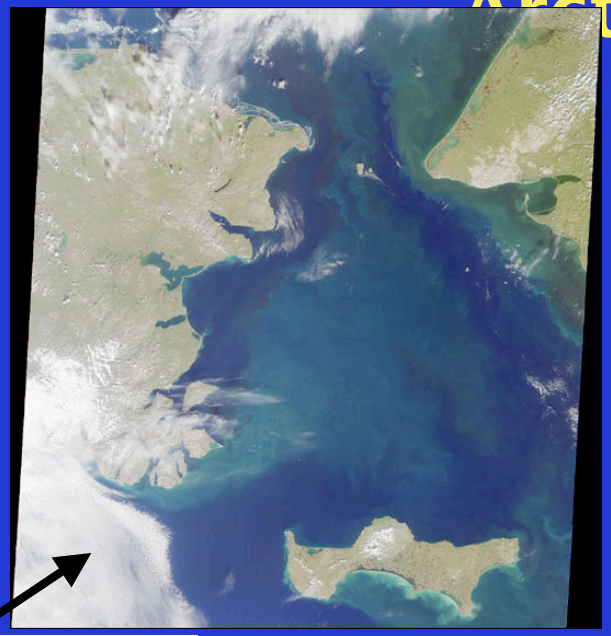
- Pelagic–benthic coupling can be studied via underlying sediment processes on various time scales

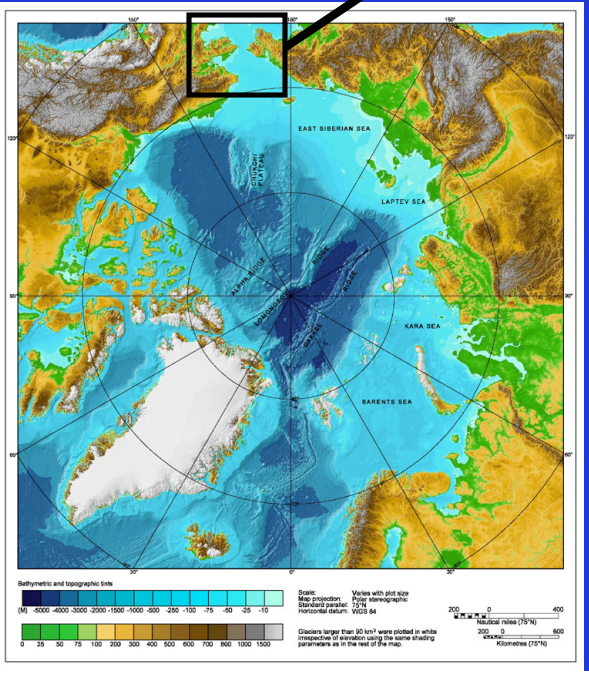
  ¬ Sediment metabolism can be an indicator of weekly–seasonal carbon depositional processes

  ¬ Sediment chlorophyll a (Chl a) as tracer of pelagic–benthic coupling; can persist from months to years in cold water sediments (Itakura et al. 1997; Lewis et al. 1999; Hansen and Josefson 2001)

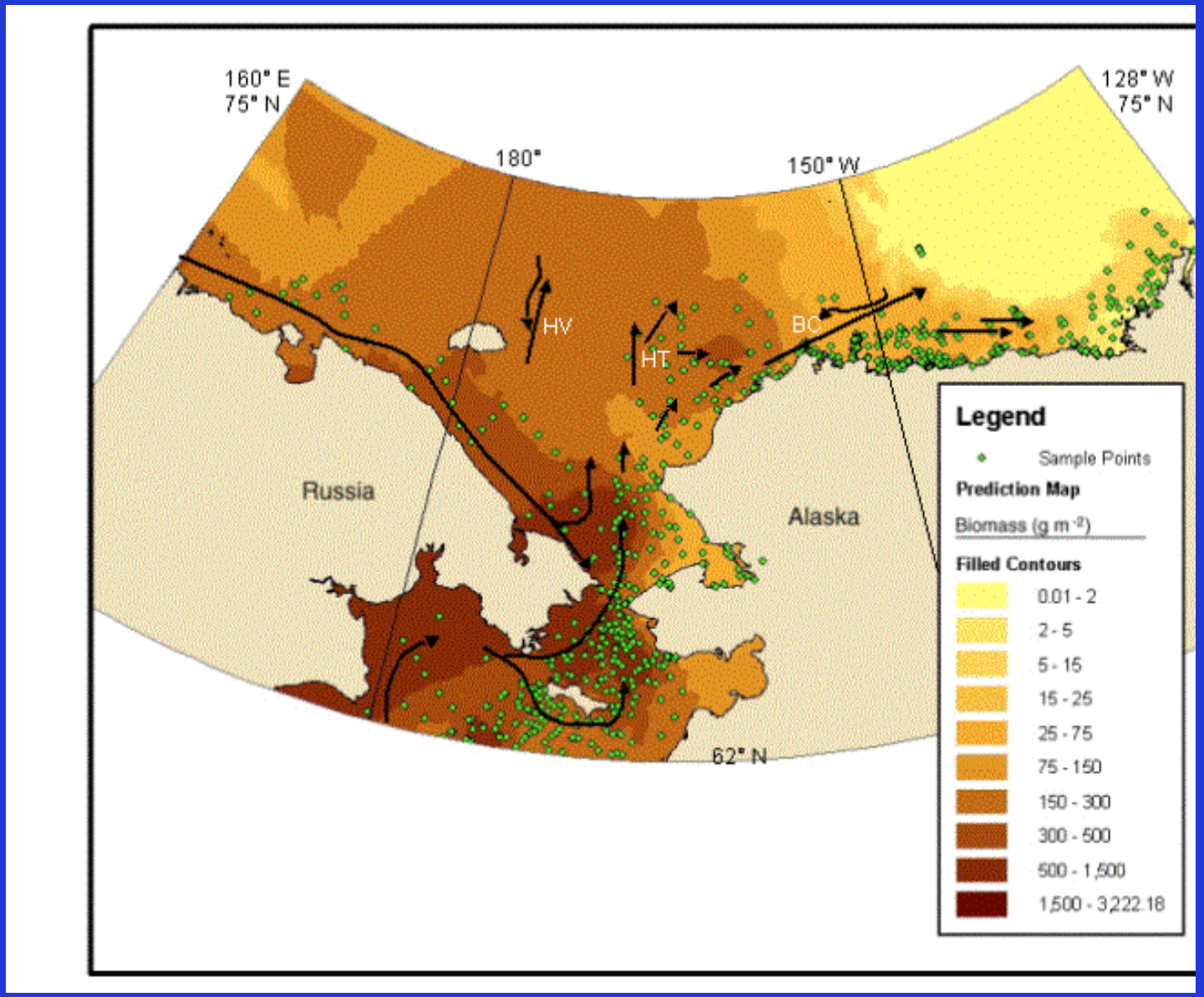
  ¬ Benthic faunal populations act as multi–year, long–term integrators of a variety of marine processes

Bering Strait Region in the North American Arctic

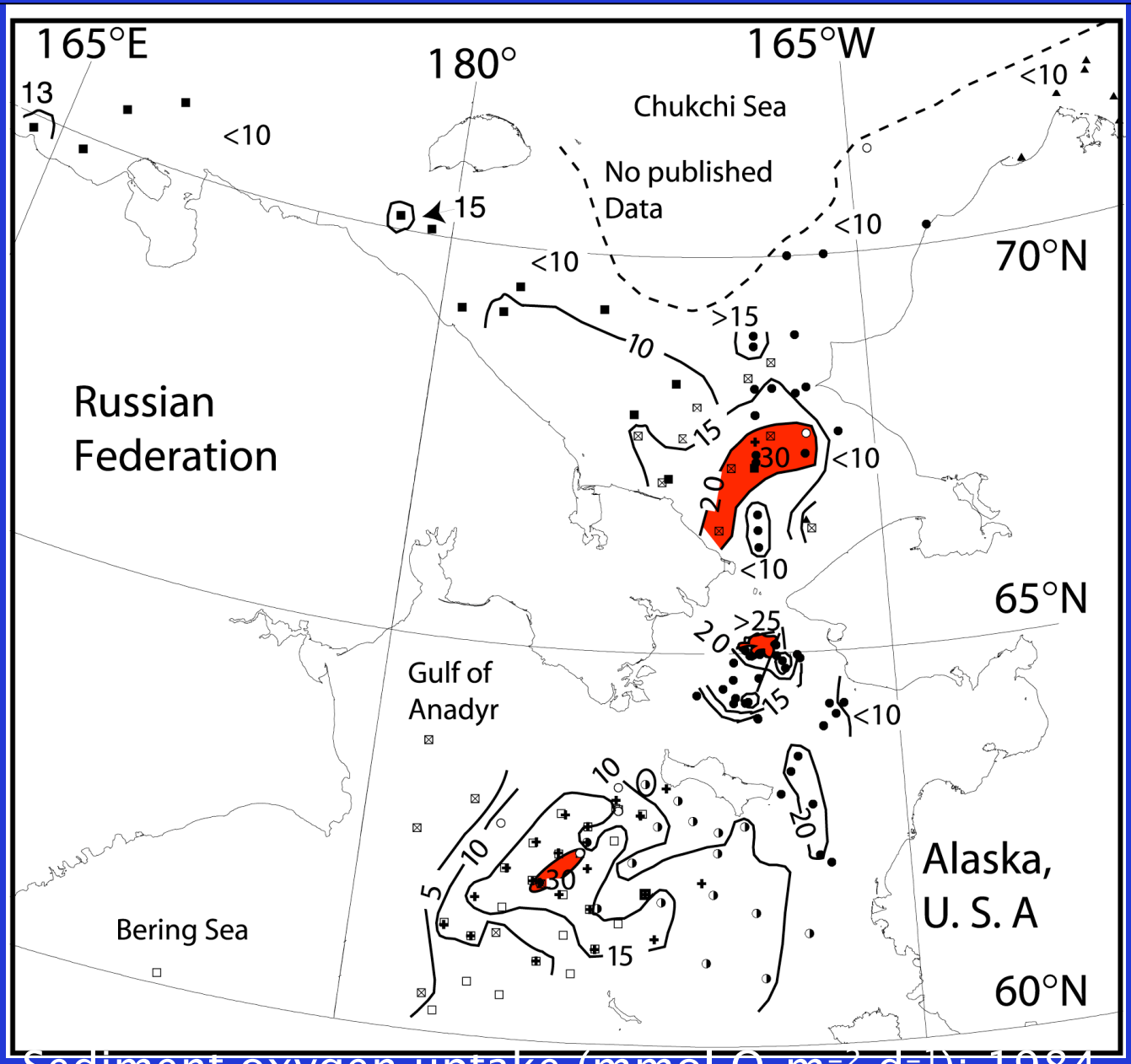




- seasonal ice cover
- nutrient-rich Pacific water enters Arctic Ocean
- low to high water column production: 50–800 g C m^{-2} y^{-1} (Springer et al. 1996)
- variable zooplankton concentrations
- low to high carbon flux to benthos: sediment respiration 1–35 mmol O_2 m^{-2} d^{-1} (Grebmeier et al. 1995; Grebmeier and Dunton, 2000; Grebmeier and Cooper 2002)
- low to high sediment chl a: 0–13 µg cm^{-3} (Cooper et al. 2002)
- low to high benthic biomass, reaching some of the highest levels in the Arctic (<50–2400 g wet m^{-2})
- many benthic feeding higher

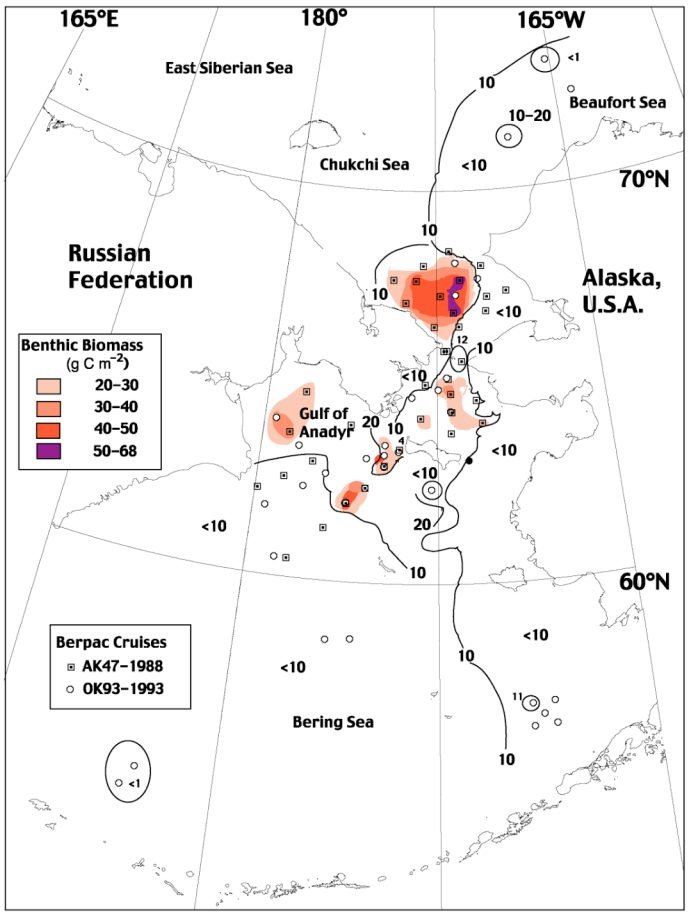


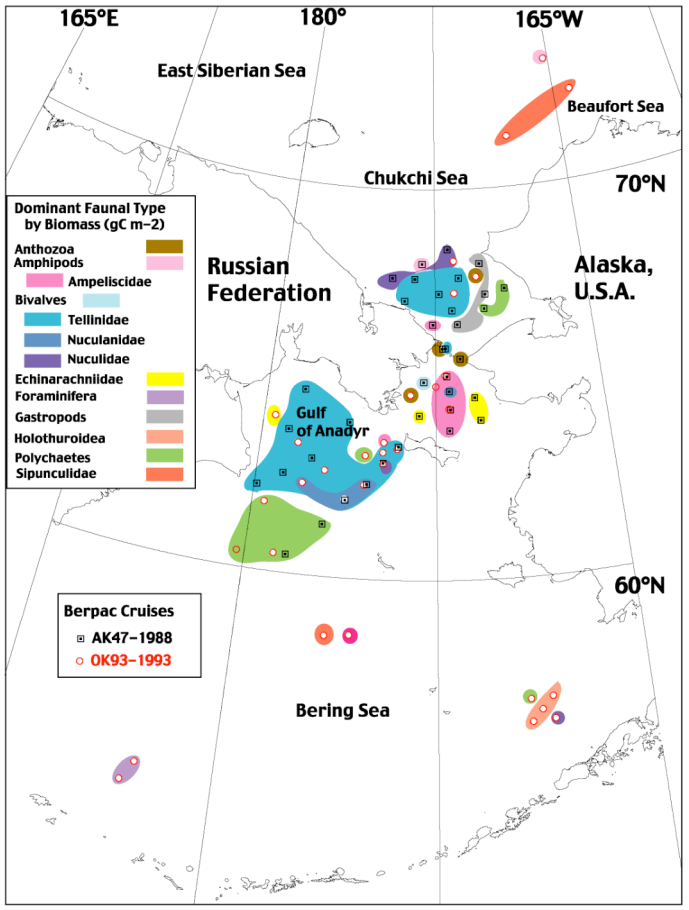
Benthic biomass in the western North American Arctic (Dunton and Grebmeier, see http: www.utmsi.utexas.edu/staff/dunton/)



Sediment oxygen uptake (mmol $O_2 m^{-2} d^{-1}$); 1984–1995

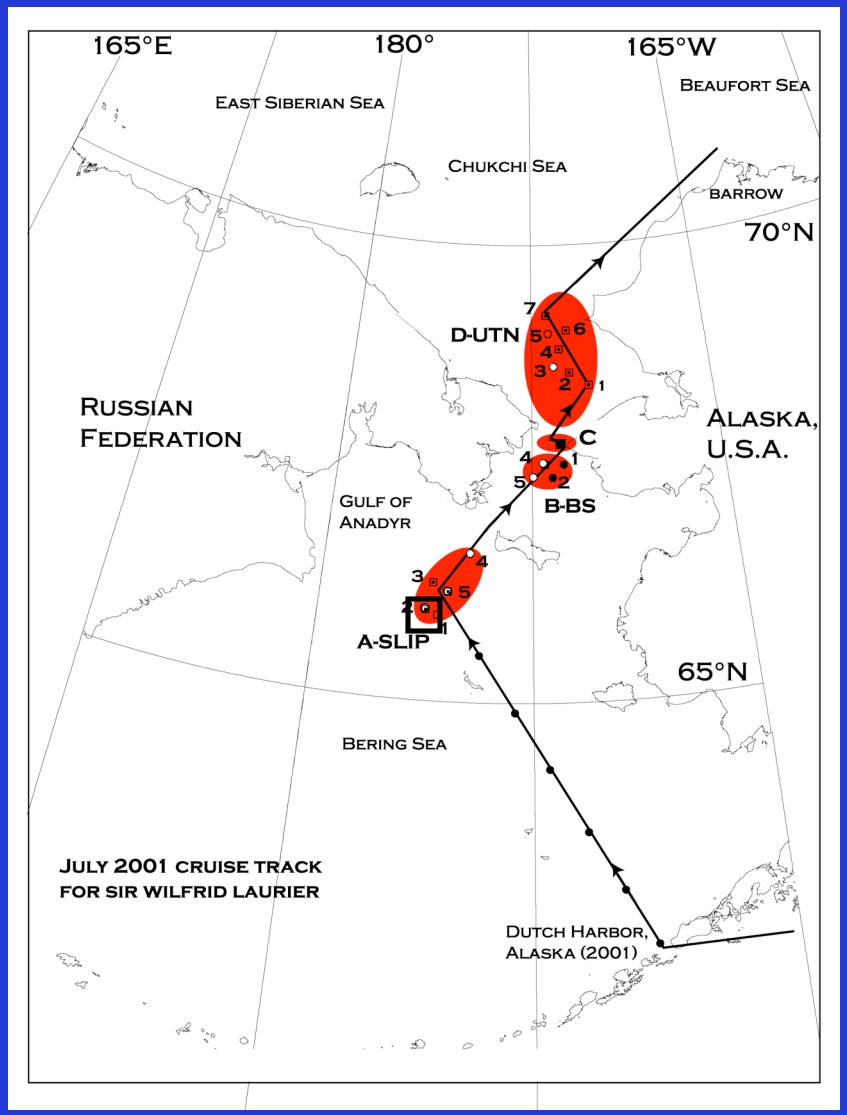
[Grebmeier and Dunton 2000





Strong pelagic–benthic coupling between overlying water column processes and underlying benthic faunal biomass on shallow Arctic shelves; benthic faunal population structure varies with sediment grain size and hydrographic regimes

[Grebmeier and Cooper



Bering Strait Long-Term Observatory Project

(Cooper, Grebmeier, Codispoti and Sheffield)

(http://arctic.bio.utk.edu)

Objectives

1) land-based marine sampling program on Little Diomede Island in Bering Strait

2) annual July oceanographic study in collaboration with Eddy Carmack (IOS/DFO Canada)

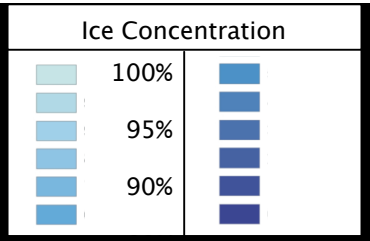
3) Marine mammal collection program

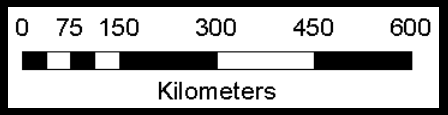
4) NOAA NBS mooring 2003, 75 m

Northern Bering Sea: SLIPP area

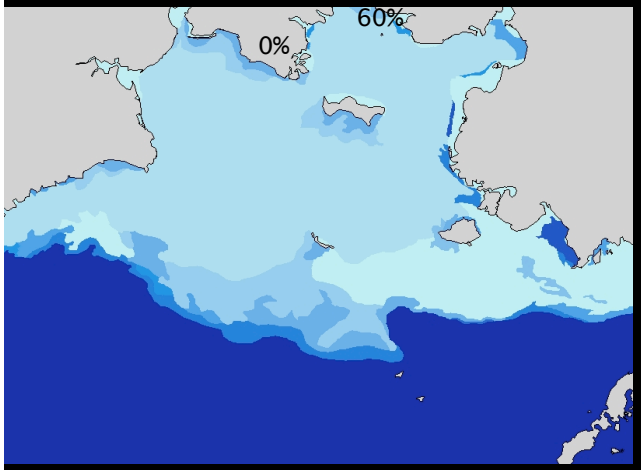
- Bering Sea possibly shifting towards an earlier spring transition between ice-covered and ice-free conditions
- Surface sea temperature increase in the 1990s vs the 1980s, tied to the Arctic Oscillation further to the north (Stabeno and Overland, 2001, EOS 82:317-321)
- Retrospective benthic studies in the region indicate changes occurring in both carbon deposition and benthic biomass since the late 1980's
- Region south of St. Lawrence Island has the longest time-series record, indicates a reduction in bivalve standing stock and size as well as a change in species composition, which may directly influence the declining populations of the threatened diving seaduck

Sea Ice Melt

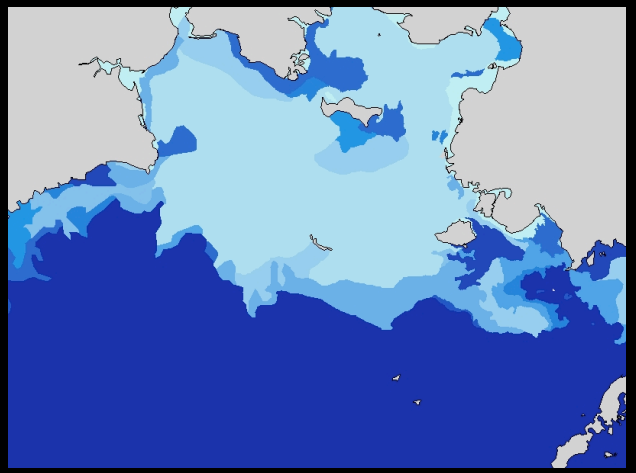




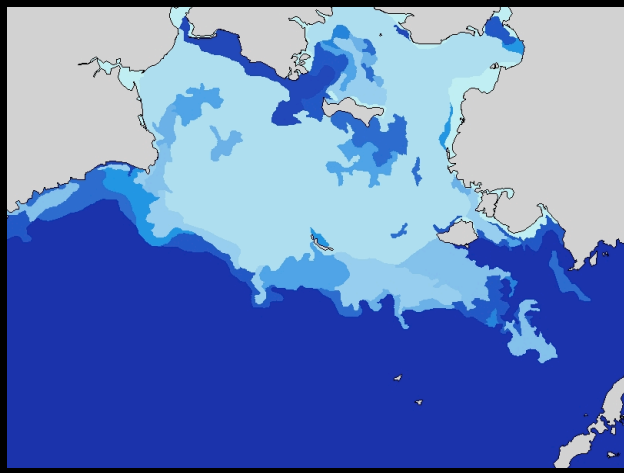
19 Apr 99



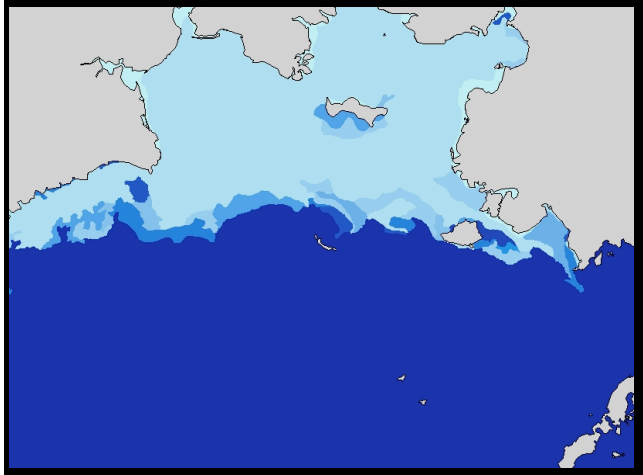
03 May 99



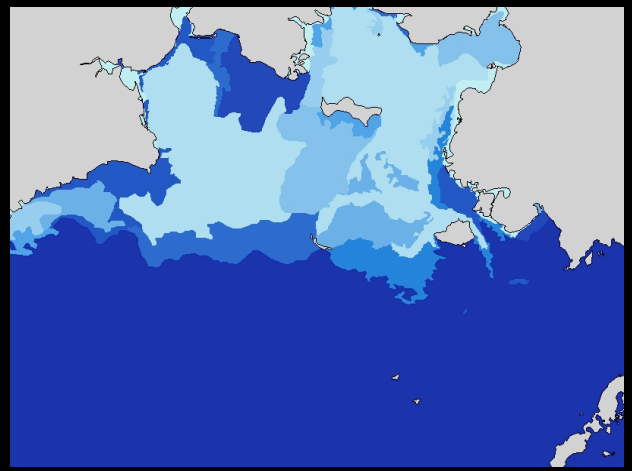
14 May 99



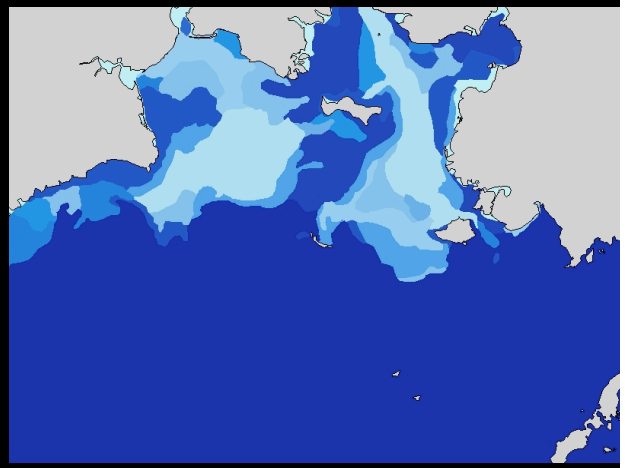
20 Apr 01



04 May 01



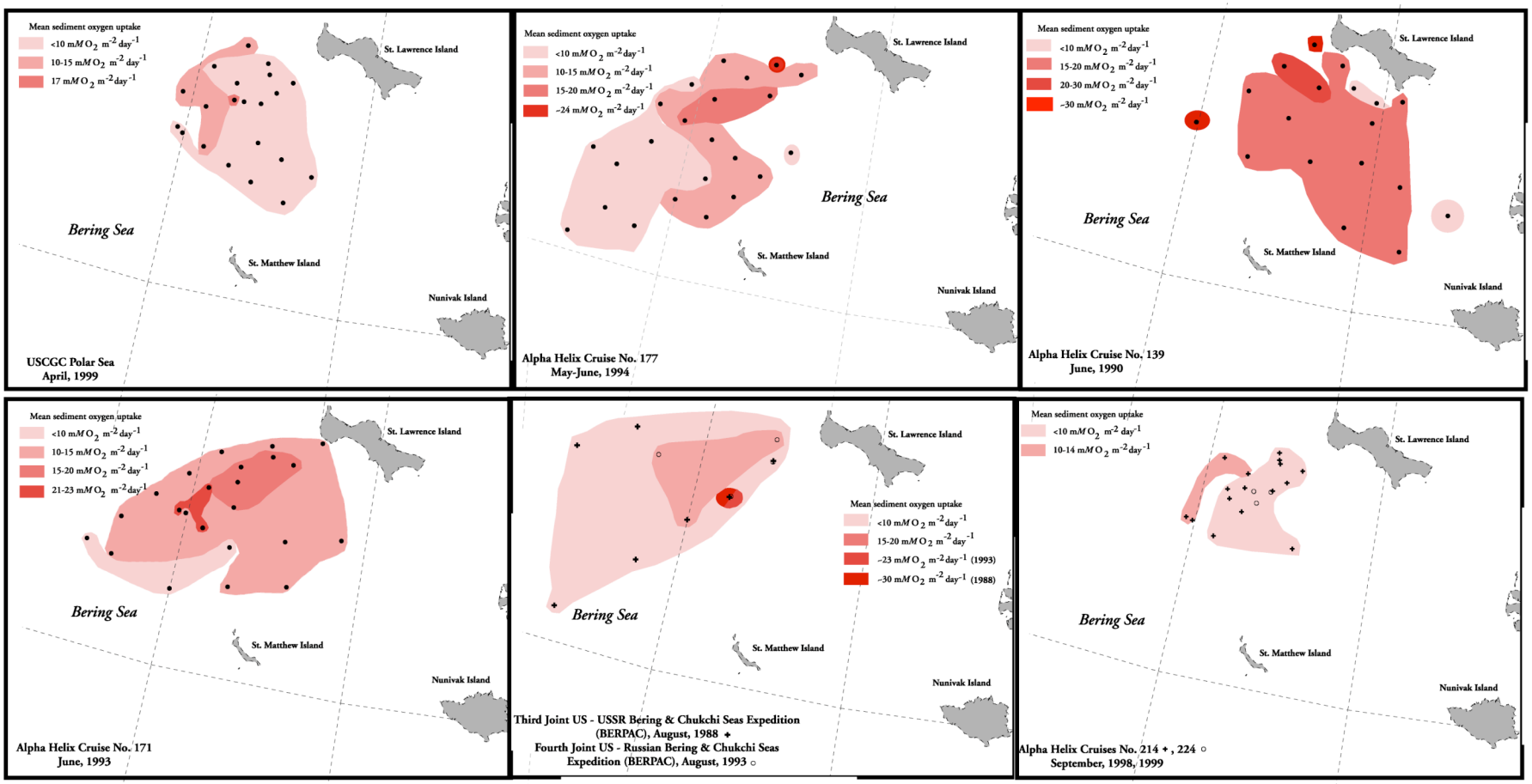
14 May 01



(Clement 2002-MS thesis)

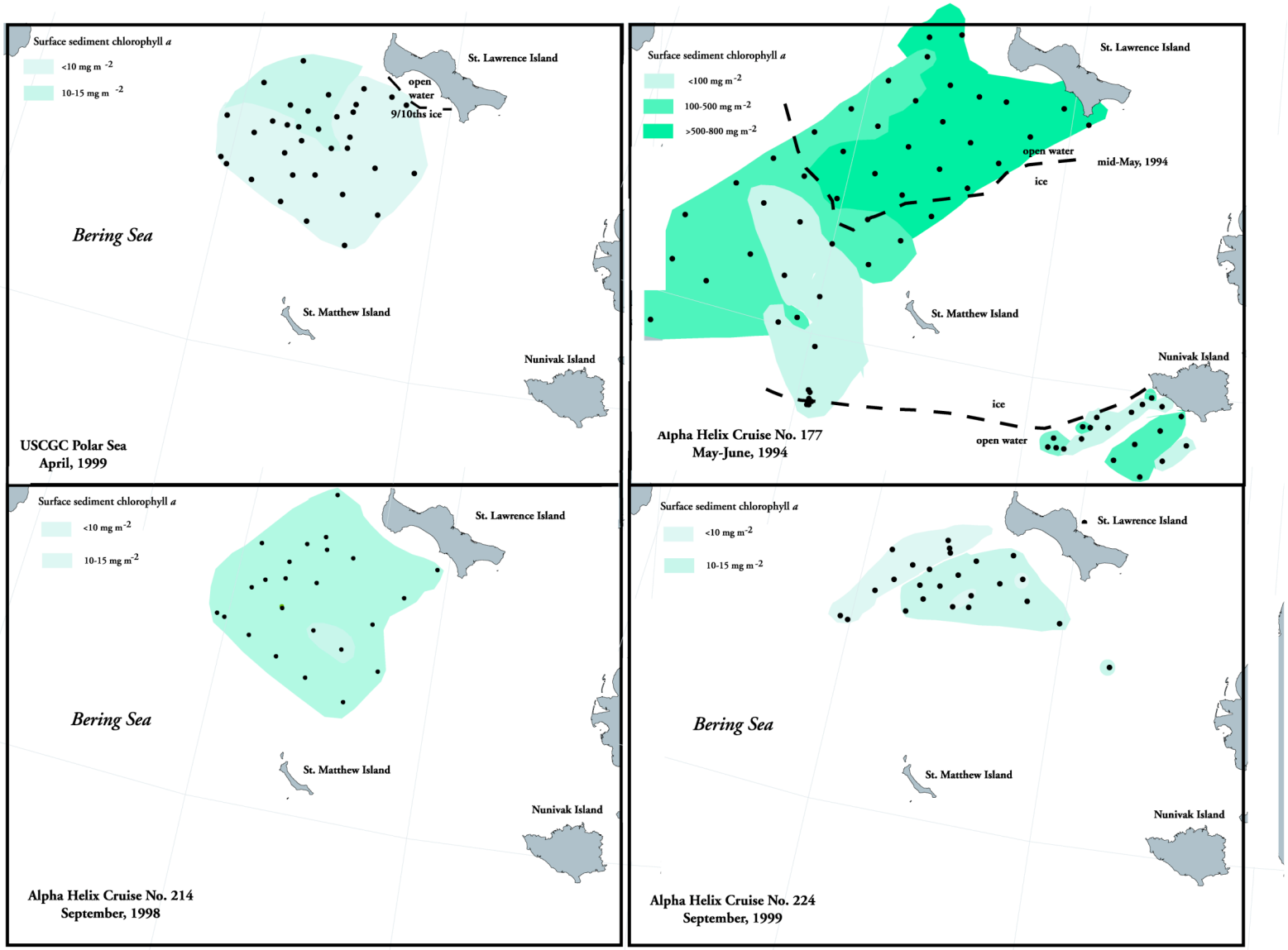
Spectacled Eider and benthic food supply (dominated by bivalves: *Nuculana radiata, Nucula belloti, Macoma calcarea*)

Sediment oxygen uptake (mmol O_2 m^{-2} d^{-1})

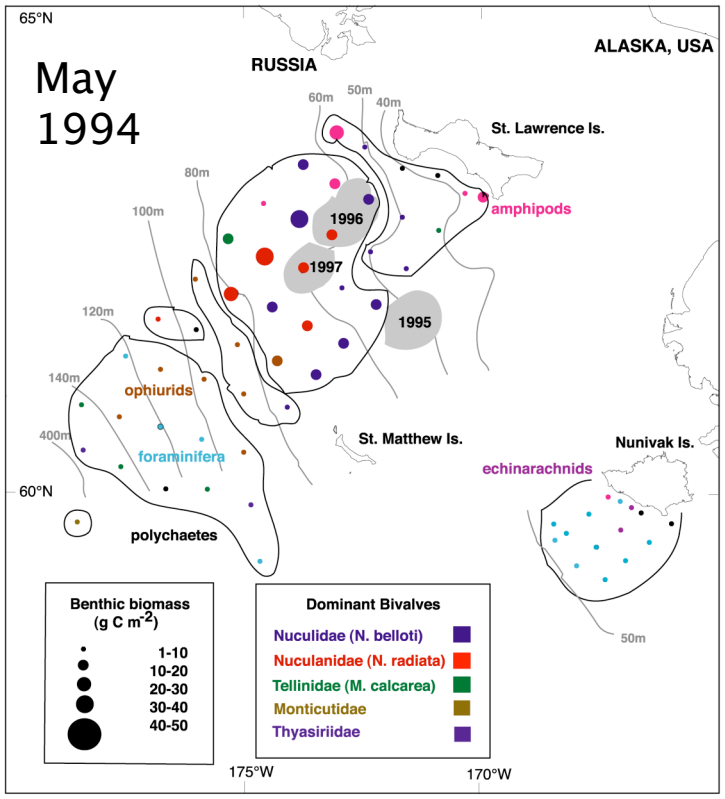


Cooper et al. 2002, MEPS 226:13–26

Sediment chlorophyll (mg m^{-2})

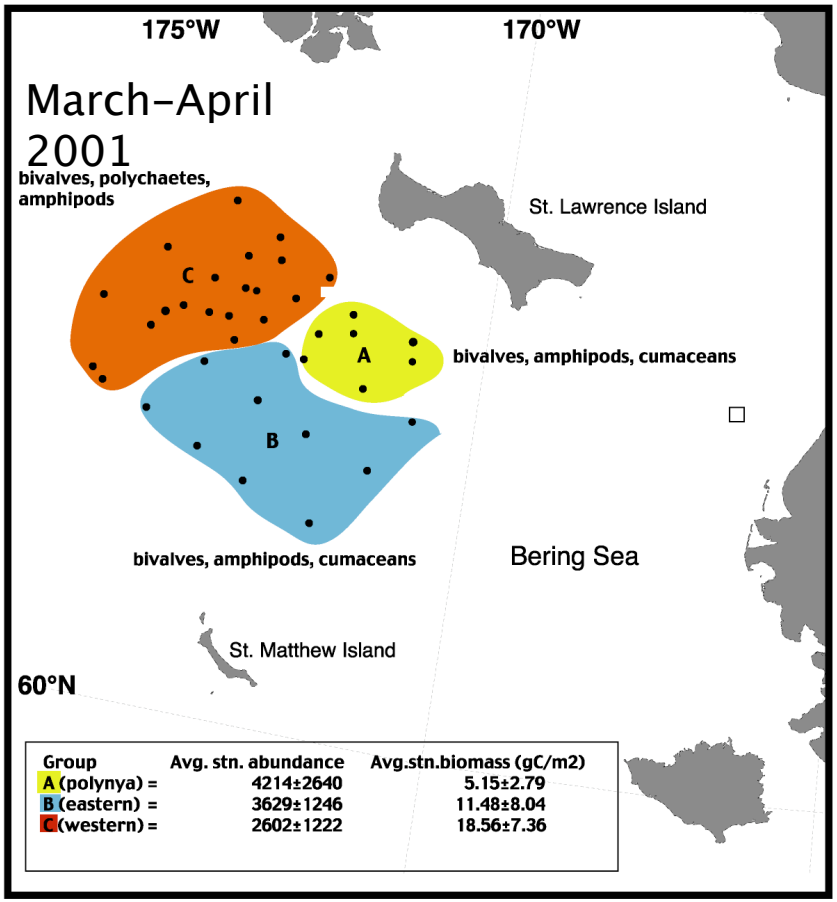


Cooper et al. 2002, MEPS 226:13–26



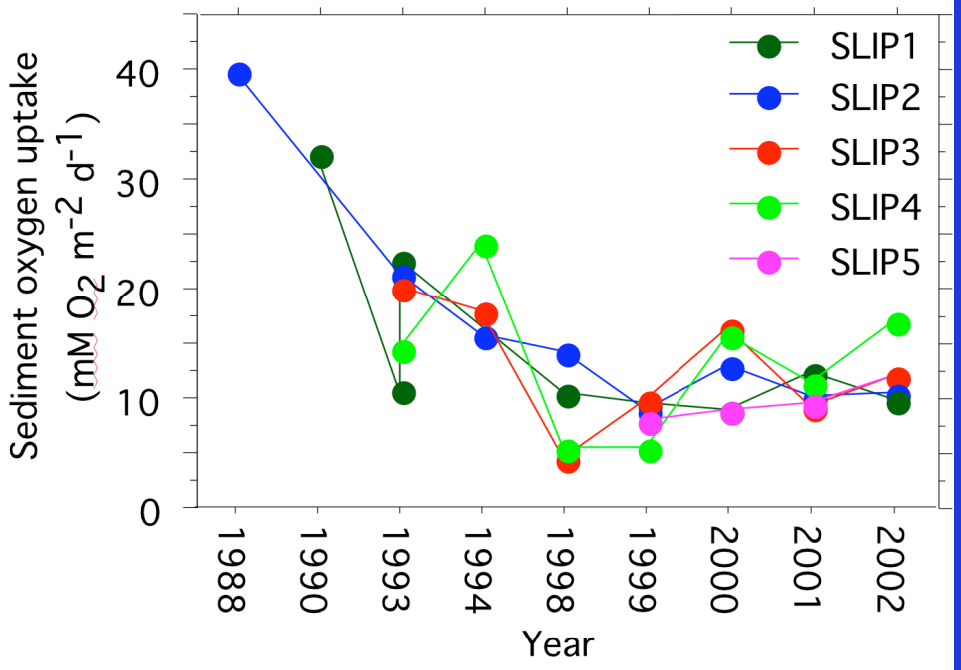
Benthic community structure (based on faunal abundance) in relation to total station benthic biomass (colorer coded by dominant faunal type) in the region south of St. Lawrence Island, Alaska, May/June 1994. Dated shading is observed location of Spectacled Eider flocks.

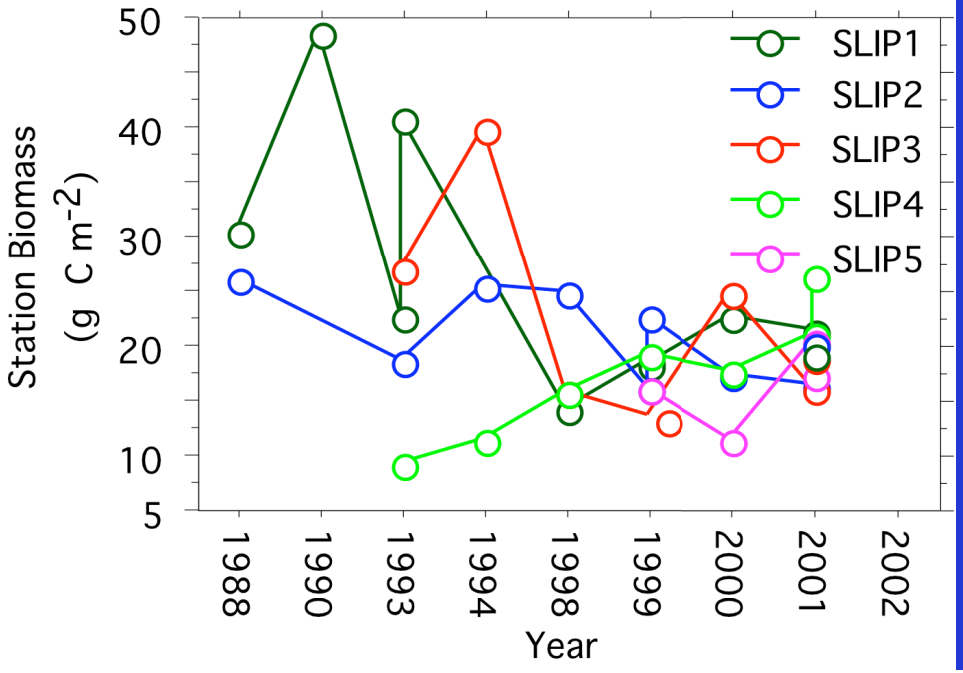
(Grebmeier and Dunton, 2000)



Simpkins, M.A, L.M. Hiruki-Raring, G. Sheffield, J.M. Grebmeier, and J.L. Bengtson (submitted)

Benthic community structure on shelf south of St. Lawrence Island dominated by bivalves; important for Spectacled Eiders



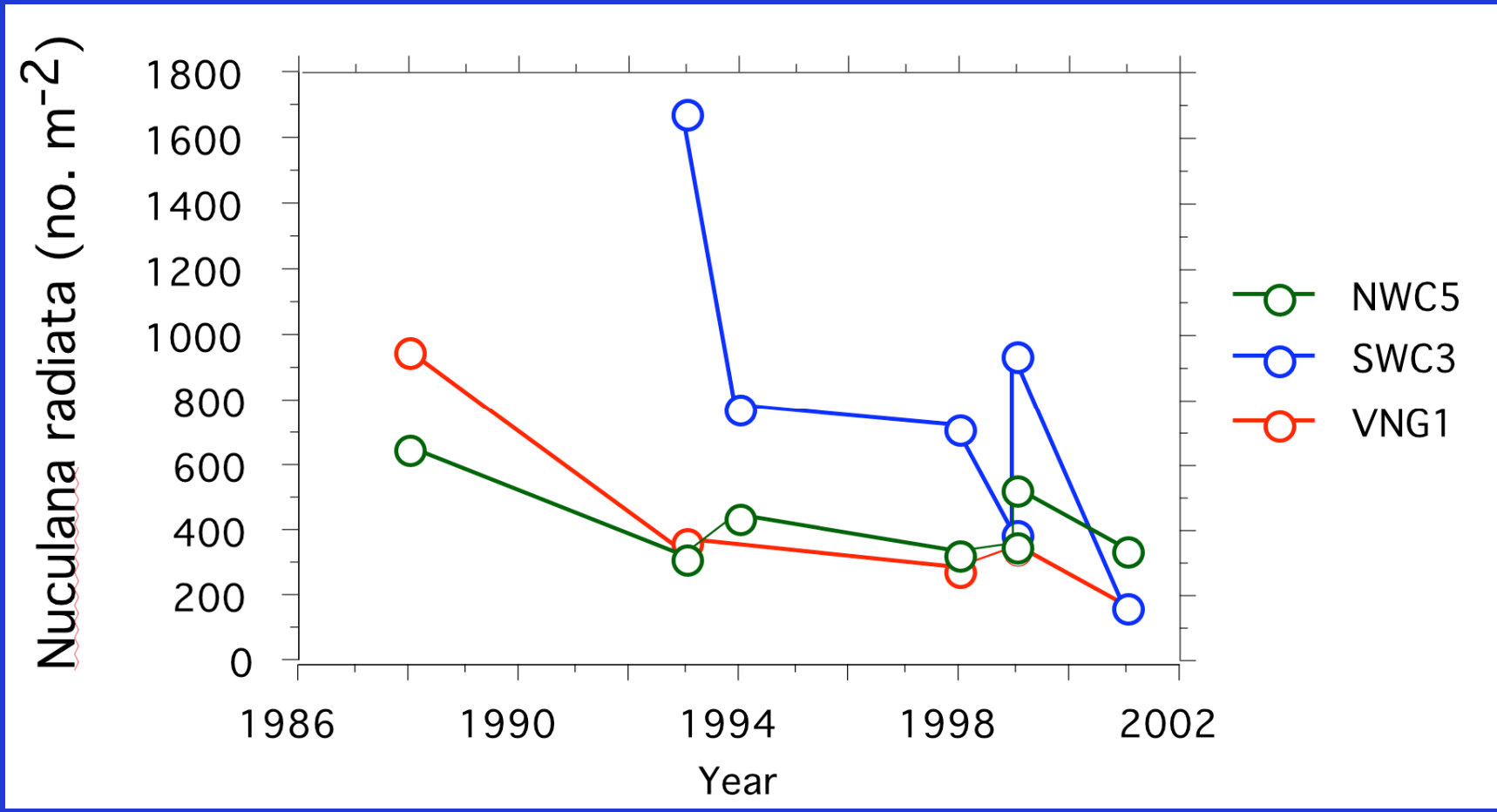


Long-term observatory station sites south of St. Lawrence Island

- overall decline late 1980's to 1998, then level out in both sediment oxygen uptake (indicator of carbon flux to sediments) and overall benthic standing stock

- retrospective study indicates changes in dominant bivalve from *Macoma calcarea* to *Nuculana radiata*

[Grebmeier et al. in



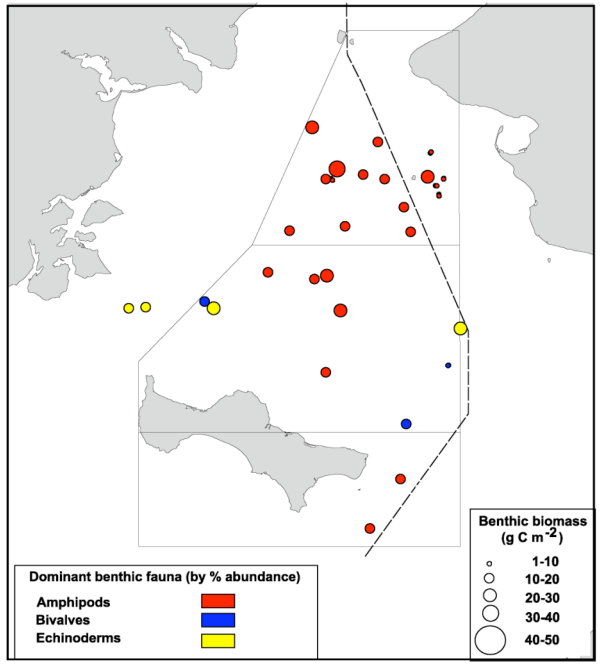
[Grebmeier et al. in prep.]

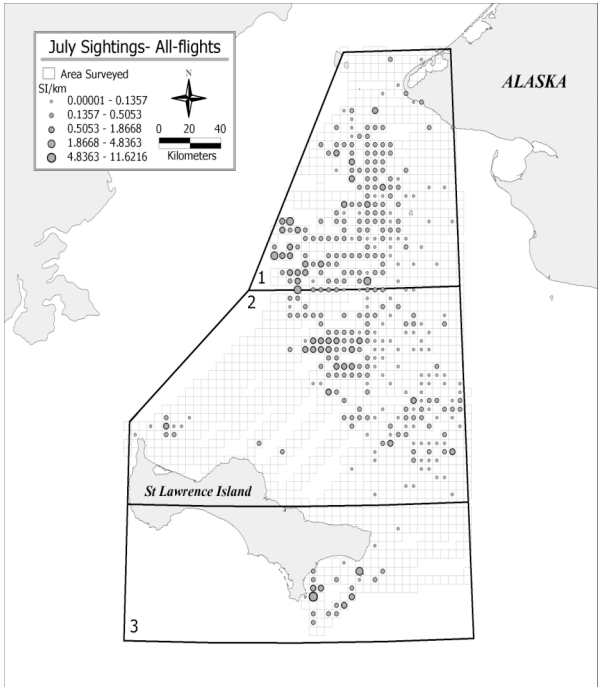
Decline in dominant bivalve abundance at stations influenced primarily by hydrographic conditions (NWC5 and VNG1) and by predation by Spectacled Eider seaduck (SWC3)

Chirikov Basin in the 1980s

(Moore et al. in press, Can.J. Zool.)

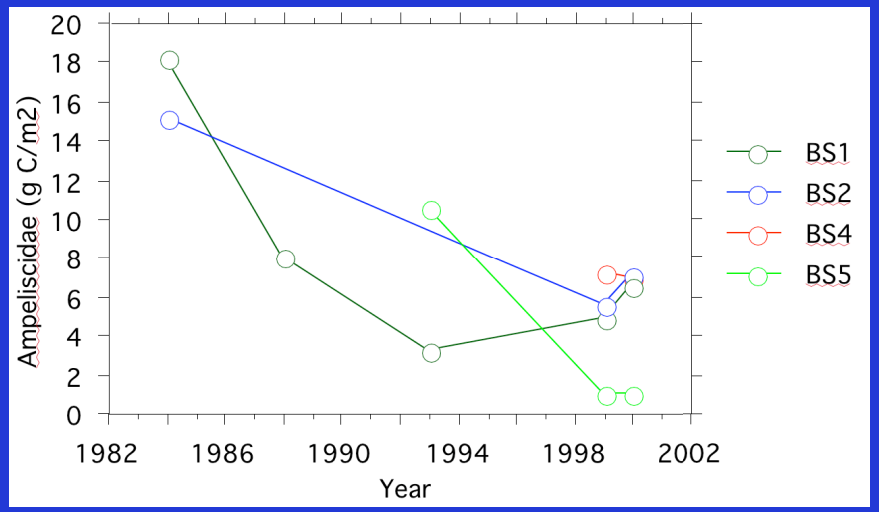
- Basin is downstream end of Gulf of Anadyr-Bering Sea 'Greenbelt'
- Pelagic-benthic coupling supports high benthic biomass
- Dense assemblages of tube-building ampeliscid amphipods
- Basin is "one of the most productive benthic communities in the world" (Highsmith and Coyle, *Nature*;1990)
- Gray whale surveys indicate feeding area in northern Bering Sea

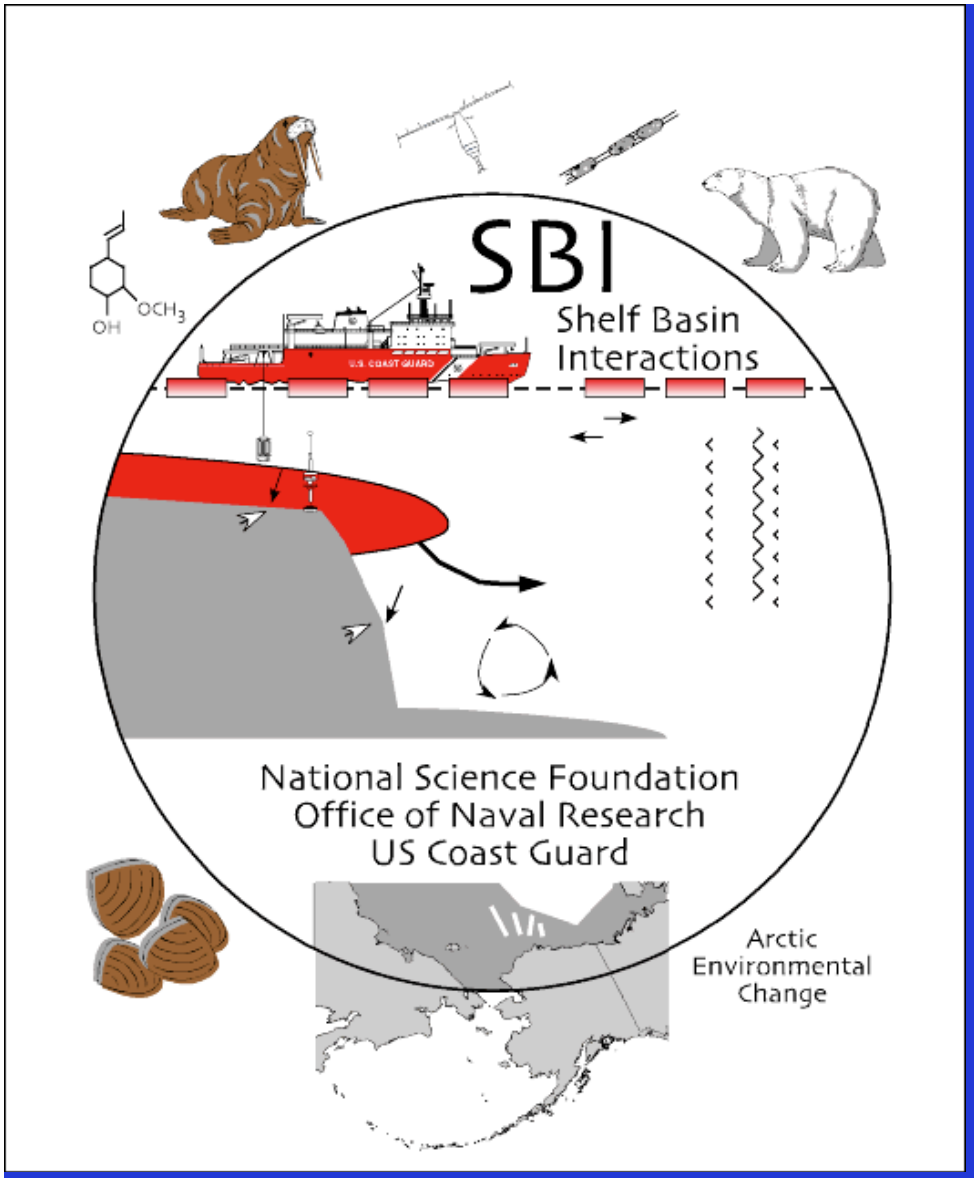


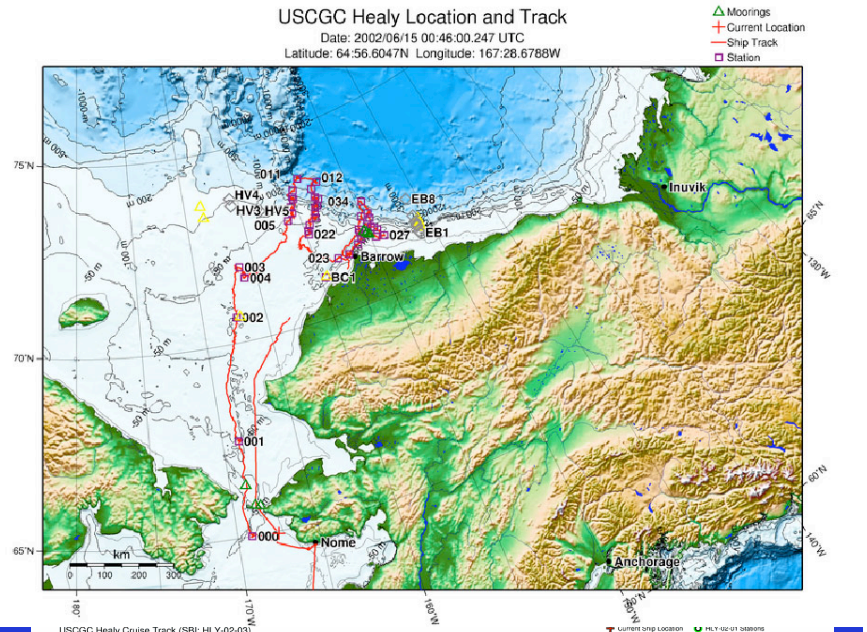


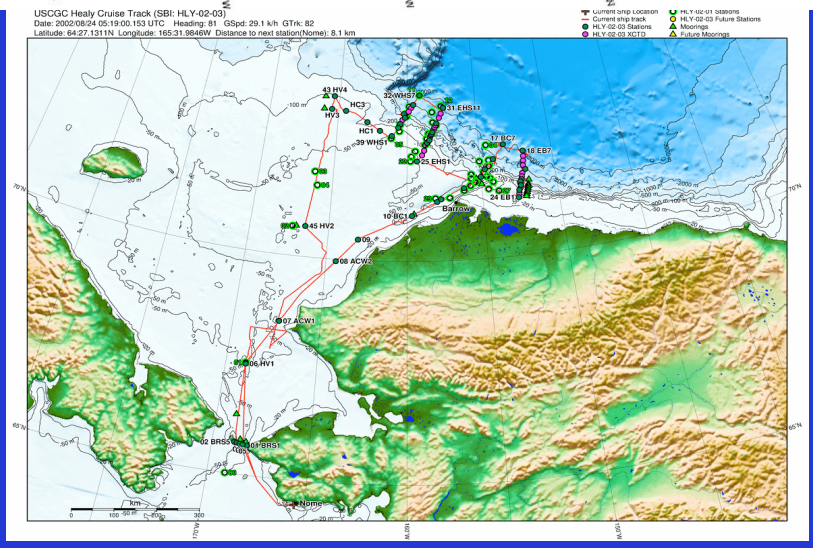
Drop in Benthic Productivity

- Highsmith and Coyle report evidence of 30% production downturn 1986–88 (*MEPS*, 1992)
- decline of ampeliscids @ 4 stations (Moore *et al.*in press, *Can. J. Zool.*)
- LeBoeuf *et al*. link this decline in the Chirikov Basin as ***causal*** to gray whale mortalities









The goal of the SBI global change project is to investigate the production, transformation and fate of carbon at the shelf-slope interface in the Arctic as a prelude to understanding the impacts of a potential warming of the Arctic

Summary

- Bering Strait region may be shifting towards an earlier spring transition between ice-covered and ice-free conditions
- Changes in the timing of productivity over the shelf and slope regions may rapidly impact trophic structure, and ultimately carbon transport from the shelf to the Arctic basin
- Retrospective benthic studies in the region indicate changes have occurred in both carbon deposition and benthic biomass since the late 1980s
- Long-term studies in focused regions are critical for differentiating climate change impacts from natural

(courtesy of Marc Webber,