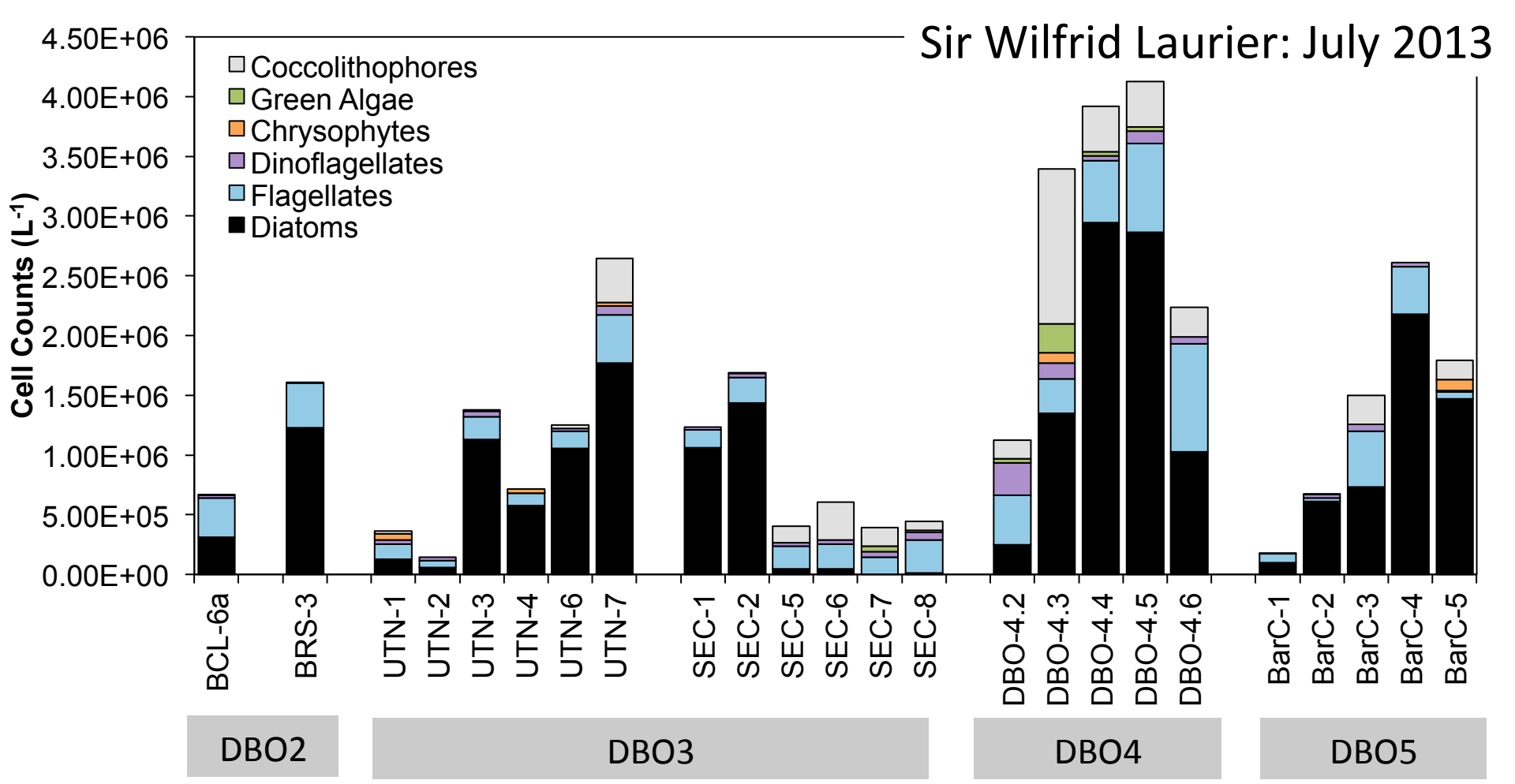
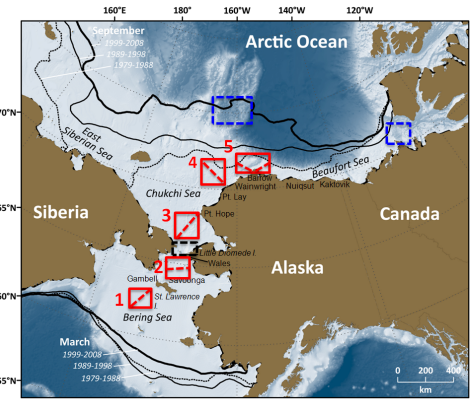
Lower Trophic Level DBO Studies, 2010-2015

Discussion Leader: Jackie Grebmeier
Components: Karina Giesbrecht, Diana Varela, Lisa Eisner, Jackie Grebmeier, Monika Kędra, Cathy Coon, Morgan Busby, Adam Spear, Aleksy, Pinchok, others?



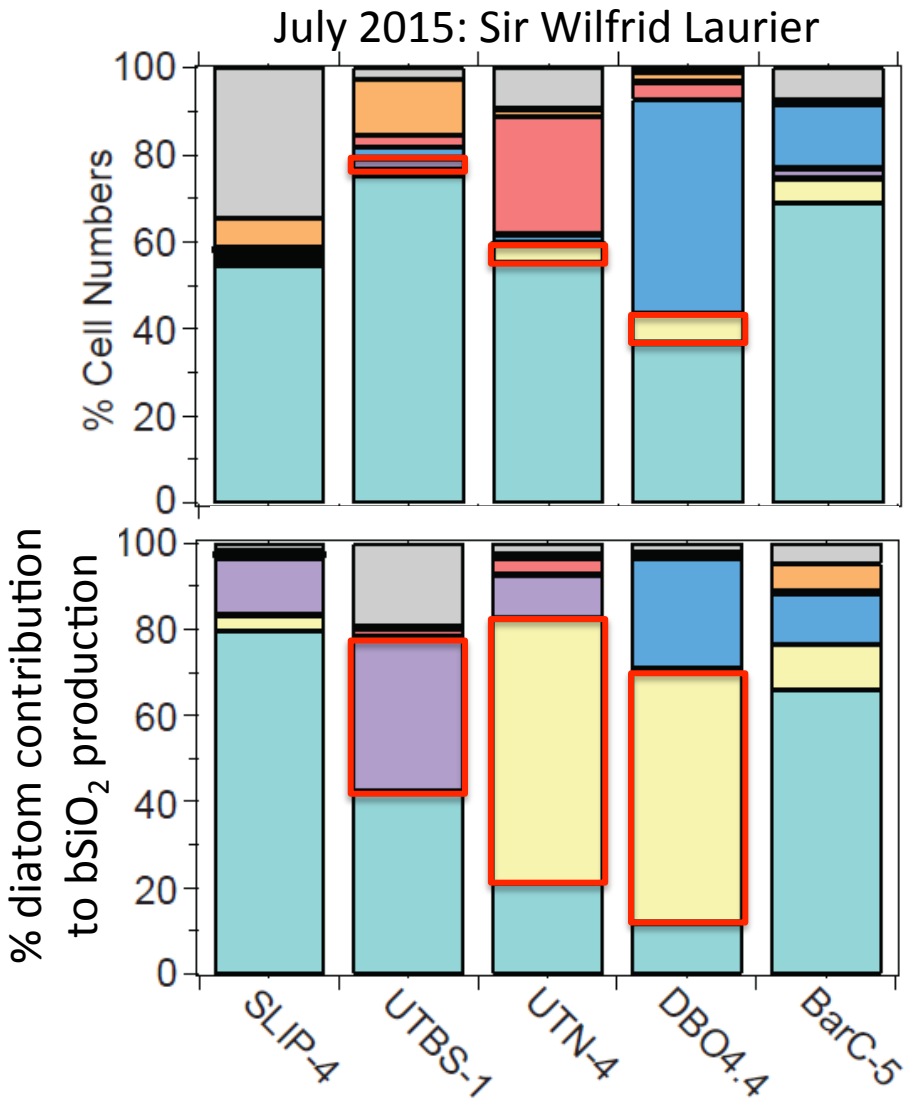


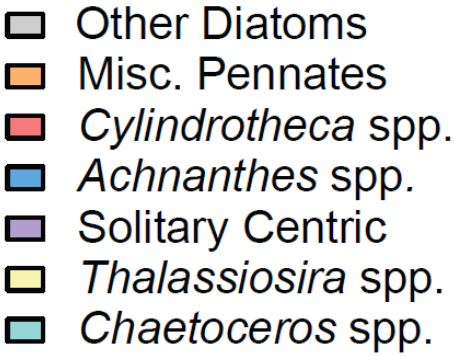
Phytoplankton community composition (Chlorophyll max)

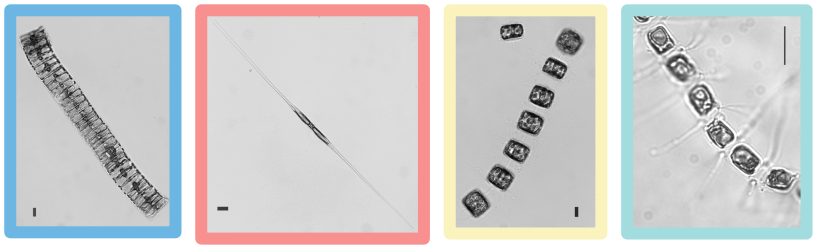
- Diatoms tend to be most abundant, especially when cell counts are high
- Notable abundance of coccolithophores on the DBO3 and DBO4 lines

[Karina Giesbrecht]

Cell numbers don't tell the whole story



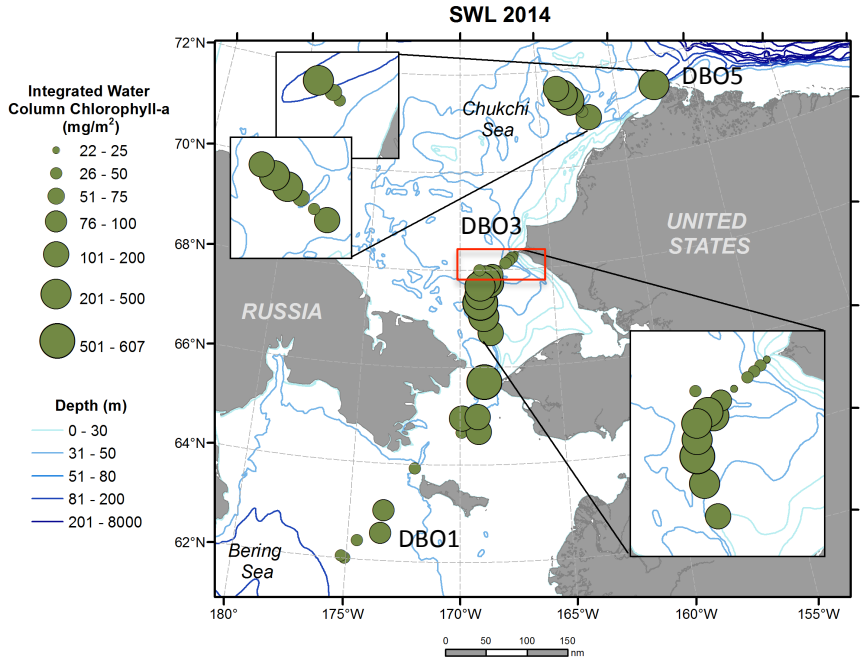




- Quantified diatom contribution to $bSiO_2$ production using fluorescent tracer PDMPO

[Diana Varela]

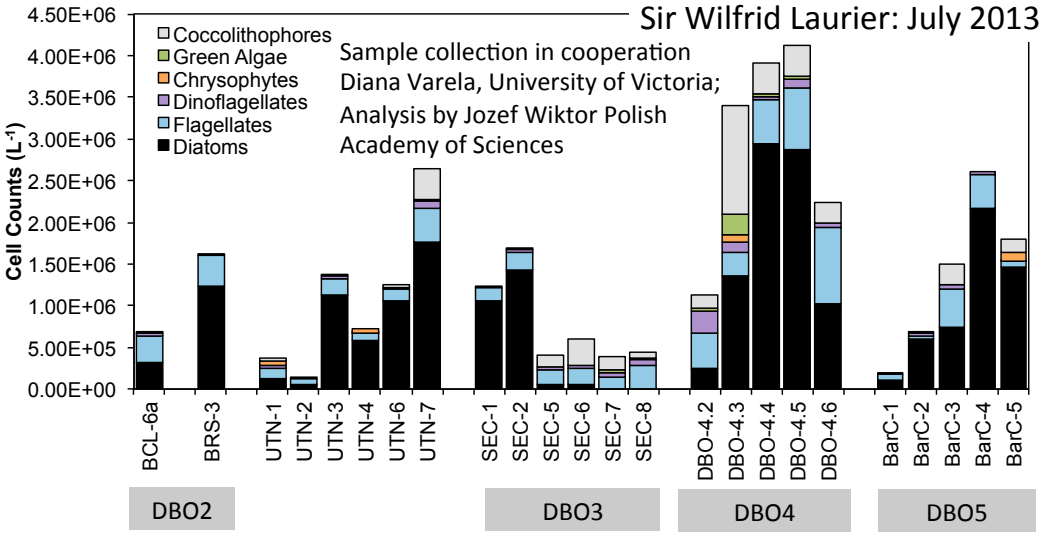
Plankton and DBO Data Products-Jackie Grebmeier

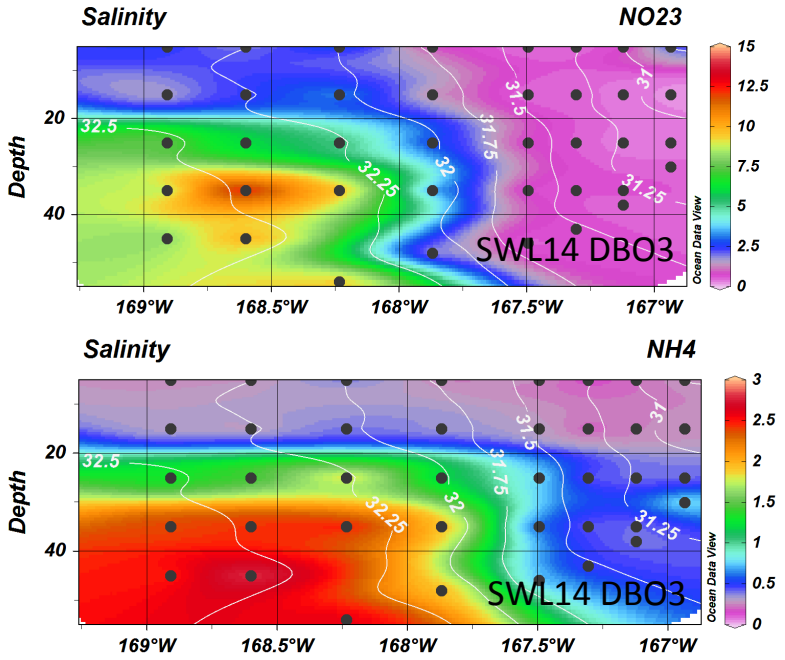


Top Left: Integrated Chlorophyll *a* during annual DBO cruise

Bottom left*:* Phytoplankton taxonomy, with dominance by diatoms in western side maintained by nutrient rich Anadyr and Bering Shelf waters

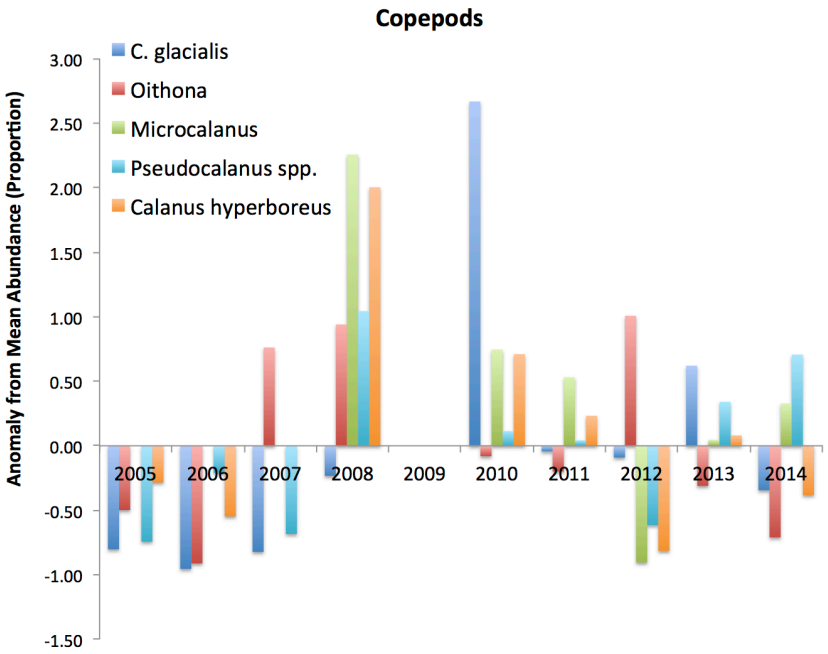
Bottom right: nitrate/nitrite (top panel) and ammonium (bottom panel) (µM)



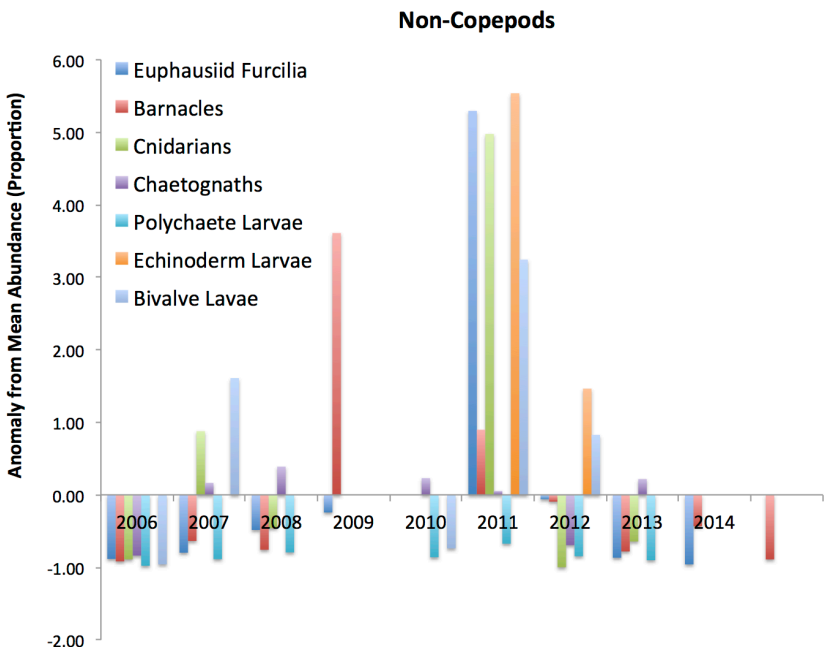


Zooplankton abundances varied interannually by taxa/species

COPEPODs



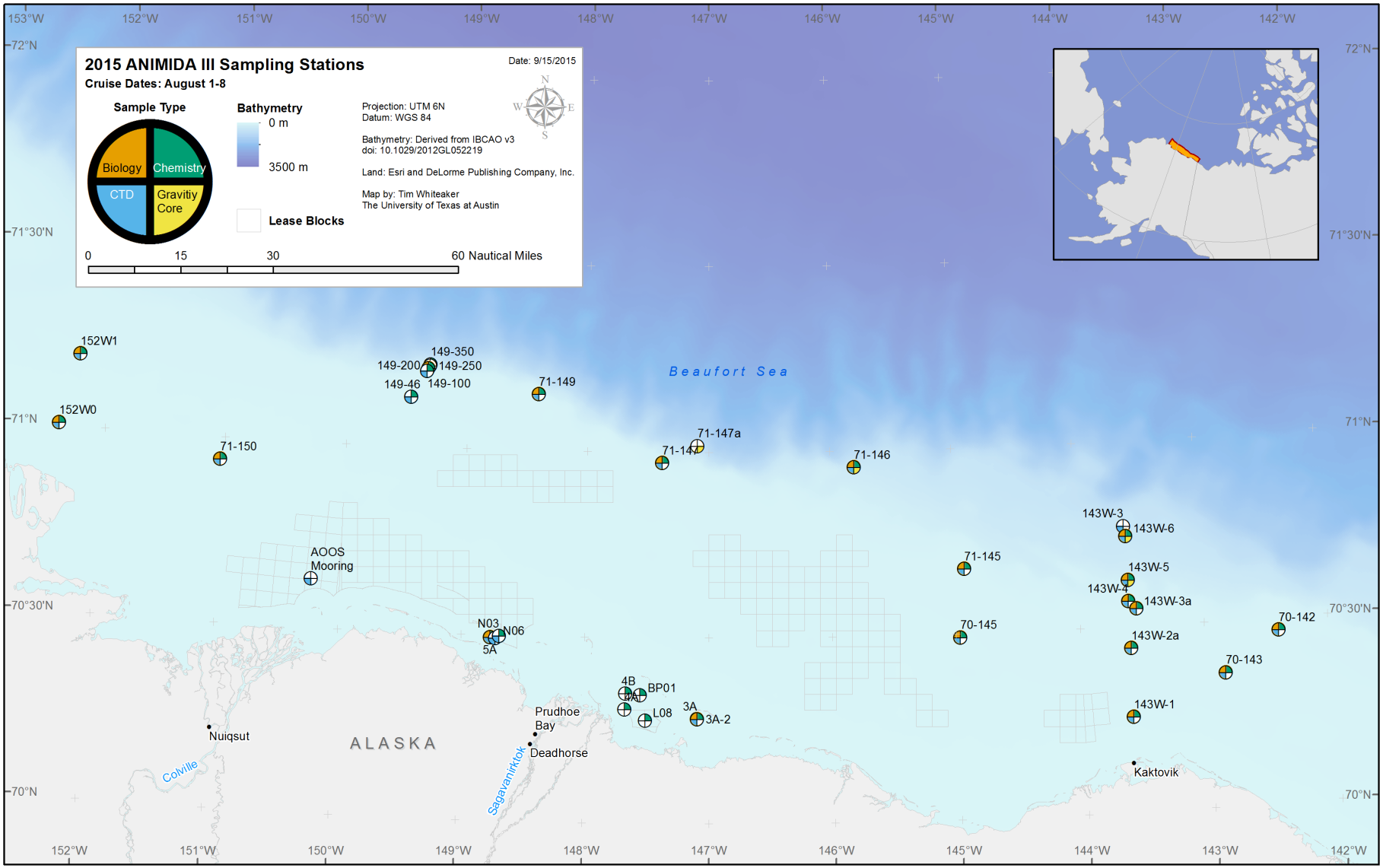
NON-COPEPODs



- Copepods had greater abundances in 2008 & 2010 than in 2005-2006
- 2011 had very high abundances of meroplankton, cnidarians, and krill furcilia

(Proportional deviation from mean abundance)

[Carin Ashjian-WHOI]


2015 ANIMIDA III Sampling Stations
Cruise Dates: August 1-8
Date: 9/15/2015
Sample Type
Biology
Chemistry
CTD
Gravitiy Core
Bathymetry
0 m
3500 m
Lease Blocks
Projection: UTM 6N
Datum: WGS 84
Bathymetry: Derived from IBCAO v3
doi: 10.1029/2012GL052219
Land: Esri and DeLorme Publishing Company, Inc.
Map by: Tim Whiteaker
The University of Texas at Austin
0 15 30 60 Nautical Miles
N
S
E
W
153°W
152°W
151°W
150°W
149°W
148°W
147°W
146°W
145°W
144°W
143°W
142°W
72°N
71°30'N
71°N
70°30'N
70°N
Beaufort Sea
ALASKA
152W1
152W0
149-350
149-200
149-250
149-46
149-100
71-149
71-150
71-147a
71-147
71-146
AOOS Mooring
N03
N06
5A
4B
4A
BP01
L08
3A
3A-2
Prudhoe Bay
Deadhorse
Nuiqsut
Colville
Sagavanirktok
Kaktovik
71-145
70-145
143W-3
143W-6
143W-5
143W-4
143W-3a
143W-2a
143W-1
70-142
70-143

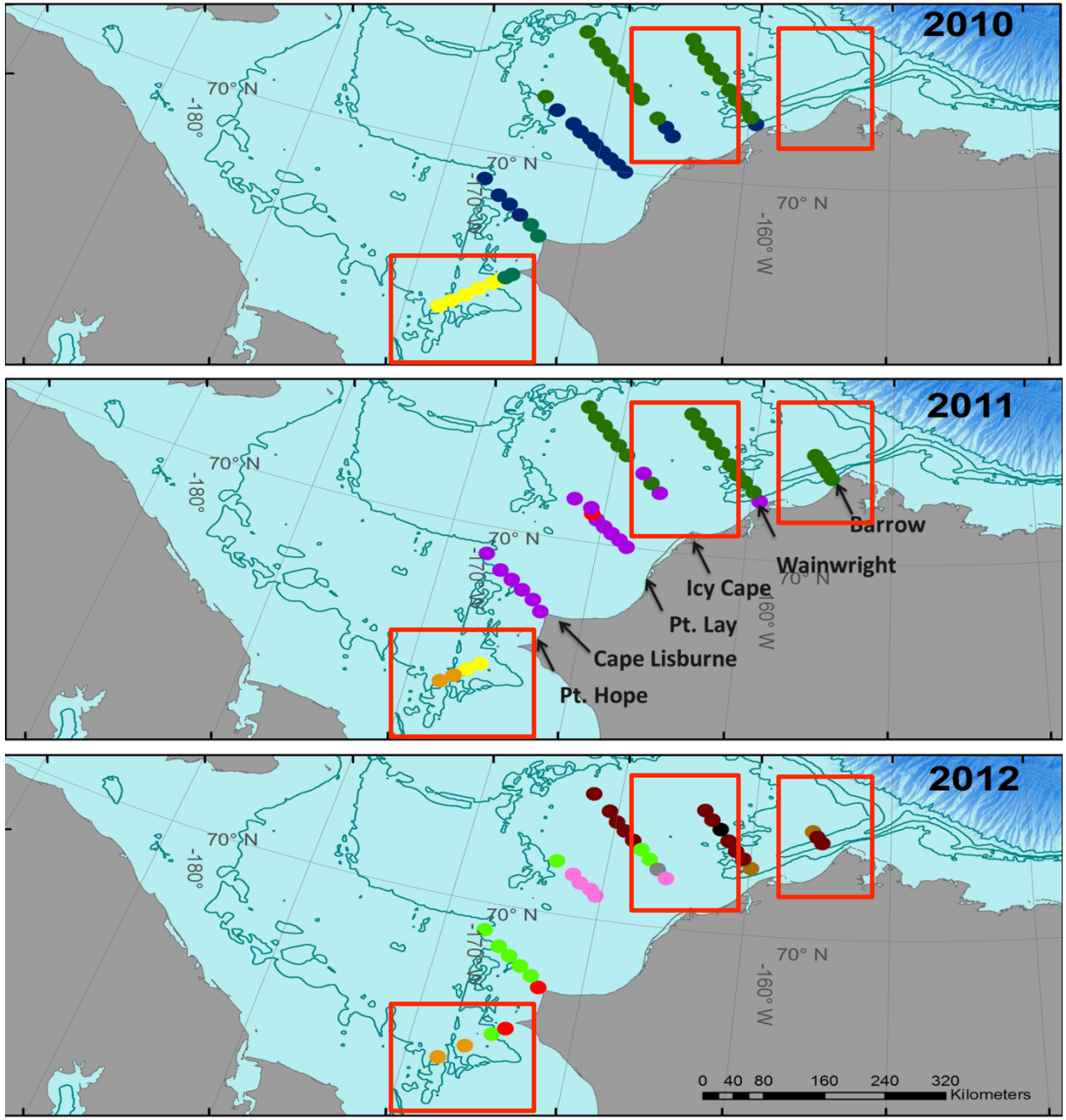
[Cathy Coon]

CHAOZ data: Zooplankton community cluster analysis

Dark green:
larvaceans
cnidarians
cirripedia
Pseudocalanus spp.
Oithona spp.

Dark red:
Calanus glacialis

Dark Blue:
cladocerans
thecosomata



BOEM
Bureau of Ocean Energy Management

Adam Spear, Jeff Napp, Janet Duffy-Anderson, Sigrid Salo, Phyllis Stabeno

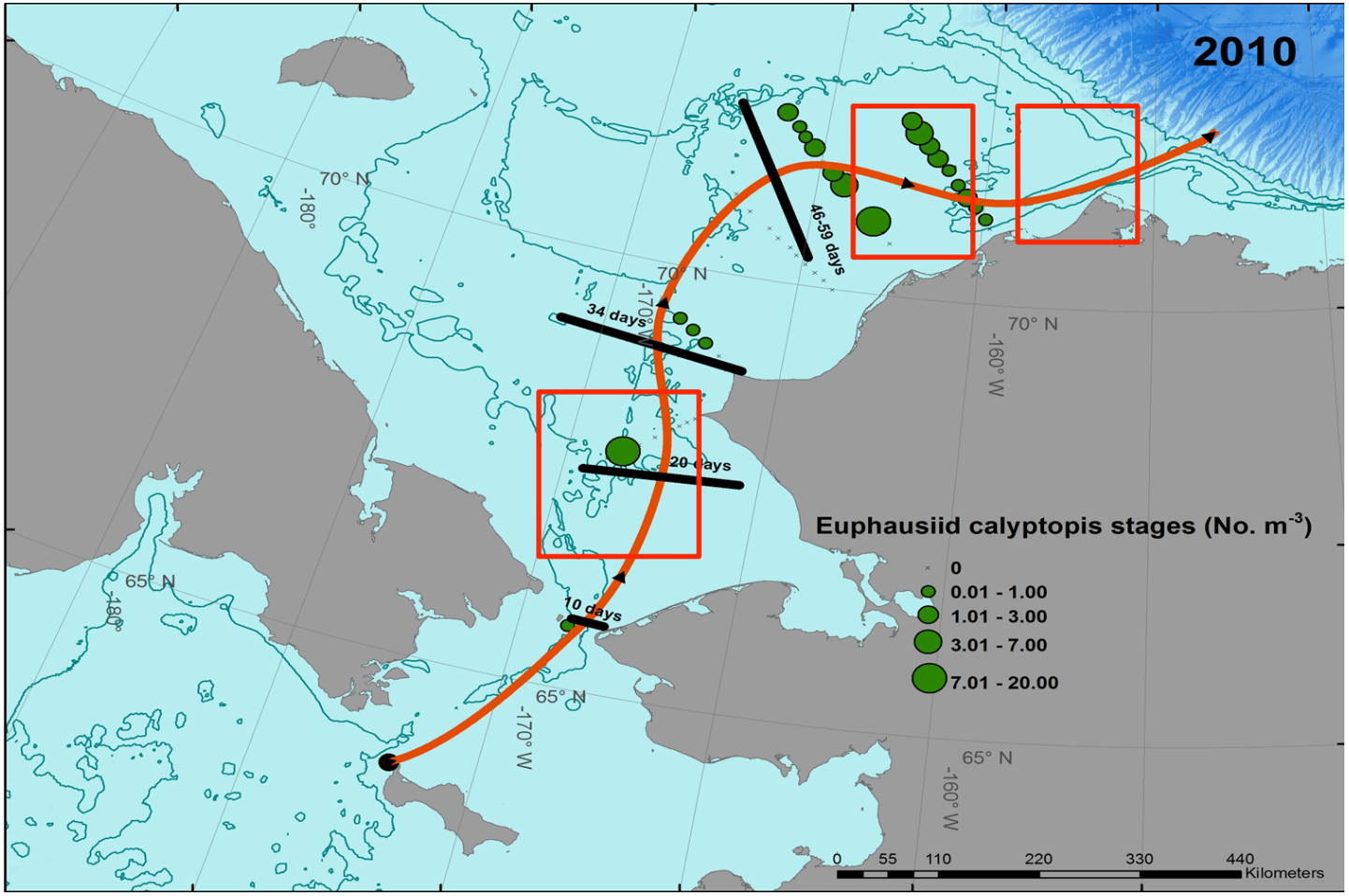
Mean abundances (No. m^{-3}) of maior taxa

Taxon	Year		
	2010	2011	2012
Euphausiids			
Calyptopis stage	1.18	0.03	0.04
Furcilia stage	9.75	6.61	8.38
Juvenile and adult stages	0.19	0.22	0.95
Amphipods			
Hyperiid amphipods	0.12	2.68	0.52
Gammarid amphipods	0.11	0.01	1.76
Copepods			
Pseudocalanus spp.	1052.69	1025.19	737.56
Calanus glacialis	82.08	63.25	290.48
Calanus hyperboreus	0.00	2.71	0.00
Other non-crustacean taxa			
Larvaceans	781.22	1096.01	8.10
Pteropods (with and without shells)	126.95	11.64	5.05
Chaetognaths	46.71	47.00	27.57

BOEM
Bureau of Ocean Energy Management

Adam Spear, Jeff Napp, Janet Duffy-Anderson, Sigrid Salo, Phyllis Stabeno (CHAOZ)

Transport duration of zooplankton from St. Lawrence Island to the northeast Chukchi



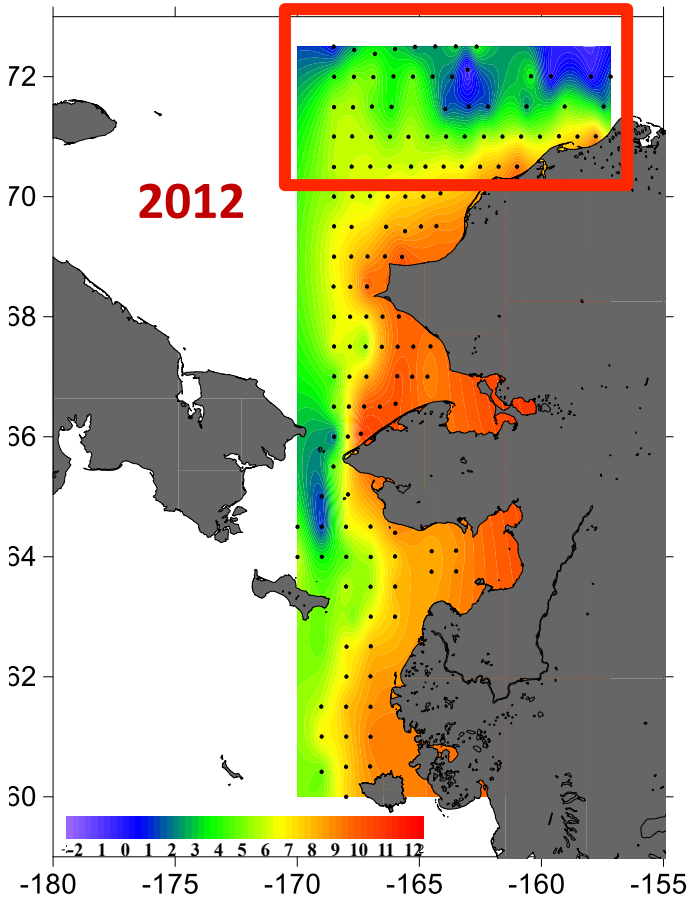
Green circles indicate counted number of euphausiid calyptopis

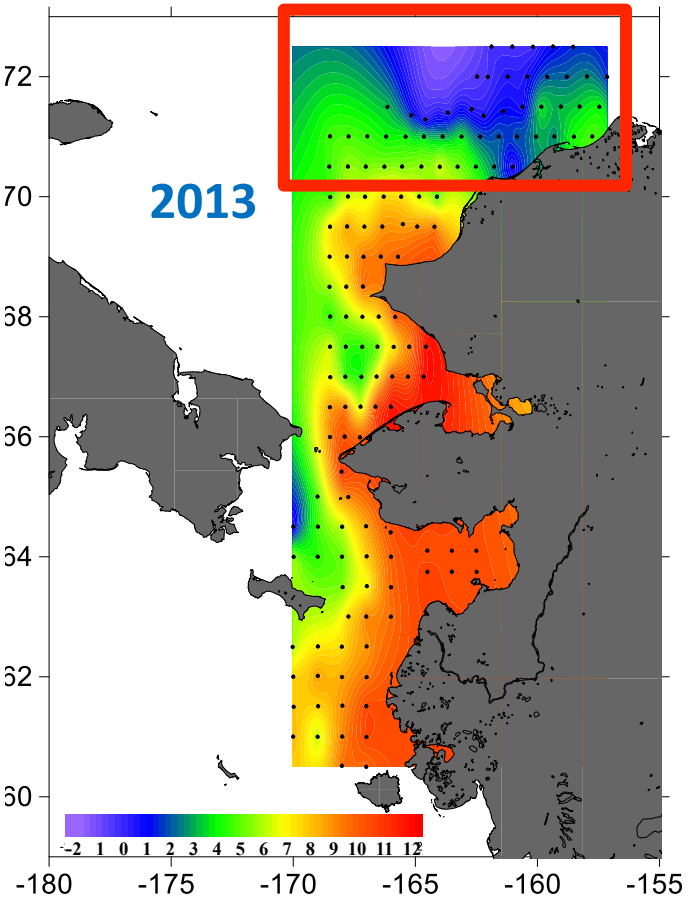
BOEM Bureau of Ocean Energy Management

Adam Spear, Jeff Napp, Janet Duffy-Anderson, Sigrid Salo, Phyllis Stabeno (CHAOZ)

Arctic EIS:

Temperature above pycnocline, 07Aug-24Sep





- most differences occurring in the northeast
- ACC reduced in 2013

Coastal Impacts Assistance Program

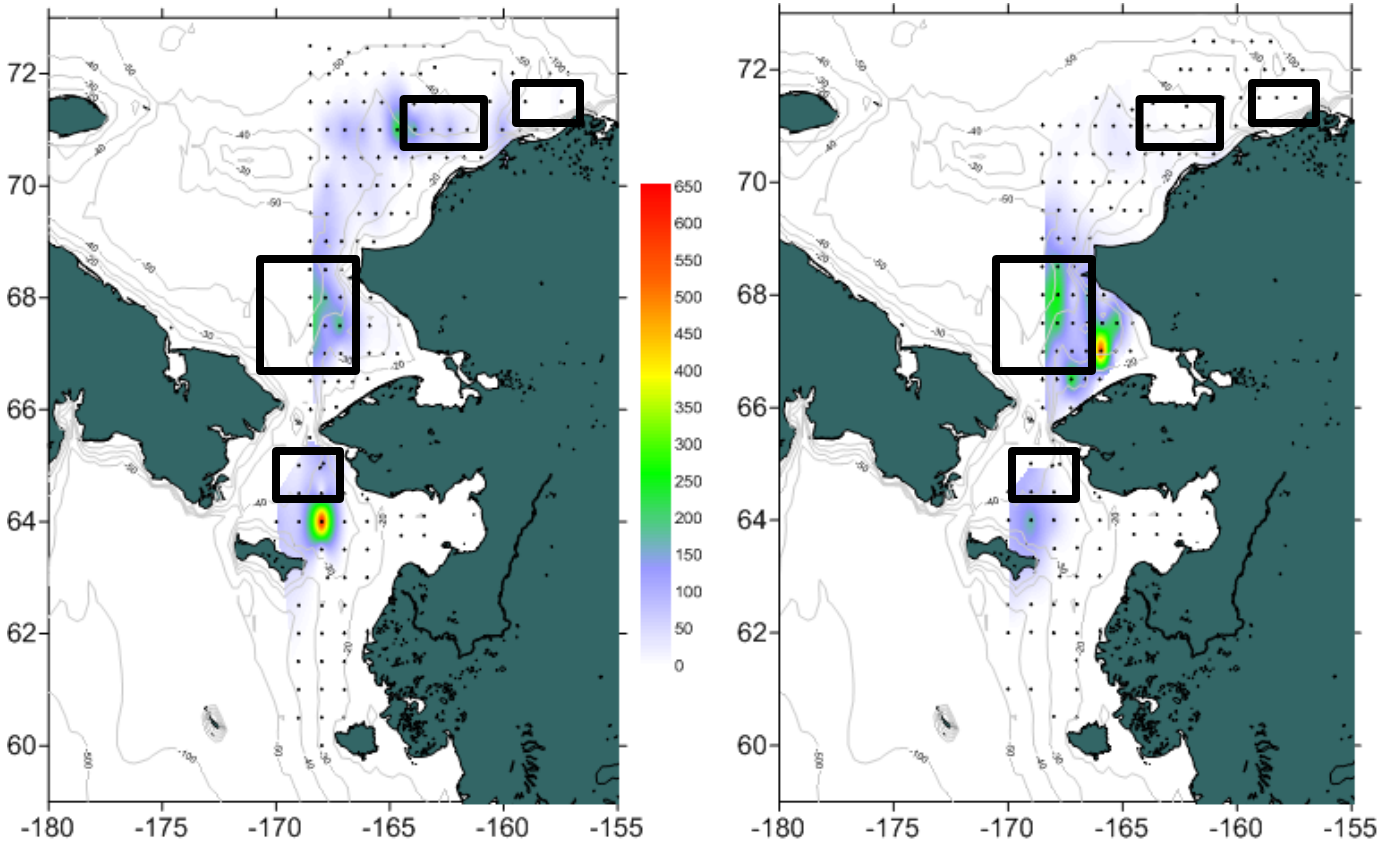
BOEM Bureau of Ocean Energy Management

Spatial Heterogeneity in Zooplankton Distribution…

Pinchuk & Eisner, Deep-Sea Research II, in revision

Pacific Species Complex

2012



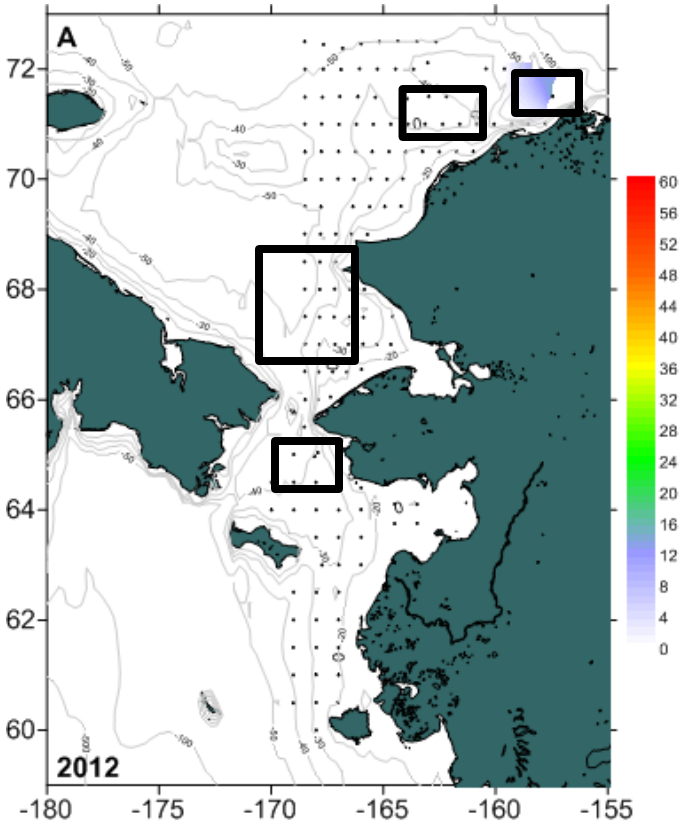
2013

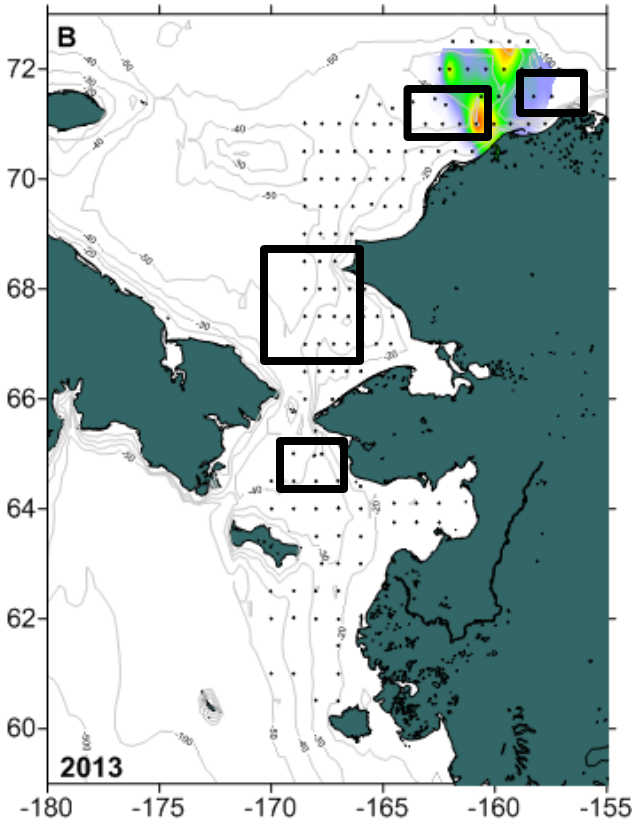
	T_{above}	T_{below}	S_{above}	S_{below}
Correlation (p<0.05)	-0.041	-0.092	**0.510**	**0.439**

- **strong positive correlations to salinity indicate a link to the Bering/ Chukchi Summer Water**
- **occur over the Central Channel and in northeast in 2012, but restricted to southern shelf in 2013** *Pinchuk & Eisner, Deep-Sea Res. II, in revision*

Arctic Species Complex

2012





2013

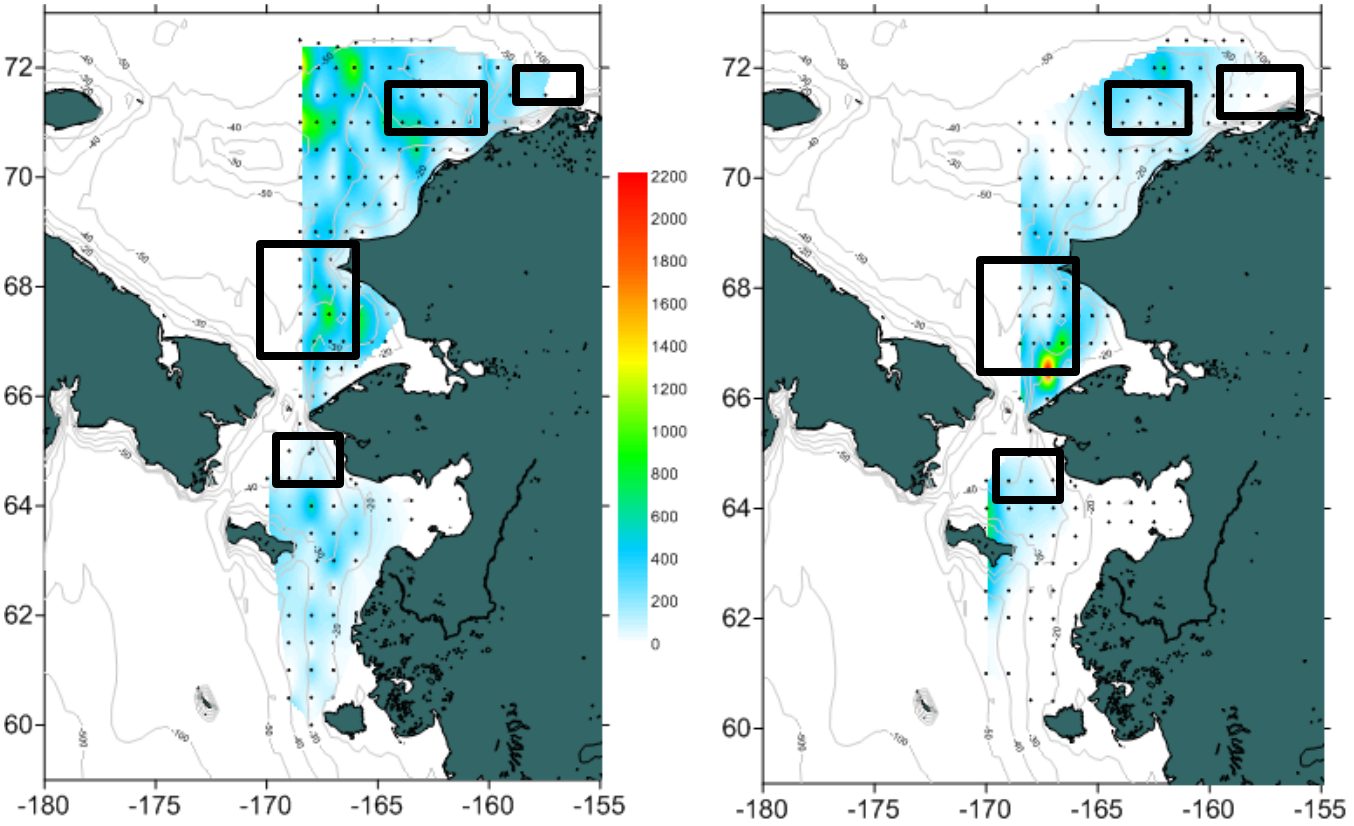
	T_{above}	T_{below}	S_{above}	S_{below}
Correlation (p<0.05)	-0.541	-0.468	-0.440	0.080

- **strong negative correlations to temperature and salinity above the pycnocline, indicate a link to Melt Water**
- **virtually absent in 2012, but expanded in the northeast in 2013**

Pinchuk & Eisner, Deep-Sea Research II, in revision

Calanus glacialis

2012

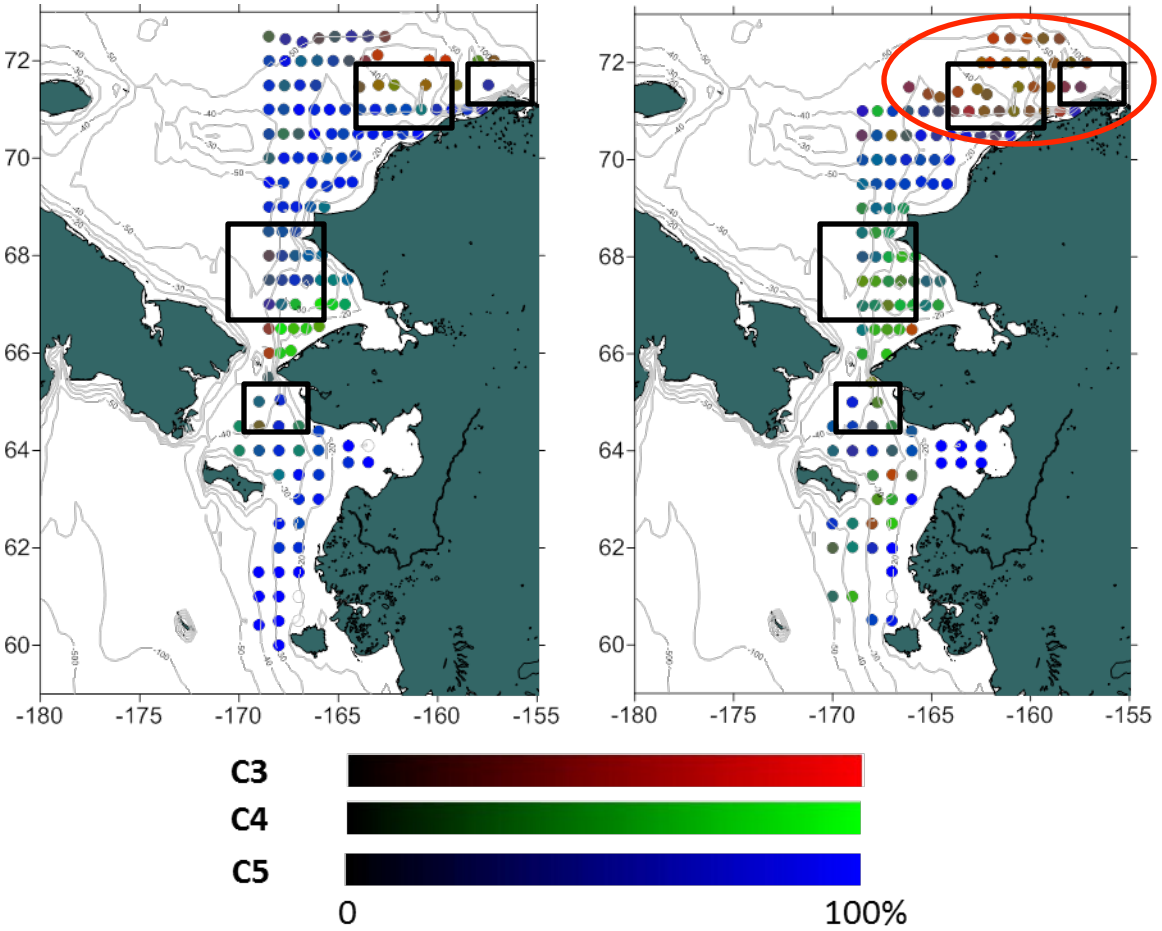


2013

- **occur over the Central Channel and in the northeast in 2012**
- **two centers of distribution in 2013: south and northeast**

Pinchuk & Eisner, Deep-Sea Research II, in revision

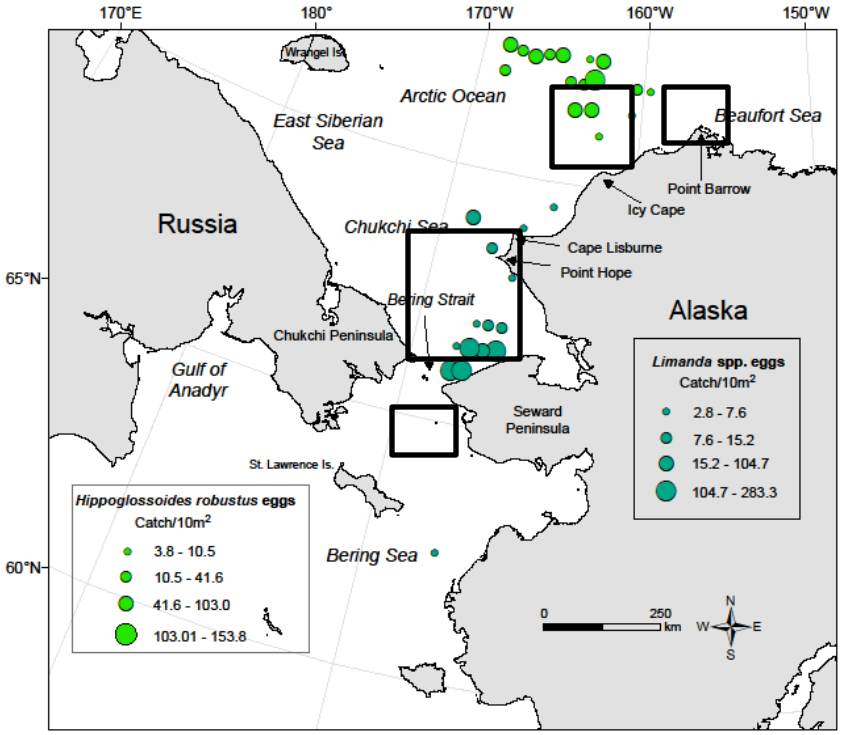
Calanus glacialis developmental stage composition



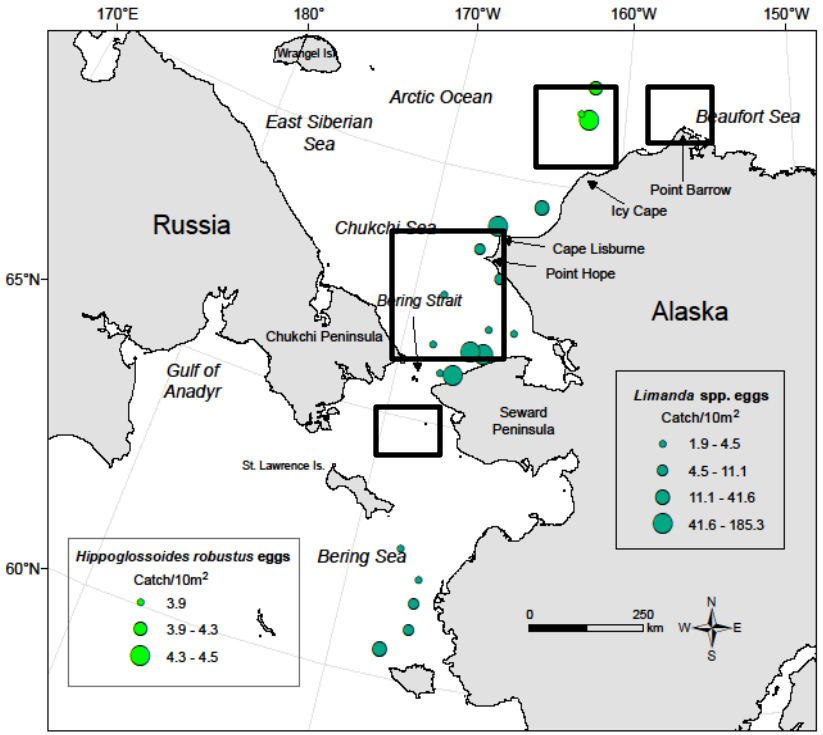
- "older" C5 copepodites over the eastern shelf in 2012
- "younger" C3 copepodites in the northeast in 2013
- two populations of separate origins: the Arctic population with longer development times expanded in 2013.

Pinchuk & Eisner, Deep-Sea Research II, in revision

Abundance and distribution of *Limanda* spp. (yellowfin sole) and *Hippoglossoides robustus* (Bering flounder) eggs

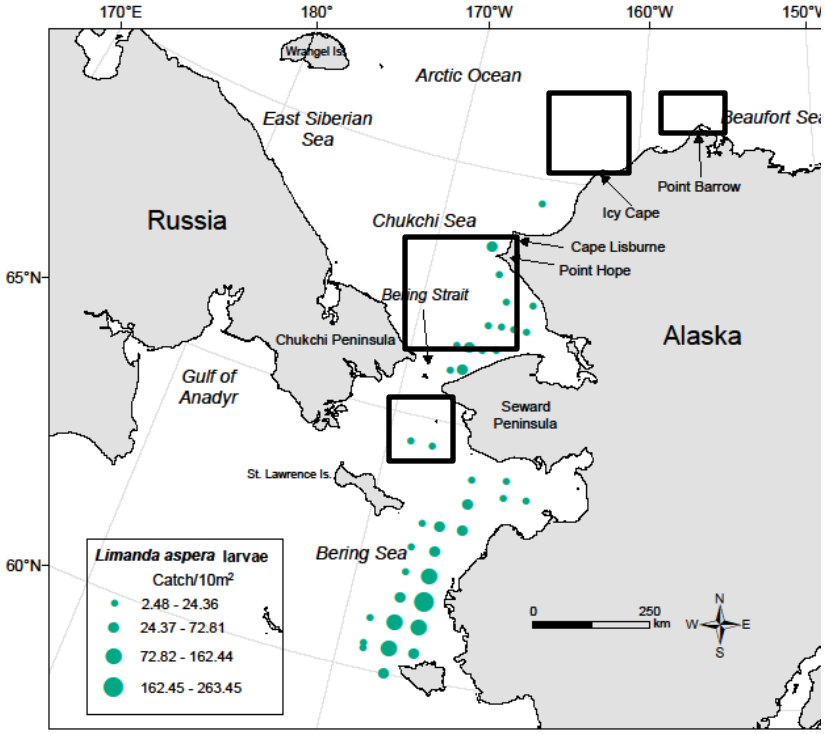


2012

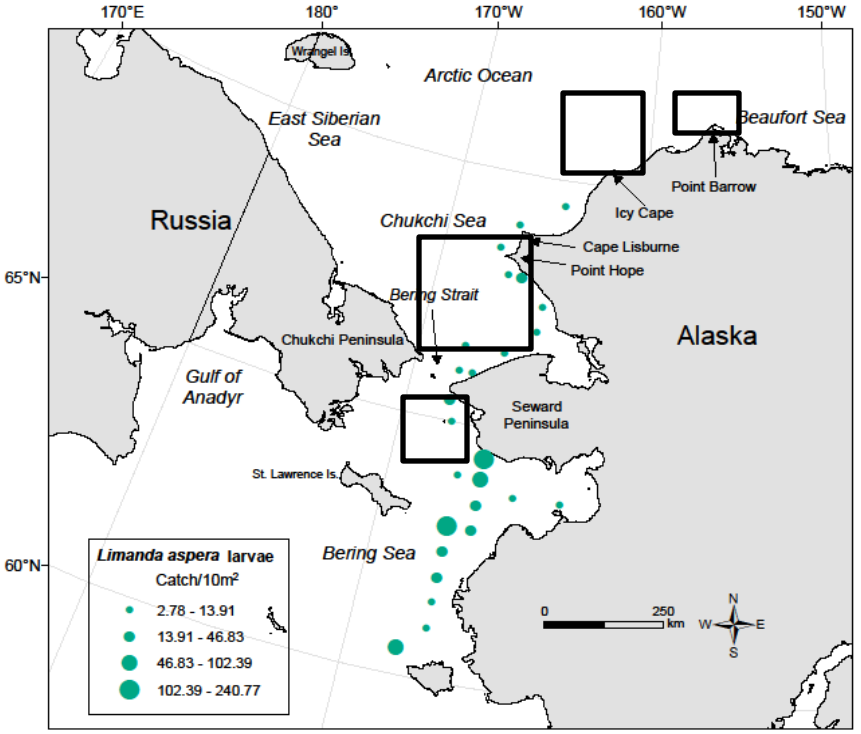


2013

Abundance and distribution of *Limanda aspera* (yellowfin sole) larvae



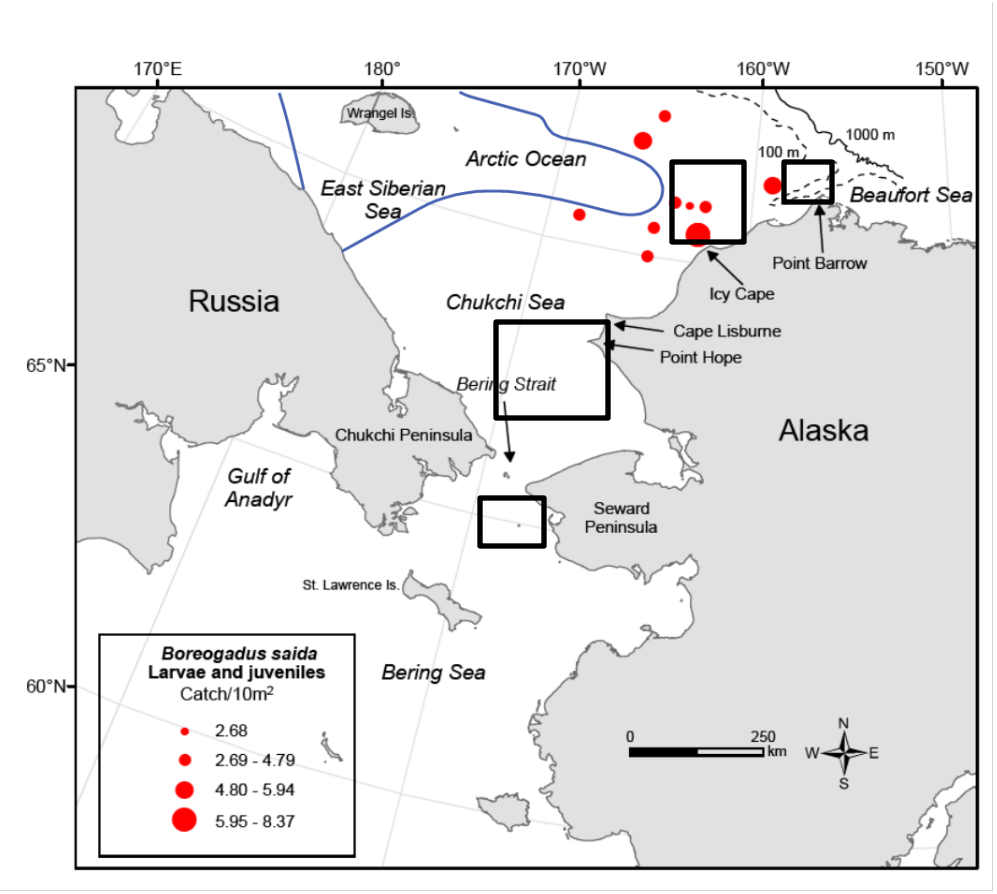
2012



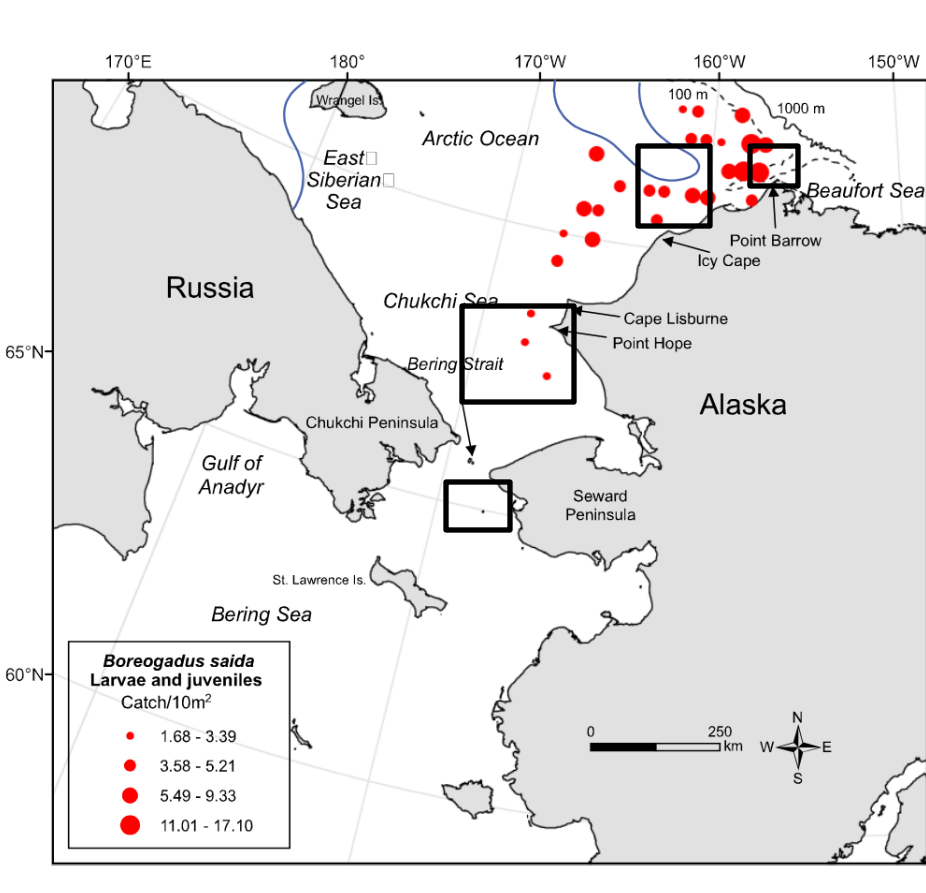
2013

Morgan Busby, Janet Duffy-Anderson, Kathryn Mier, Heather Tabisola

Abundance and distribution of *Boreogadus saida* (Arctic cod) larvae and juveniles

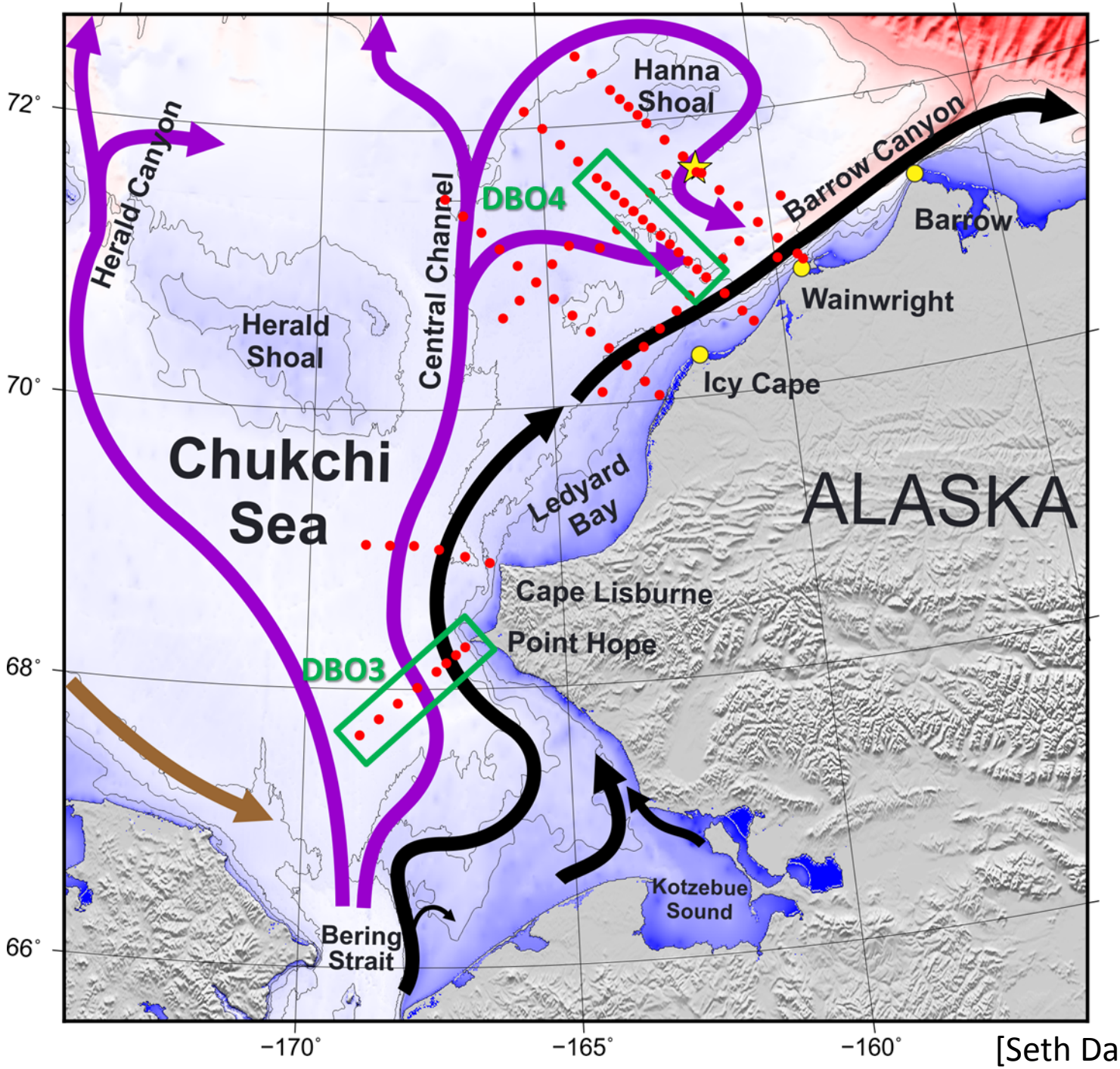


2012



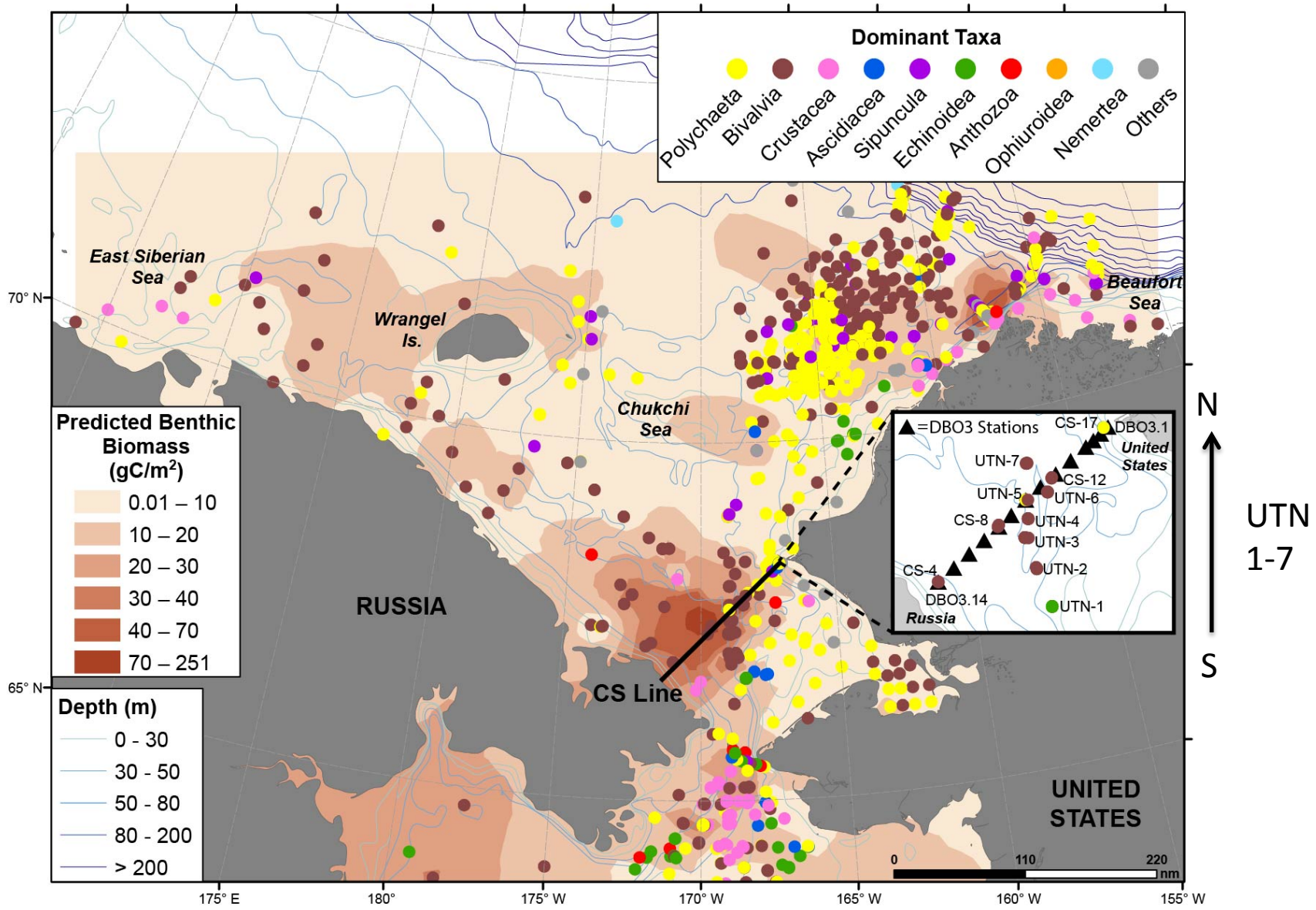
2013

Morgan Busby, Janet Duffy-Anderson, Kathryn Mier, Heather Tabisola



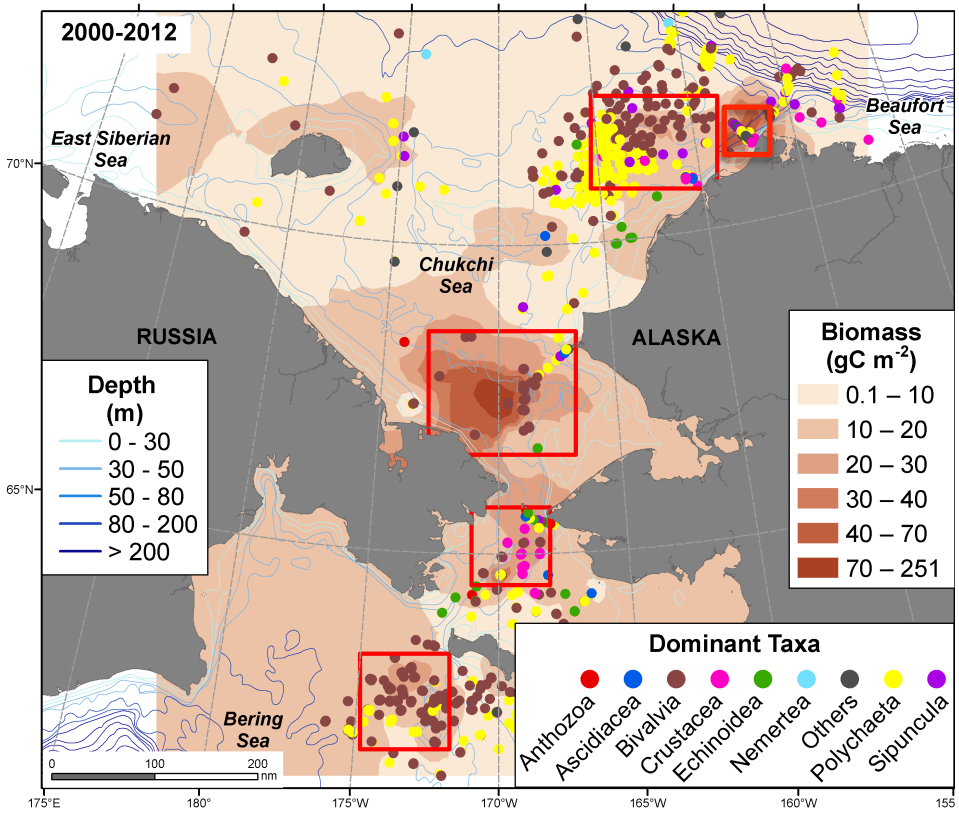
[Seth Danielson]

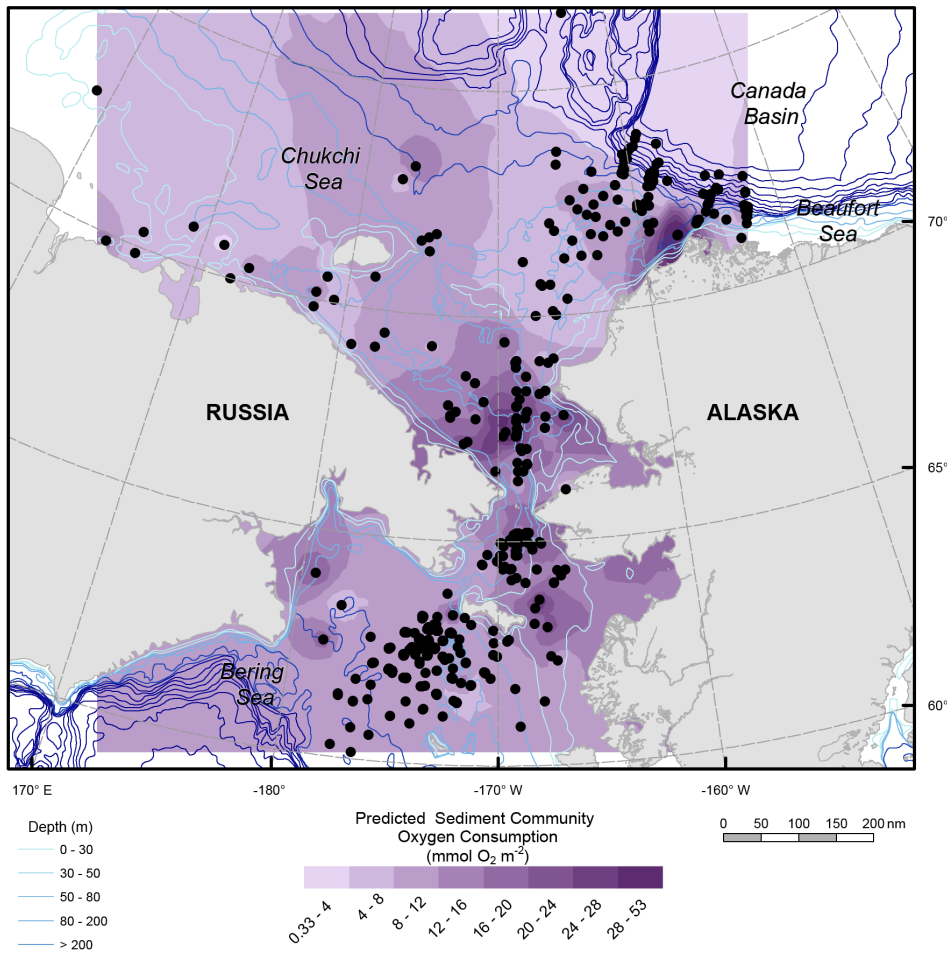
Spatial distribution of macrofaunal biomass in the Pacific Arctic (1973-2012), with time series line (RUSALCA CS=DBO3)



[Grebmeier et al. 2015, Oceanography]

Distribution of benthic biomass and dominant fauna, with DBO bounding boxes



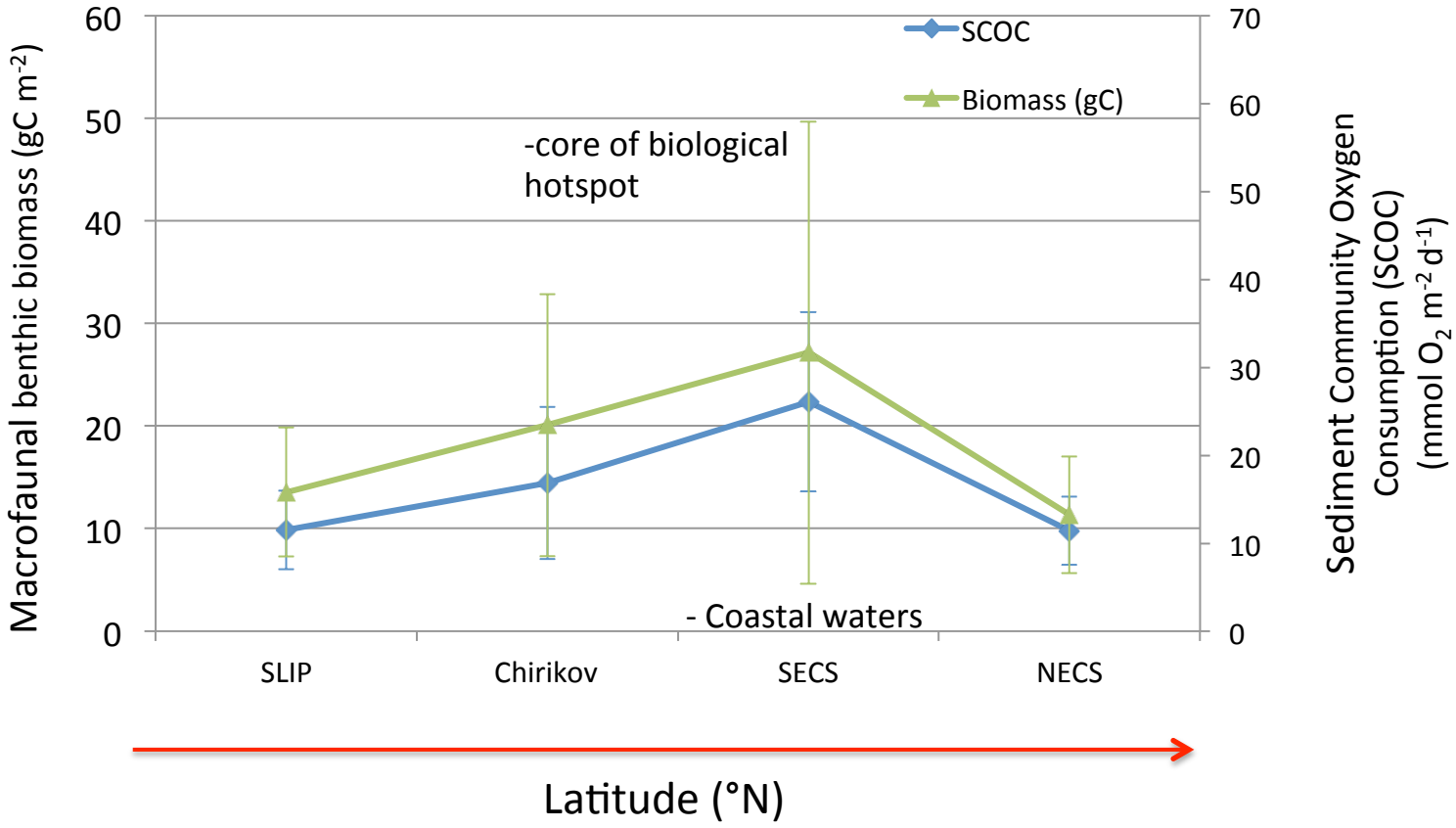


- Macrofaunal biomass increasing along a latitudinal gradient from northern Bering Sea to southern Chukchi Sea
- Recently hotspot areas sampled as part of Distributed Biological Observatory effort

- Sediment community oxygen consumption as indicator of carbon supply to the benthos

[modified from Grebmeier 2012; Grebmeier et al. 2015]

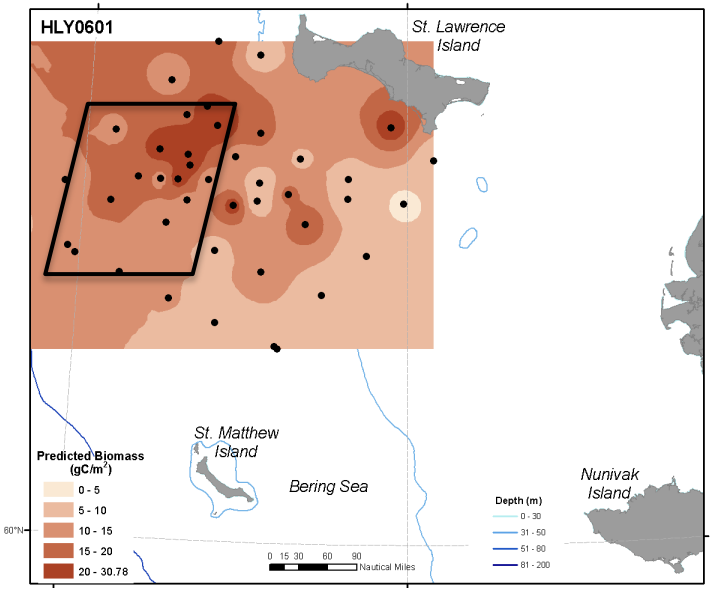
Latitudinal Trends in Macrofaunal Benthic Biomass and Carbon Supply

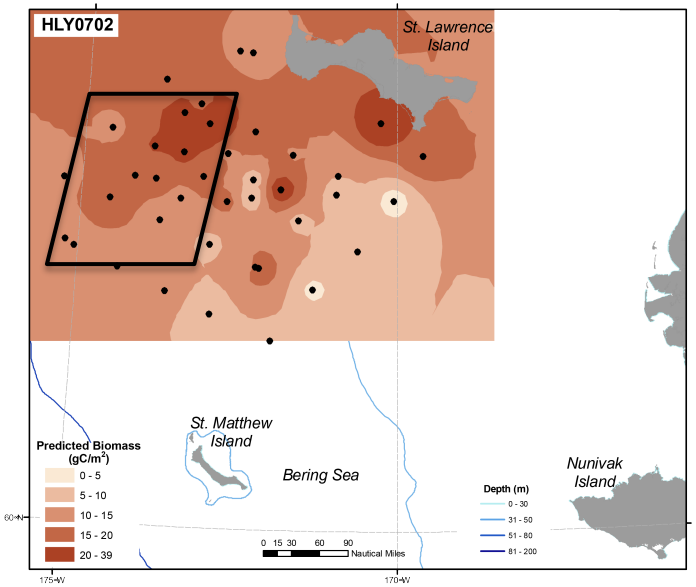


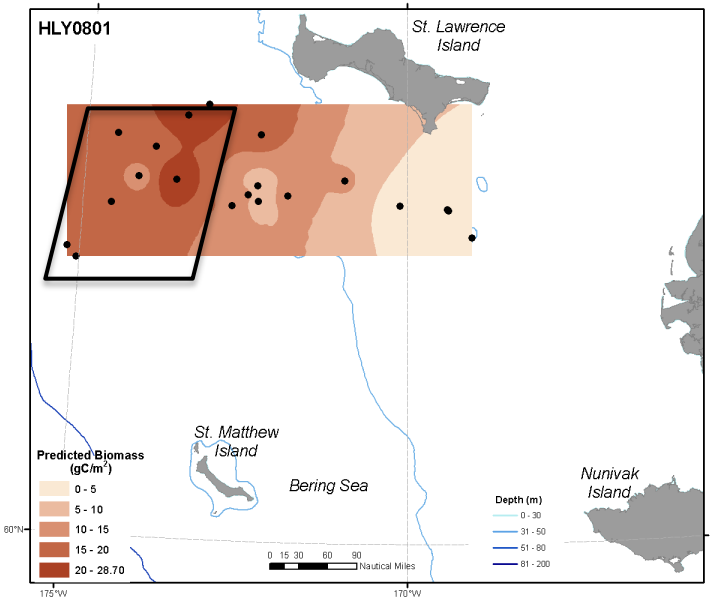
- High variability of macrofaunal biomass (green) in SE Chukchi Sea as bounding box covers both Bering Shelf-Anadyr Water (highest values) and Alaska Coastal Water (ACW) (lowest values) 2000-2012
- Finer sediments in offshore BSAW and coarser sediments in nearshore ACW indicates advective nature of overlying water flow and deposition patterns

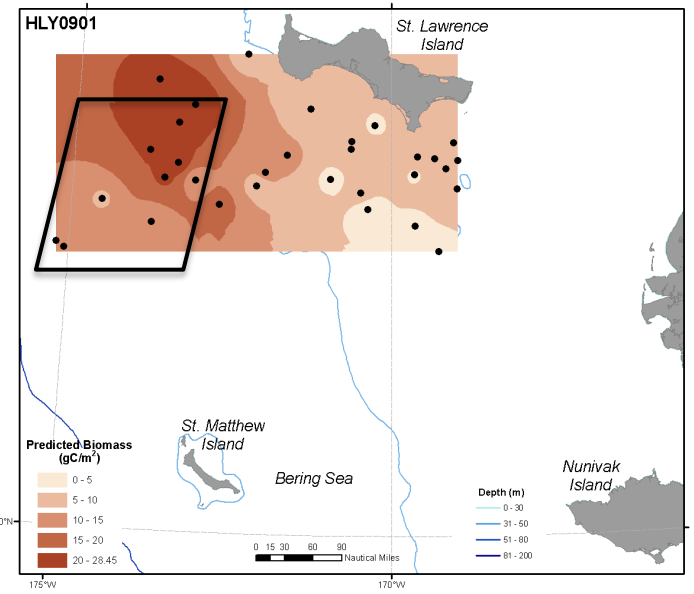
[Jackie Grebmeier]

Spatial gradient in benthic biomass (gC/m^2) in the northern Bering Sea-high west to low east trend; northward focus high biomass zone







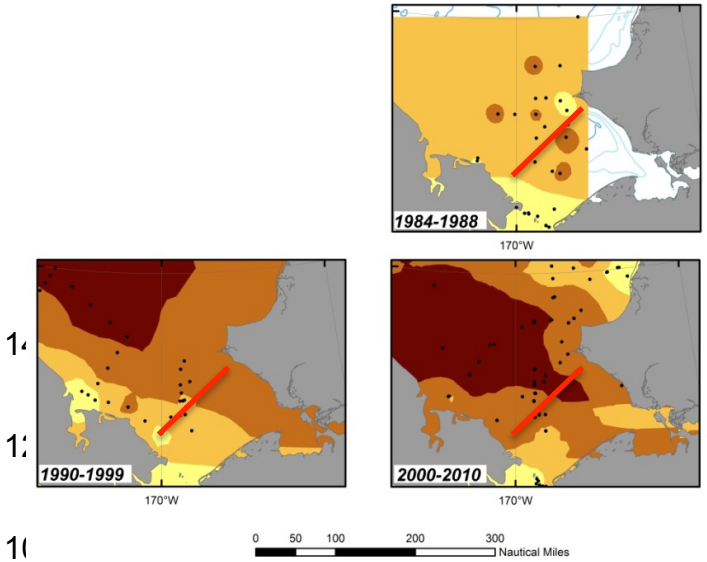


- Northward direction of core benthic biomass in hotspot

[Grebmeier and Cooper 2015, Springer Dual Career book chapter, in press]

SE Chukchi Sea (DBO3)

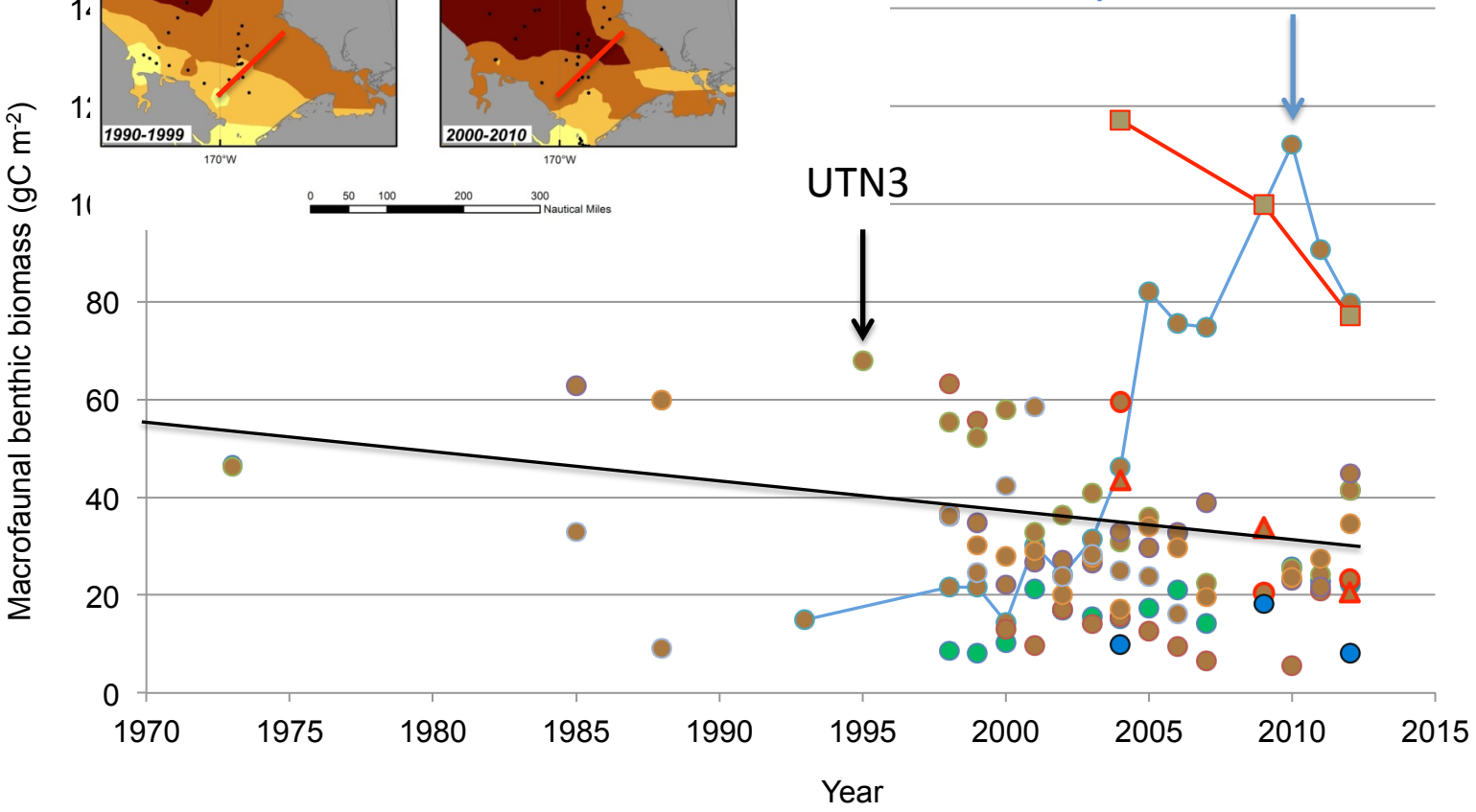
Southern Chukchi

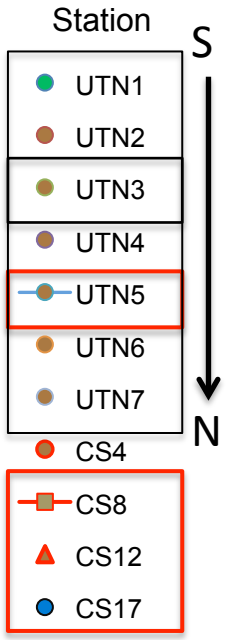


Predicted Silt & Clay Grain Size Fraction (%)
0 - 25
25 - 50
50 - 75
75 - 100

- Northward direction of core benthic biomass in hotspot to UTN5

[Stations on CS line]

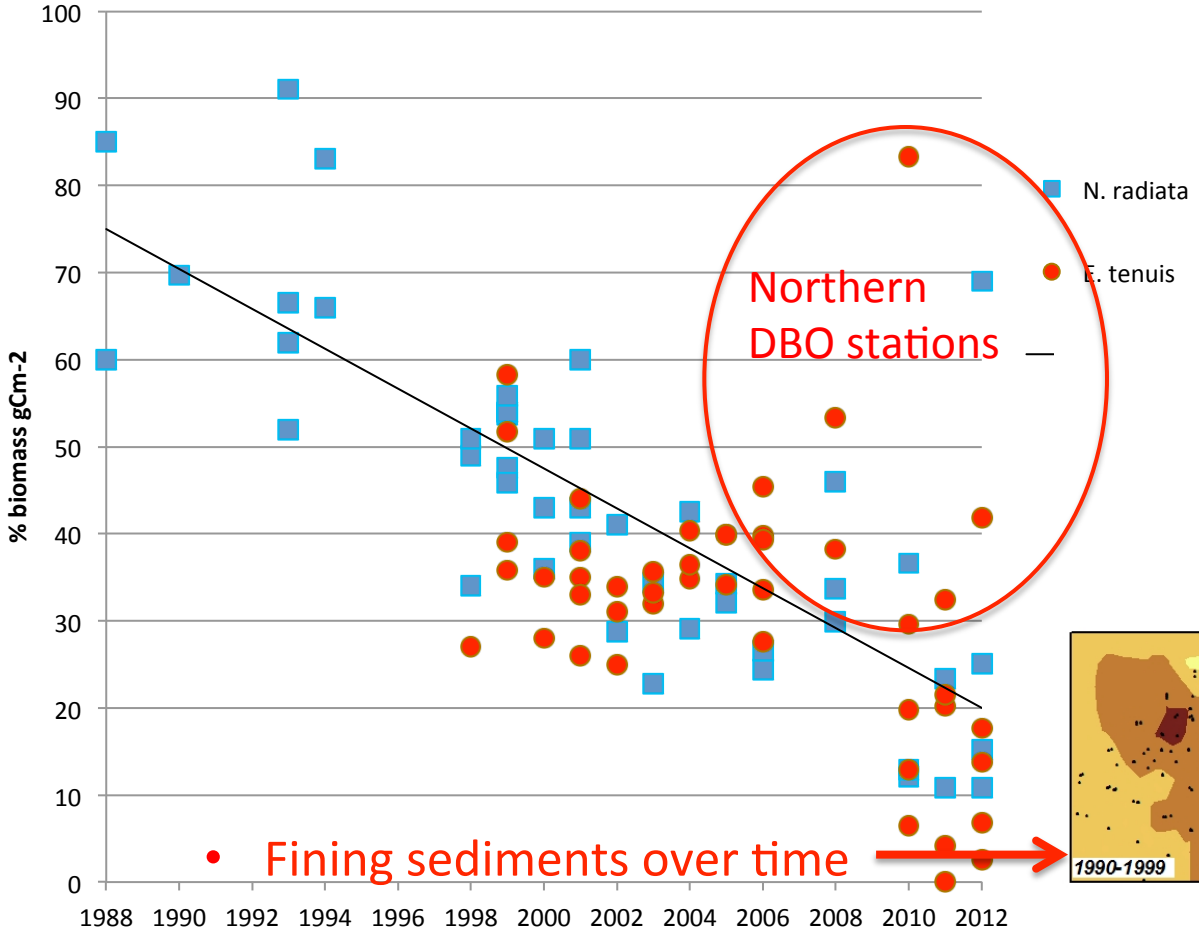


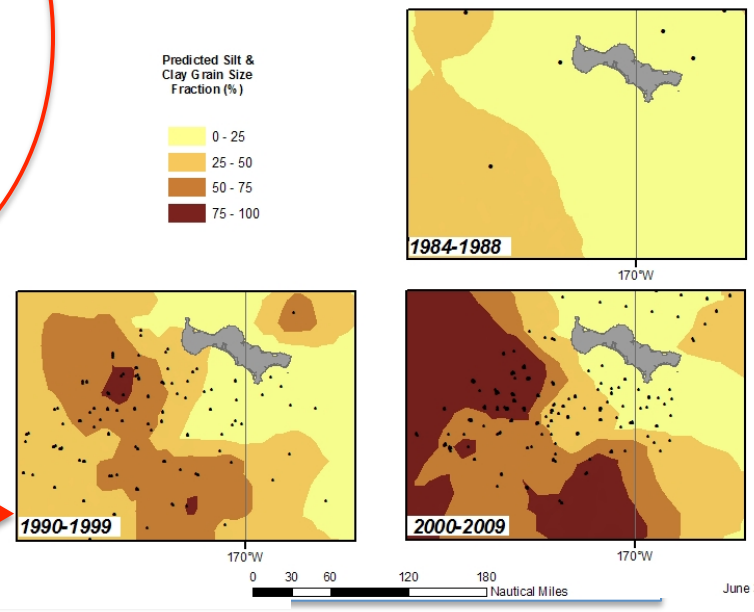


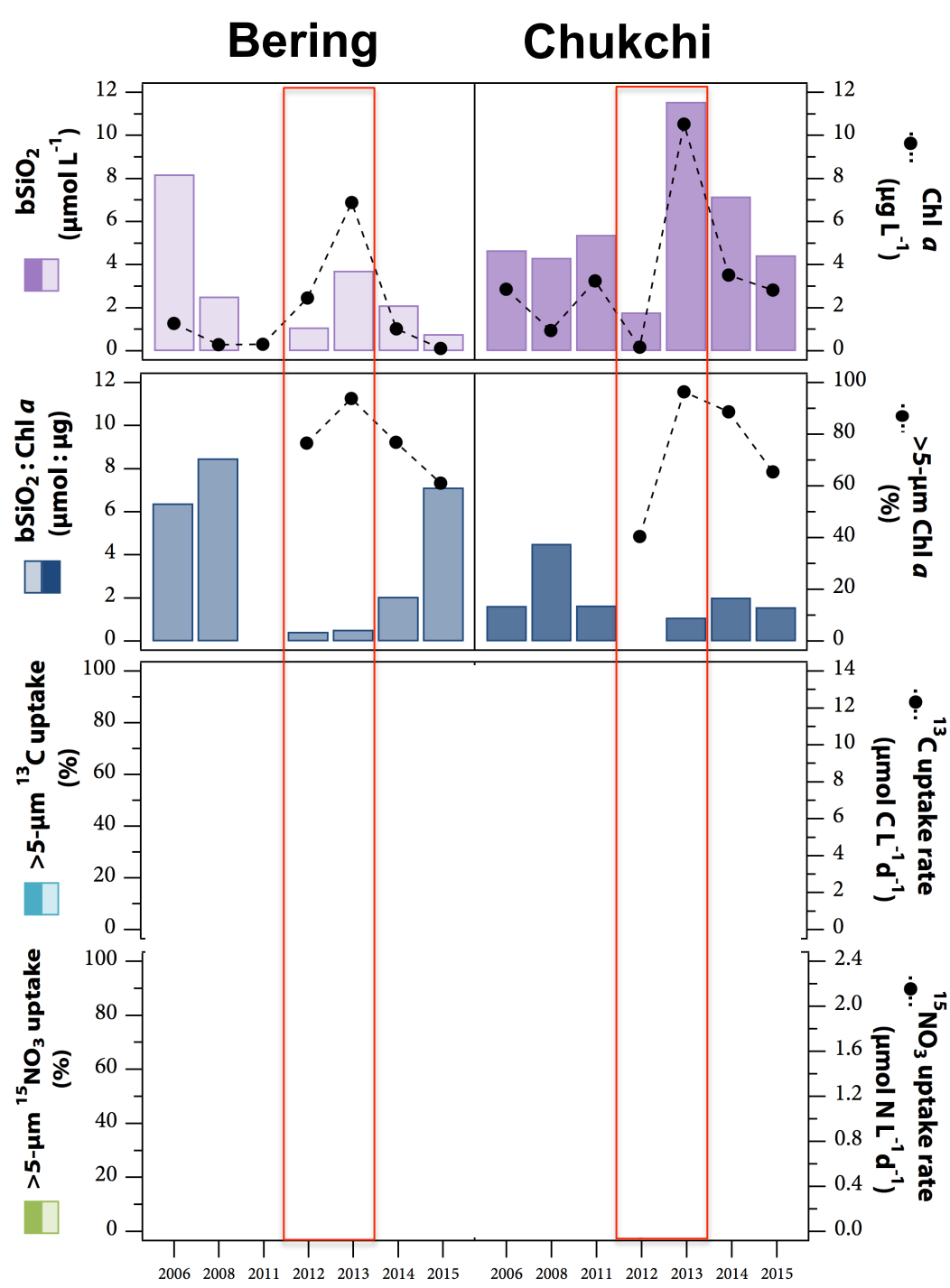
[Grebmeier et al. 2015 Oceanography]

Regional decline in dominant bivalve (*N. radiata*), with shift to smaller bivalve (*E. tenuis*) (SLIP-DBO1) [Jackie Grebmeier]

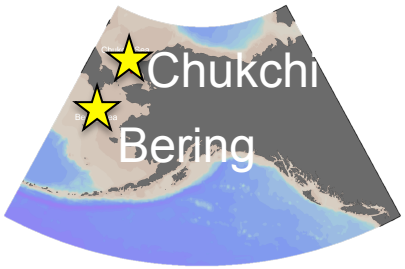
- Coincident decline in sediment community oxygen consumption indicative of reduced carbon supply to the benthos
- Impact on declining spectacled eider populations





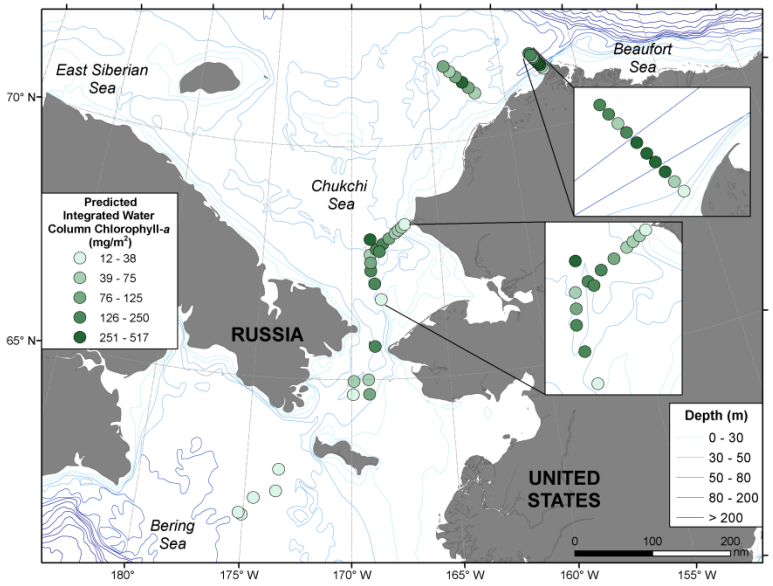


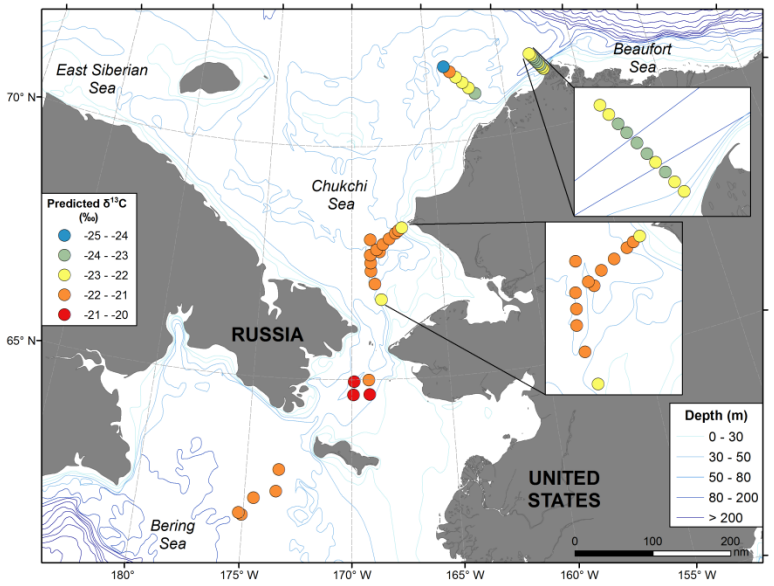
- $bSiO_2$ and chlorophyll *a*
  - Interannually variable
  - Decreasing trend from 2013
- Chukchi sea more productive with greater contribution of >5-µm cells
- 2012-2013 trend: a possible response to 2012 sea-ice minimum?

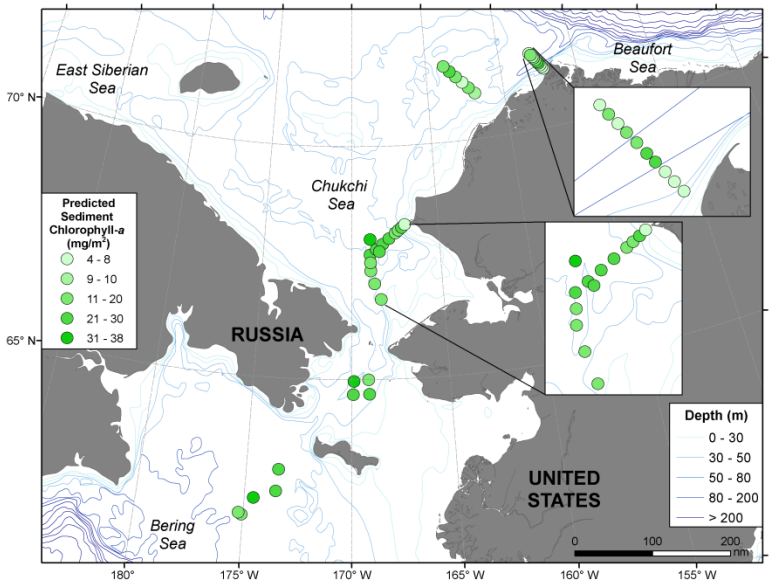


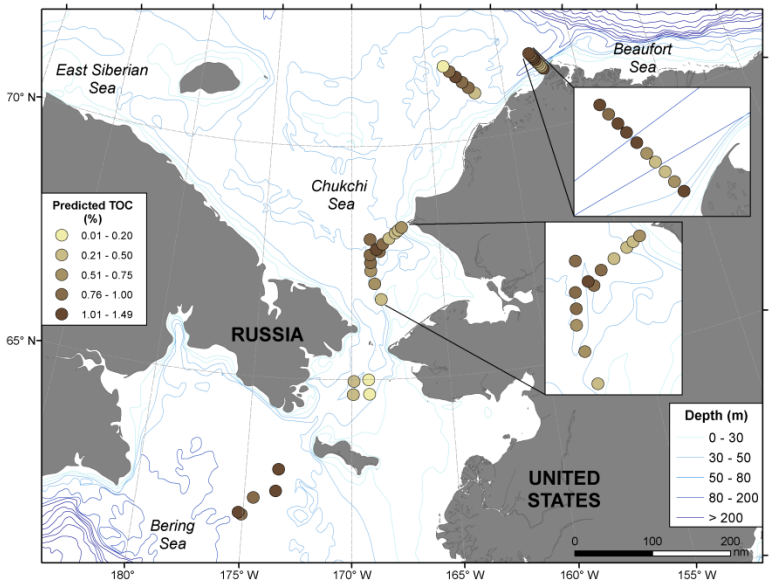
[Diana Varela]

SLW2015





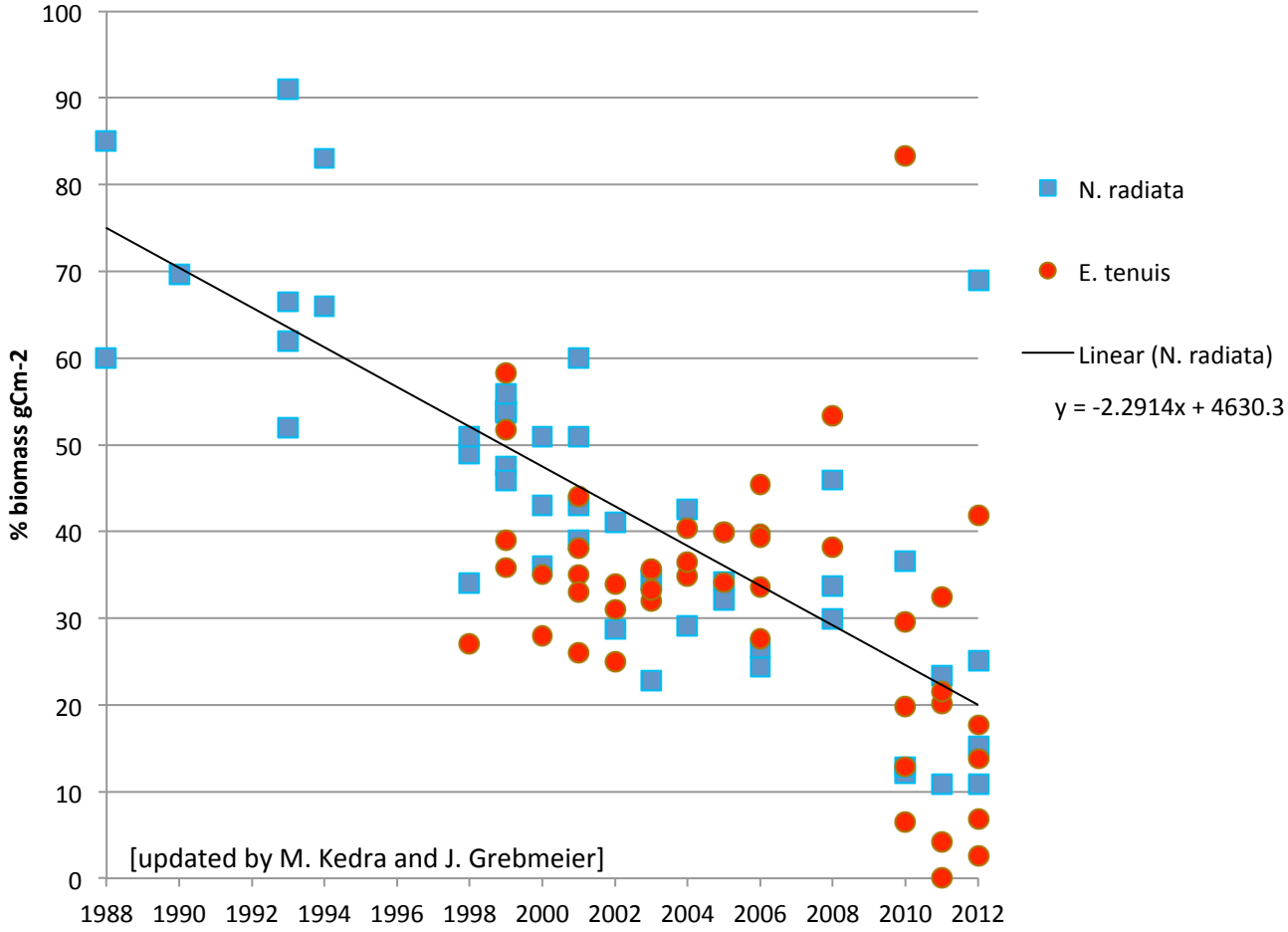




[Jackie Grebmeier and Lee Cooper]

Regional decline in dominant bivalve (*N. radiata*), with potential shift to smaller bivalve (*E. tenuis*) (SLIP-DBO1)

- Coincident decline in sediment community oxygen consumption indicative of reduced carbon supply to the benthos
- Impact on declining spectacled eider populations



dae (*Nuculana radiata*)*
e (*Ennucula tenuis*)
e (*Macoma calcarea*)
dae
idae

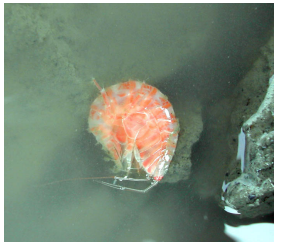
gression:
59*x* + 5,118.8
509; *p* < 0.0001

[Jackie Grebmeier]

ci. 4, 2012]

"Footprint" of ampeliscid amphipod prey hotspot contracting spatially northward in Chirikov Basin (DBO2)

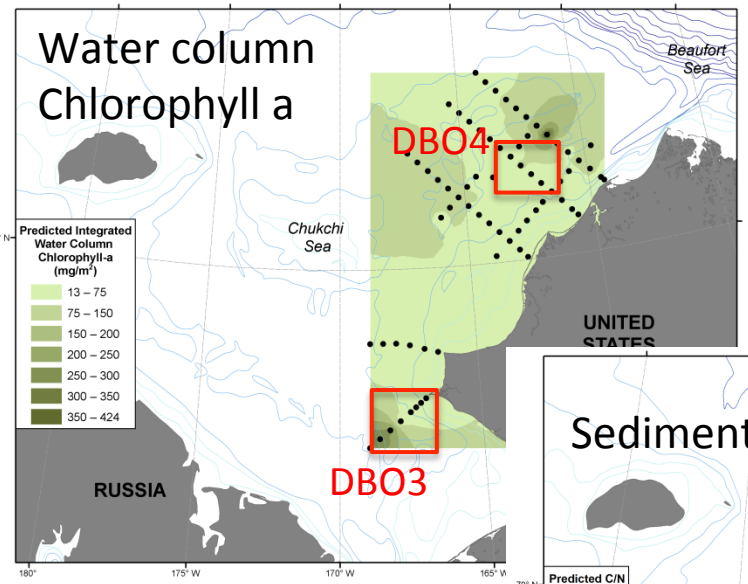
[Jackie Grebmeier]

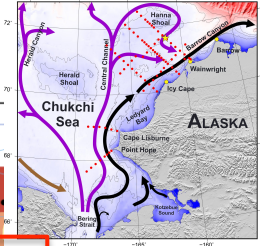


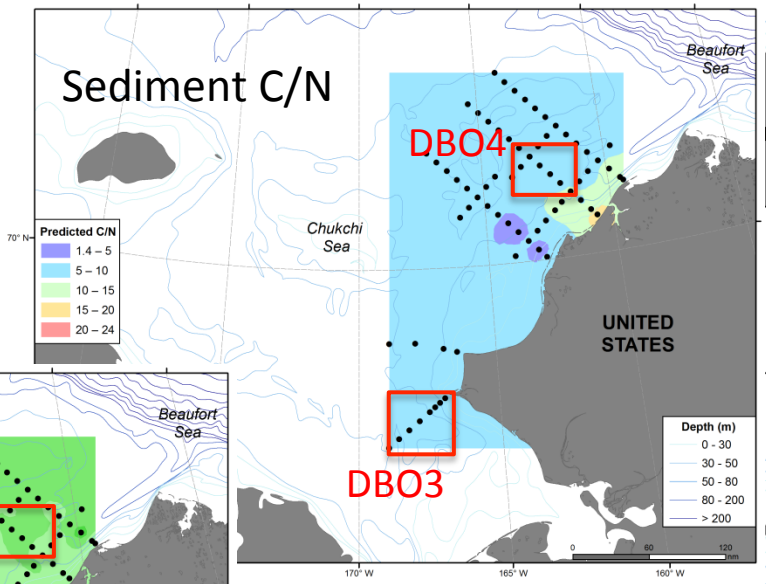
- Northward direction of core benthic biomass in hotspot
- Polychaetes replacing amphipods

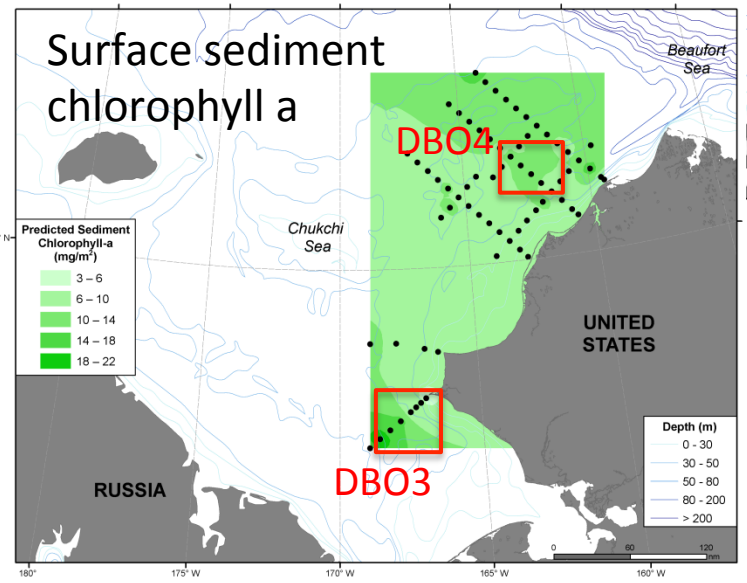
Graphic: Grebmeier, unpubl. data, see http://www.arctic.noaa.gov/dbo/dbo2-related-time-series; also Coyle et al., 2007

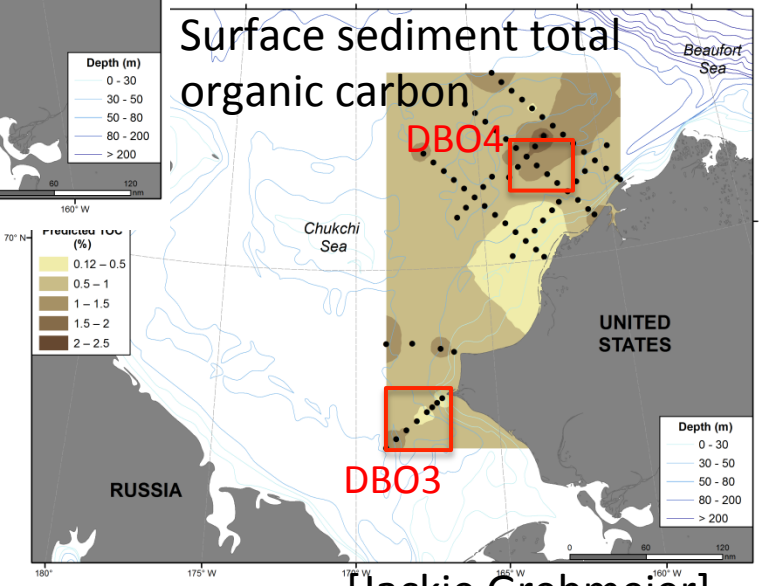
Arctic Marine Biodiversity Observing Network (AMBON) 2015







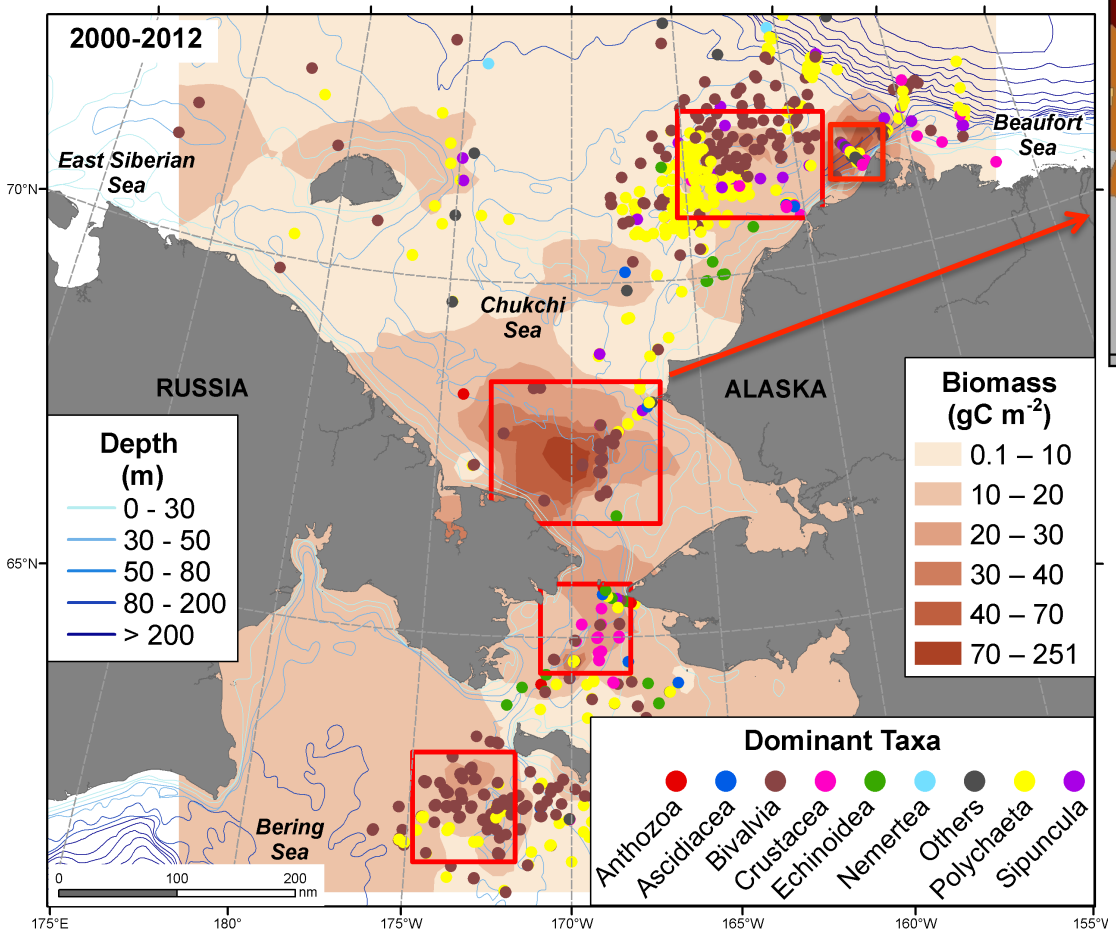




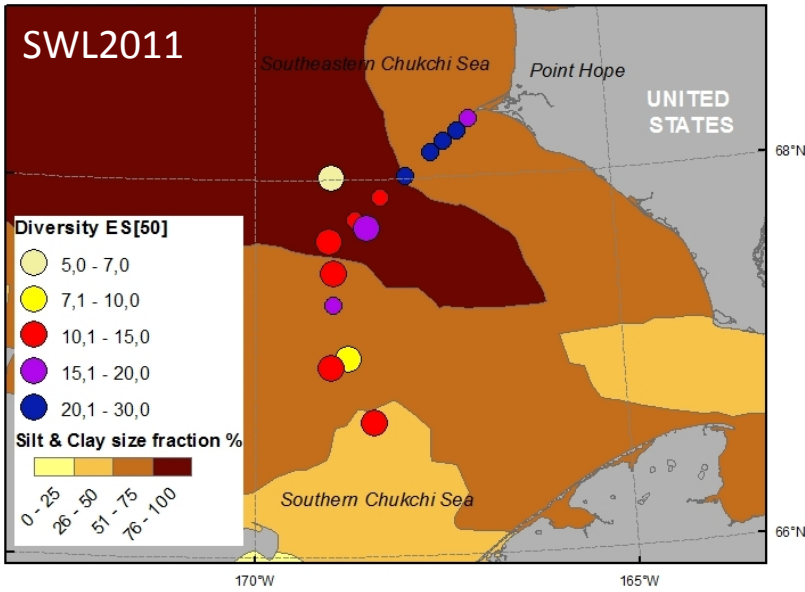
[Jackie Grebmeier]

Benthic Biomass and Dominant Taxa in the Northern Bering and Chukchi Seas, with Diversity Index on DBO 3

Below: Distribution of benthic biomass and dominant fauna, with DBO bounding boxes



[modified from Grebmeier 2012; Grebmeier et al. 2015]

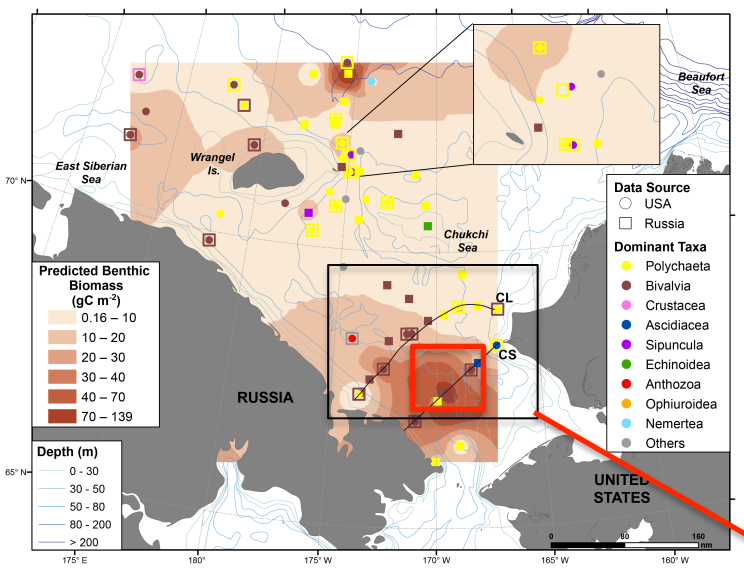


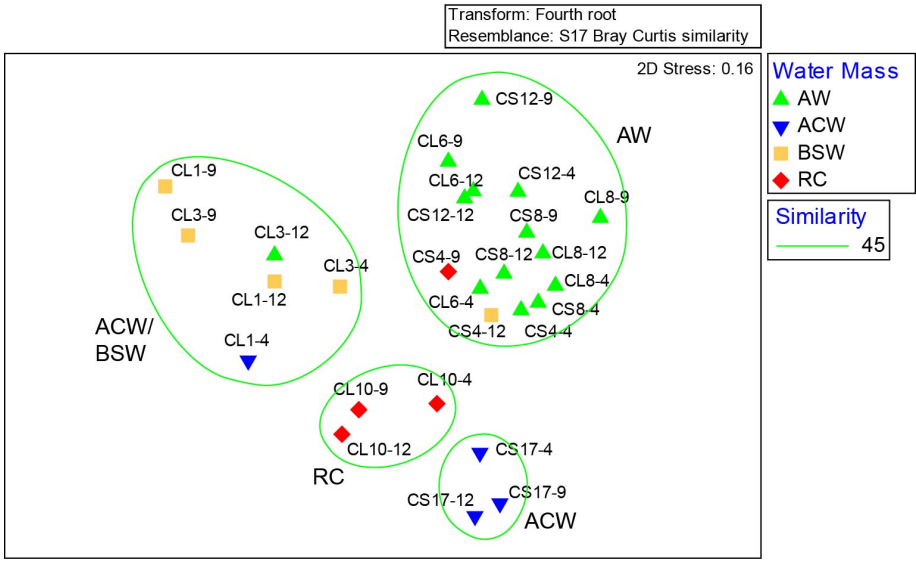
Above: Diversity values highest in coarse, nearshore sediments, with lower values in finer, silt and clay sediment

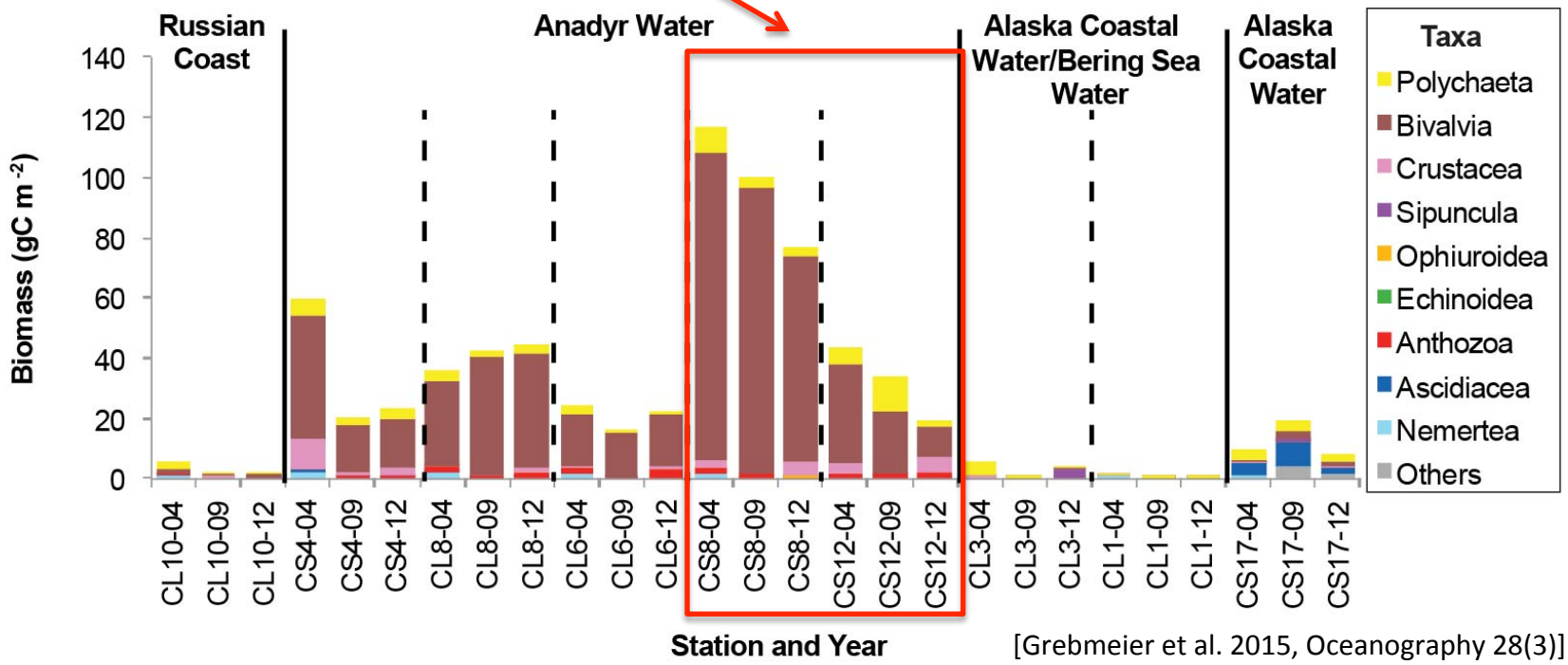
[courtesy Monika Kedra, Institute of Oceanology Polish Academy of Sciences]

[Jackie Grebmeier/UMCES]

DBO3-RUSALCA Time Series Site, Macrofaunal Similarity Clustering







[Grebmeier et al. 2015, Oceanography 28(3)]

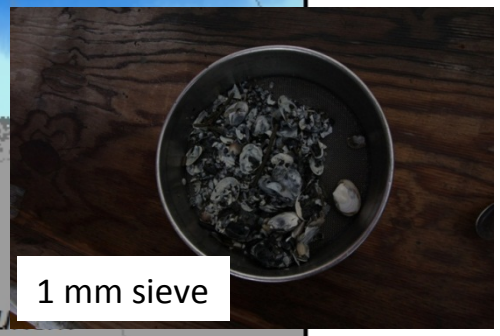
Benthic diversity

Monika Kędra[1], Jacqueline Grebmeier [2], Lee Cooper[2]

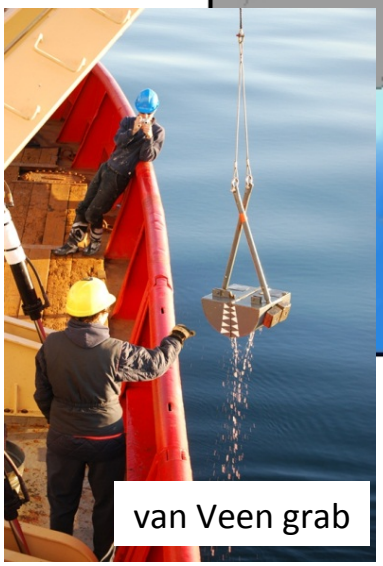
[1] Institute of Oceanology Polish Academy of Sciences, Sopot, Poland

[2]Chesapeake Biological Laboratory Center for Environmental Science, University of Maryland, USA

Biological
Distributed
Observatory
Arctic

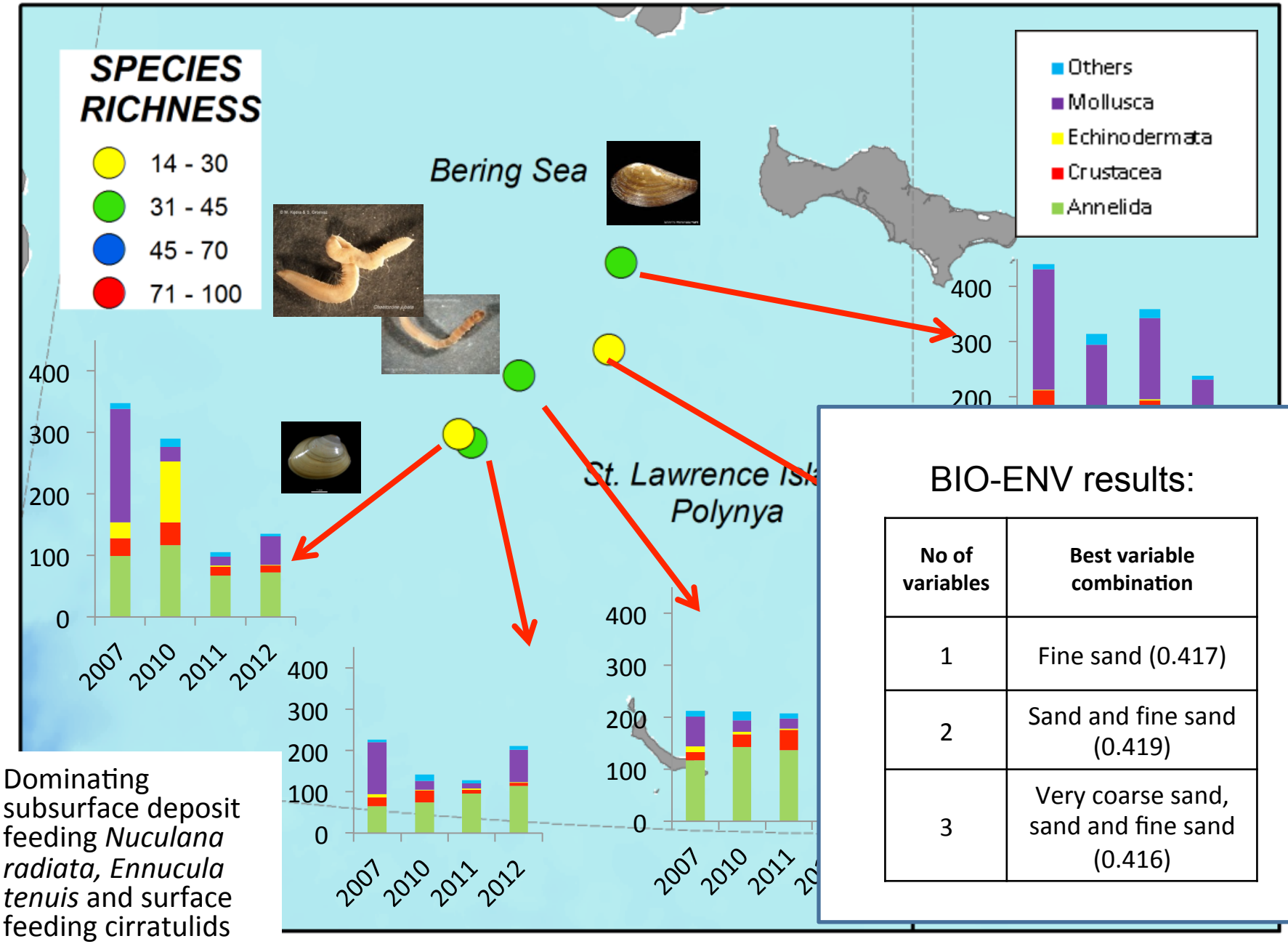


Barrow Canyon
Chukchi Sea
Southeastern Chu
RUSSIA
Southern Chukchi
UNITED STATES
Chirikov Basin
St. Lawrence Island Polynya
Bering Sea
65°N
60°N
180°
170°W
160°W
Species number
31 - 44
45 - 66
67 - 93



Samples collected during CCCG Sir Wilfried Laurier cruises in 2007, 2010, 2011 and 2012;
and (not processed yet) 2008; 2013, 2014, 2015 [Monika Kedra]

SLIP: south of St. Lawrence Island



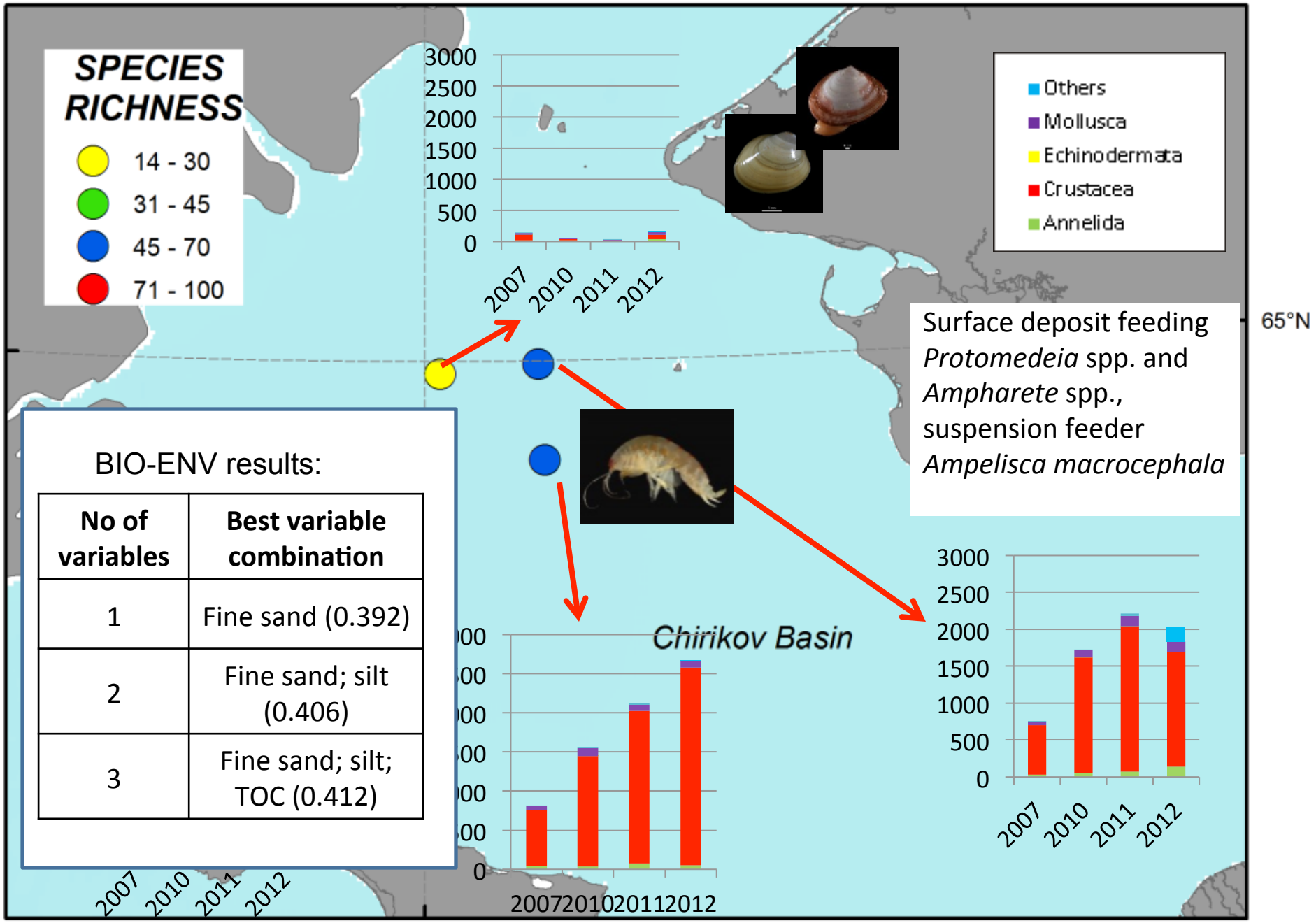
Dominating subsurface deposit feeding *Nuculana radiata, Ennucula tenuis* and surface feeding cirratulids

BIO-ENV results:

No of variables	Best variable combination
1	Fine sand (0.417)
2	Sand and fine sand (0.419)
3	Very coarse sand, sand and fine sand (0.416)

[Monika Kedra]

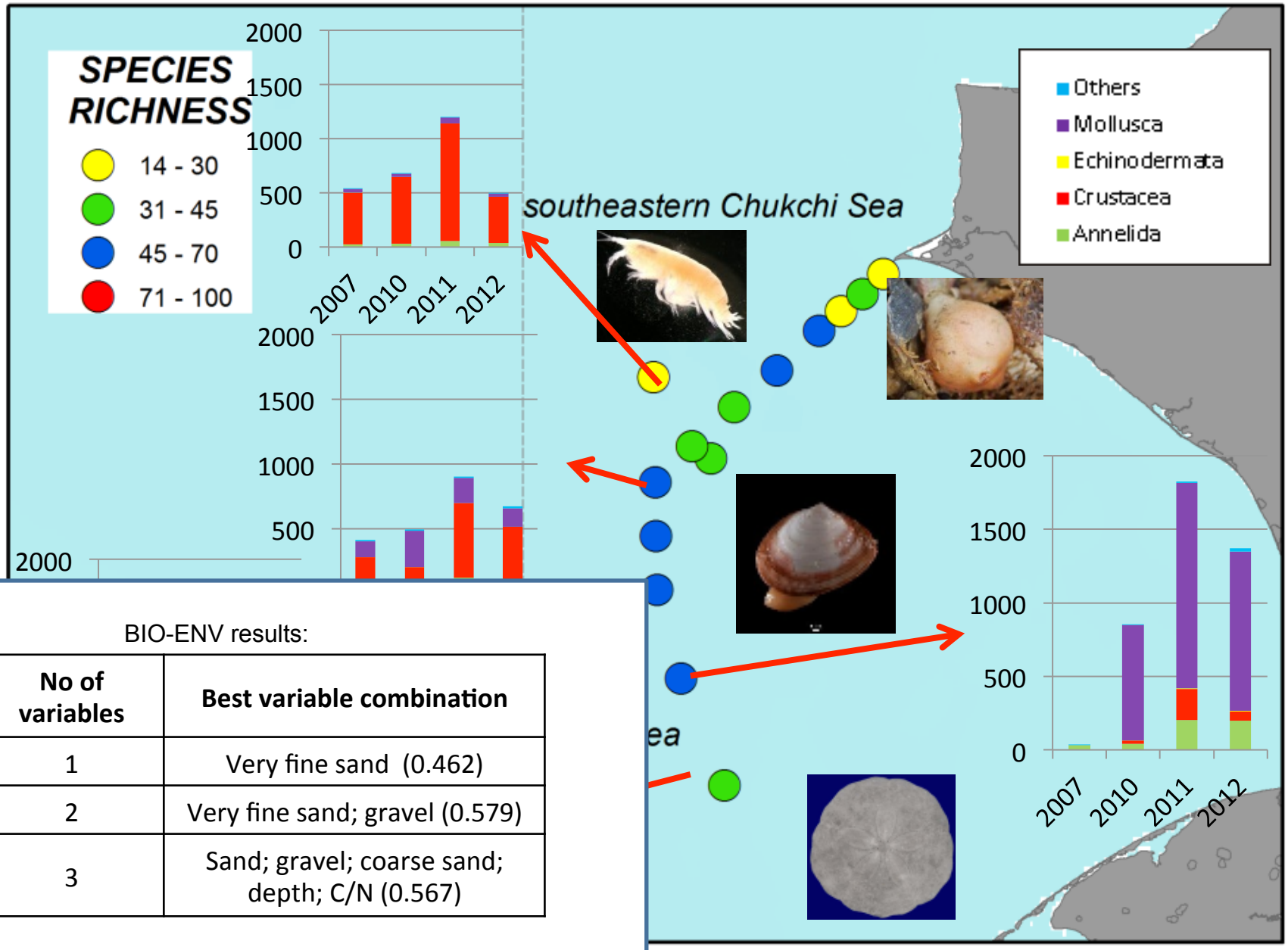
BDO site#2: Chirikov Basin



BIO-ENV results:

No of variables	Best variable combination
1	Fine sand (0.392)
2	Fine sand; silt (0.406)
3	Fine sand; silt; TOC (0.412)

DBO site #3: Southern Chukchi Sea



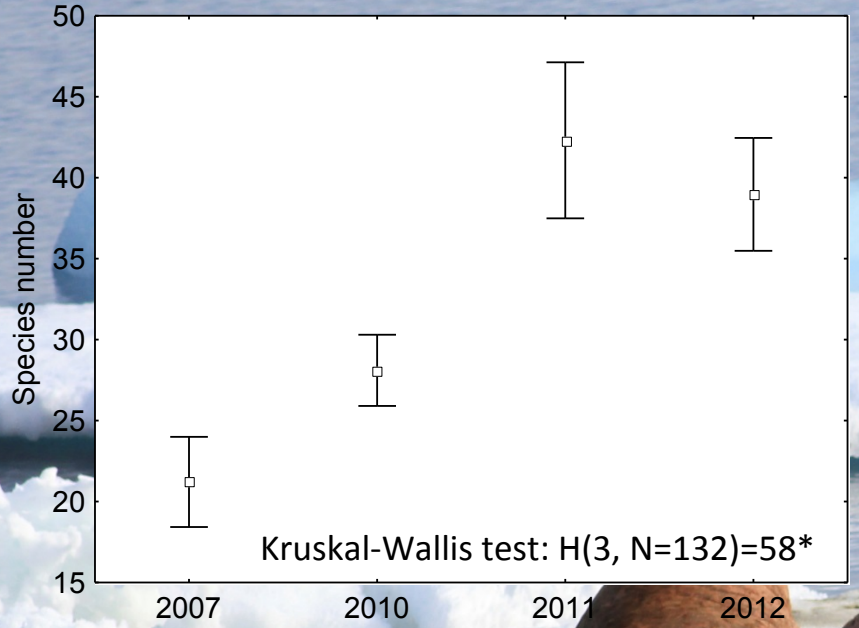
BIO-ENV results:

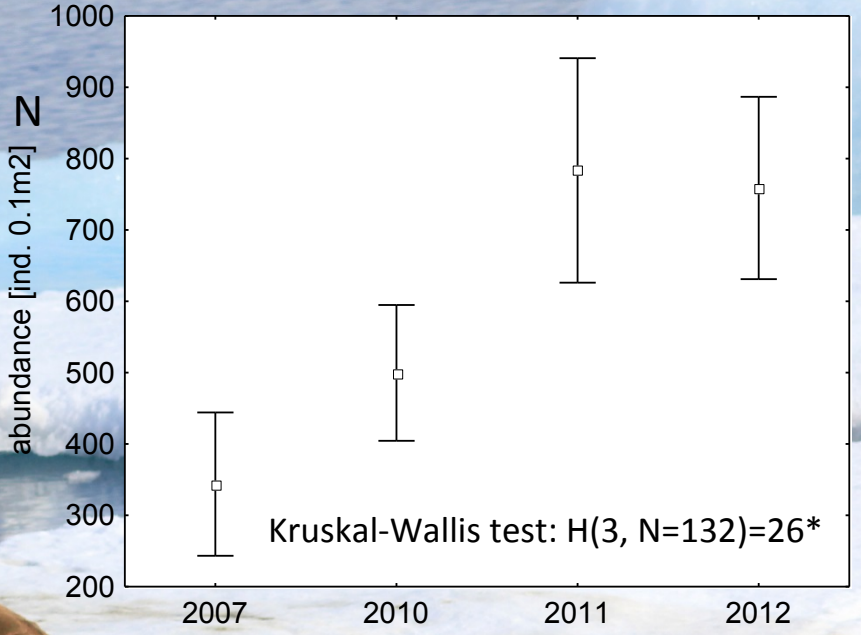
No of variables	Best variable combination
1	Very fine sand (0.462)
2	Very fine sand; gravel (0.579)
3	Sand; gravel; coarse sand; depth; C/N (0.567)

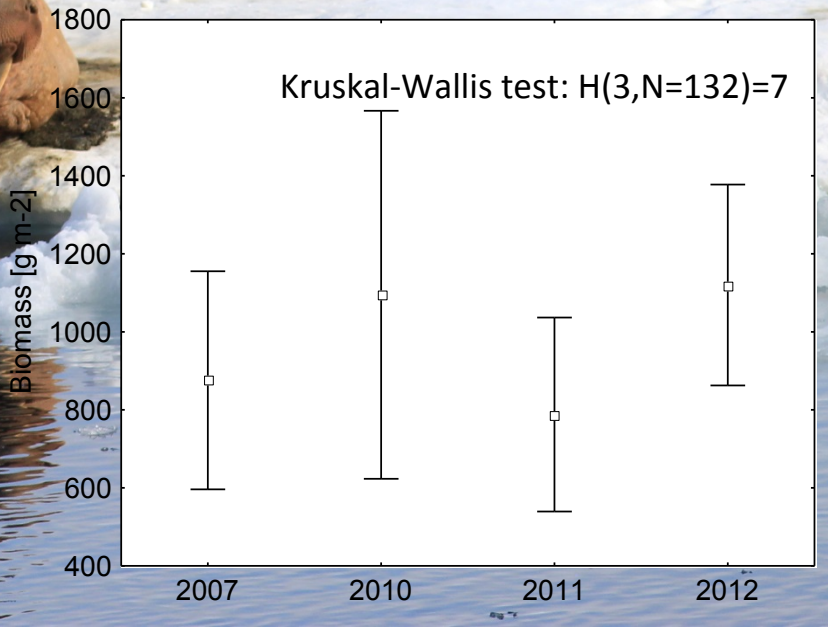
[Monika Kedra]

DBO site #3: Southern Chukchi Sea

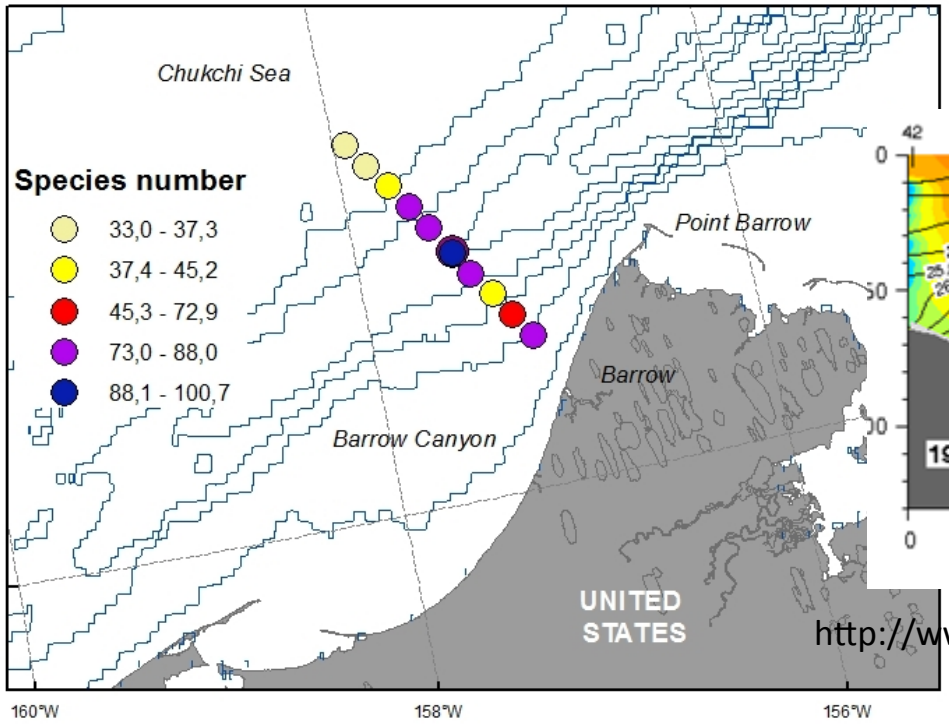
[Monika



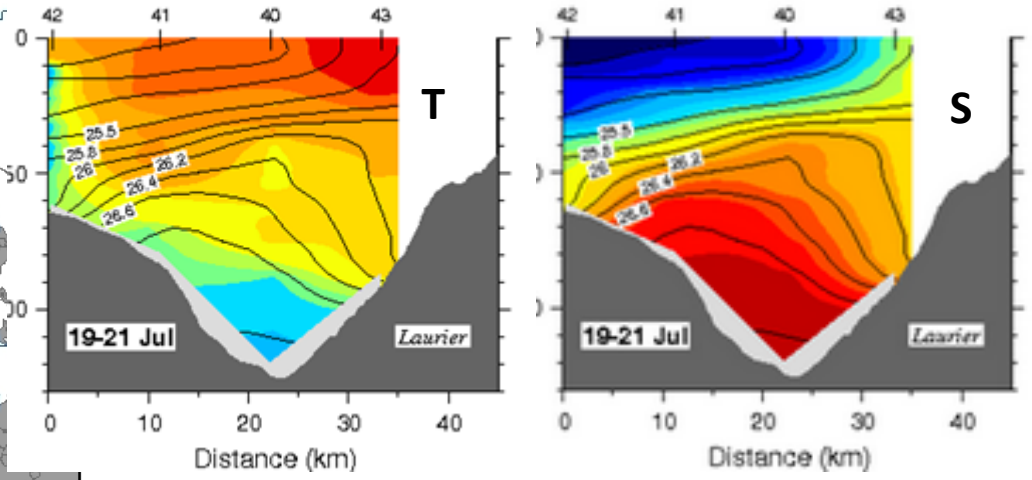




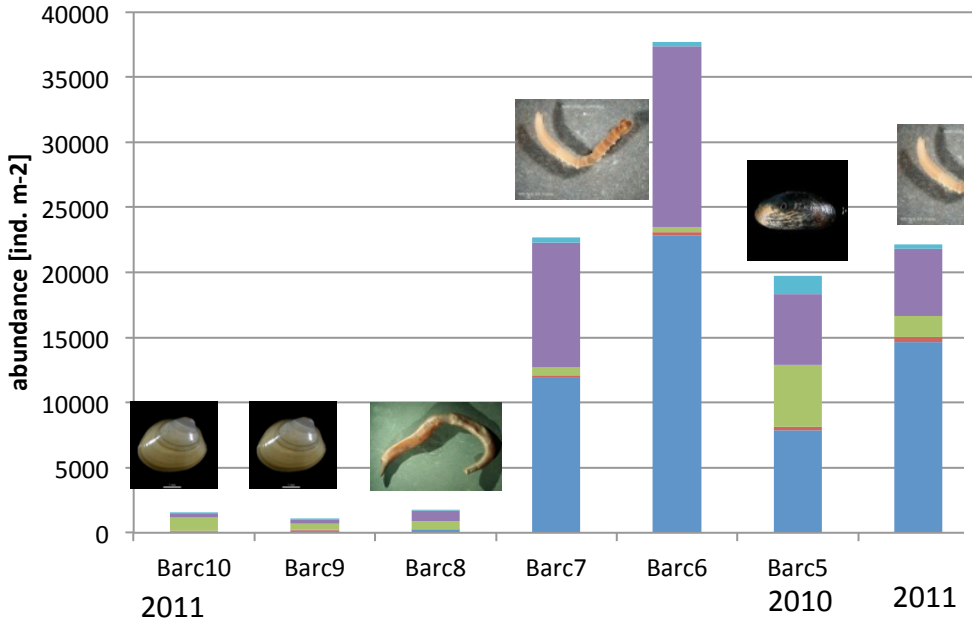
More species, higher densities,
Same biomass
→ increase of „wrong" species

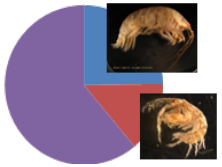


DBO site #5; Barrow Canyon



http://www.arctic.noaa.gov/dbo/cruise_data_2010_pilot_study.html





Spearman correlations:
Species richness & bot. sal.: 0.55*
Species richness & chl a: 0.59*
Species richness & TOC : 0.4*

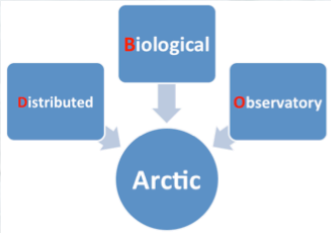
Similar correlations found for abundance and biomass

[Monika Kedra]

Thank you for your attention.

Questions and comments?

Thank you to all DBO collaborators, field and laboratory technicians over the years for the time series efforts. Financial support for the science provided by the US NSF, NOAA, BOEM, NASA, and ongoing international science partners in the Pacific Arctic Group.



http://www.arctic.noaa.gov/dbo/

BOEM
Bureau of Ocean Energy Management

NASA

NSF

National Oceanic and Atmospheric Administration
NOAA
U.S. Department of Commerce

PAG
Pacific Arctic Group