# Distributed Biological Observatory: A Change Detection Array in the Pacific Arctic-Session Introduction and US DBO Updates

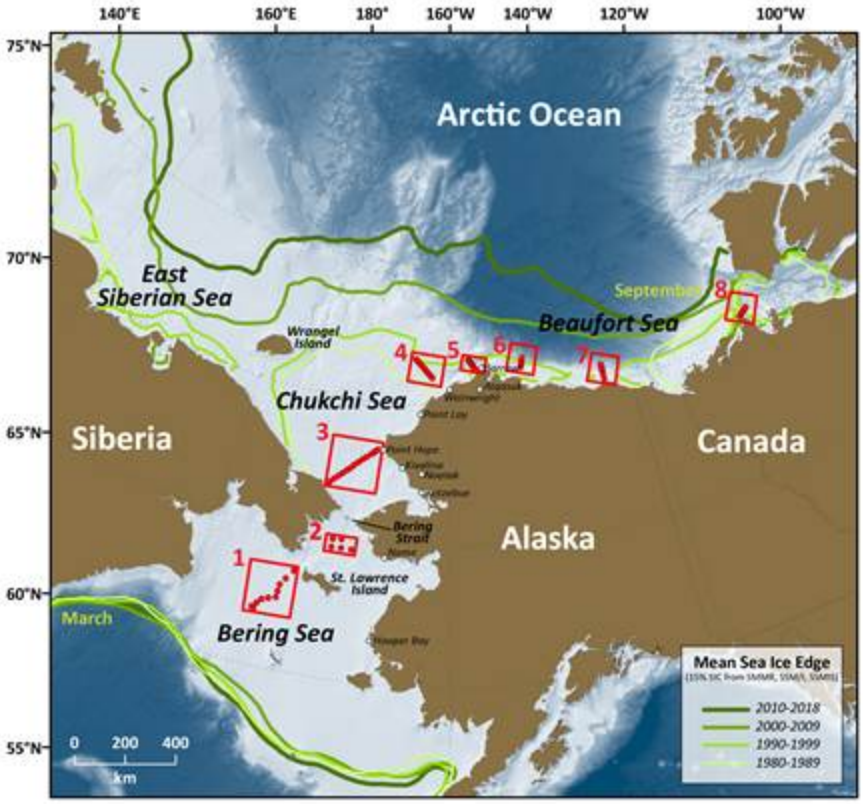
**Jacqueline M. Grebmeier**
Chesapeake Biological Laboratory
University of Maryland Center for Environmental Science
Solomons, Maryland, USA

## 3-2 Distributed Biological Observatory (DBO)

- Brief updates of recent activities and results of DBO
  - USA DBO results (Jackie Grebmeier)-10 min
  - Japan DBO results (Shigeto Nishino)
  - Korean DBO results (Jinyoung Jung)
  - Presentations

**Pacific Arctic Group Meeting**
Hangzhou, Zhejiang Province, China
October 15, 2019

# Linking Physics to Biology: the Distributed Biological Observatory (DBO)



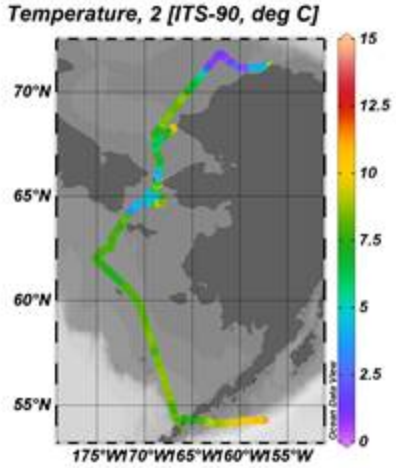

[updated from Moore and Grebmeier 2018]

- **Ship-based sampling:**
  - CTD and ADCP
  - Chlorophyll, nutrients, carbon products
  - Plankton (size, biomass and composition)
  - Benthos (size, biomass and composition)
  - Seabird and marine mammal surveys
  - Fishery acoustics
  - Bottom trawling (every 3-5 years)
- **Autonomous sensor sampling:**
  - Gliders, moorings, saildrone
  - Satellite observations
- **DBO lines also embedded in process cruises**

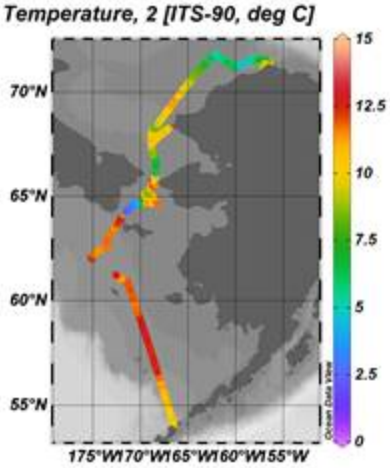
- DBO sites (red boxes) are **regional "hotspot"** transect lines and stations, based on high productivity, biodiversity, and/or overall **rates of change**
- DBO serves as a **change detection array** for consistent monitoring of biophysical responses
- Sites occupied by **national and international entities** with shared data plan

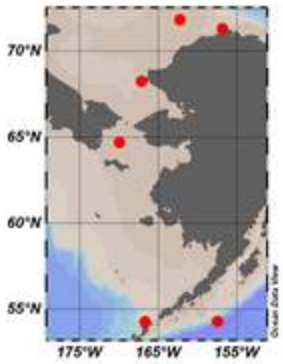
# Surface seawater SWL18 and SWL19 in mid-July

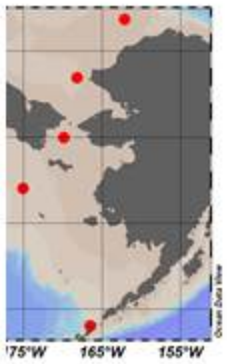
## 2018



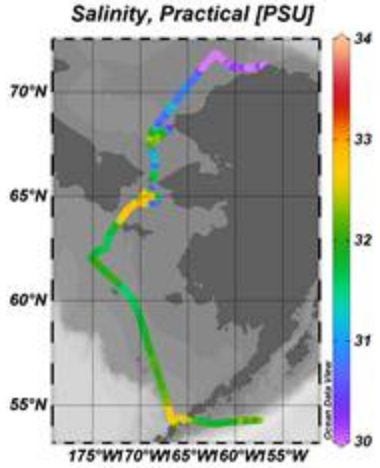

## 2019

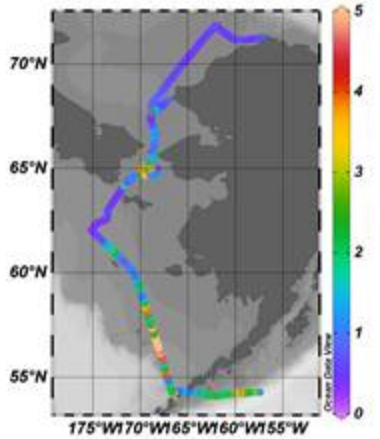


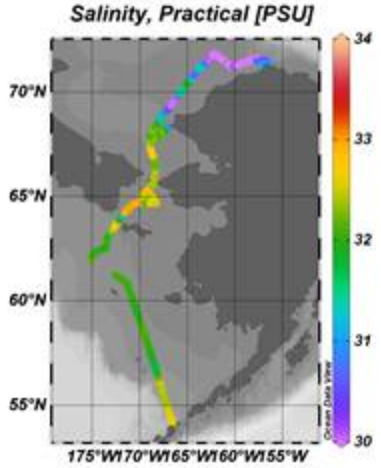



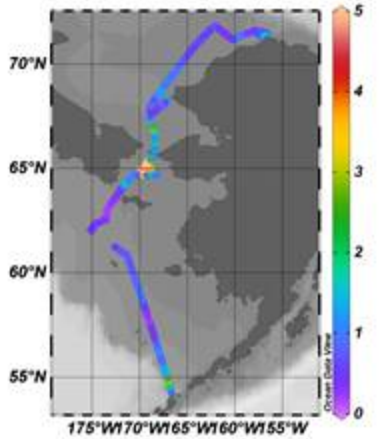

## 2018



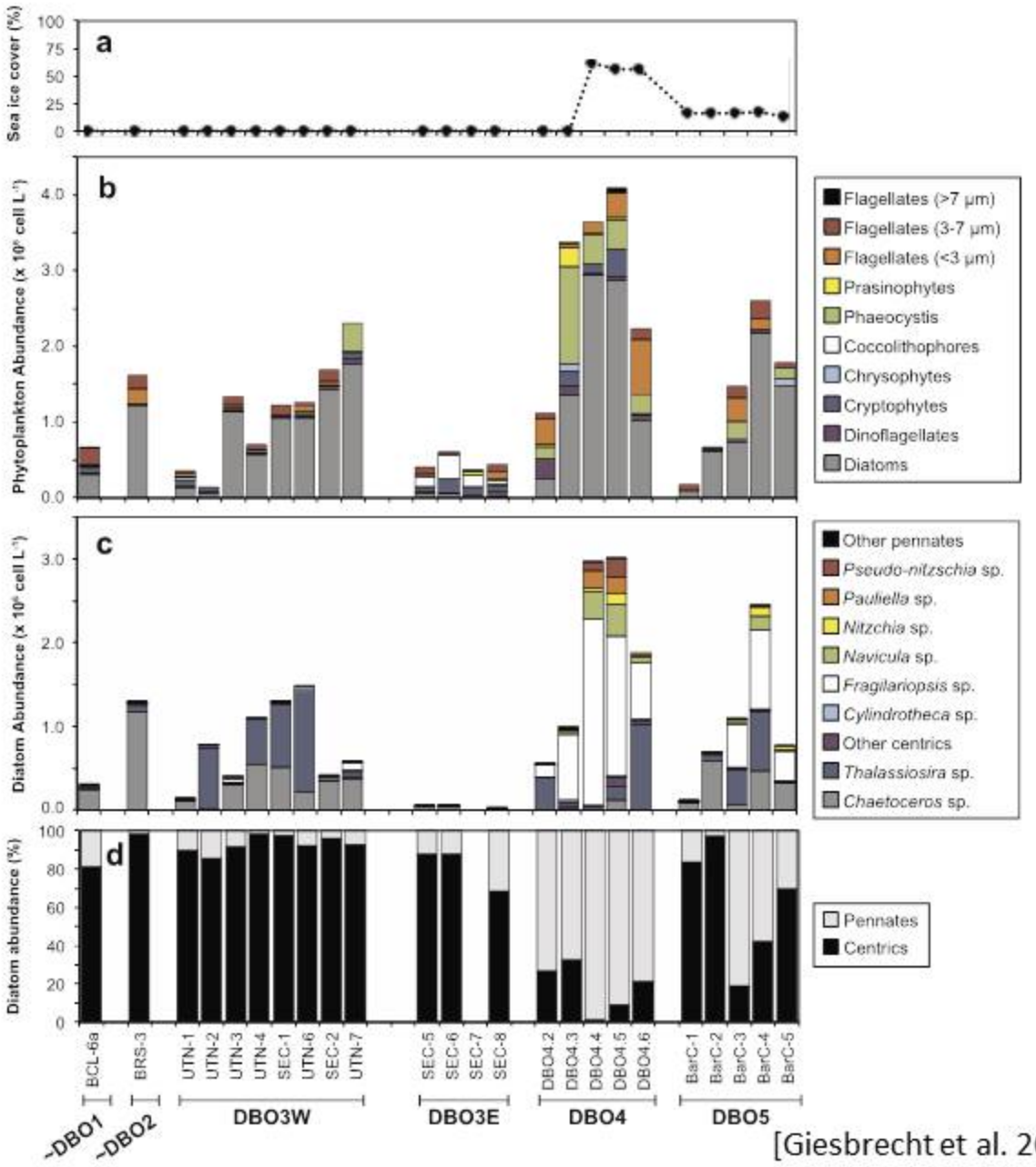

## 2019




[courtesy S. Zimmerman, DFO]

# Sea Ice cover and Phytoplankton Type

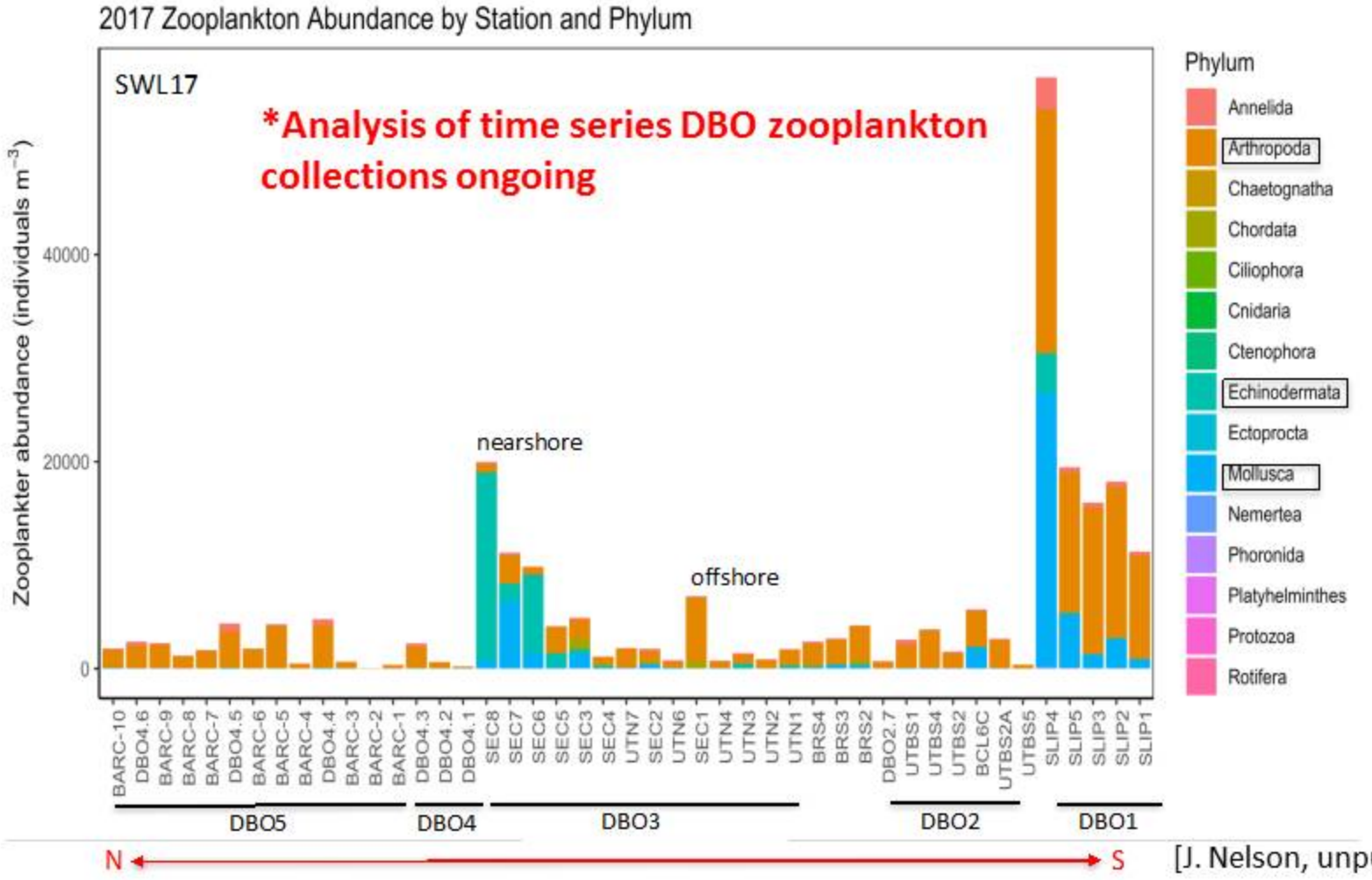



[Giesbrecht et al. 2018]

- Highest sea ice algae in NE Chukchi Sea where sea ice remaining in July (DBO4)
- Phytoplankton abundance greatest in offshore nutrient-rich Bering Sea-Anadyr water
- Centric diatoms dominate in southern sites (DBO1-3), changing to dominance of pennate diatoms in the NE Chukchi Sea (DBO4-5) where most recent ice observed

***SWL14-18 phytoplankton collected and identified**

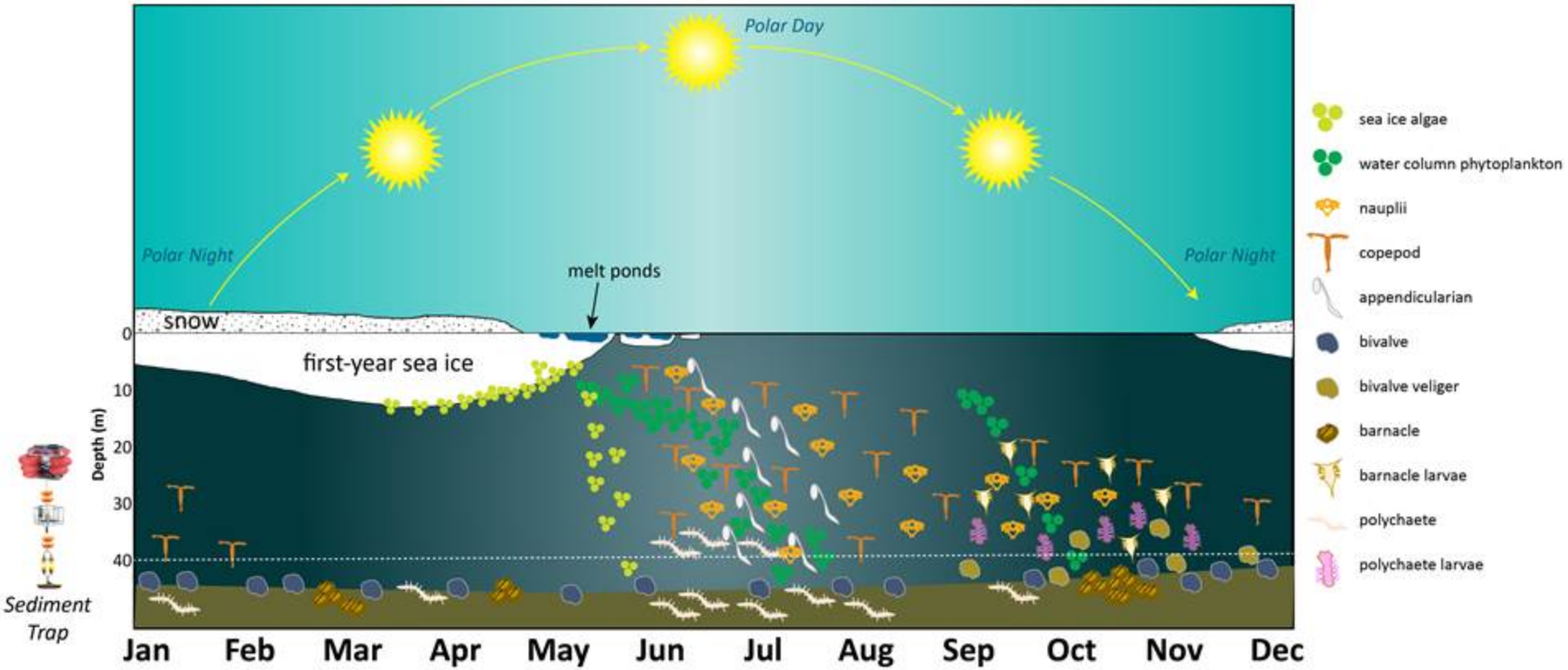
# Abundance of zooplankton phyla for the SWL 2017 DBO July cruise




[J. Nelson, unpubl. data]

- High abundances at SEC6-SEC8 (DBO3-east) of echinoderm and molluscan larvae, barnacle cirripedia and small copepods (*Oithonia*), larger calanoid copepods
- High abundance of molluscan and echinoderm larvae at the DBO1 SLIP stations, with pelagic zooplankton dominated by small cyclopoid and calanoid copepods, *Calanus glacialis*

# Schematic of annual cycle of pelagic development for DBO sediment traps

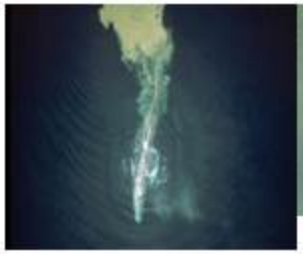
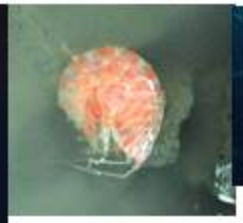



[graphic by K. Frey, data from C. Lalande]

- Sediment traps deployed DBO2, DBO3, DBO4 (Chukchi Environmental Observatory)
- 2019 obtained support for new trap at DBO1 (Lalande, Grebmeier, Stabeno, Mordy)

# Benthic Foragers: Response to Changes in Sea Ice

**Gray whales** = shifts in distribution reflects sea-ice related prey decrease (amphipods: time and space), plus opportunity feed on euphausiids and staying longer north near Barrow to feed

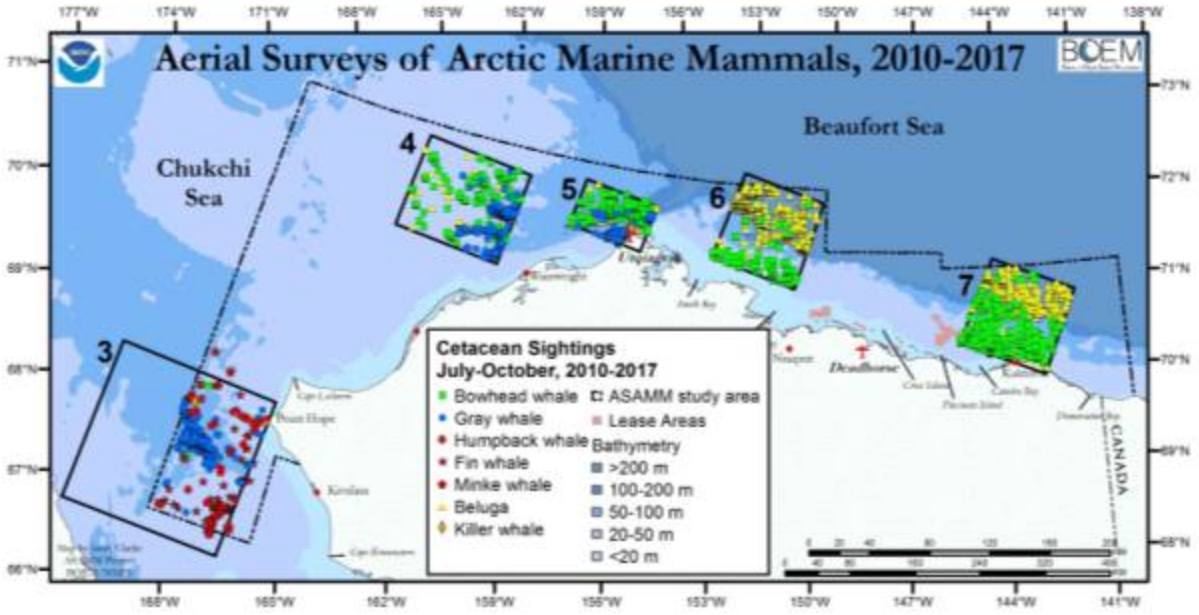




**Walrus** = loss of sea ice platform for riding, resting, nursing calves & <u>access</u> to Chukchi shelf feeding areas



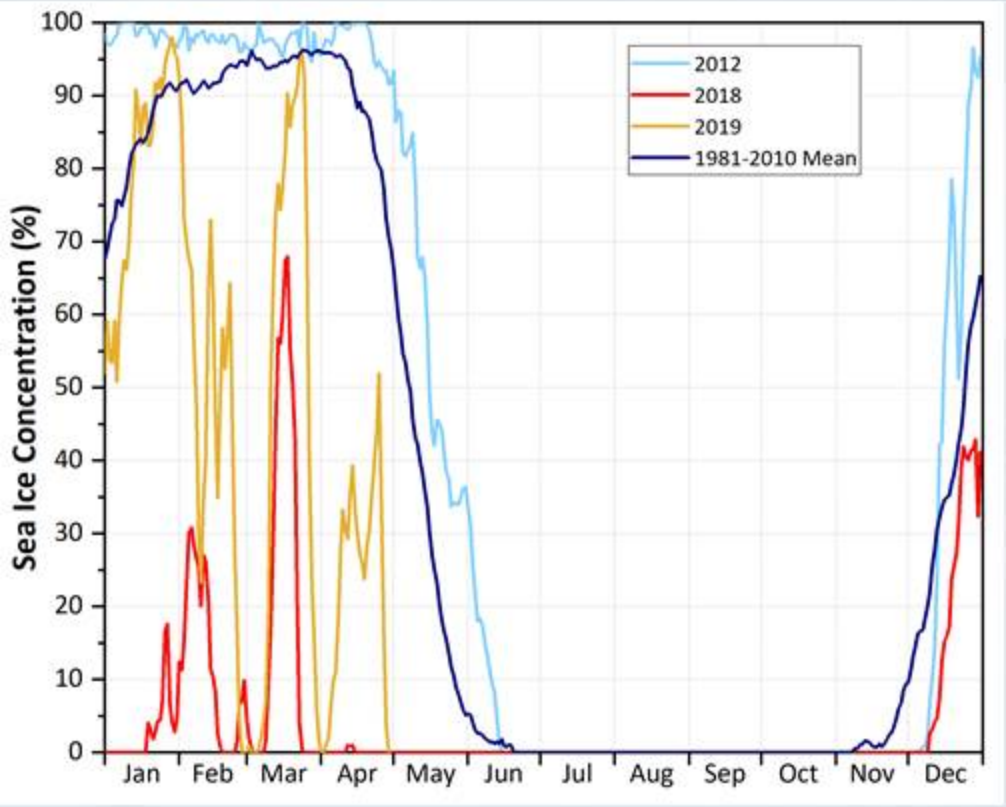
[Tony Fischbach, USGS]

**Diving seaducks** = changing sea ice location as resting platform


[Janet Clark, NOAA]

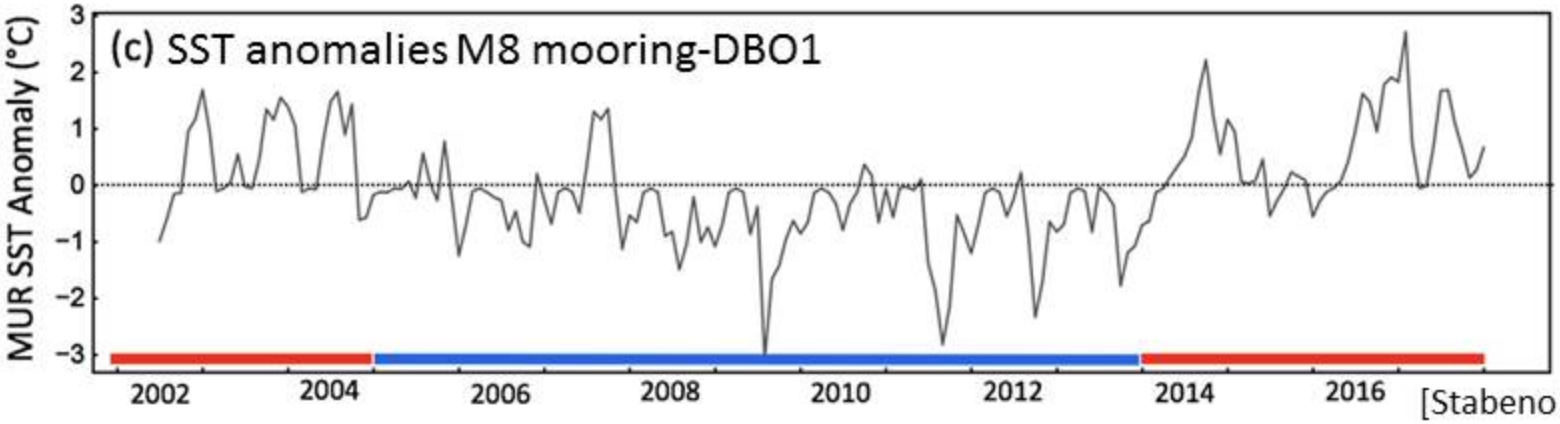
# DBO1 region, Northern Bering Sea




[K. Frey, Clark Univ]

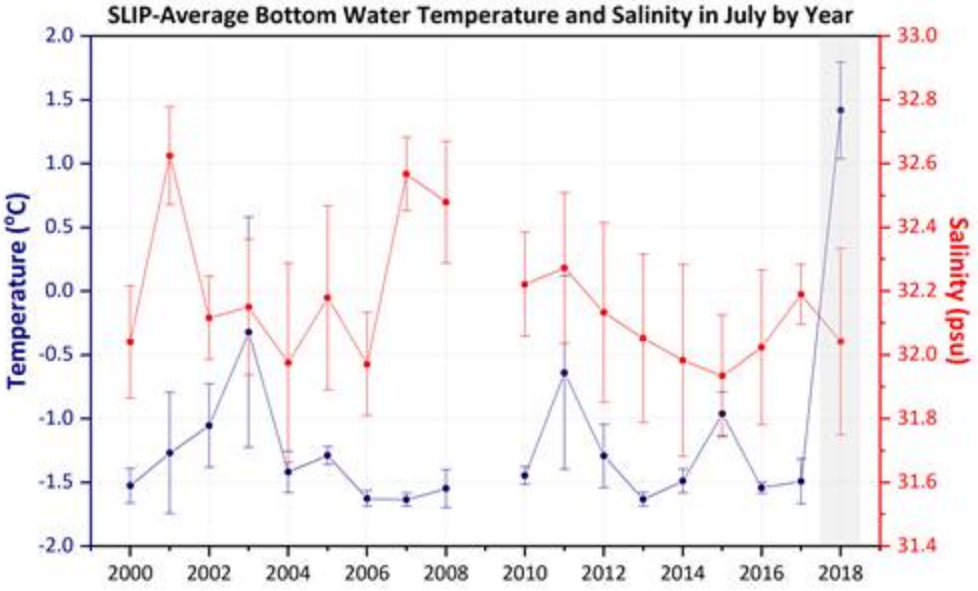
- The lack of a thermal cold-water barrier south of St. Lawrence Island (DBO1) in 2018 resulted in key commercial fish (cod, pollock) moving north to Bering Strait
- Ongoing DBO-NCIS activities with national and international networking of seasonal sampling (e.g., DBO, EcoFOCI) track key drivers and trophic response to ongoing sea ice reduction and warming surface and bottom waters in the northern Bering and Chukchi Sea
- Region may be at tipping point, and ecosystem moving to a new state with unknown consequences

# 2018: A Tipping Point for the Northern Bering Sea (DBO1)?




[Stabeno et al. 2018]

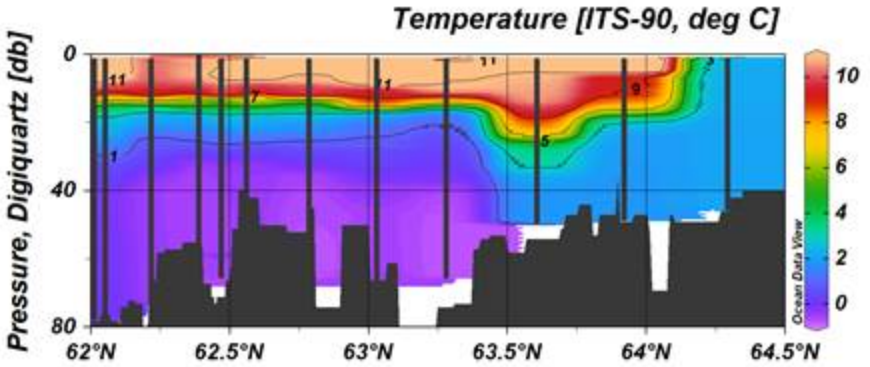
- Time series of SST monthly mean anomalies. The colored lines at the bottom indicate periods of limited ice (red) and more extensive (blue) in December/January

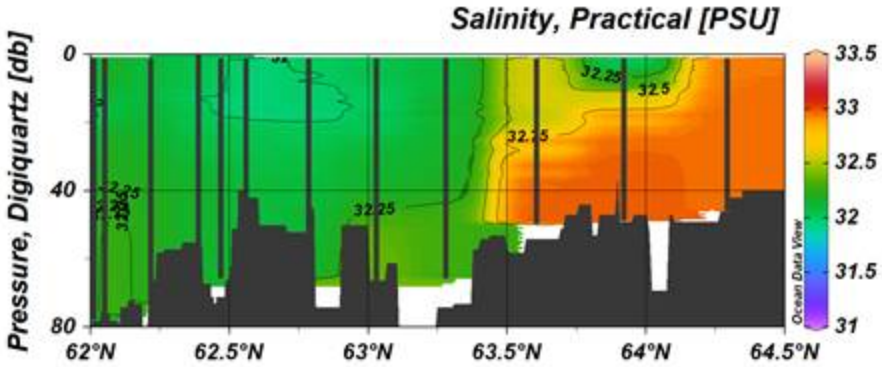


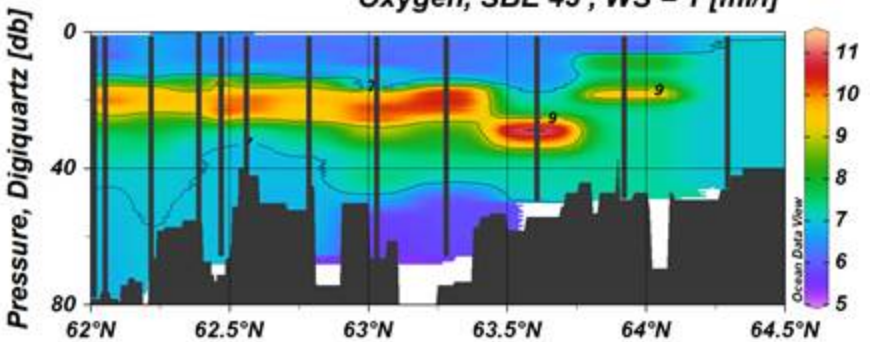

[Grebmeier et al., Oceanography, 2018]

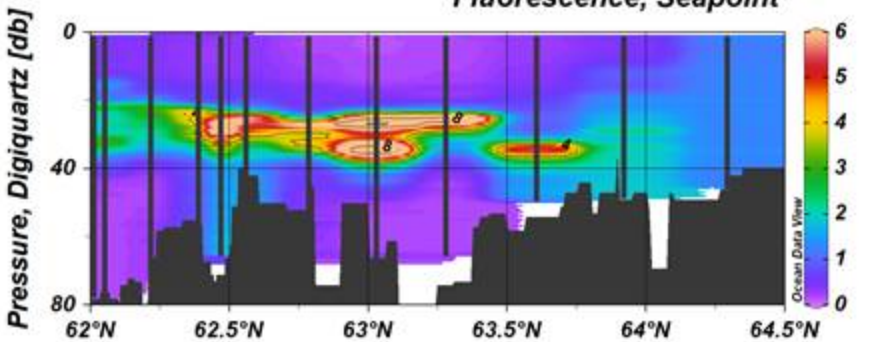
- Gray shading: SLIP1-5 stations in 2018 had an average bottom water temperature that was a statistically significant outlier, without any SD bar overlap
- Although salinities becoming fresher in recent years, they still have overlapping SD bars

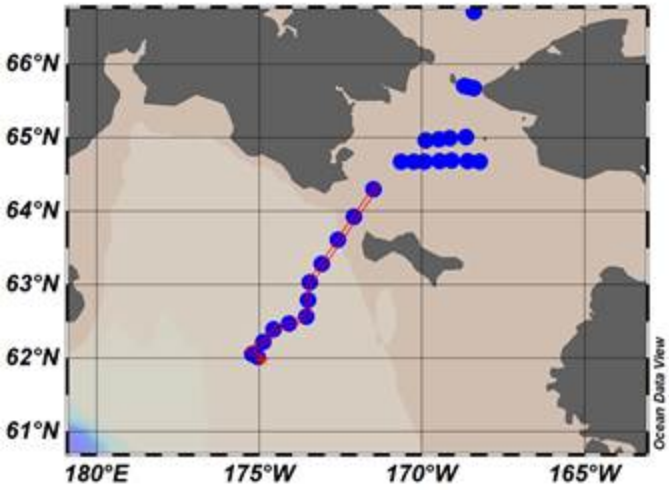
# DBO 1-SWL19, July 2019

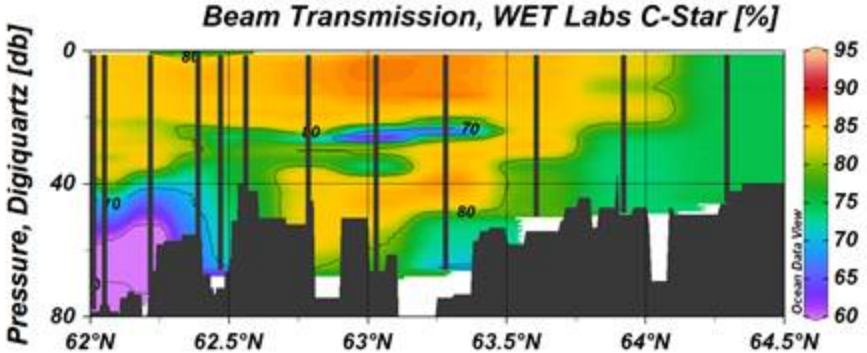


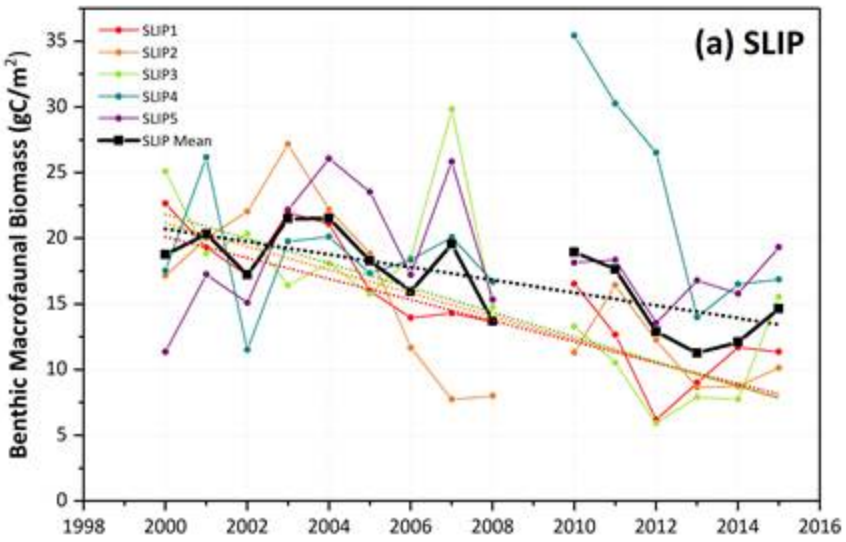




[courtesy S. Zimmerman, DFO]

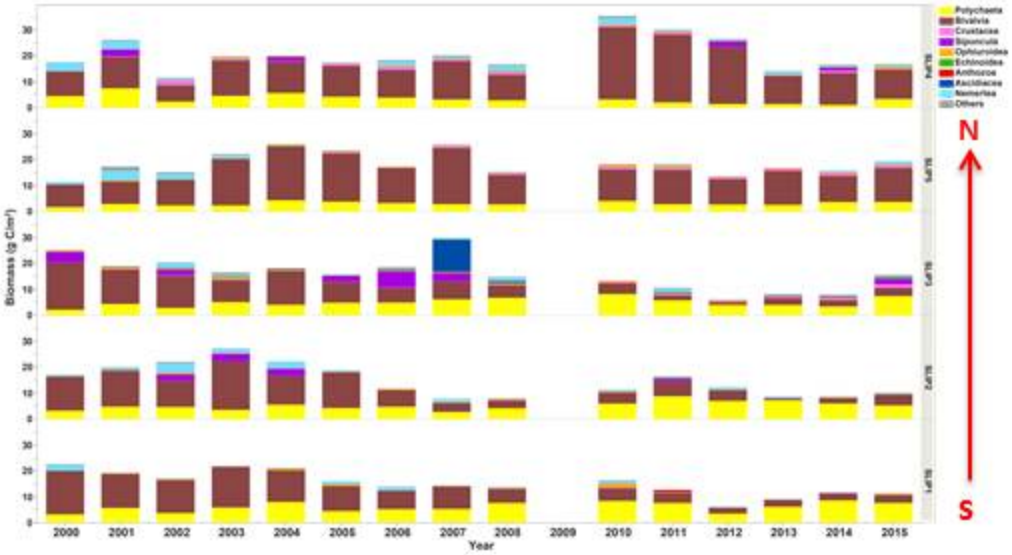
# Macrofaunal biomass and composition at time series stations (DBO1: SLIP1-5) south of St. Lawrence Island, 2000-2015

## Time series benthic biomass in the DBO1




- Significant declining trend in southern SLIP1-3 stations and average values using Mann-Kendall (Kendall's tau) trend analysis ($p<0.0001$)

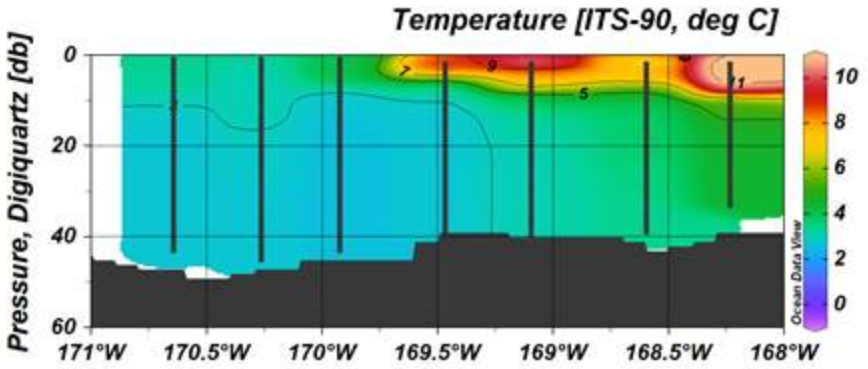
## Macrofaunal composition for SLIP time series sites in DBO1

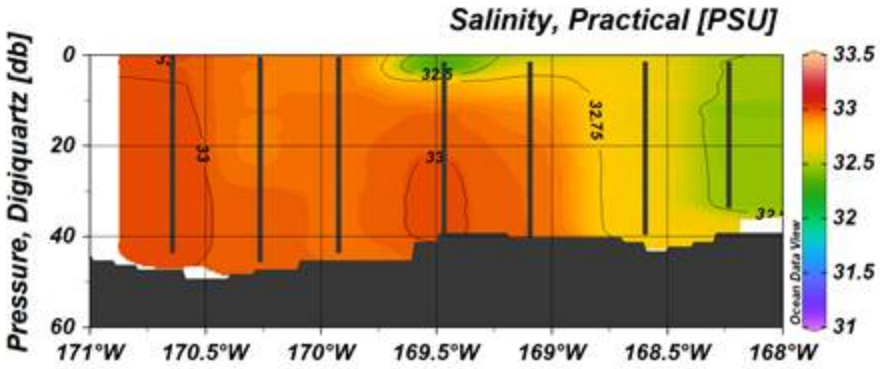


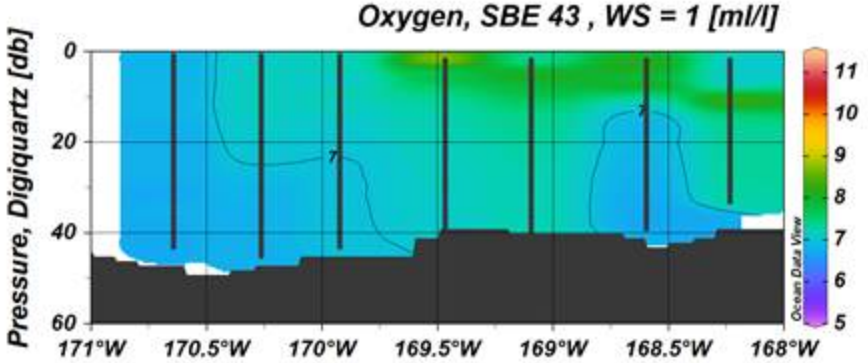

- Stations stacked from southern site (SLIP1) to northern site (SLIP4)
- Change in dominance from bivalve (brown) to polychaete (yellow) fauna in 2008 in southern sites

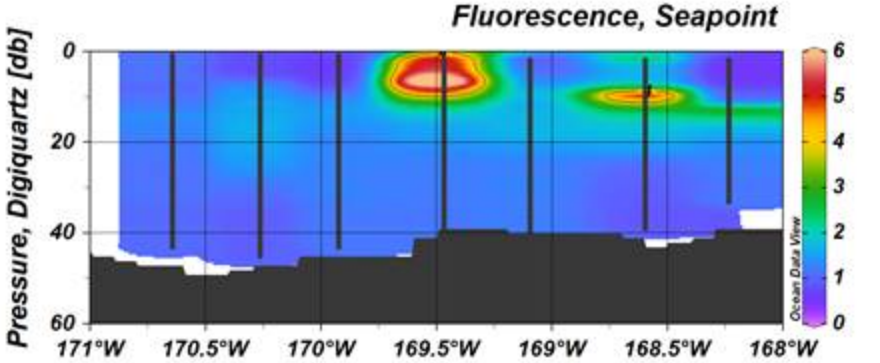
[Grebmeier et al., Oceanography, 2018]

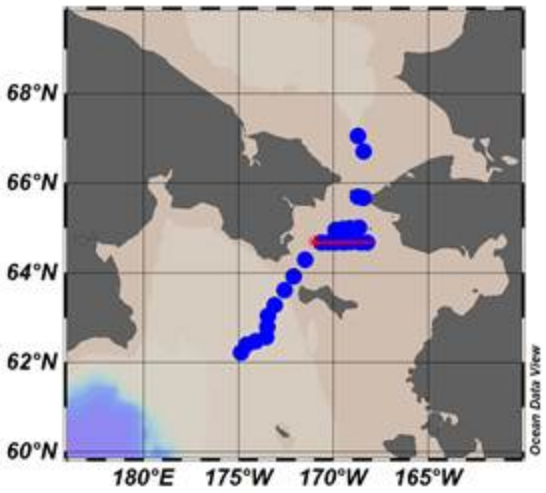
# DBO 2 - **South**

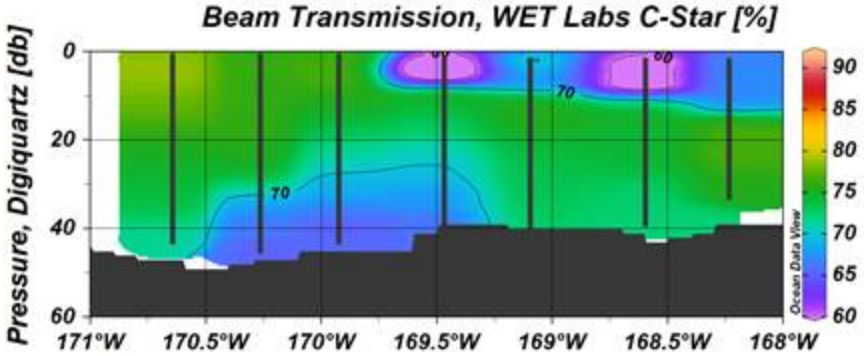


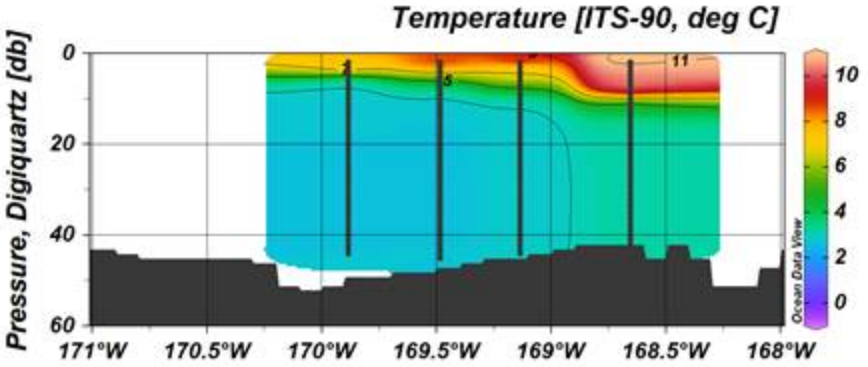



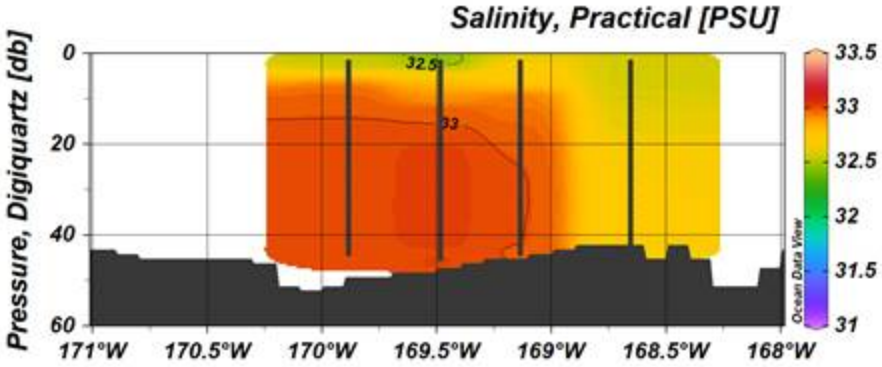



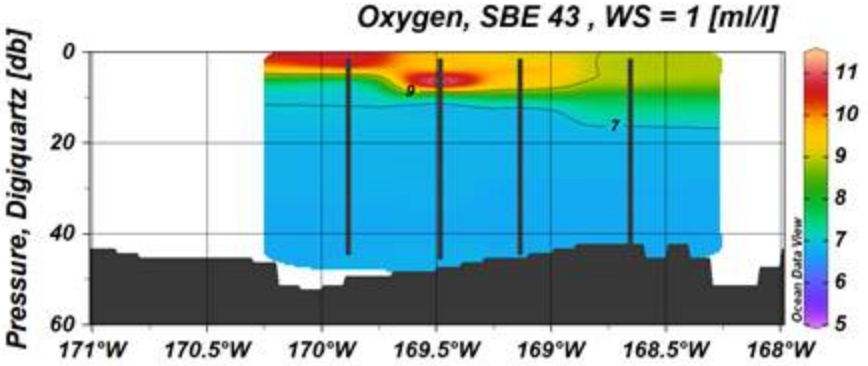



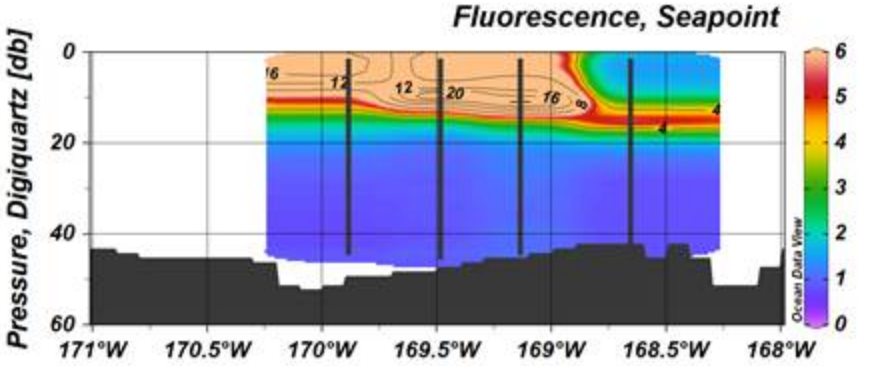

[courtesy S. Zimmerman, DFO]

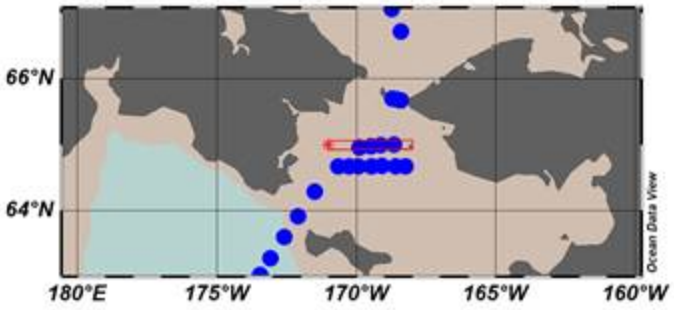
# DBO 2-North: SWL19, July 2019

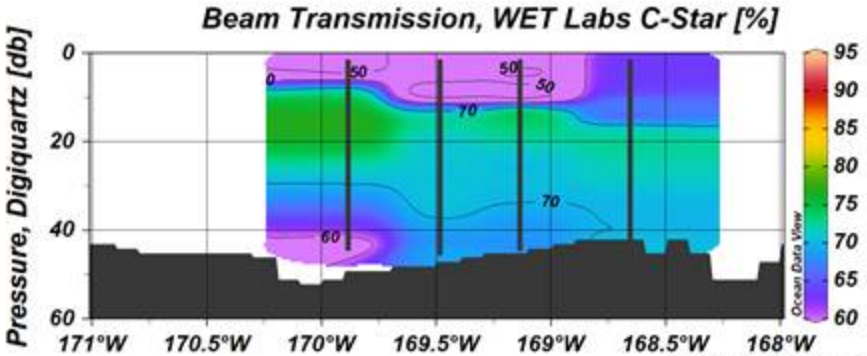


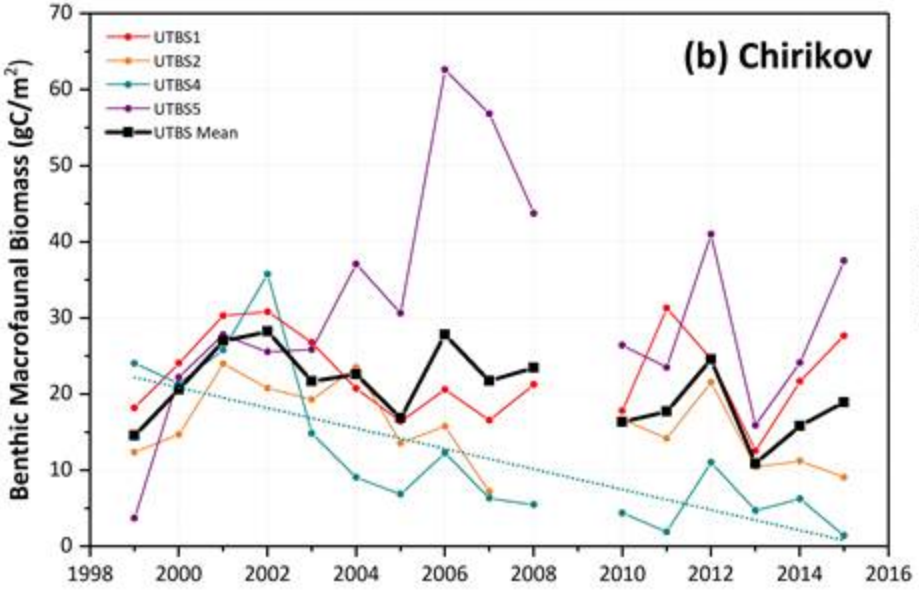




[courtesy S. Zimmerman, DFO]

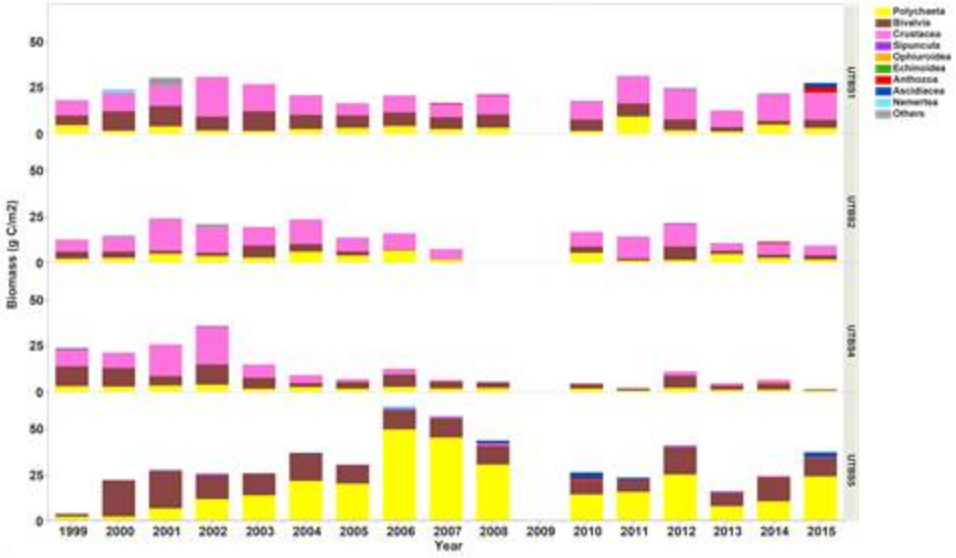
# Macrofaunal biomass and composition at time series stations (DBO2: UTBS stations) north of St. Lawrence Island, 2000-2015

## Time series benthic biomass in the DBO2




- Recent years variability in biomass trends at Chirikov DBO2 stations, with only one significant trend at northwest time series station UTBS4 using Mann-Kendall (Kendall's tau) trend analysis ($p<0.0001$)

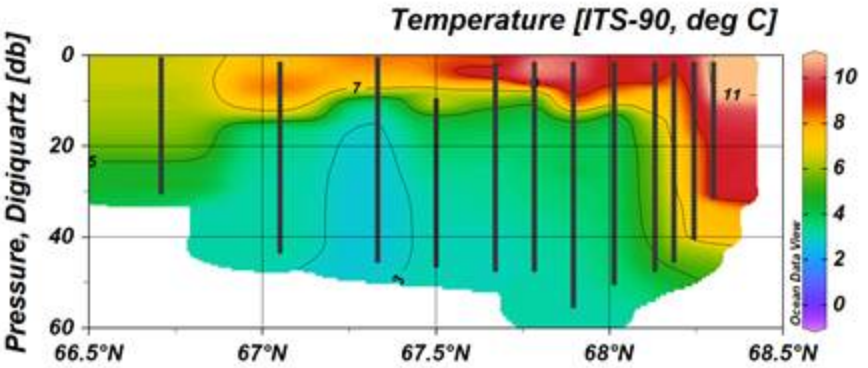
## Macrofaunal composition for UTBS time series sites in DBO2

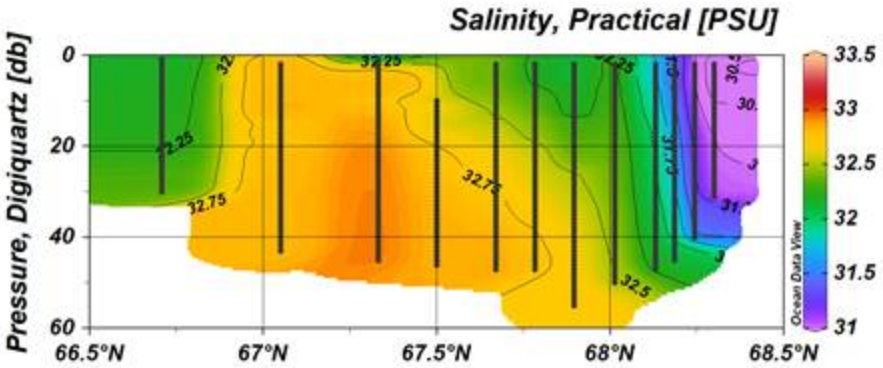


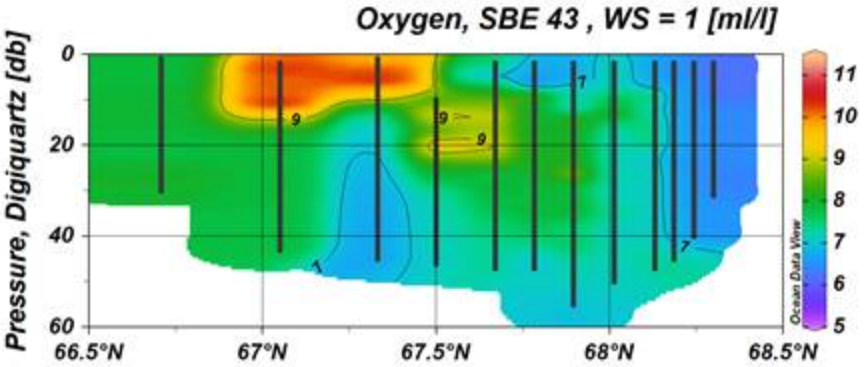

- Station stacked spatially from UTBS5 (SW) and UTBS4 (NW) and UTBS2 (SE) and UTBS1 (NE)
- UTBS5 (lower graph) dominated by ampeliscid amphipods in the 1980s, but changed to bivalves in the early 2000s and became dominated by polychaetes from 2003

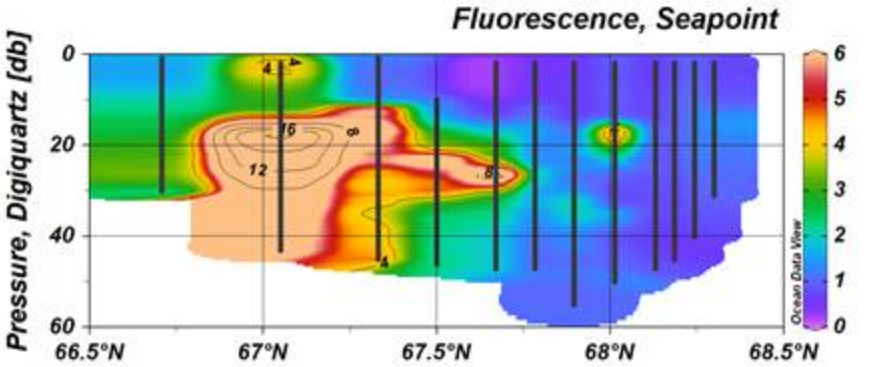
[Grebmeier et al., Oceanography, 2018]

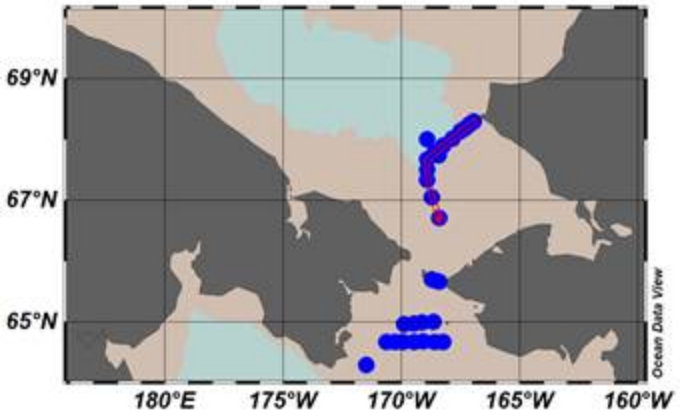
# UTN and SEC (DBO3)

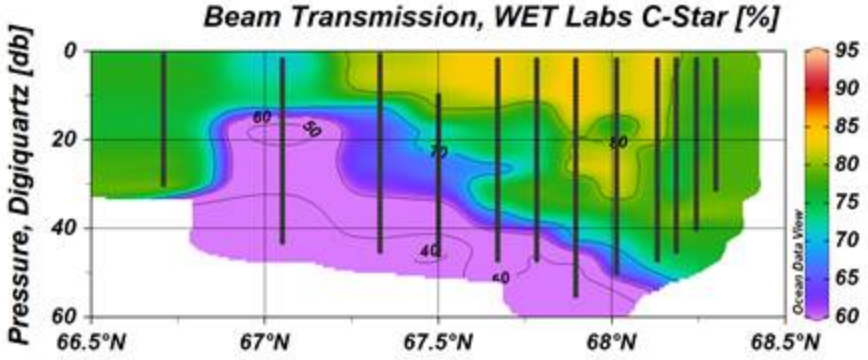


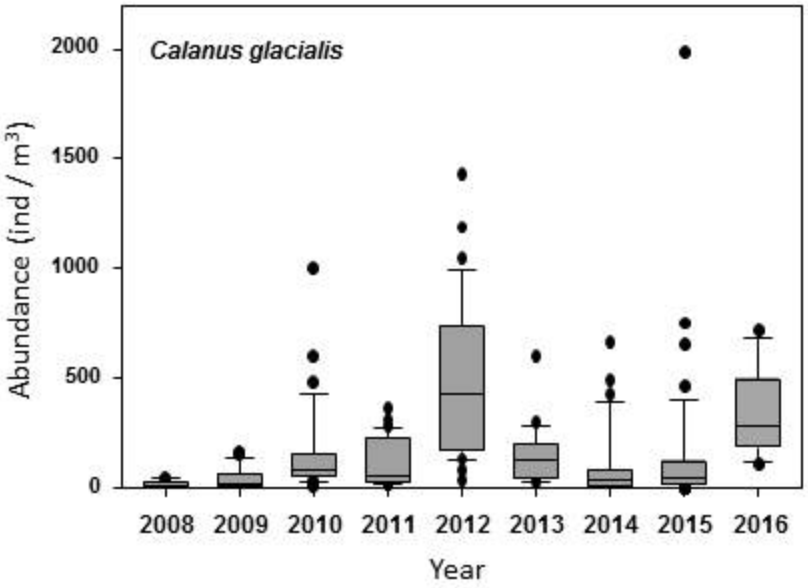



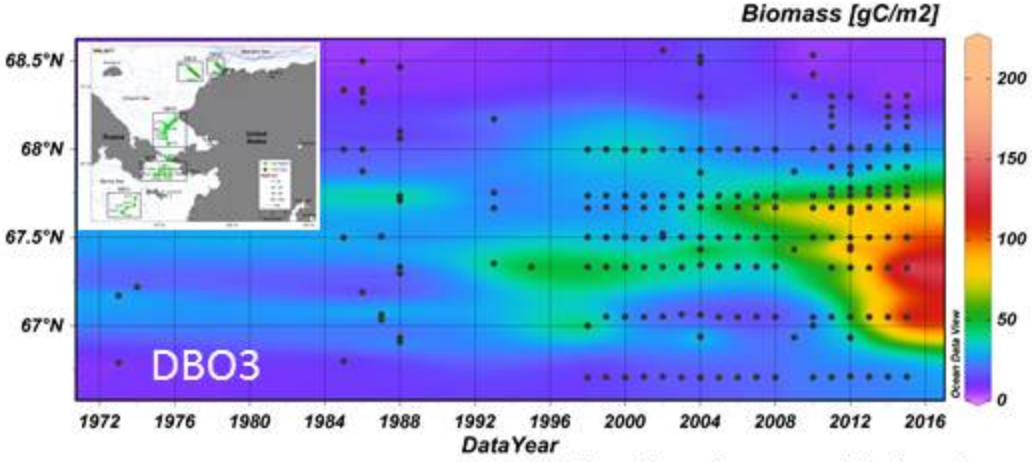

[courtesy S. Zimmerman, DFO]

# DBO3-Adding to long-term time series

## Zooplankton




## Macrofaunal Biomass




[Grebmeier unpubl. data]

Relate copepod abundance to hydrographic conditions

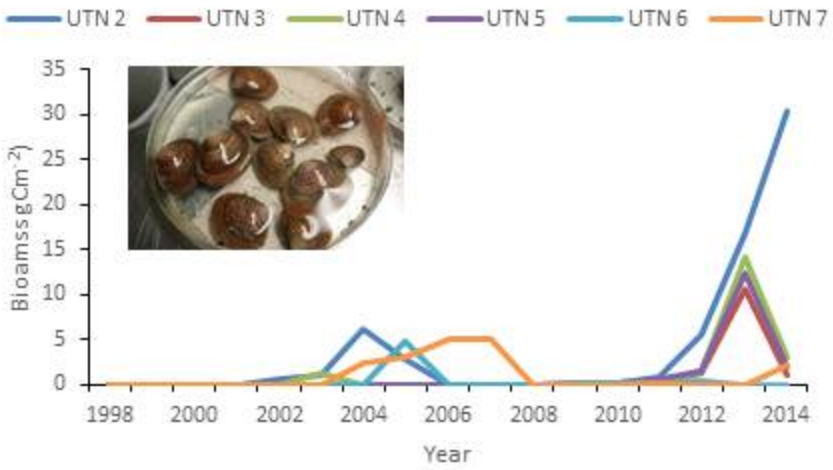
= warm years dominated by small *Pseudocalanus*

= lipid-rich *Calanus* more abundant in cold years

[R. Hopcroft]

## Example Data

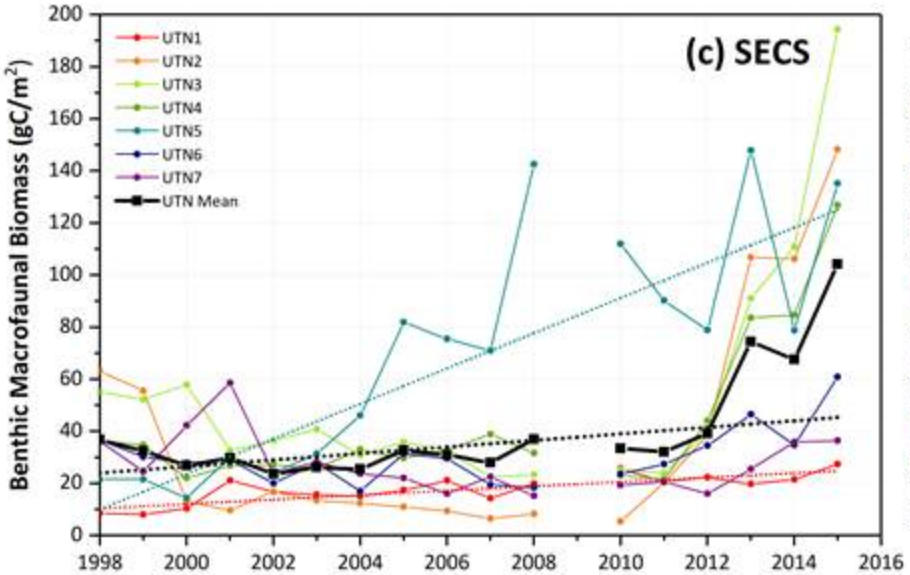
Biomass of *Serripes groenlandicus* in DBO 3




[Goethel unpubl. data]

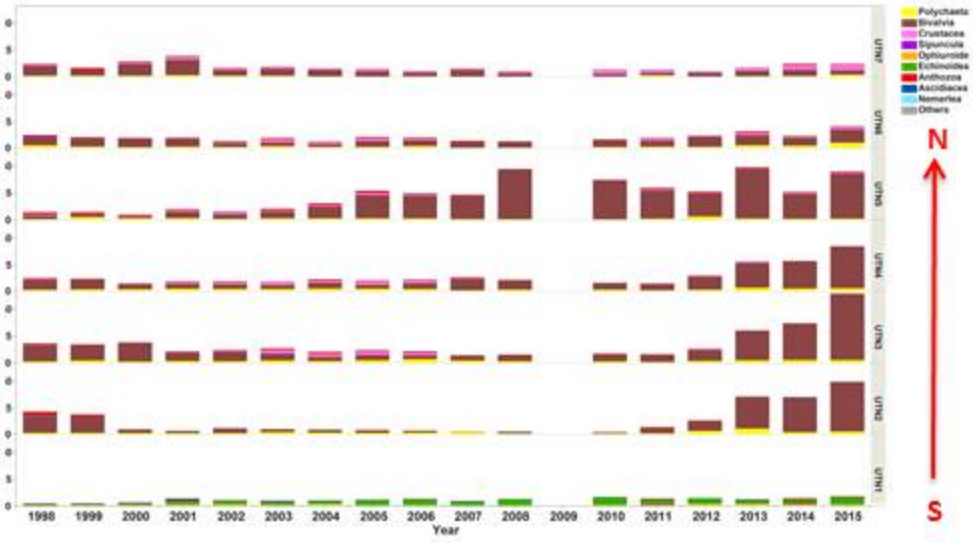
# DBO3 Macrofaunal biomass and composition at time series stations (UTN1-7) in SE Chukchi Sea, 2000-2015

## Time series benthic biomass in the DBO3




- Significant increasing trend at UTN1 in south and UTN5 in the north, as well as average values
- Expanding high biomass region spatially since 2012

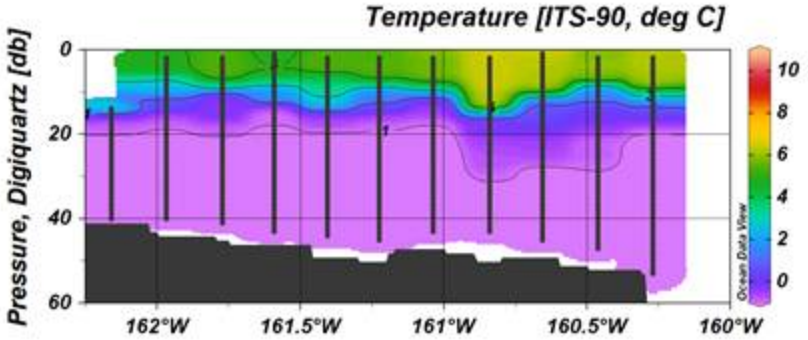
## Macrofaunal composition for UTN time series sites in DBO3

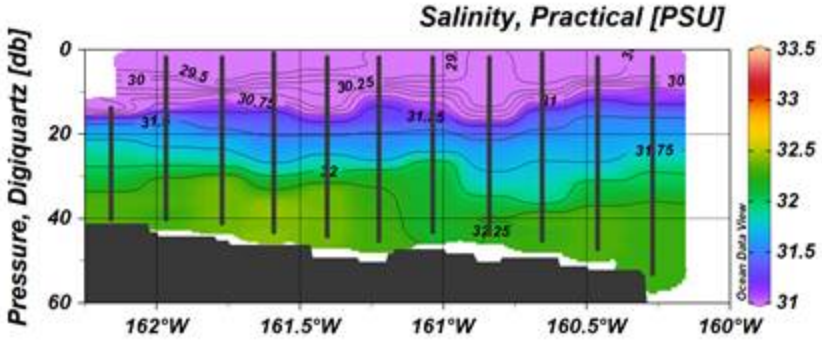


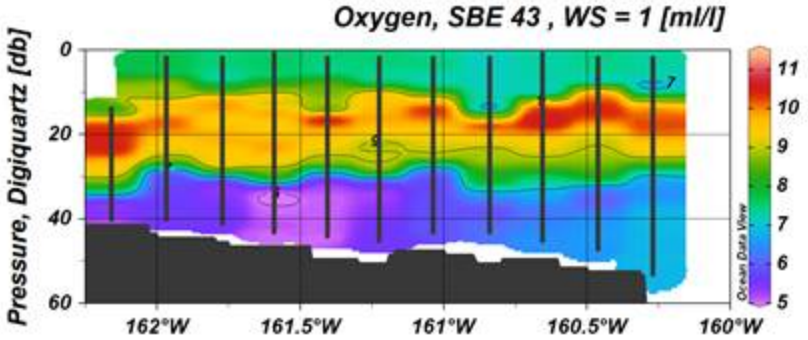

- Station stacked latitudinally from UTN1 in the south to UTN7 in the north
- Large bivalve (brown) biomass expansion southward from UTN5 to UTN2 since 2012 coincident with observations of increased primary production in SECS (Arrigo and van Dijken 2015)

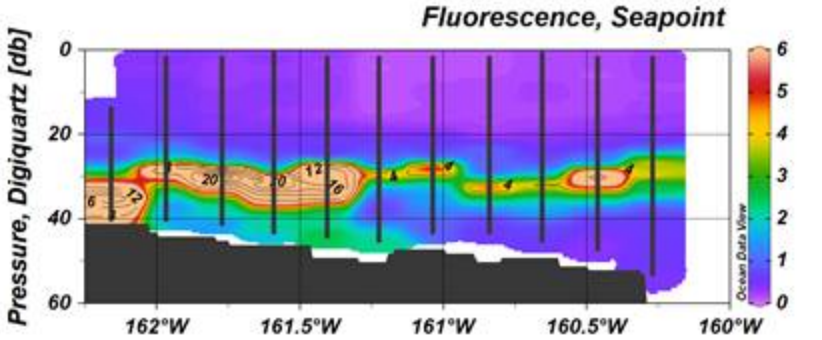
[Grebmeier et al., Oceanography, 2018]

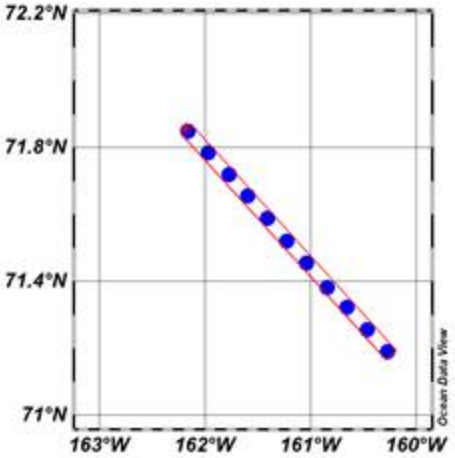
# DBO4 – new 2018 positions

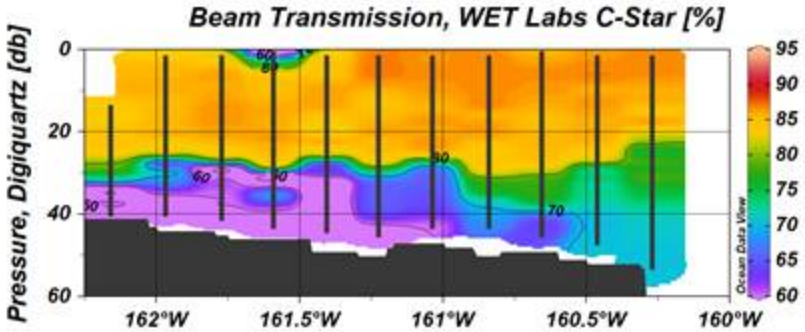


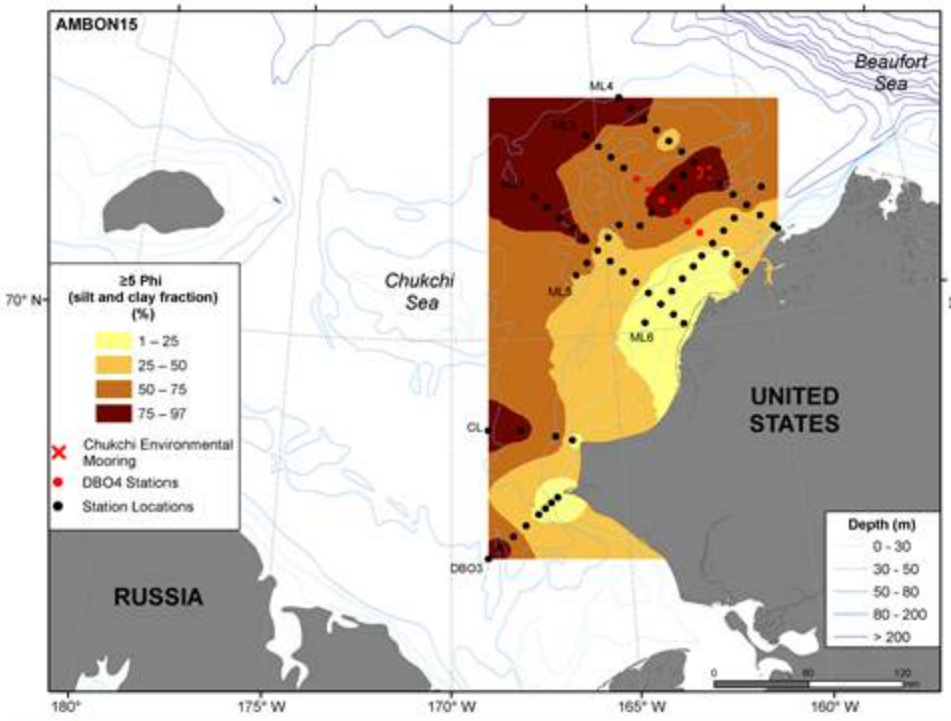

[courtesy S. Zimmerman, DFO]

# Arctic Marine Biodiversity Observing Network (AMBON)

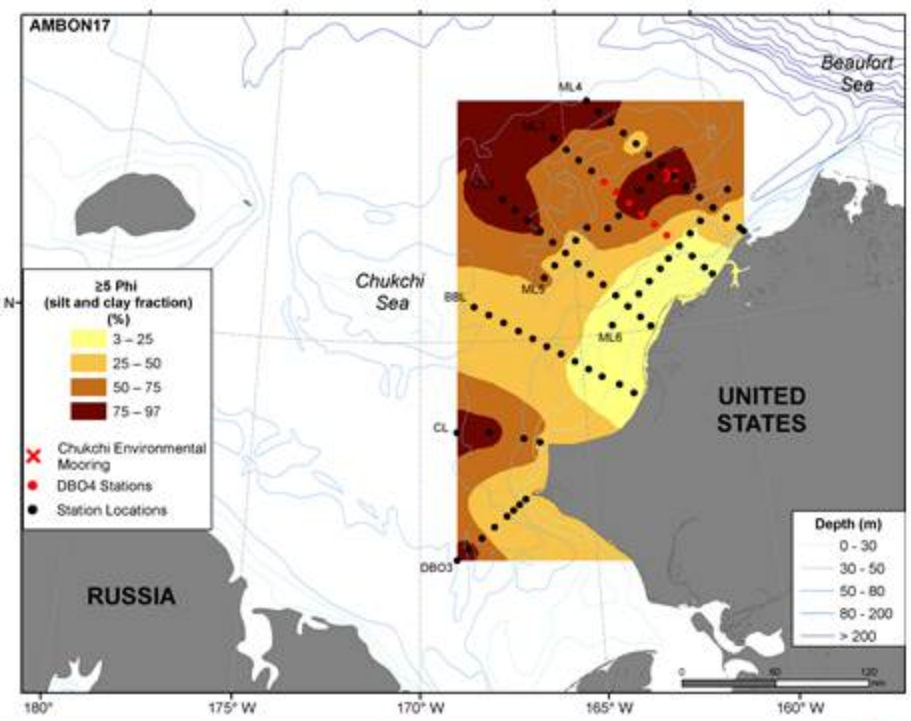
Comparing between 2015-2017

## Sediment silt and clay content (≥5 phi, %)

### 2015




### 2017



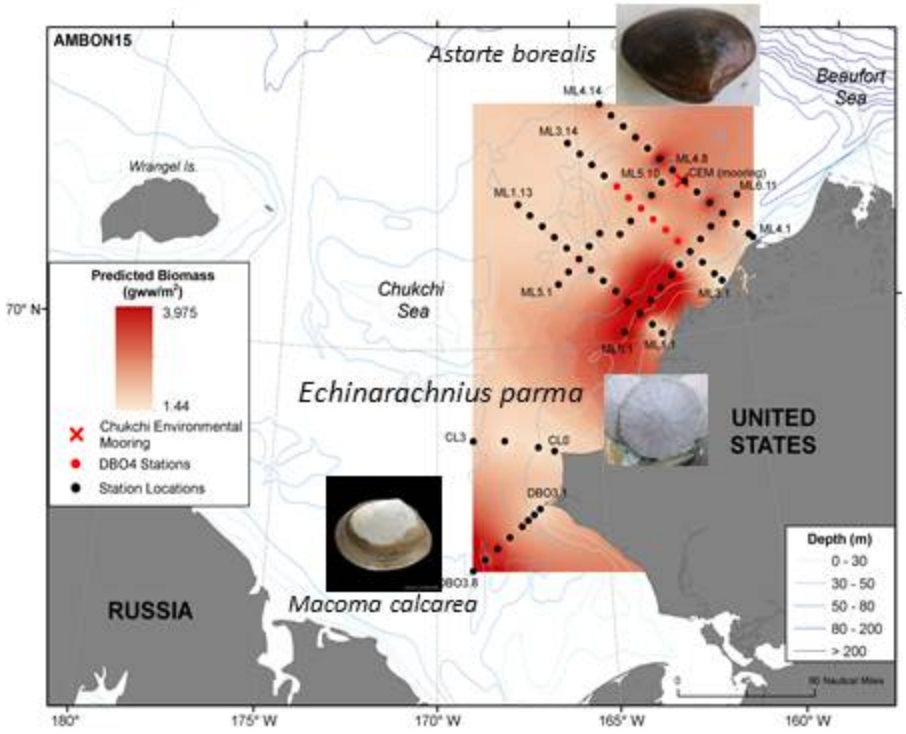

- Highest % silt/clay in offshore DBO3, CL line, SE Hanna Shoal, and west of Hanna Shoal, indicate slower currents both years
- Lower % silt/clay in ACW under faster currents both years
- In 2018 moved DBO4 line NE to cross CEO and deposition area

# Arctic Marine Biodiversity Observing Network (AMBON)

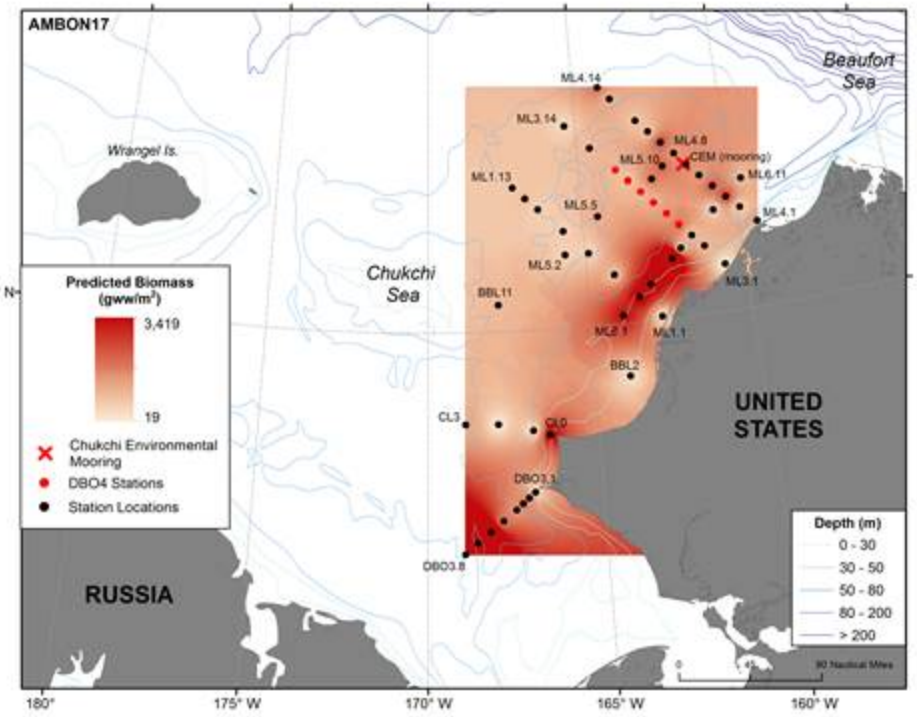
Comparing between 2015-2017

## Macrofauna Benthic Biomass (gww/m$^2$)

### 2015

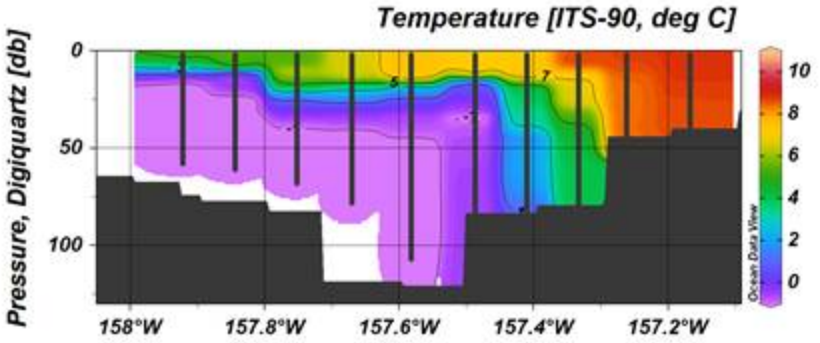


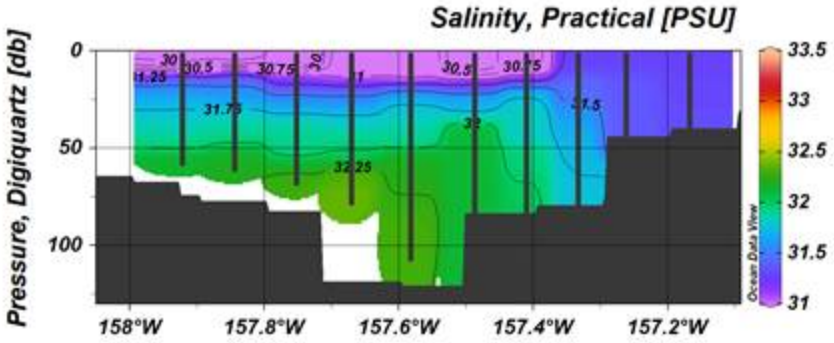

### 2017

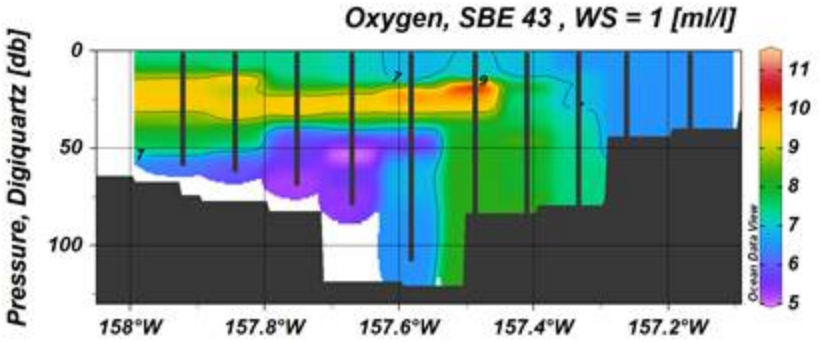


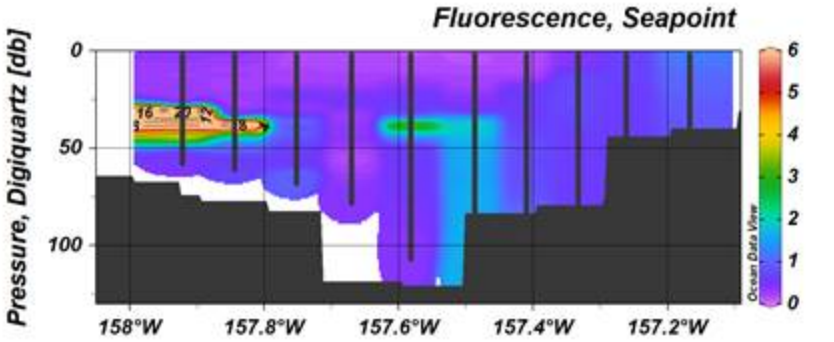

- Highest biomass dominated by bivalves offshore DBO3 and ML4 line
- The biomass on ML6 line is dominated by sand dollars; once wet weight biomass values converted to carbon dry weight biomass this patch will decline in biomass dramatically
- ML4 line (subset as DBO4-n in 2018) still in progress

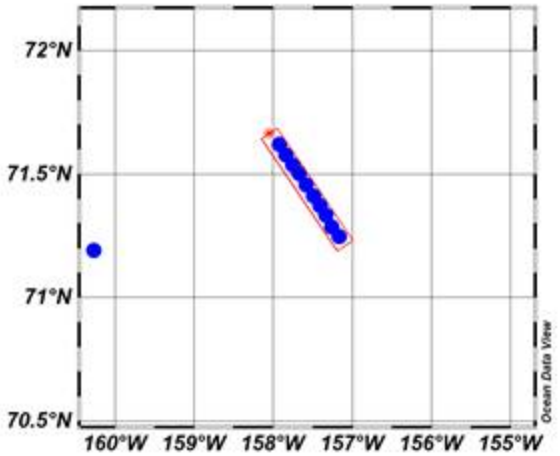
# DBO5 – BarC Barrow Canyon

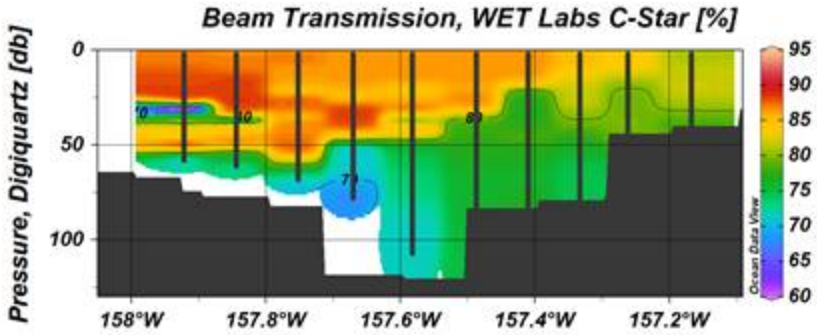



[courtesy S. Zimmerman, DFO]

https://arcticdata.io/

# DBO Data Discovery Portal

**DBO International Data Policy, approved by partners within PAG in 2015**



- DBO data contributions since April 17, 2014
- 1,096 contributions DBO data
- 4,505 downloads of DBO data

***New DBO Project page from US Arctic Data Center in progress-will go live in fall 2019**

https://arcticdata.io/catalog/#profile/CN=DBO,DC=dataone,DC=org

**Special DSR Issue-The Distributed Biological Observatory: A Change Detection Array in the Pacific Arctic Region**
**Guest Editors:** Jacqueline M. Grebmeier, Sue E. Moore, Lee W Cooper, and Karen E Frey
**15 accepted papers+introduction, May 2019-COMPLETE**

## INTRODUCTION

**1. The Distributed Biological Observatory: A Change detection array in the Pacific Arctic region - An Introduction**
Jacqueline M. Grebmeier, Sue E. Moore, Lee W Cooper, and Karen E Frey

## SEA ICE AND PHYSICAL OCEANOGRAPHY

**2. Distributed Biological Observatory Region 1: Physics, chemistry and plankton in the northern Bering Sea**
Phyllis J. Stabeno, Shaun W. Bell, Nicholas A. Bond, David G. Kimmel, Calvin W. Mordy, Margaret E. Sullivan

**3. The encoding of wind forcing into the Pacific-Arctic pressure head, Chukchi Sea ice retreat and late-summer Barrow Canyon water masses**
Stephen Okkonen, Carin Ashjian, Robert G. Campbell, Philip Alatalo

**4. Seasonal to mesoscale variability of water masses and atmospheric conditions in Barrow Canyon, Chukchi Sea**
Robert S. Pickart, Carolina Nobre, Peigen Lin, Kevin R. Arrigo, Carin J. Ashjian, Catherine Berchok, Lee W. Cooper, Jacqueline M. Grebmeier, Ian Hartwell, Jianfeng He, Motoyo Itoh, Takashi Kikuchi, Shigeto Nishino, Svein Vagle

**5. Pathways, timing, and evolution of Pacific winter water through Barrow Canyon**
Emily L. Shroyer, Robert S. Pickart

**6. On the nature of wind-forced upwelling in Barrow Canyon**
Maria N. Pisareva, Robert S. Pickart, Peigen Lin, Paula S. Fratantoni, Thomas J. Weingartner

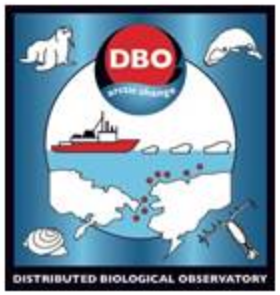
**7. Characteristics and dynamics of wind-driven upwelling in the Alaskan Beaufort Sea based on six years of mooring data**
Peigen Lin, Robert S. Pickart, G.W.K. Moore, Michael A. Spall, Jianyu Hua

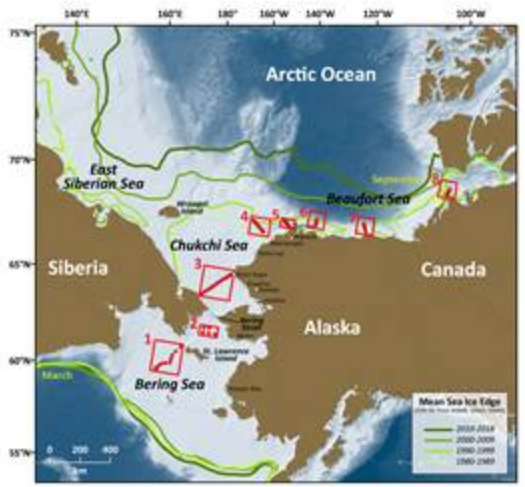
## PHYTOPLANKTON AND NUTRIENTS

**8. A decade of summertime measurements of phytoplankton biomass, productivity and assemblage composition in the Pacific Arctic region from 2006-2016**
K.E. Giesbrecht, D.E. Varela, J. Wiktor, J.M. Grebmeier, B. Kelly, J.E. Long

**9. Impact of spatiotemporal variability in phytoplankton size structure on benthic macrofaunal distribution in the Pacific Arctic**
Hisatomo Waga, Toru Hirawake, Amane Fujiwara, Jacqueline M. Grebmeier, Sei-Ichi Saitoh

**Question: Is there interest in a 2nd DBO special issue?**




*Grebmeier, Moore, Cooper, Frey: DBO DSR Special Issue Manuscript Titles*

## BENTHOS AND FISH

**10. Changes in abundance and biomass of the bivalve Macoma calcarea in the northern Bering Sea and the southeastern Chukchi Sea from 1998 to 2014, tracked through dynamic factor analysis models**
Christina L. Goethel, Jacqueline M. Grebmeier, Lee W. Cooper

**11. Benthic trophic sensitivity to on-going changes in Pacific Arctic seasonal sea ice cover – Insights from the nitrogen isotopic composition of amino acids**
Monika Kędra, Lee W. Cooper, Mengjie Zhang, Dana Biasatti, Jacqueline M. Grebmeier

**12. High-latitude benthic bivalve biomass and recent climate change: testing the power of live-dead discordance in the Pacific Arctic**
Caitlin A. Meadows, Jacqueline M. Grebmeier, Susan M. Kidwell

**13. A Video Seafloor Survey of Epibenthic Communities in the Pacific Arctic including Distributed Biological Observatory stations in the Northern Bering and Chukchi Seas**
Lee W. Cooper, Marisa L. Guarinello, Jacqueline M. Grebmeier, Alynne Bayard, James Lovvorn, Christopher North, Jason Kolts

**14. Developing an observational design for epibenthos and fish assemblages in the Chukchi Sea**
Katrin Iken, Franz Mueter, Jacqueline M. Grebmeier, Lee W. Cooper, Seth L. Danielson, Bodil A. Bluhm

## MARINE BIRDS AND MAMMALS

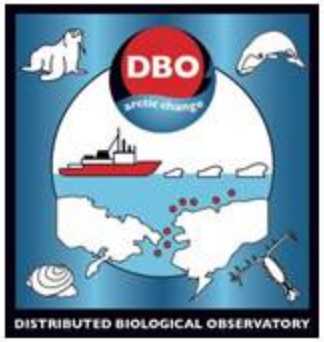
**15. Representation of the Pacific Arctic seabird community within the Distributed Biological Observatory array, 2007–2015**
Kathy J. Kuletz, Daniel Cushing, Erik E. Osnas, Elizabeth A. Labunski, Adrian Gall

**16. Marine birds and mammals as ecosystem sentinels in and near Distributed Biological Observatory regions: An abbreviated review of published accounts and recommendations for integration to ocean observatories**
Sue E. Moore, Kathy J. Kuletz

# 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. We thank the Captain and crew of the USCGC Healy and CCGS Sir Wilfrid Laurier for support for the DBO program. Financial support for the science provided by the US NOAA, NSF, BOEM, NASA, and ongoing international science partners in the Pacific Arctic Group.




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

http://arctic.cbl.umces.edu

BOEM
Bureau of Ocean Energy Management

NASA

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

NSF

PAG