The Distributed Biological Observatory: A Change Detection Array in the Pacific Arctic

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25 June 2019
2nd Conference on the Implementation of the Ecosystem Approach to Management in the Arctic
Bergen, Norway

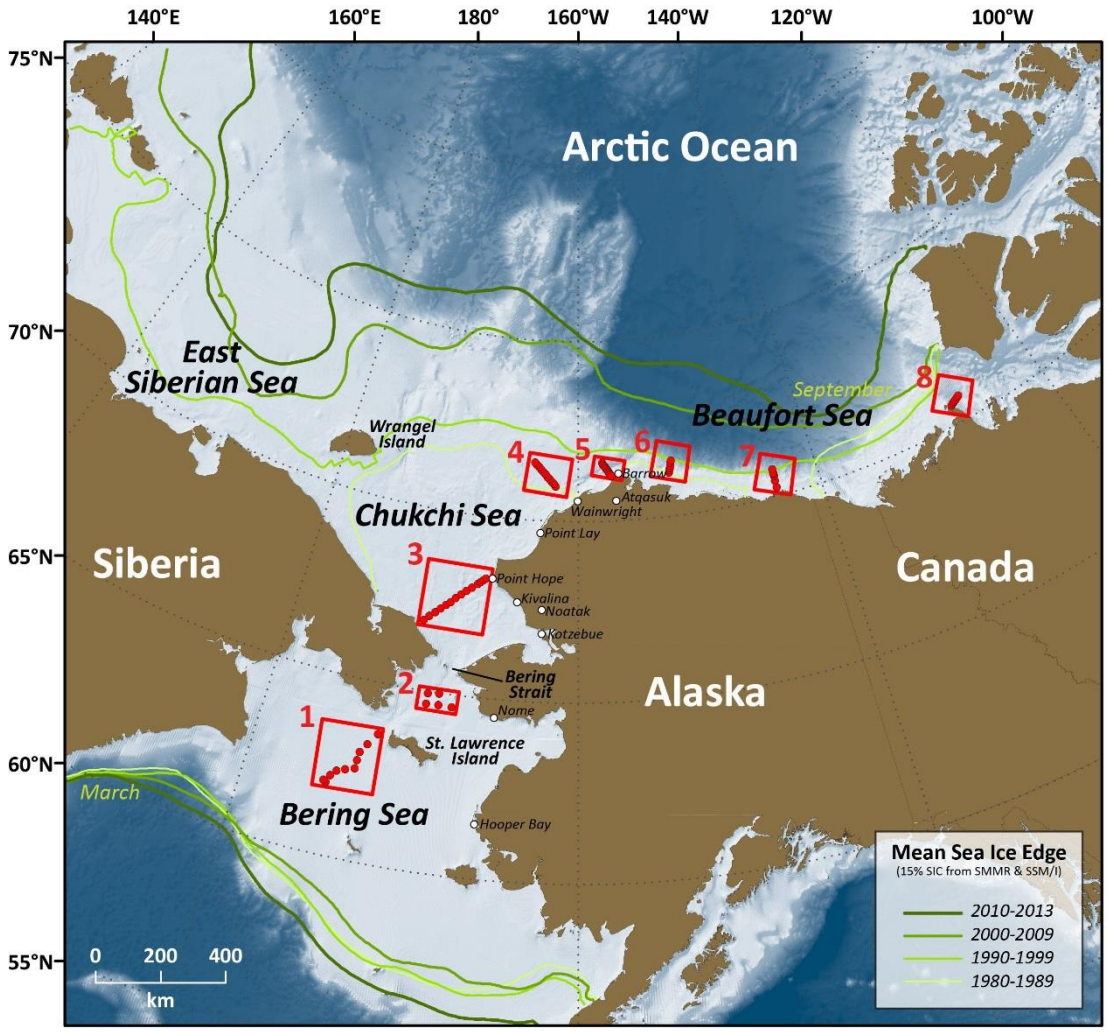
Outline

>100 year old bowhead whale
Photo: C. George

- What is the Distributed Biological Observatory (DBO)?
- Loss of Sea Ice in the Pacific Arctic
- Pelagic–Benthic Coupling and DBO 'hotspots' on the Bering/Chukchi shelf
- Building an Ecosystem Model for the Pacific using the DBO sampling framework
- Brief Summary

Distributed Biological Observatory (DBO)

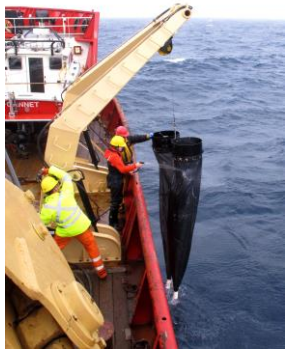
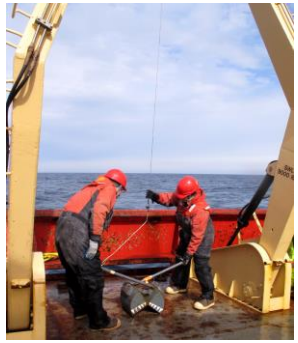
http://www.pmel.noaa.gov/dbo/



[modified by Karen Frey from Grebmeier et al. 2010, EOS 91]

- Eight DBO Regions
- DBO 1-4: continental shelf
- DBO 5-8: outer continental shelf, slope, basin & canyon
- All regions are focused on areas of high productivity
- All regions are within the seasonal ice zone domain
- International sampling coordinated by the Pacific Arctic Group (PAG)

DBO Standardized Sampling: initiated in 2010

Core ship-based sampling:

- CTD and ADCP
- Chlorophyll
- Nutrients
- Ice algae/Phytoplankton (size, biomass and composition)
- Zooplankton (size, biomass and composition)
- Benthos (size, biomass and composition)
- Seabird standard surveys (no additional ship time)
- Marine mammal watches & surveys (no additional ship time)

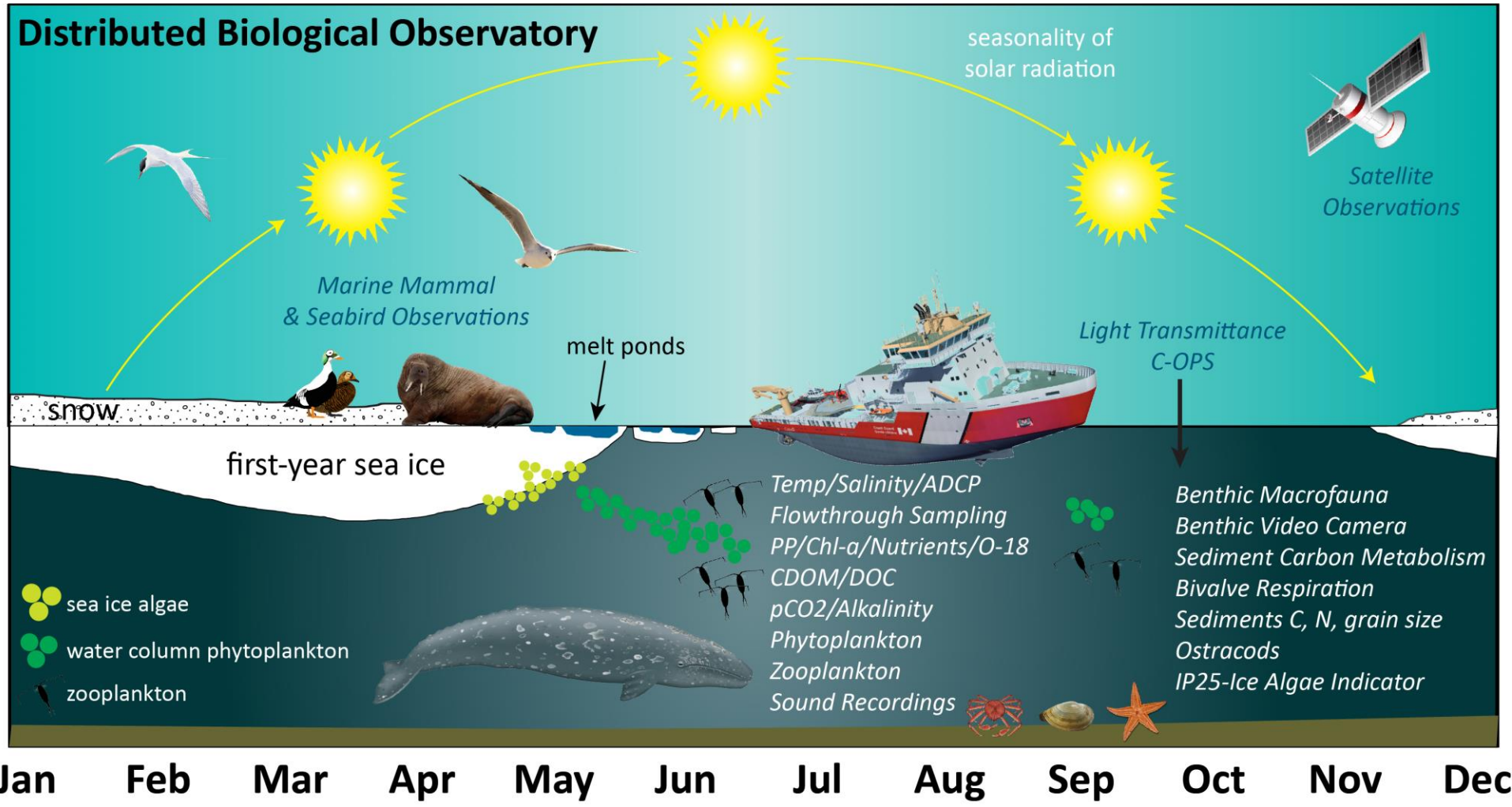
Second tier ship-based sampling:

- Fishery acoustics (less effort than standardized bottom trawling)
- Bottom trawling (every 3-5 years)

Shipboard measurements

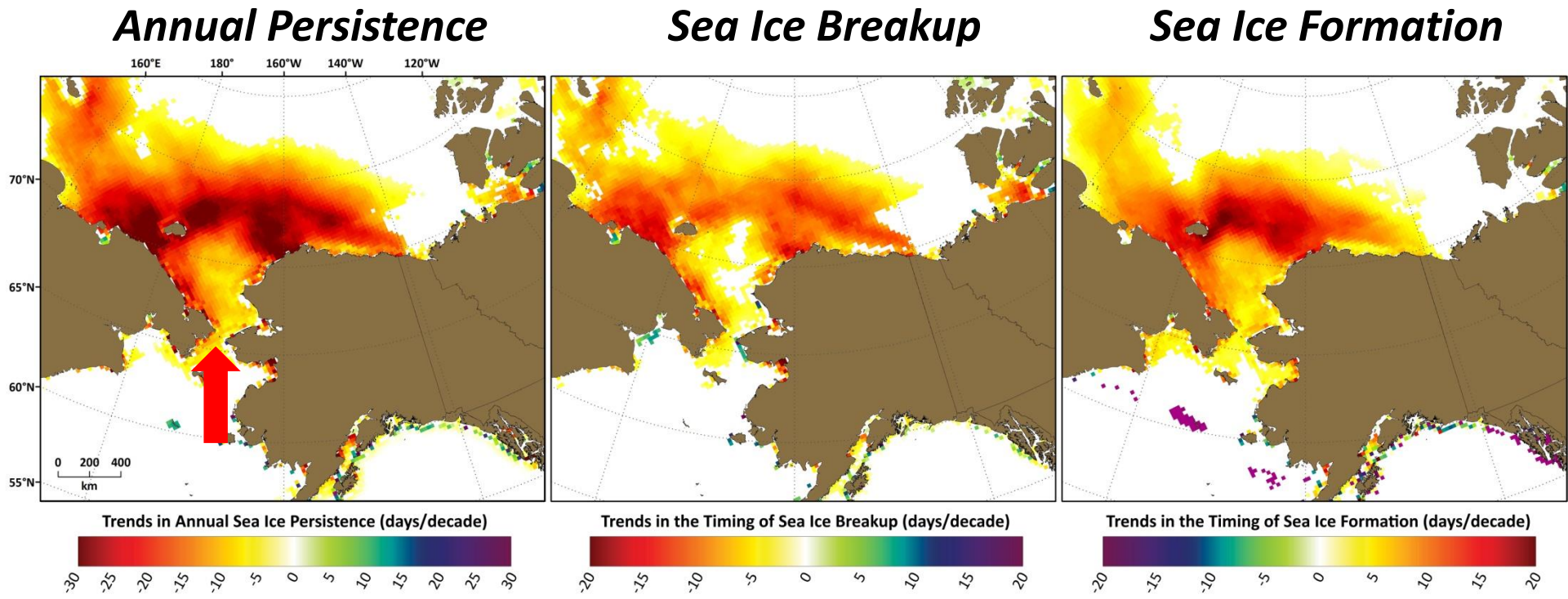
- Record underway measurements from the seawater loop, meteorological sensors, sounder, and navigation information

Additional DBO Sampling Components: remote sensing and autonomous instruments



Key: C-OPS=Compact-Optical Profiling System, Temp= Temperature, ADCP= Acoustic Doppler Current Profiler, C=Carbon, CDOM=Chromophoric Dissolved Organic Matter, Chl-a=Chlorophyll a, DOC=Dissolved Organic Carbon, IP-25=Ice proxy with 25 C atoms, N=Nitrogen, O-18=Oxygen-18 ratios, PP=Primary Production. All lower taxa analyses include composition, abundance and biomass data.

Trends in Sea Ice Cover/Timing of Events: Regional Differences In the Pacific Arctic

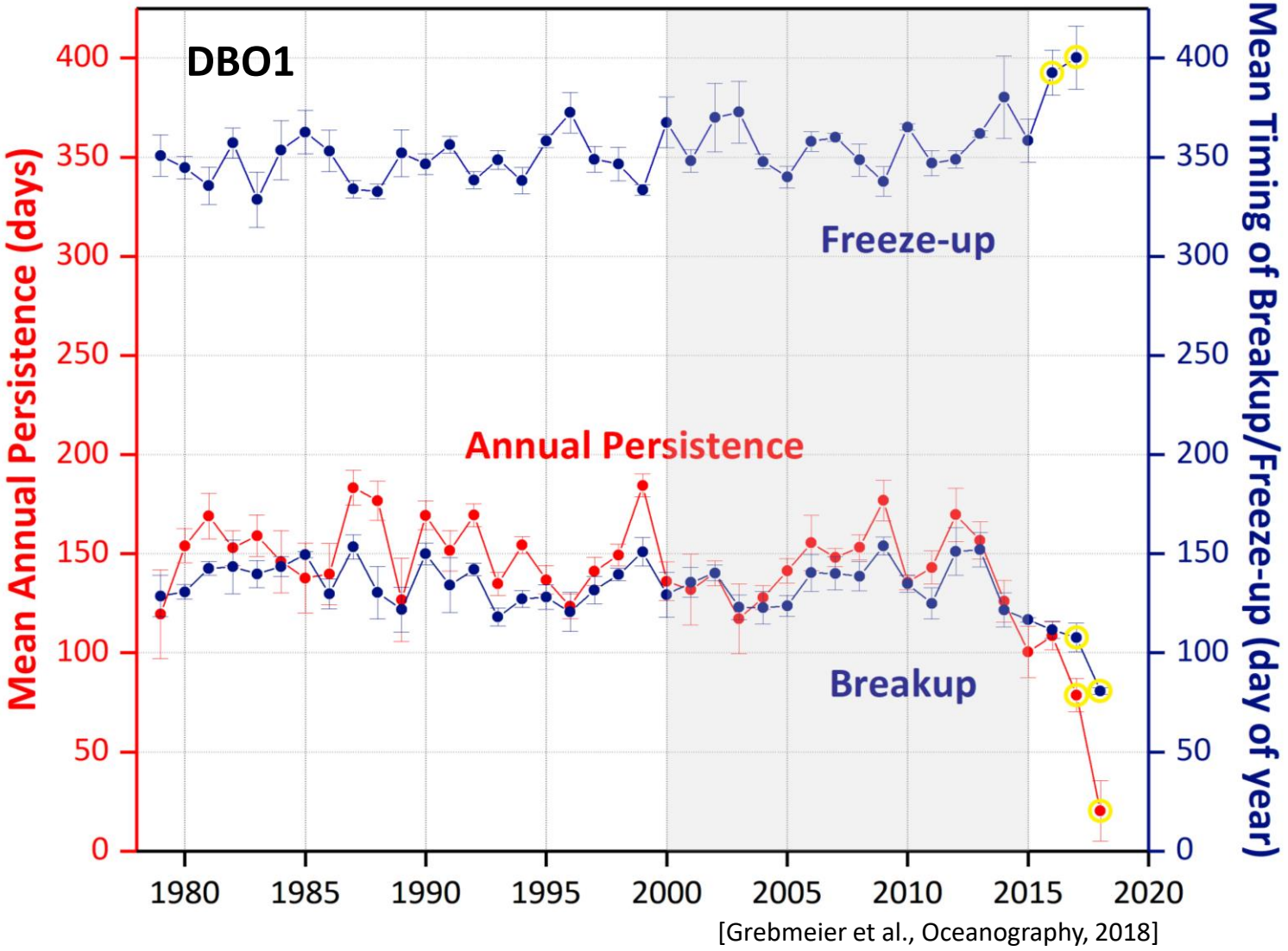


Based on SMMR and SSM/I Satellite-Derived Sea Ice Concentrations (1979-2008)
Slide Courtesy of Karen Frey, Clark University; Frey et al. 2015

(Mann-Kendall, p<0.1)

Bering Strait inflow + 50% from 2001 to 2011
Record-high heat flux in 2007 & 2015 (Woodgate 2018)

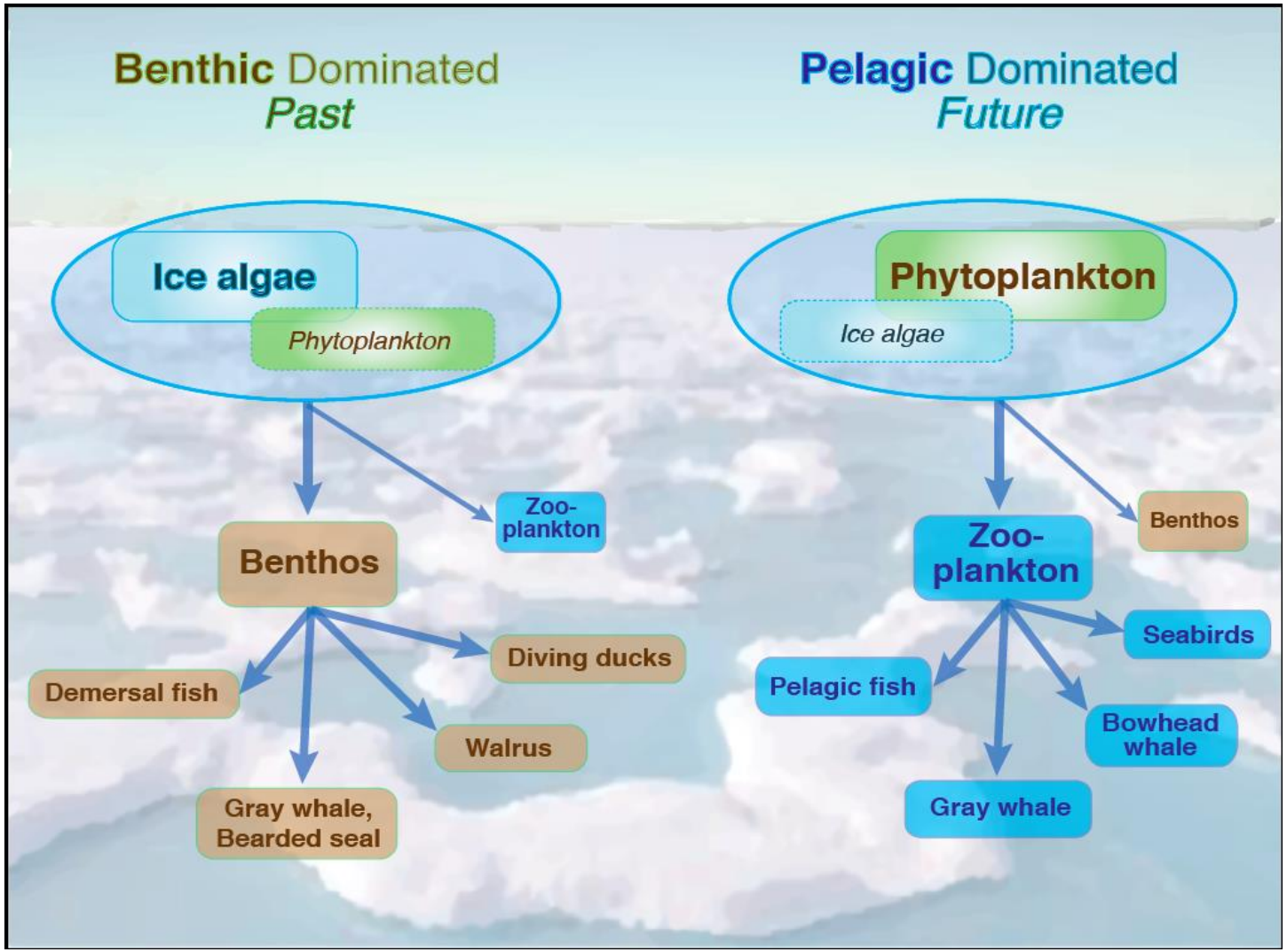
Sea ice trends in the northern Bering Sea (DBO1): - was 2018 a 'Tipping Point' in winter sea ice loss?



[Grebmeier et al., Oceanography, 2018]

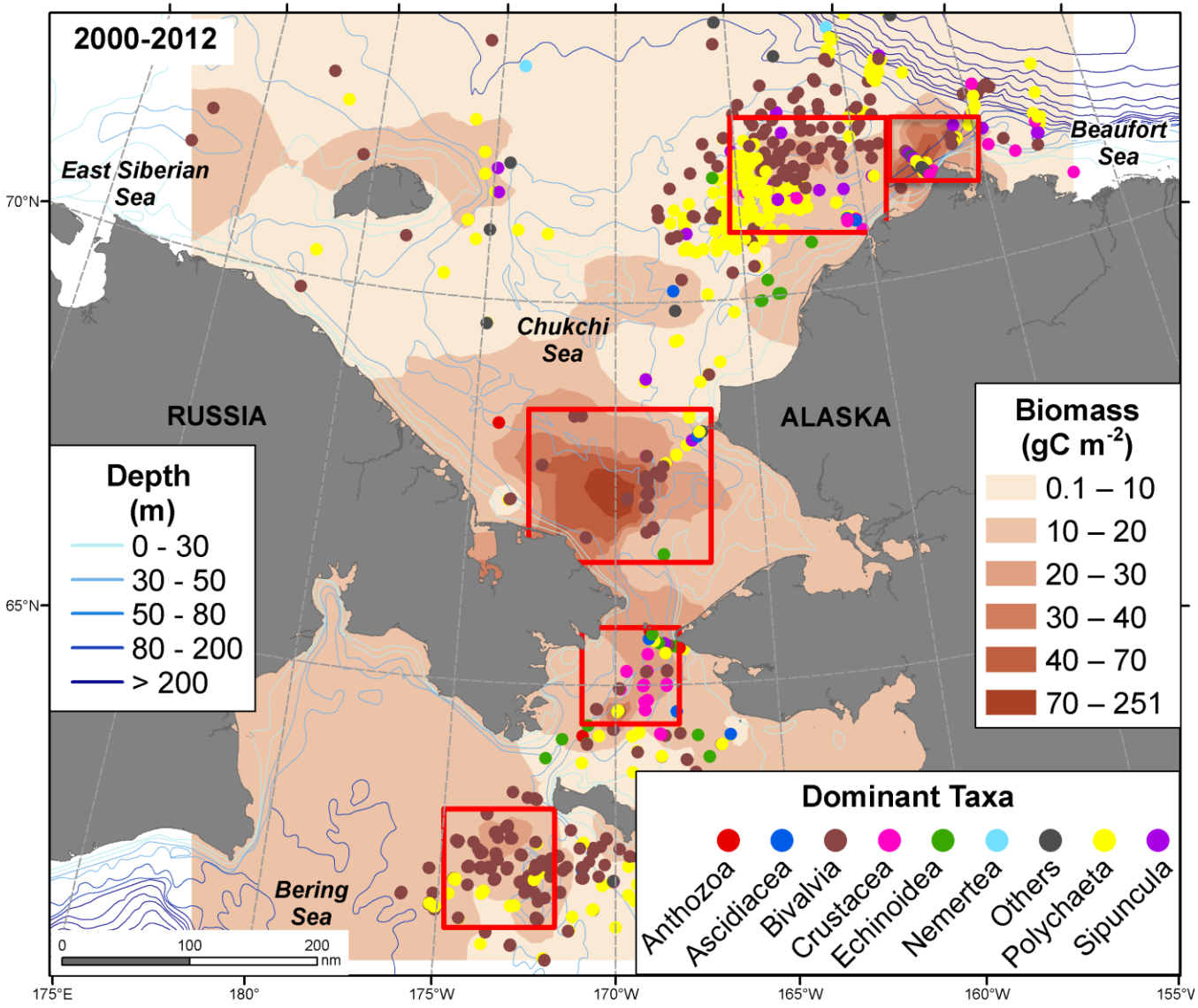
- yellow circles indicate significant outliers using a double Grubb's Test (p <0.0001)

How does sea ice loss impact the food web?
Pelagic-Benthic Coupling Model



Moore and Stabeno 2015

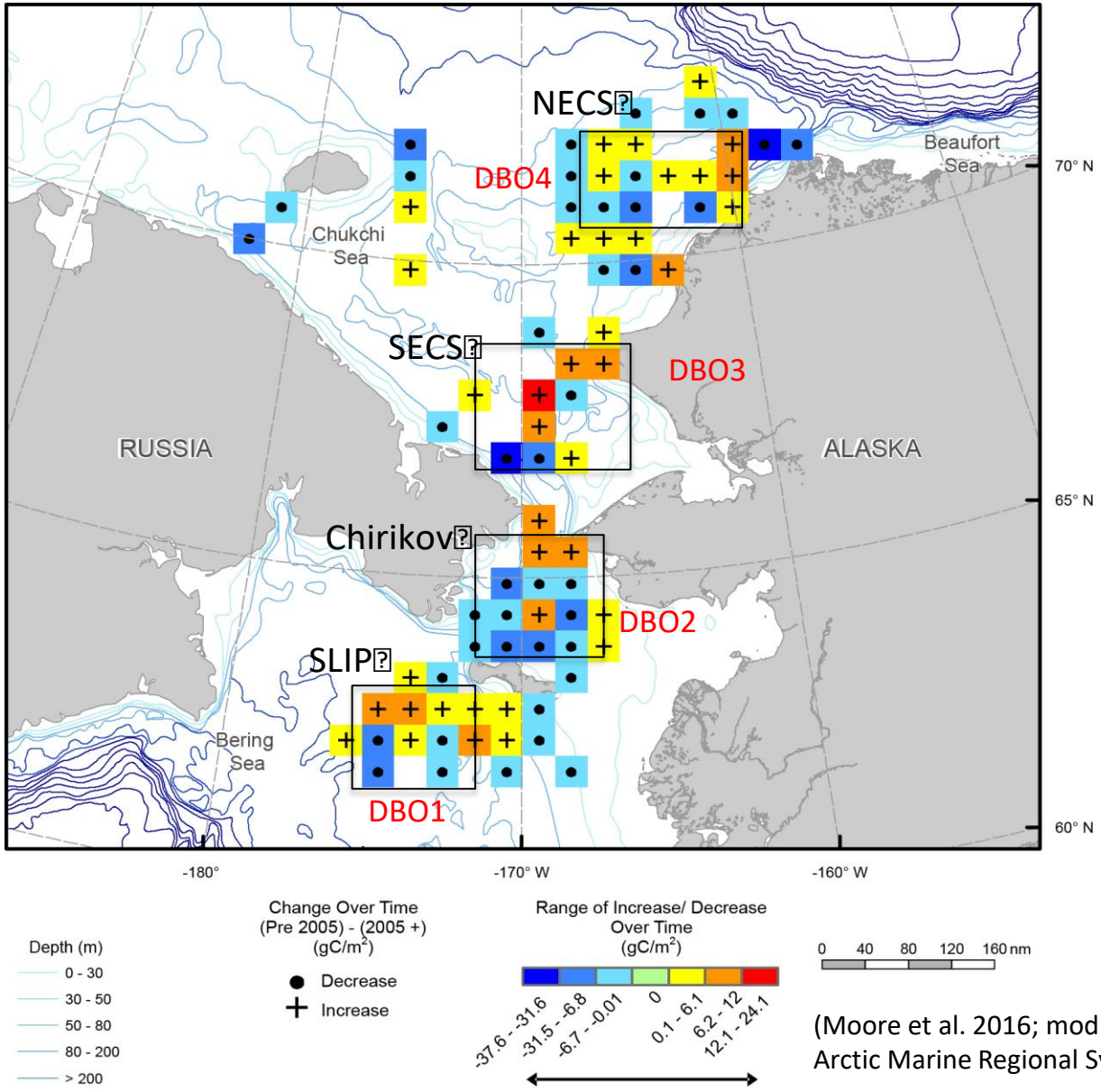
Rich benthic communities in Bering/Chukchi Sea system, 2000-2012



- **"foot prints"** of high benthic biomass reflect pelagic-benthic coupling and export of carbon to sediments
- macrofauna dominated by amphipods, bivalves, polychaetes, and sipunculids

[modified from Grebmeier et al. 2015, *Progress in Oceanography*

Benthic macrofaunal biomass pre- and post-2005 shows northward migration benthic hotspots: SLIP, Chirikov, SECS



- time series data from 1973-2012
- northward movement of centroid benthic biomass at DBO 1-3 regions
- related to changes in advection, production and deposition areas

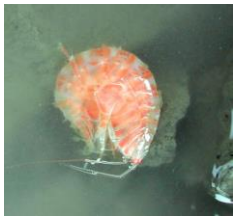
Key:

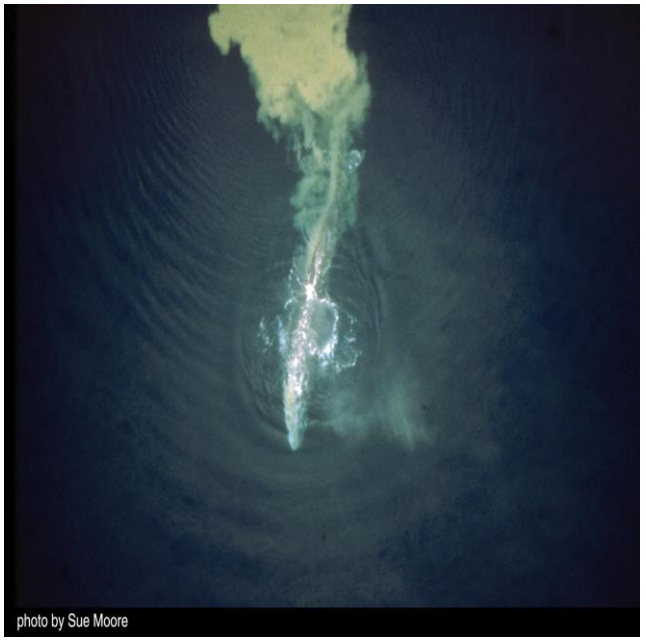
- SLIP=St. Lawrence Island Polynya
- Chirikov=Chirikov Basin
- SECS=SE Chukchi Sea
- NECS=NE Chukchi Sea

(Moore et al. 2016; modified from Grebmeier et al. 2015, data from Pacific Arctic Marine Regional Synthesis (PacMARS) Grebmeier and Cooper 2014]

Response of Upper Trophic Foragers 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 north of Bering Strait





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

Diving seaducks = changing sea ice location as resting platform

Building an Ecosystem Model for the Pacific Arctic based on the DBO sampling framework

Pacific water inflow through Bering Strait peaks in mid-summer

Nutrients and zooplankton are advected from the northern Bering to the Chukchi and Beaufort Seas

A conceptual model for the Pacific Arctic region must include both pelagic-benthic coupling and advective elements

The Arctic Marine Pulses (AMP) model is a provisional conceptual model based on the DBO sampling framework

Building the AMP Conceptual Model

Moore and Stabeno 2015; Grebmeier et al. 2015/PACMARS

Pelagic-benthic coupling model

- Northern Bering and Chukchi Sea

DBO Regions 1-4

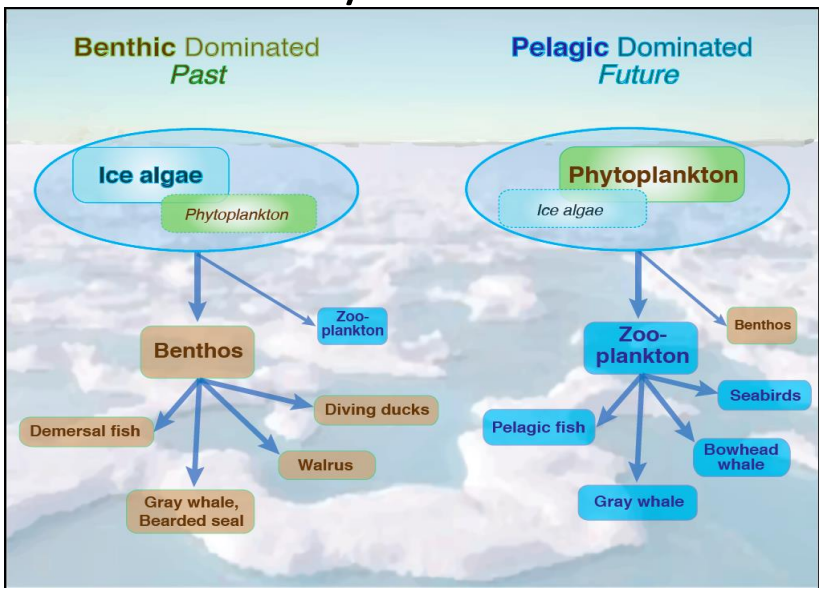
Advective model

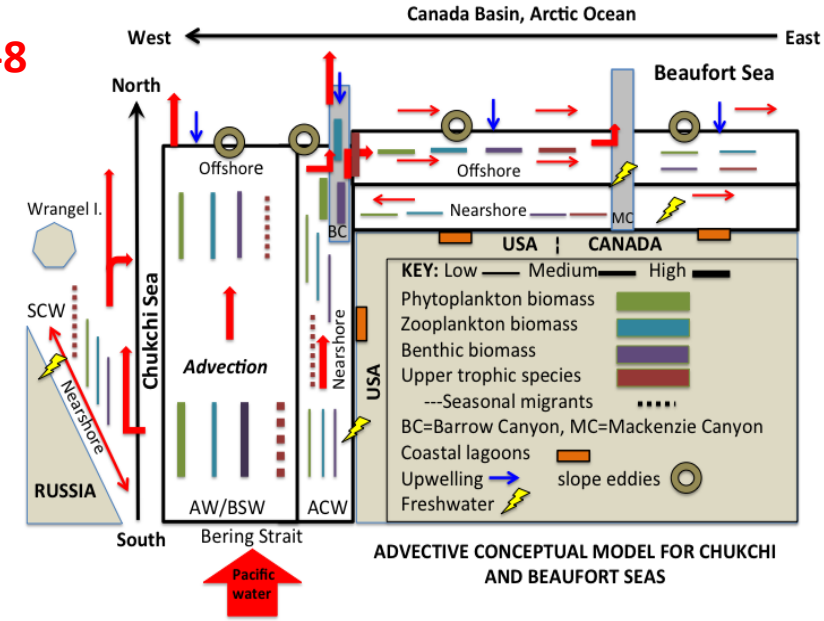
- Northern Chukchi and Beaufort Sea

DBO Regions 1-8

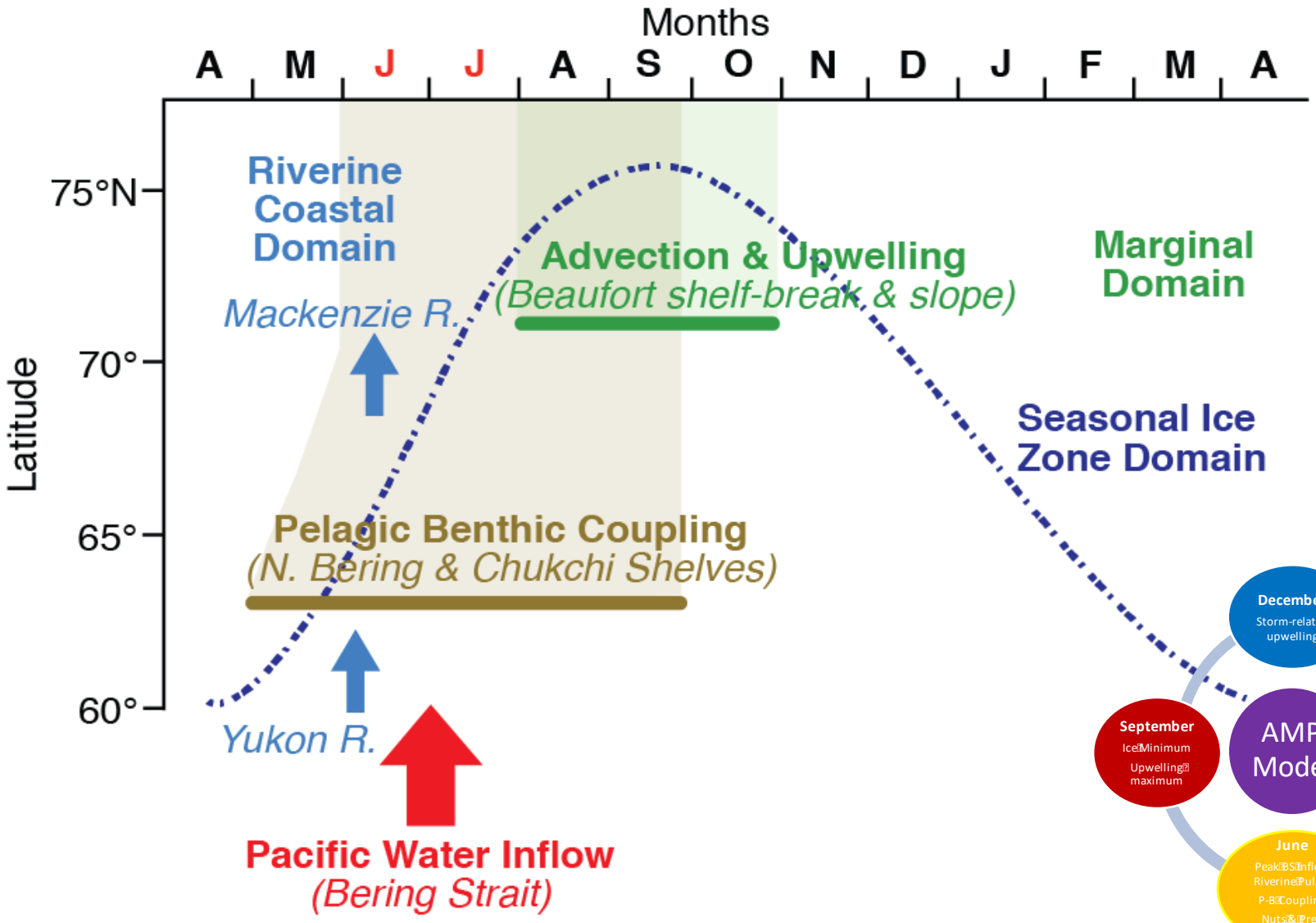
Arctic marine pulses model

- Dynamic seasonal model linking contiguous domains



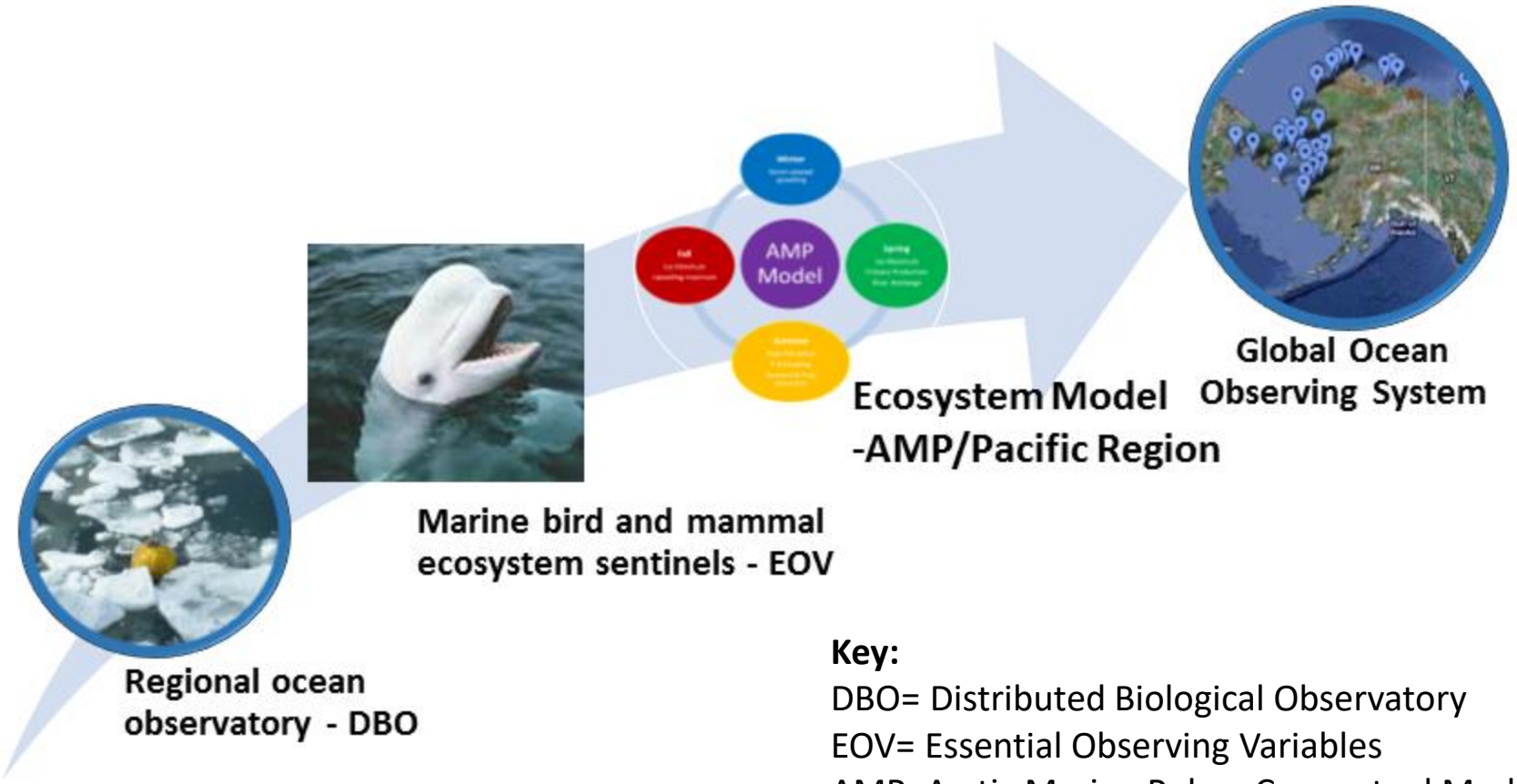


Arctic Marine Pulses (AMP) Model:
the Pacific Arctic Domain



[Moore et al. 2018 DSR]

Scaling DBO Observations from the Regional to Global Scale



[Moore and Kuletz 2018]

Key:
DBO= Distributed Biological Observatory
EOV= Essential Observing Variables
AMP=Arctic Marine Pulses Conceptual Model

- Ongoing development of the Atlantic DBO (Reigstad and Ingvaldsen 2017, pers. comm.)
- DBO expansion into eastern Beaufort Sea and Baffin Bay (Tremblay, pers. comm.)

Brief Summary

- Biological sampling across a range of ecological scales is required to detect environmental responses to physical forcing.
- Benthic macrofaunal time series indicate a northward shift in benthic biomass in the Bering Strait region.
- Tracking lower trophic level shifts via changes in upper trophic level species' movement & feeding patterns provides insight to ecosystem status & trends.
- The DBO framework provides capacity for multidisciplinary analyses of biological and biogeochemical time series in relation to changes in physical forcing (**DBO Special Issue of DSRII coming soon**).
- The DBO can serve as a model for pan-Arctic ocean observations.

Thank You for your attention
Questions and comments?

Thank you to the DBO national and international 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/
http://pag.arcticportal.org/
http://arctic.cbl.umces.edu

Also, special thanks to PICES for travel support to this conference!

BOEM Bureau of Ocean Energy Management

NASA

NSF

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

PAG Pacific Arctic Group