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

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Outline

- 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

>100 year old bowhead whale
Photo: C. George
Distributed Biological Observatory (DBO)  
http://www.pmel.noaa.gov/dbo/

• 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

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

Annual Persistence  Sea Ice Breakup  Sea Ice Formation

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

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?

- 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

**Advective model**
- Northern Chukchi and Beaufort Sea

**Arctic marine pulses model**
- Dynamic seasonal model linking contiguous domains

**DBO Regions 1-4**
- Benthic Dominated Past
  - Ice algae
  - Phytoplankton
  - Benthos
  - Zooplankton
  - Diving ducks
  - Walrus
  - Demersal fish
  - Seabirds
  - Gray whale, Bearded seal

**DBO Regions 1-8**
- Pelagic Dominated Future
  - Phytoplankton
  - Ice algae
  - Benthos
  - Zooplankton
  - Pelagic fish
  - Bowhead whale
  - Seabirds

**Canada Basin, Arctic Ocean**
- West
  - Wrangel Island
  - Offshore
  - Nearshore

- East
  - Beaufort Sea
  - Bering Strait
  - AW/BSW
  - SCW

**USA**
- Coastal lagoons
- Phytoplankton biomass
- Zooplankton biomass
- Benthic biomass
- Upwelling
- Coastal lagoons
Arctic Marine Pulses (AMP) Model: the Pacific Arctic Domain

Months

A M J J A S O N D J F M A

Latitudes

Riverine Coastal Domain
Mackenzie R.
Advection & Upwelling (Beaufort shelf-break & slope)
Pelagic Benthic Coupling (N. Bering & Chukchi Shelves)
Yukon R.
Pacific Water Inflow (Bering Strait)

Marginal Domain
Seasonal Ice Zone Domain

AMP Model
December
Storm-related upwelling
September
Ice Minimum
Upwelling maximum
March
Ice Maximum
Primary Production
June
Peak BSI inflow
Riverine Pulses
P-B Coupling
Nuts & Prey Advection

[Moore et al. 2018 DSR]
Scaling DBO Observations from the Regional to Global Scale

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

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

[Moore and Kuletz 2018]
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.
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http://www.arctic.noaa.gov/dbo/
http://pag.arcticportal.org/
http://arctic.cbl.umces.edu

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