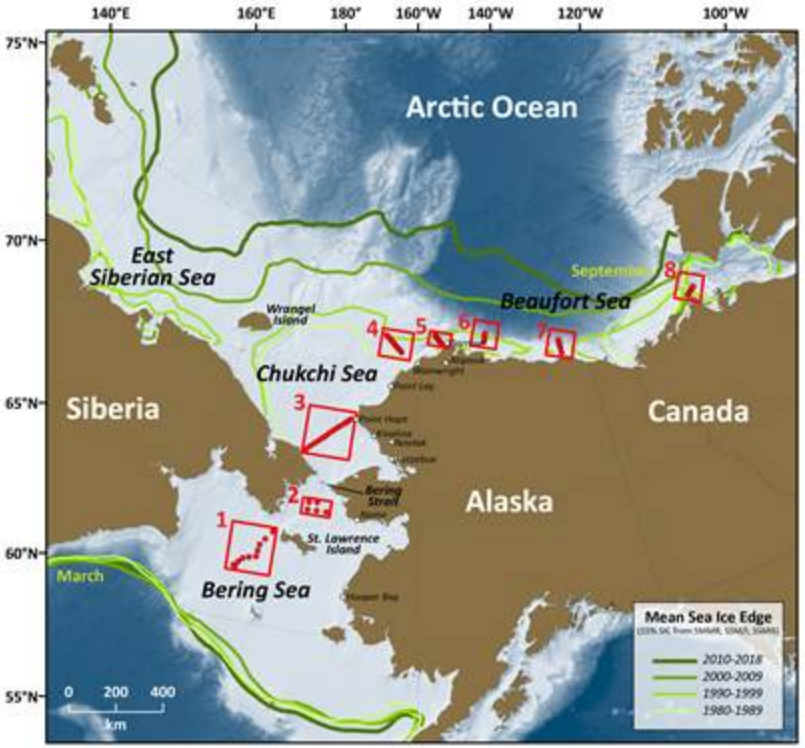
USA Country Report

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

Pacific Arctic Group Meeting
Hangzhou, Zhejiang Province, China
October 14, 2019

ASGARD: Arctic Shelf Growth, Advection, Respiration, and Deposition (ASGARD) Rate Measurements Project (only mooring retrieval Chirikov and SE Chukchi Sea)
CEO: Chukchi Environmental Observatory
DBO: Distributed Biological Observatory
Arctic EIS II: Arctic Ecosystem Integrated Study II (2019 NOAA trawl survey)
Bering Strait moorings (Woodgate)
JOIS/AON-BGOS: Joint Ocean Ice Study/Arctic Observing Network-Beaufort Gyre Observing System (Bill Williams talk)
Saildrones (also gliders)

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

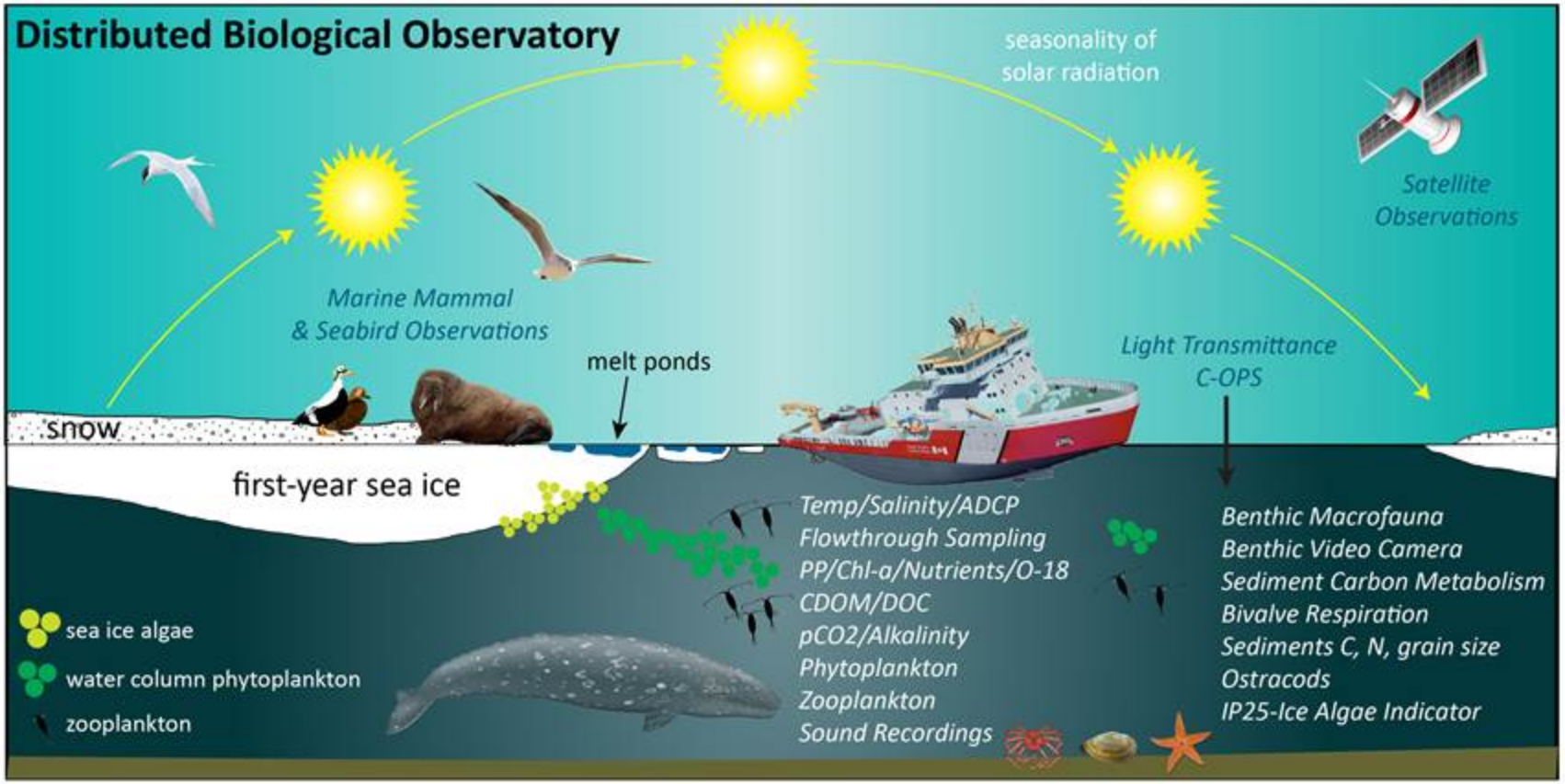


[Grebmeier, Moore, Cooper, Frey, 2019]

- **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

Sampling Components of the Distributed Biological Observatory

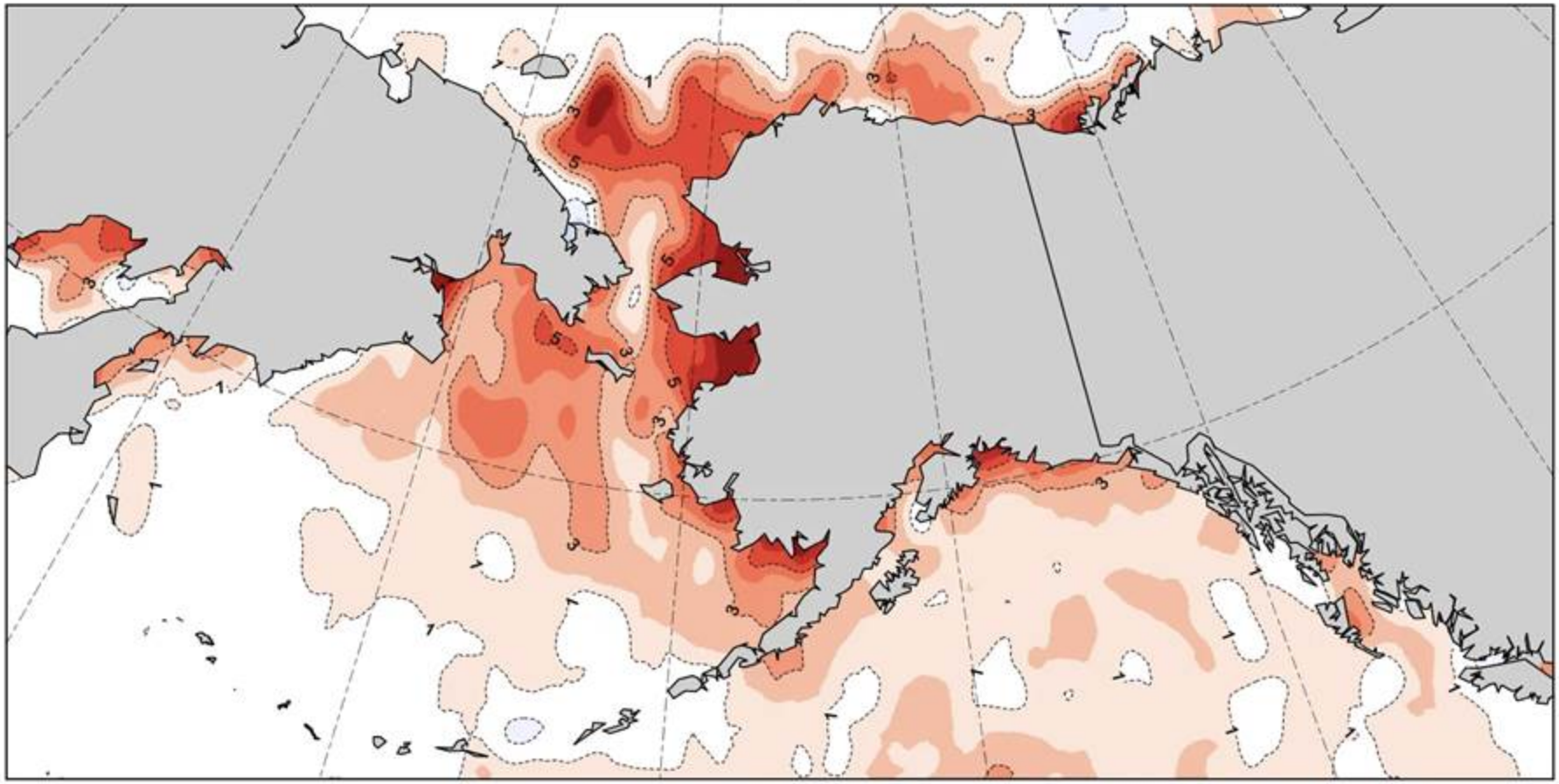


[Grebmeier et al. 2019, DSR 162:1-7]

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-18/16 ratios, PP=Primary Production. All lower taxa analyses include composition, abundance and biomass data.

Sea Surface Temperature Departure from Normal

June 28-July 4, 2019



ACCAP
Alaska Center for Climate Assessment and Policy
a NOAA RISA team

Graphic by @AlaskaWx

-7 -5 -3 -1 1 3 5 7

Degrees C

OISSTv2 courtesy of NOAA/PSD/ESRL

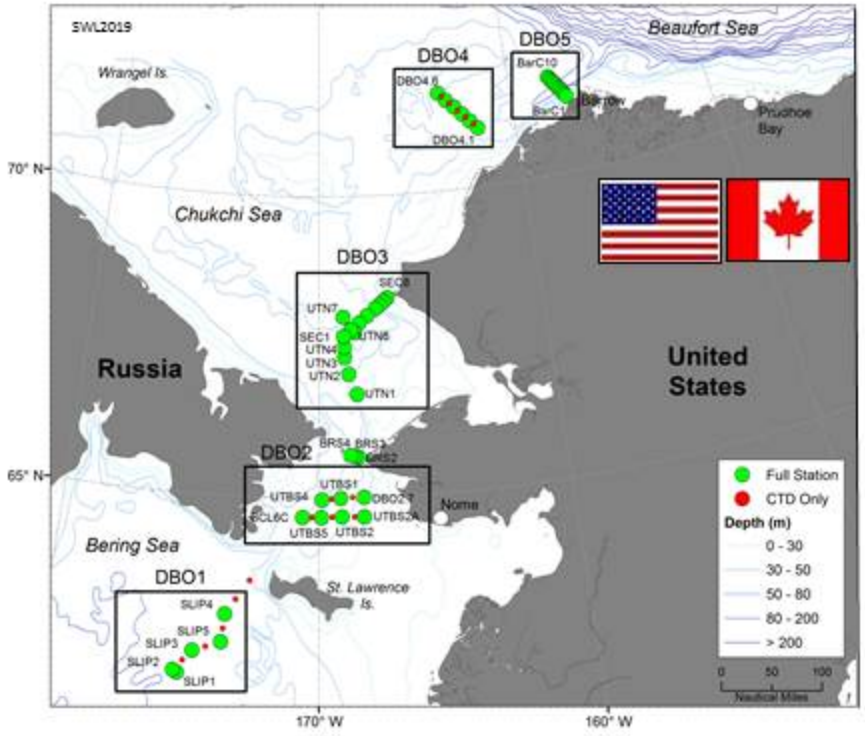
2019 PAG and DBO Cruise Plan Table

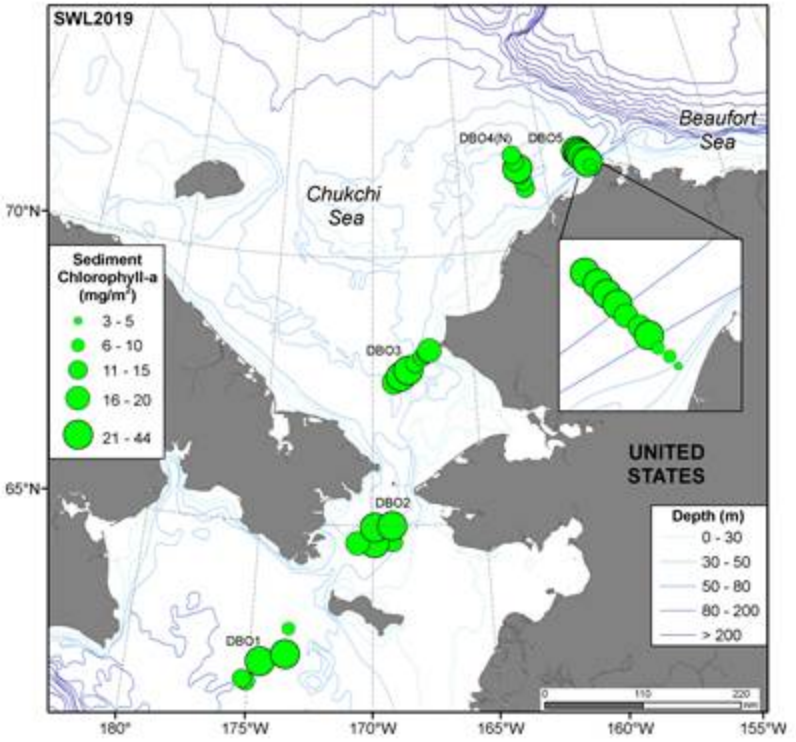
2019 PAG and DBO Field Season (version 10_08_19): Sampling Contributors. Projects Key: AON=US Arctic Observing Network (National Science Foundation); ArCS=Arctic Challenge for Sustainability; ArcticEIS2=Arctic Ecosystem Integrated Survey, C30=Canada's Three Oceans; CHINARE=Chinese Arctic Research Expedition; DBO=Distributed Biological Observatory; EcoFOCI= JAMSTEC= Japan Agency for Marine-Earth Science and Technology; JOIS=KOPRI = Korea Polar Research Institute; MOSAiC= Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC); NIPR = National Institute of Polar Research; NOAA=National Oceanic and Atmospheric Administration; Office of Naval Research (ONR) Marginal Ice Zone (MIZ) project; PMEL=Pacific Marine Environmental Laboratory. **DBO Region Key**: DBO1=So. St. Lawrence Is., DBO2=Chirikov Basin, DBO3=So Chukchi Sea, DBO4=NE Chukchi Sea, DBO5=Barrow Canyon, DBO6=East Beaufort Sea, DBO7-Beaufort Sea Central, DBO8=Bathurst polynya region.

Dates 2019 (Port calls)	Ship	DBO Region	Projects	PAG contact	Chief Scientist
July 12-24 (Dutch Harbor-Utqiaġvik)	Sir Wilfrid Laurier	1,2,3,4,5	C30/DBO (AON)	Jackie Grebmeier jgrebmei@umces.edu	John Nelson John.Nelson@dfo-mpo.gc.ca
June-Sept (Shanghai-Shanghai)	Xuelong	-	CHINARE/MOSAiC	Jianfeng He hejianfeng@pric.org.cn	Jianfeng He hejianfeng@pric.org.cn
Aug 1-Oct 2 (Dutch Harbor-Nome-Nome-Nome-Dutch Harbor)	R/V Ocean Starr	2,3,4,5	Arctic IES (Integrated Ecosystem Survey)	Ed.Farley@noaa.gov	Geoff Lebon, Geoff.t.lebon@noaa.gov Ed Farley, ed.farley@noaa.gov Kris Cieciel, Kristin.cieciel@noaa.gov
Aug 1-25 (Dutch Harbor-Utqiaġvik)	Araon	1,2,3	K-AOOS (Korea-Arctic Ocean Observing System	Sung-Ho Kang shkang@kopri.re.kr	Eun Jin Yang ejyang@kopri.re.kr
Aug 27 – Sept 20 (Dutch Harbor-Nome-Nome-Dutch Harbor)	F/V Northwest Explorer	,2	Northern Bering Sea Assessment	Ed.Farley@noaa.gov	Jim Murphy jim.murphy@noaa.gov
Aug 2-22 (Nome-Nome)	Healy	1,2,3,4,5	DBO/NCIS=Northern Chukchi Integrated System	Jackie Grebmeier jgrebmei@umces.edu	Robert Pickart rpickart@whoi.edu and Jackie Grebmeier jgrebmei@umces.edu
Sept (Nome-Nome)	Norseman II	3	Bering Strait Mooring Project/AON	Rebecca Woodgate woodgate@apl.washington.edu	Rebecca Woodgate woodgate@apl.washington.edu
Sept 18-Oct 6 (Dutch Harbor-Kodiak)	Dyson	1 and M8	EcoFOCI	Phyllis Stabeno, Phyllis.stabeno@noaa.gov	Geoff Lebon geoffrey.t.lebon@noaa.gov
Sept -Oct	Louis S. St-Laurent	-	JOIS/AON-BGOS	Bill.Williams@dfo-mpo.gc.ca	Bill.Williams@dfo-mpo.gc.ca
Sep 27- 10 Nov 2019 (Sekinehama, Japan, return Sekinehama, Japan)	Mirai	1,2,3	Japanese Atmospheric cruise; National Institute of Polar Research (NIPR)	Takashi Kikuchi takashik@jamstec.go.jp	Dr. Kazutoshi Sato stakashik@jamstec.go.jp
Oct	Sir Wilfrid Laurier	4,8	C30	Bill.Williams@dfo-mpo.gc.ca	Humfrey.Melling@dfo-mpo.gc.ca

Canada's Three Oceans (C30) and the DBO: *CCGS Sir Wilfrid Laurier*, July 11-23, 2019

Focus: sampling along latitudinal transect lines developed as a "change detection array" for consistent monitoring of biophysical responses to changing environmental conditions





DBO data collections

- Seawater temperature and salinity; velocity measurements
- Nutrients, chlorophyll, carbon products, CDOM
- Phytoplankton, zooplankton and macrobenthic abundance, biomass, community structure
- Marine mammal and seabird surveys

Contacts: John Nelson
John.Nelson@dfo-mpo.gc.ca and
Jackie Grebmeier
jgrebmei@umces.edu

DBO Transects: CCGS Sir Wilfrid Laurier (July 11-July 23, 2019)

CTD/Rosette

Bongo nets

Incubation experiments

Laboratory filtrations

Over the side 150kHz ADCP

C-OPS

vanVeen grabs

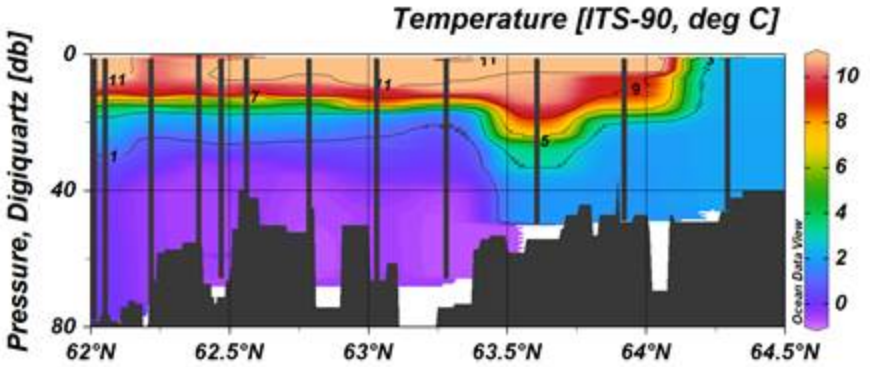
Bird observations

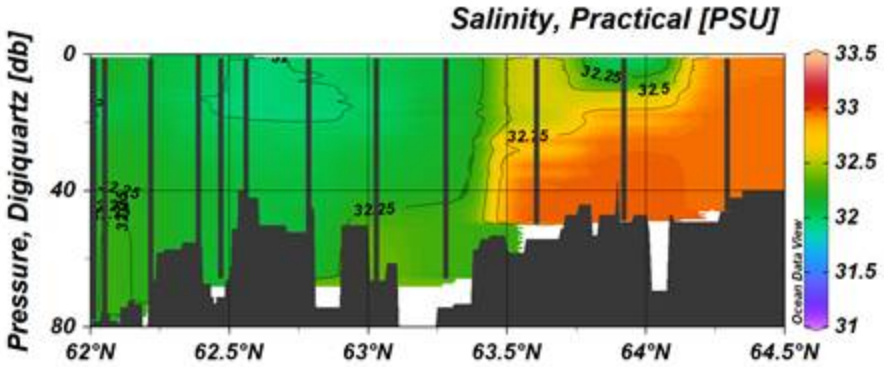
Science:

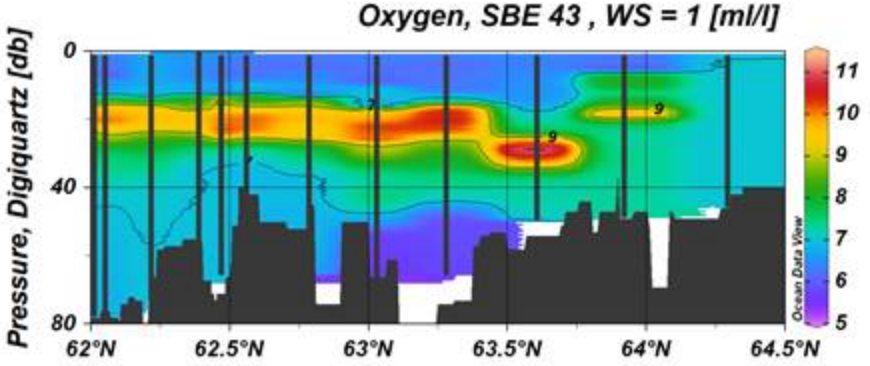
- CTD stations, most with Rosette sampling (chlorophyll, nutrients, phytoplankton)
- Bongo net hauls for zooplankton
- deployments of 150 kHz ADCP
- Benthic sampling stations with up to 5 vanVeen grabs at each station\
- Benthic Video-camera recordings
- stations where water was collected for methane and nitrous oxide analysis
- stations sampled for apparent optical properties
- Subset of stations were used for primary productivity incubation experiments
- Seabird and Marine Mammal observations
- Meteorological and position data from ship sensors

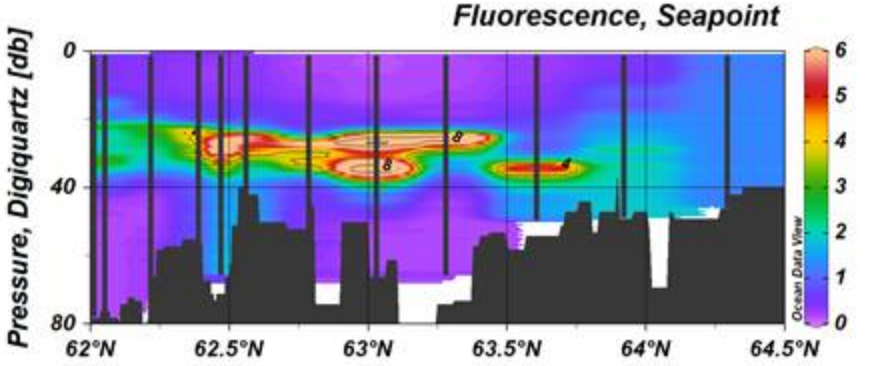
Fisheries and Oceans Canada
Pêches et Océans Canada

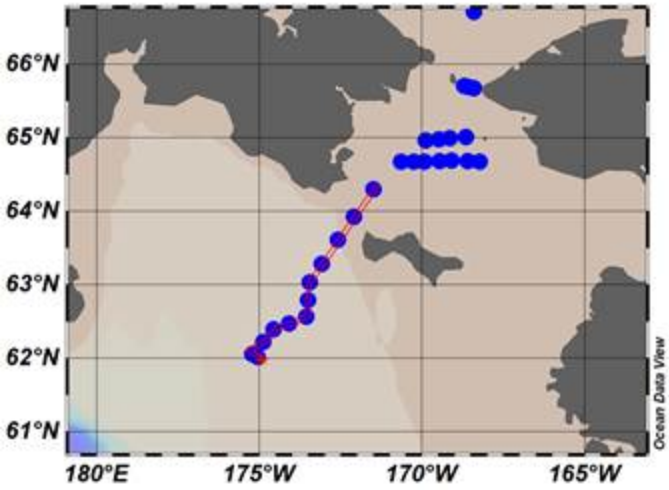
DBO 1-SWL19, July 2019

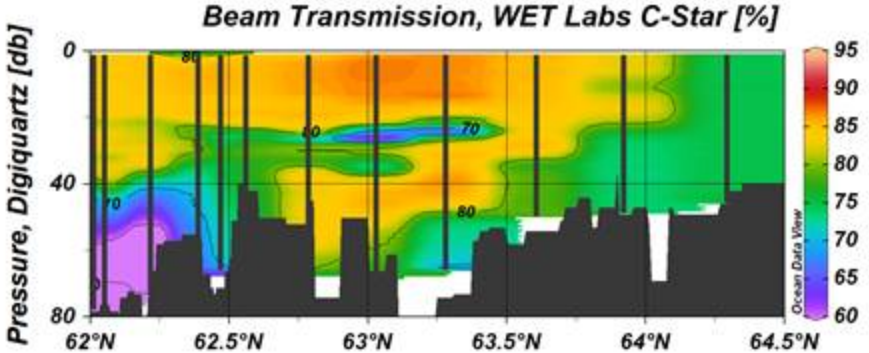










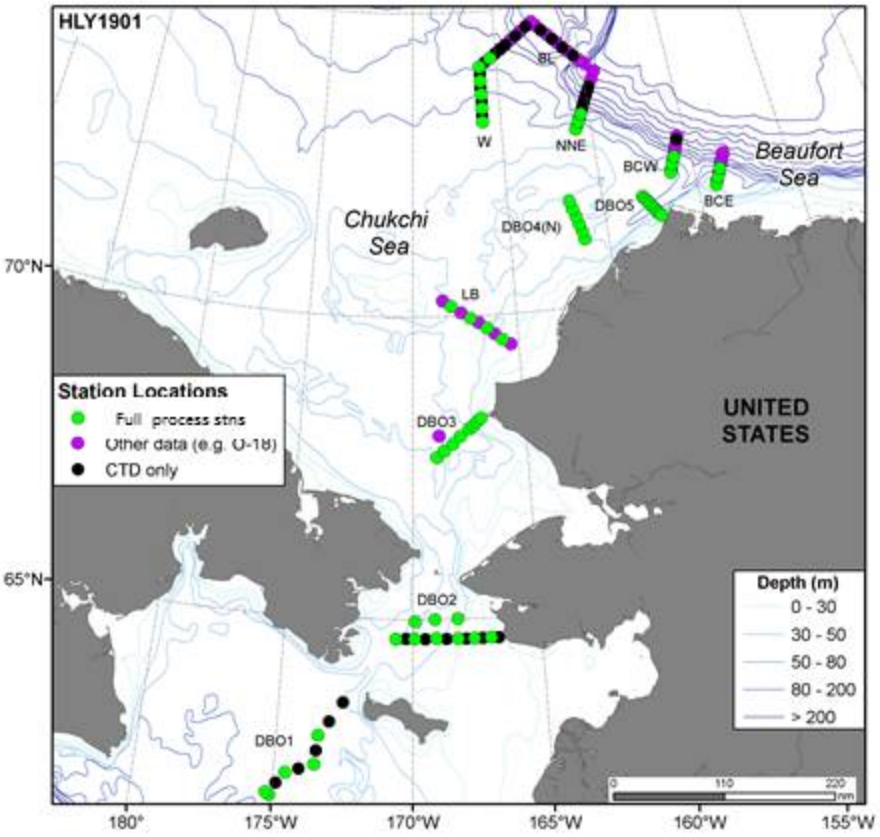


[courtesy S. Zimmerman, DFO]

2019 DBO (Distributed Biological Observatory)-NCIS (Northern Chukchi Sea Integrated Study); Aug 2-23, 2019

Standard measurements and process studies (DBO1,2,3,4,5), Barrow Canyon,

- Physical: CTD and ADCP, mooring retrieval and replacement (JAMSTEC and NOAA)
- Chemical: nutrients, oxygen-18,
- Chlorophyll-a, carbon components, Harmful Algal Bloom (HAB) components
- Biological: Zooplankton and larval fish abundance and biomass
- Benthos: macrobenthos abundance, biomass and population structure
- Sediment: organic carbon/nitrogen content, chl-a content, grain size, radioisotopes, HABs
- Benthic oxygen uptake and nutrient exchange
- Marine mammal and seabird surveys



*Full process stations included standard CTD/rosette, water column and sediment measurements

Chief Scientist: Robert Pickart (WHOI)
and co: Jackie Grebmeier/UMCES:
jgrebmei@umces.edu

Contact: Phyllis Stabeno/NOAA:
phyllis.stabeno@noaa.gov

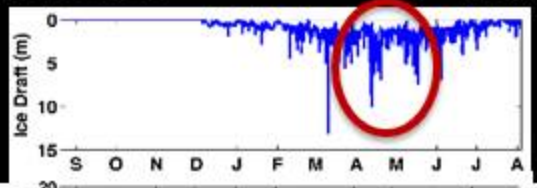
EcoFOCI
Ecosystems & Fisheries-Oceanography Coordinated Investigations

Chukchi Ecosystem Observatory (CEO)

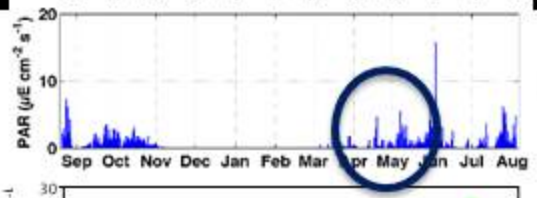
71.6 °N
161.5 °W

Moorings successfully turned in Sept 2019

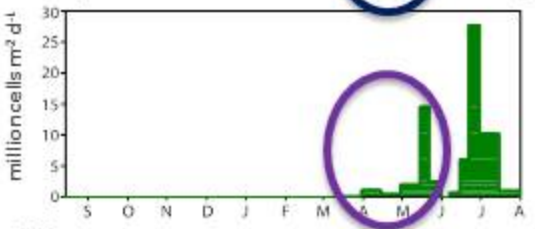
September → August



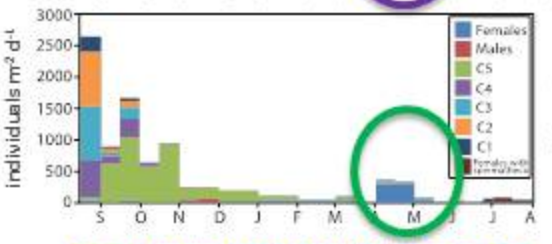
Ice Draft



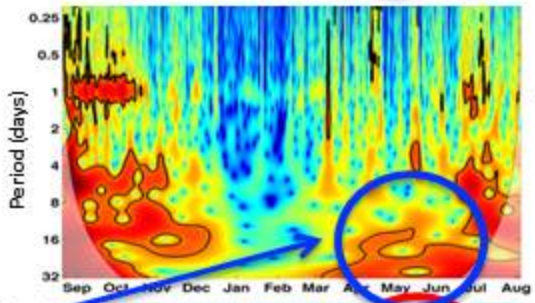
Light



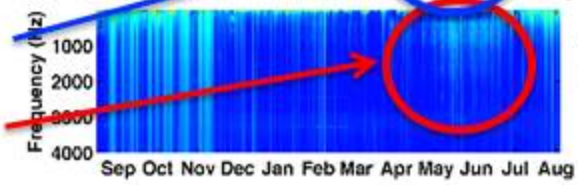
Ice Algae



Copepod Zooplankton



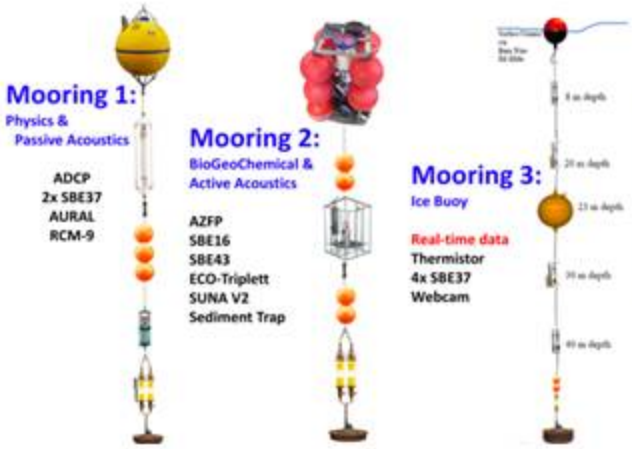
Acoustic Backscatter



Acoustic Sound Recording

Arctic Cod

Bearded Seals



New in 2017-18
Discrete water sampler for nutrients & phytoplankton

- Developing a better mechanistic understanding of the Arctic marine ecosystem.
- Fostering coordination and cooperation among research programs: multiple site visits by research vessels each summer. **Let us know if you stop by!!**

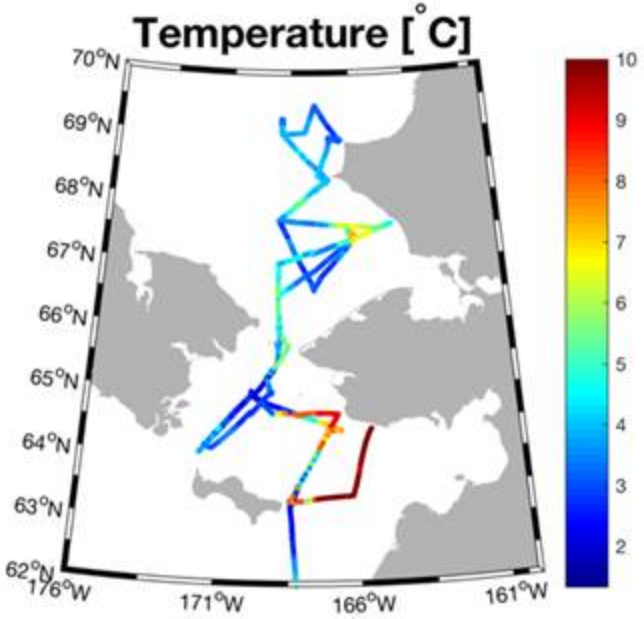
DATA AVAILABLE
sldanielson@alaska.edu
www.ChukchiEcosystemObservatory.org

UAF COLLEGE OF FISHERIES AND OCEAN SCIENCES
University of Alaska Fairbanks

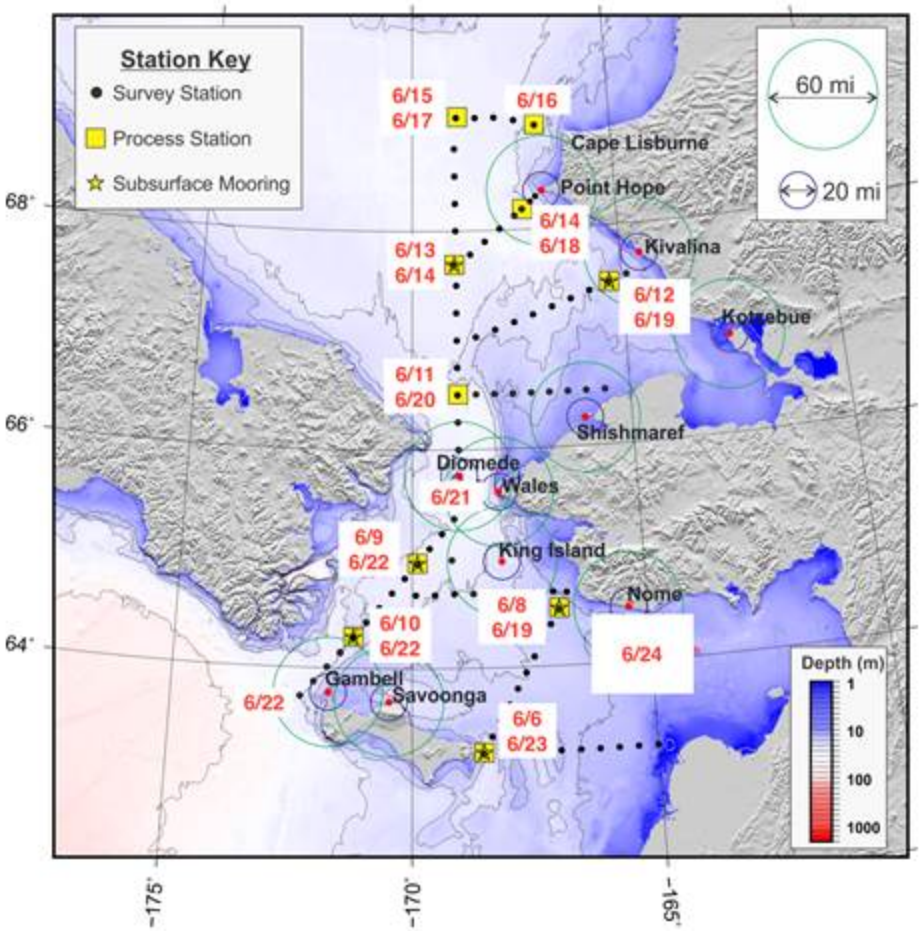
ASGARD project

Focus on physical, chemical and biological **rates.** Shipboard measurements during and right after the spring bloom.

Year-round moorings 2017-2019



Mooring Retrieval 2019 only DONE



- June 2017 & 2018 field seasons on Sikuliaq complete.
- 2nd year of moorings to be recovered in 2019..
- Cruise reports available online at NPRB website.

COLLEGE OF FISHERIES AND OCEAN SCIENCES
University of Alaska Fairbanks
sldanielson@alaska.edu

Arctic Integrated Ecosystem Survey II

Ed Farley, Carol Ladd, Kris Cieciel, Alex DeRobertis, Janet Duffy-Anderson, Lisa Eisner, Jeff Guyon, Dave Kimmel, Ron Heintz, Libby Logerwell, Phyllis Stabeno & Chris Wilson

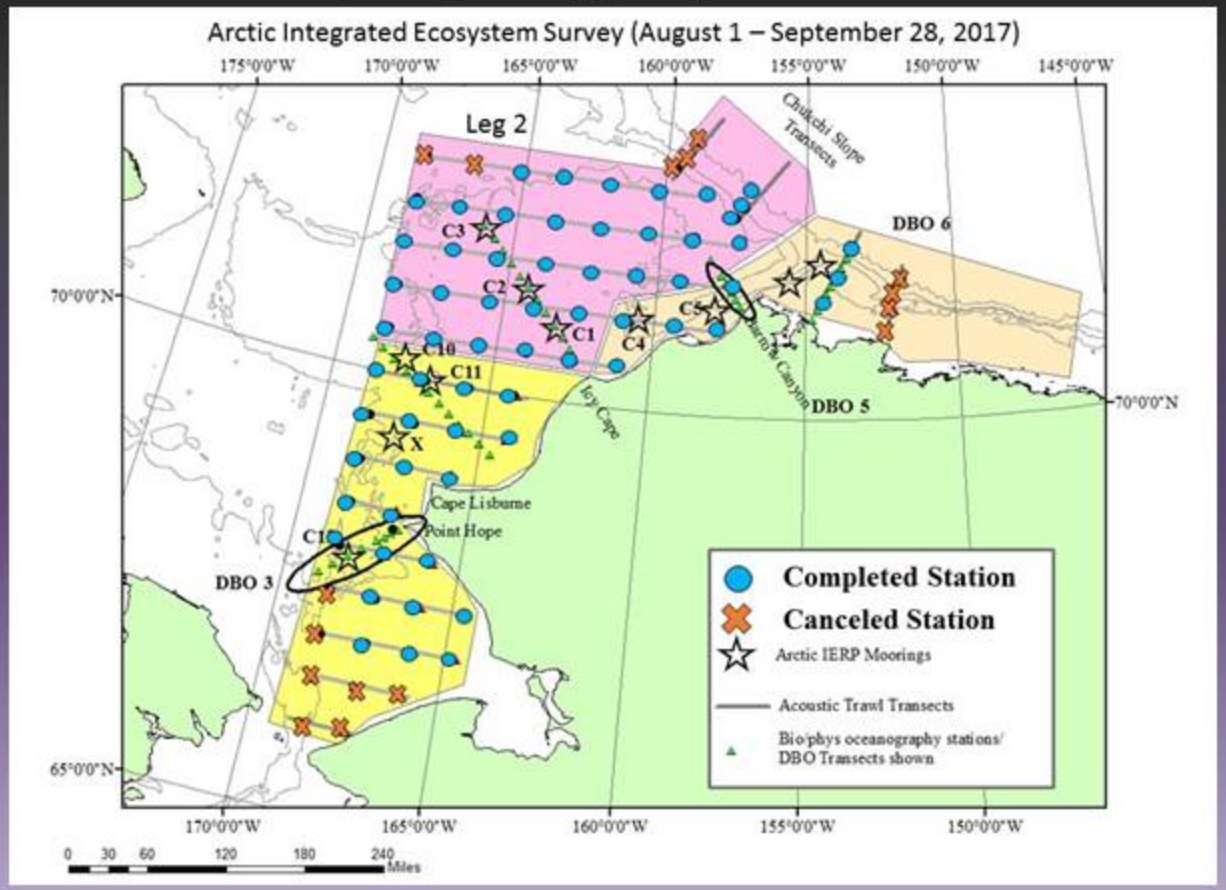
Franz Mueter

Louise Copeman

Ryan McCabe, Calvin Mordy & Danny Grunbaum

Kathy Kuletz

Field sampling: Aug/Sep 2017 and 2019



NORTH PACIFIC RESEARCH BOARD Arctic Program

How Will Warming Likely Affect Abundance of Fishes and Invertebrates?

Arctic cod

saffron cod

Pacific herring

capelin

chum salmon

pink salmon

snow crab

jellyfish

NORTH PACIFIC RESEARCH BOARD Arctic Program

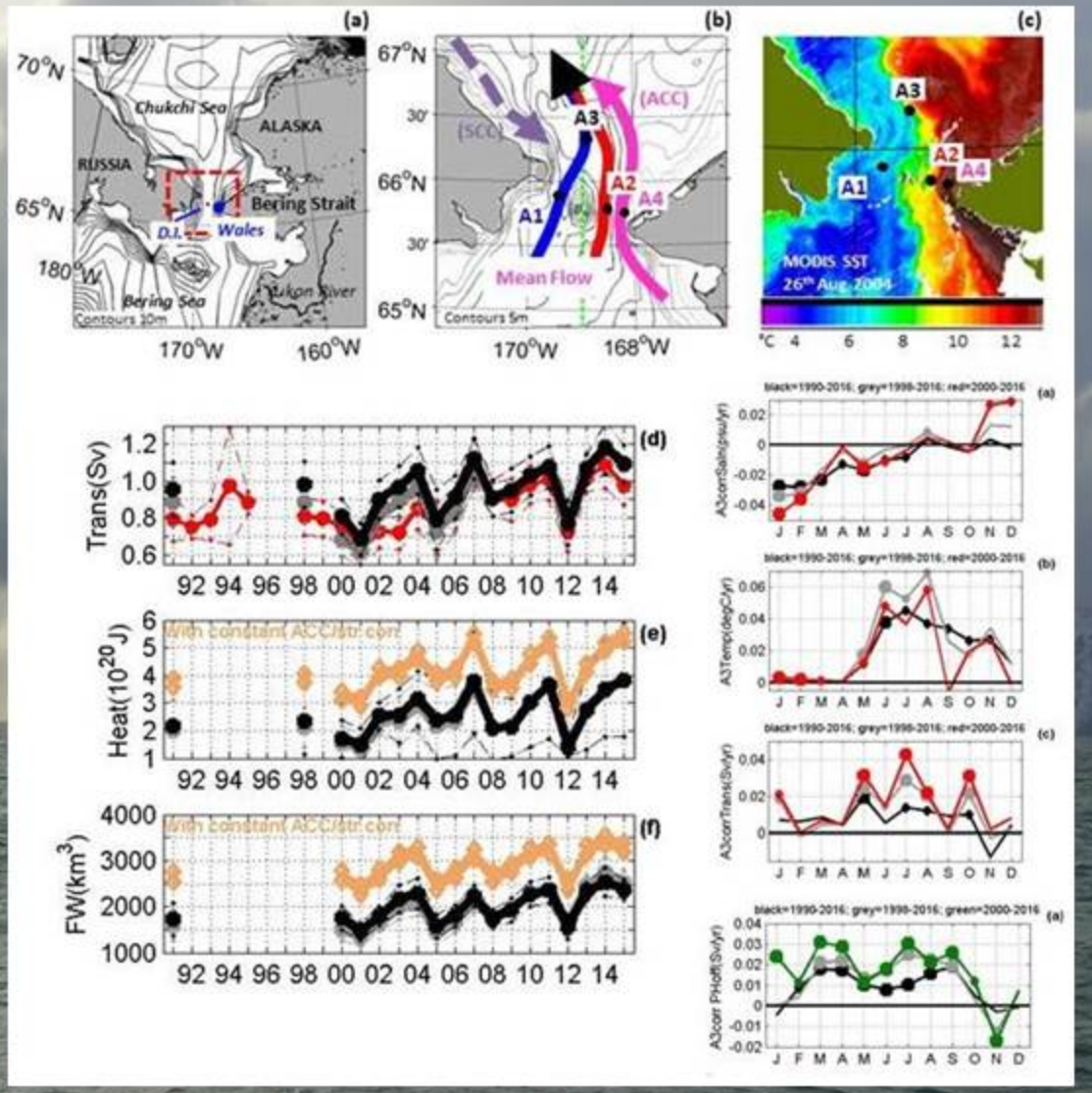
www.nprb.org/arctic-program

Bering Strait Mooring Program – Sept 2019 *Rebecca Woodgate*

University of Washington, Seattle, USA

Funded by NSF-AON

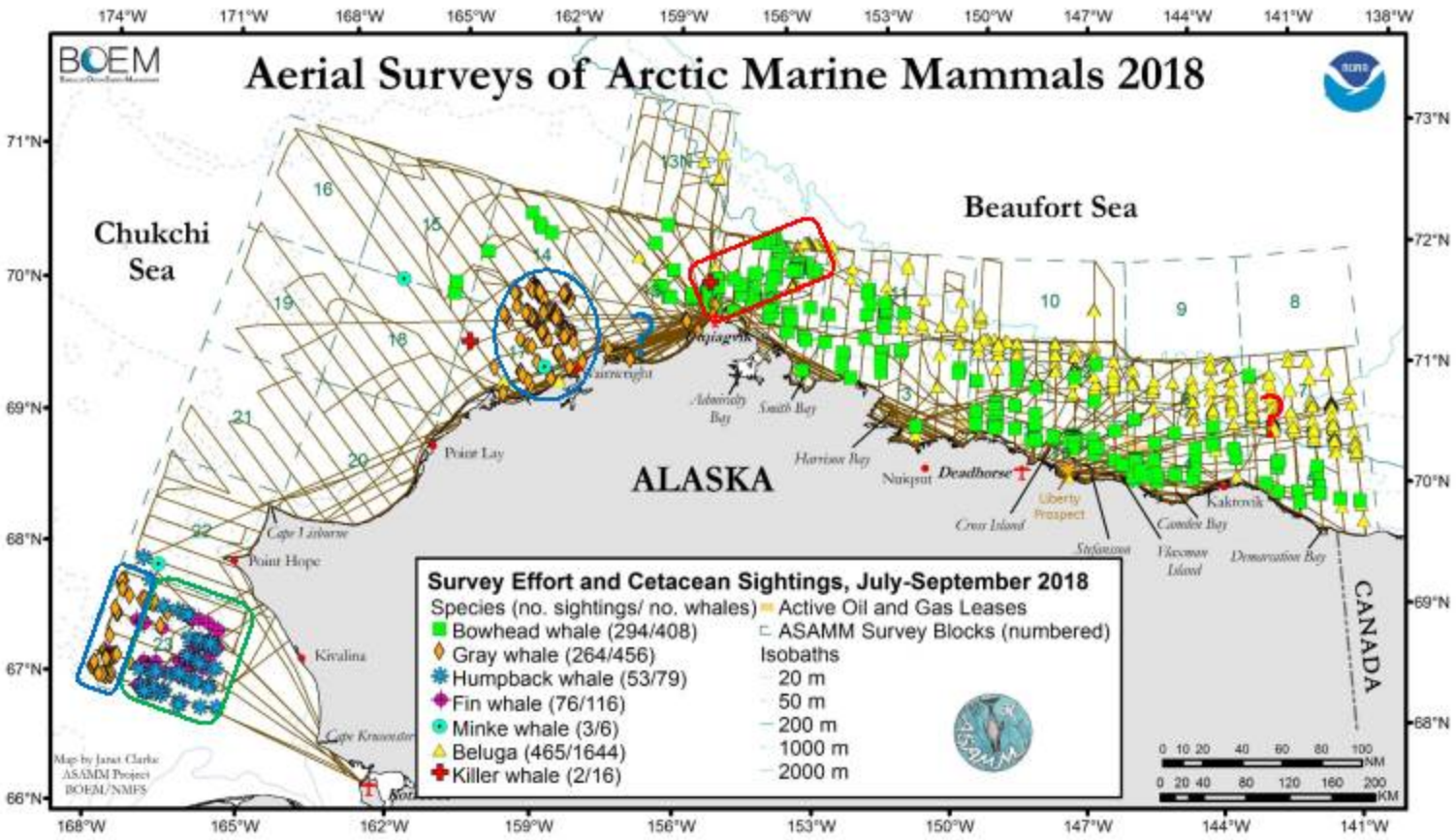
- **September 2019 Norseman2 cruise recovered & redeployed the 3 Bering Strait moorings, and took CTD sections, finding the Chukchi remarkably warm. Recent findings:**
- **The Bering Strait inflow to the Arctic increased from 2001 (~0.7Sv) to 2014 (~1.2Sv)**
- **This is due to increasing far-field, pressure-head forcing, not local wind changes**
- **Concurrently heat and freshwater fluxes strongly increased (3-5x10^{20}J, 2300-3500km^3)**
- **Seasonal data show winter freshening, pre-summer warming, summer/fall flow increase**
- **Woodgate presents a new climatology (1Sv) for the strait, including seasonality for heat and freshwater**



Woodgate, R.A., 2018, Increases in the Pacific inflow to the Arctic from 1990 to 2015, and insights into seasonal trends and driving mechanisms from year-round Bering Strait mooring data, Progress in Oceanography, 160, 124-154, doi:10.1016/j.pocean.2017.12.007

Find data and papers at http://psc.apl.washington.edu/HLD/Bstrait/bstrait.html

DBO 3, 4, 5, 6, and 7



2018

Bowhead whales – **missing in summer (red question mark), when they have normally been found well offshore in deep water from July through early August*;** lots of use of Barrow Canyon (red box); lowest calf count since summer surveys started in 2012.

Gray whales – continuing to show love for the area between Hanna Shoal and Wainwright (blue oval) and sustaining use of that area well into fall; pretty much abandoned the area between Pt. Franklin and Pt. Barrow; benthic hotspot in southern Chukchi (blue box) still active in summer but not much in fall; **moderately low calf ratio compared to past years*.**

Subarctics – **the southern Chukchi continues to be quite attractive to fin whales and humpback whales (green box)*,** although distribution was somewhat more limited than that observed in previous years.

DBO-3 – gray whale hot spot, humpbacks and other subarctic cetaceans

DBO-4 and DBO-5 – bowhead whales, gray whales, belugas nearshore

DBO-6 and DBO-7 – bowhead whales, belugas

http://www.afsc.noaa.gov/NMML/cetacean/bwasp/

[Janet Clark]

Innovative Technology for Arctic Exploration

ITAE Pacific Marine Environmental Laboratory

Jessica Cross, NOAA/PMEL, Seattle, Washington, USA

2018 Saildrone Projects; now in water for 2019

Two Projects in the Pacific Arctic in 2018

Bering Strait & Chukchi Sea

July through September 2018

Ocean Acidification

- No active acoustics
- Assess important questions about physical circulation, ice melt, ecosystems, and ocean acidification in the region

Fisheries Survey

- Active acoustics
- Understand the fate of the age-0 Arctic cod and other pelagic fish species on the Chukchi shelf

FOR INFORMATION

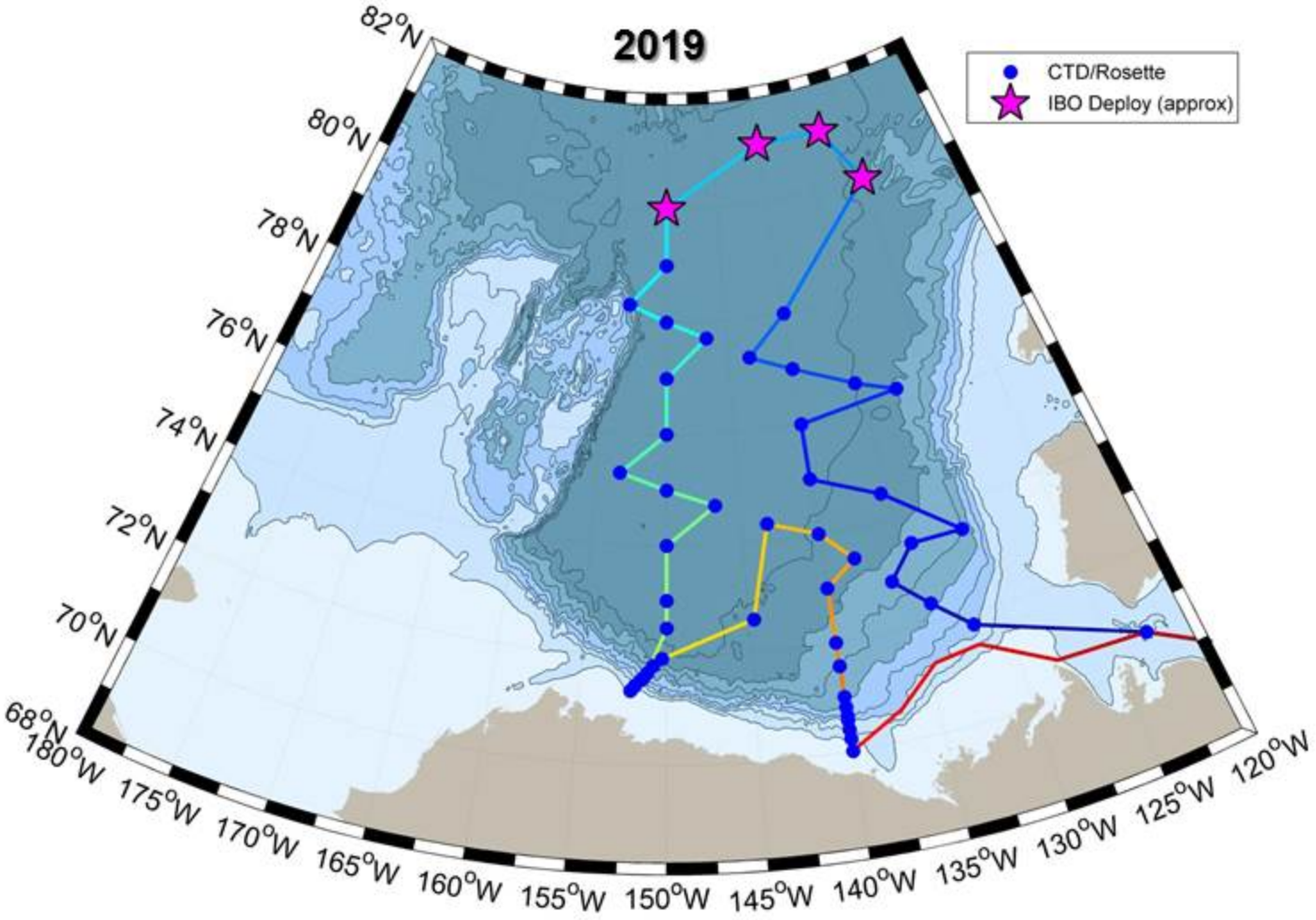
Notice of Operations
https://www.pmel.noaa.gov/itae/mariner-and-public-notice-research-platforms

Saildrone Research Blog
https://www.pmel.noaa.gov/itae/follow-saildrone-2018

Email Updates – sign-up using
https://goo.gl/forms/4fBQkg2GXp3obCn42

Contact
Heather Tabisola, Research Coordinator
heather.tabisola@noaa.gov, 206.526.6662

Joint Ocean Ice Studies (JOIS) - Arctic Observing Network - Beaufort Gyre Observing System (AON-BGOS)



Beaufort Gyre Observing System: Canada and USA

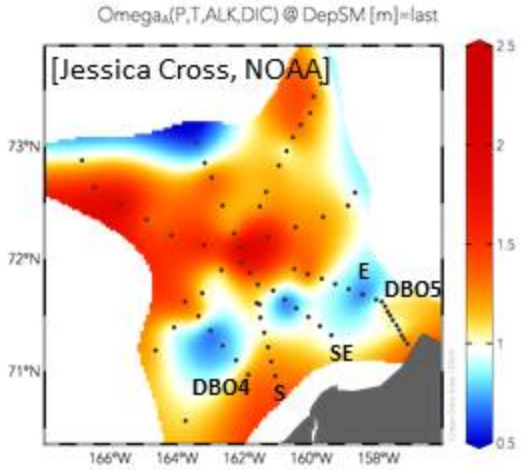
[see Bill Williams PAG 2019 talk for update]

Examples of environmental stressors occurring in the Pacific Arctic

- Ocean acidification could impact ecosystem services in the Arctic region

Implications of ocean acidification in the Pacific Arctic: Experimental responses of three Arctic bivalves to decreased pH and food availability

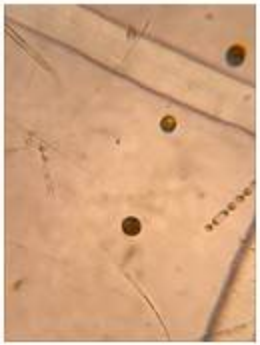
Christina L. Goethel, Jacqueline M. Grebmeier, Lee W. Cooper, Thomas J. Miller

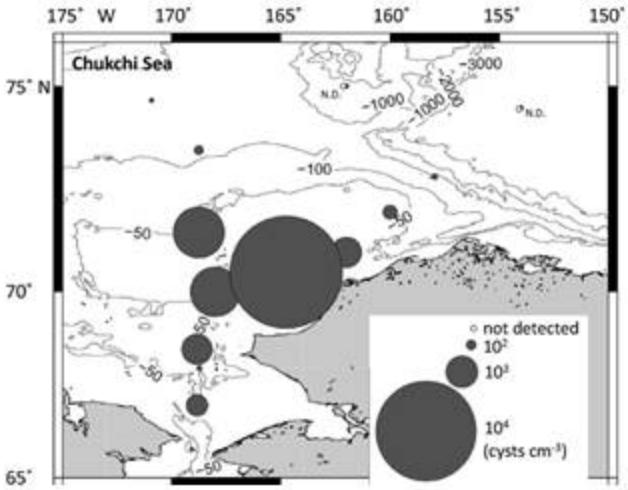


- Corrosive waters (blue) prevalent on SE side of Hanna Shoal, area of focused carbon deposition and high bivalve biomass

Harmful Algal Blooms (HABs) are increasing in Pacific Arctic with declining sea ice, more sunlight and warmer seas

- Blooms of *Alexandrium* sp. that are dinoflagellates that cause paralytic shellfish poisoning.
- Don Anderson (WHOI) has found overwintering cysts in the mud and hotspot of seasonal blooms (DBO-NCIS cruises 2018-2019)

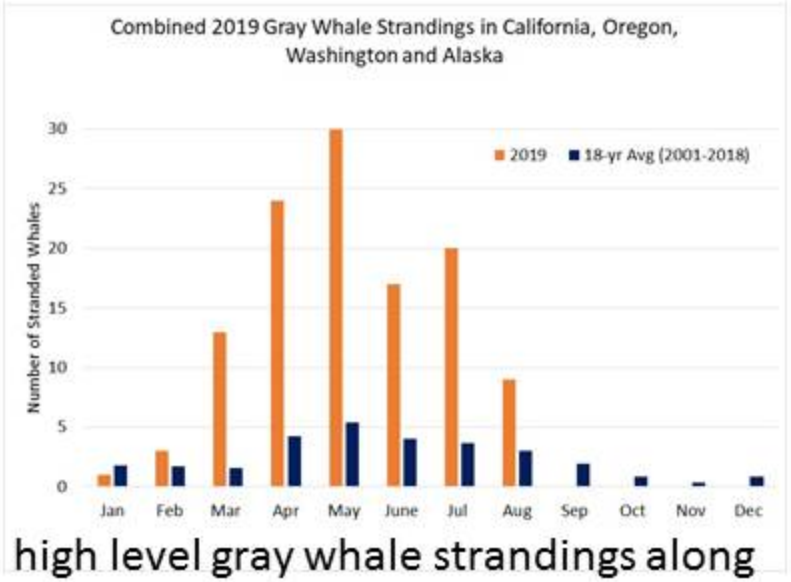




(Anderson et al. 2018, figure modified from Natsuike et al. (2013)

2019 Gray Whale Die-Offs along Pacific Coast- Mexico to Alaska

Dead gray whale in northern California. Photo by M. Flannery, California Academy of Sciences



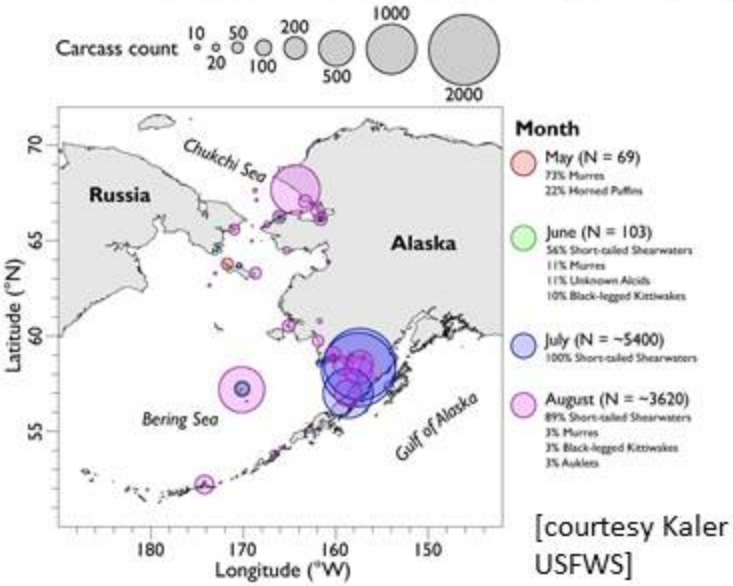
- high level gray whale strandings along west coast from Mexico to Alaska; NOAA declared it as an Unusual Mortality Event (UME)

NOAA Declares Unusual Mortality Event for Ice Seals)

- NOAA declares UME for bearded, ringed, and spotted seals in the Bering and Chukchi seas in September 2019

- The increase in ice seal mortality is nearly 5 times the average number

UME for Seabirds 2019



[courtesy Kaler & Kuletz, USFWS]

2020 PAG and DBO Cruise Plan Table

2020 PAG and DBO Field Season (version 10_14_19): Sampling Contributors. Projects Key: AON=US Arctic Observing Network (National Science Foundation); ArCS=Arctic Challenge for Sustainability; ArcticEIS2=Arctic Ecosystem Integrated Survey, C30=Canada's Three Oceans; CHINARE=Chinese Arctic Research Expedition; DBO=Distributed Biological Observatory; EcoFOCI= JAMSTEC= Japan Agency for Marine-Earth Science and Technology; JOIS=KOPRI = Korea Polar Research Institute; MOSAiC= Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC);NCIS=Northern Chukchi Integrated Study; NIPR = National Institute of Polar Research; NOAA=National Oceanic and Atmospheric Administration; Office of Naval Research (ONR) Marginal Ice Zone (MIZ) project; PMEL=Pacific Marine Environmental Laboratory. **DBO Region Key**: DBO1=So. St. Lawrence Is., DBO2=Chirikov Basin, DBO3=So Chukchi Sea, DBO4=NE Chukchi Sea, DBO5=Barrow Canyon, DBO6=East Beaufort Sea, DBO7-Beaufort Sea Central, DBO8=Bathurst polynya region.

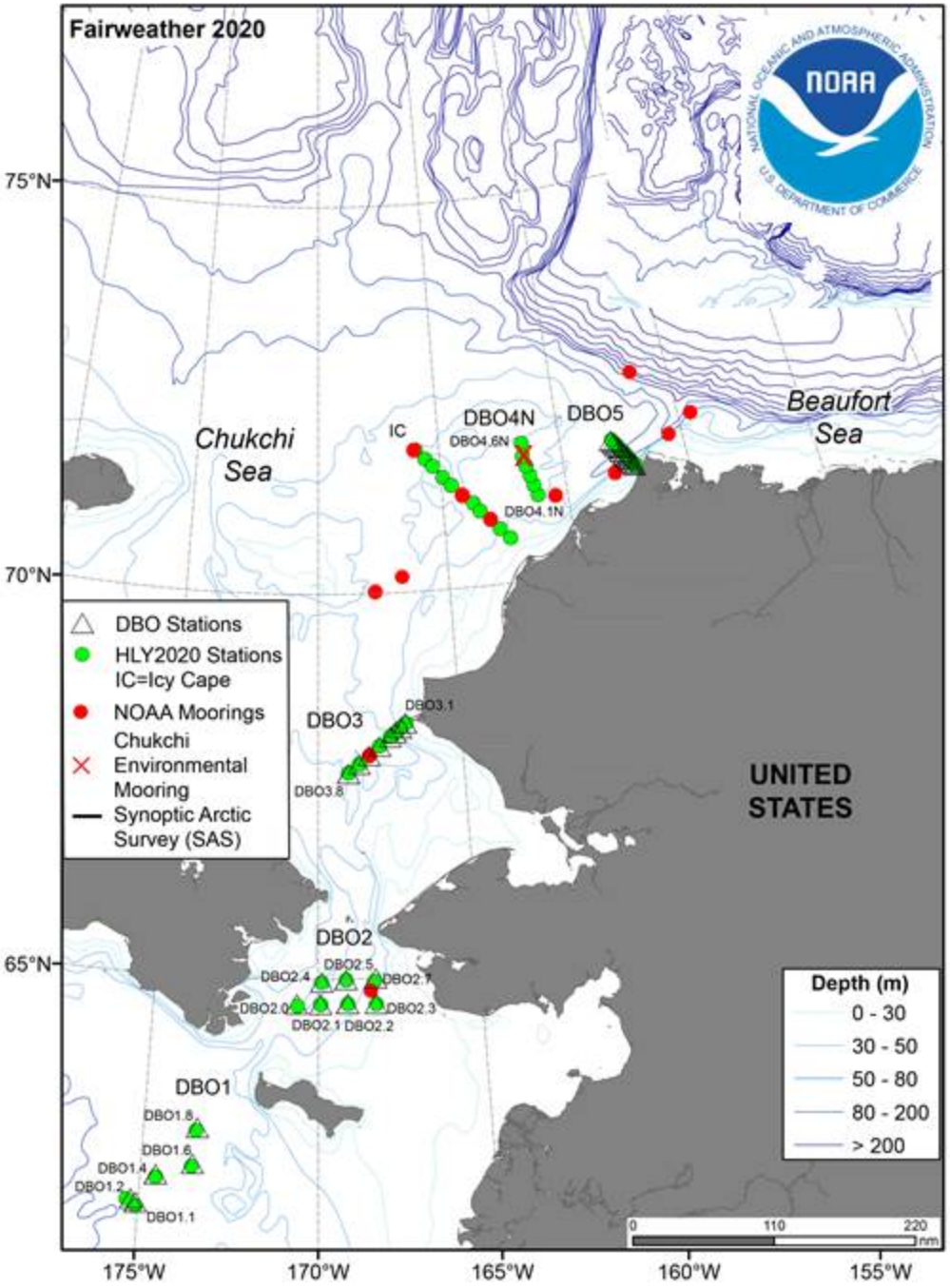
Dates 2019 (Port calls)	Ship	DBO Region	Projects	PAG contact	Chief Scientist
July 12-24 (Dutch Harbor-Utqiaġvik)	Sir Wilfrid Laurier	1,2,3,4,5	C30/DBO (AON)	Jackie Grebmeier jgrebmei@umces.edu	John Nelson John.Nelson@dfo-mpo.gc.ca
June-Sept (Shanghai-Shanghai)	Xuelong	-	CHINARE/MOSAiC	Jianfeng He hejianfeng@pric.org.cn	Jianfeng He hejianfeng@pric.org.cn
Aug 1-25 (Dutch Harbor-Utqiaġvik)	Araon	1,2,3, 5	K-AOOS (Korea-Arctic Ocean Observing System	Sung-Ho Kang shkang@kopri.re.kr	Eun Jin Yang ejyang@kopri.re.kr
Aug 1-230(Dutch-Dutch)	Healy	2,3,5	Harmful Algae Bloom Study	Robert Pickart rpickart@whoi.edu	Robert Pickart rpickart@whoi.edu
Aug 1-24 (Nome-Nome)	Fairweather	1,2,3,4,5	EcoFOCI/DBO-NCIS	Jackie Grebmeier jgrebmei@umces.edu and Phyllis.stabeno@noaa.gov	Jackie Grebmeier jgrebmei@umces.edu
Sept (Nome-Nome)	Norseman II	3	Bering Strait Mooring Project/AON	Rebecca Woodgate woodgate@apl.washington.edu	Rebecca Woodgate woodgate@apl.washington.edu
Sept-TBD (Dutch Harbor-Kodiak)	Dyson	1 and M8	EcoFOCI	Phyllis Stabeno, Phyllis.stabeno@noaa.gov	Geoff Lebon geoffrey.t.lebon@noaa.gov
Sept -Oct	Louis S. St-Laurent	-	JOIS/AON-BGOS	Bill.Williams@dfo-mpo.gc.ca	Bill.Williams@dfo-mpo.gc.ca
Sep-Nov (TBD)	Mirai	1,2,3	Japanese Atmospheric cruise; National Institute of Polar Research (NIPR)	Takashi Kikuchi takashik@jamstec.go.jp	Dr. Kazutoshi Sato stakashik@jamstec.go.jp
Sept-Nov	Healy	-	Glider Program	Craig Lee <craiglee@uw.edu>	Craig Lee <craiglee@uw.edu>
Oct	Sir Wilfrid Laurier	4,8	C30	Bill.Williams@dfo-mpo.gc.ca	Humfrey.Melling@dfo-mpo.gc.ca

EcoFOCI/DBO-NCIS;
August 1-24, 2020
Nome-to-Nome

Chief Scientist: Jackie Grebmeier, DBO/UMCES

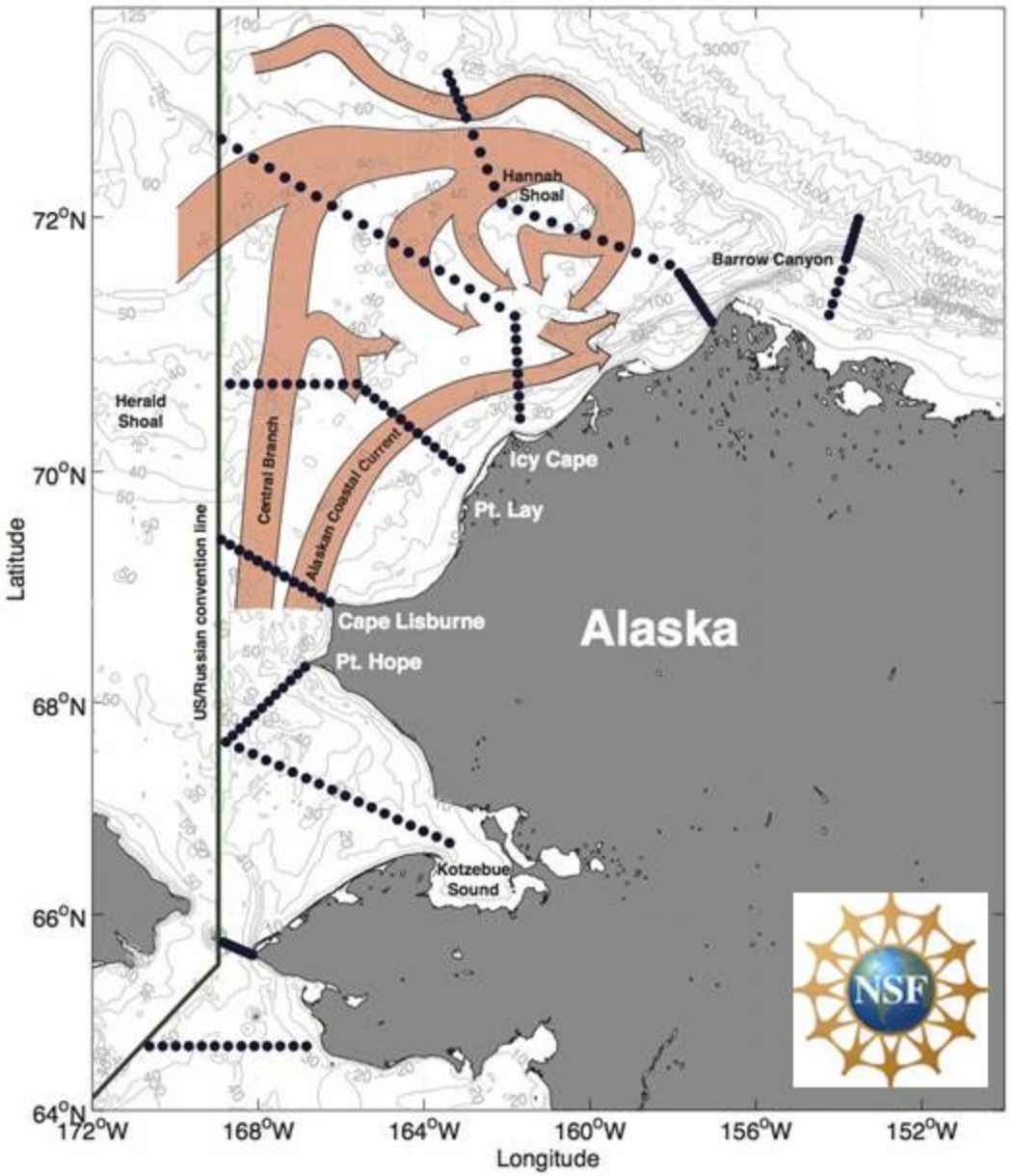
Co-PI: Phyllis Stabeno, EcoFOCI, NOAA PMEL

Goal: evaluate ecosystem status and change via the EcoFOCI and DBO time series efforts, including turnaround of ~20 NOAA moorings and CEO mooring in NE Chukchi Sea



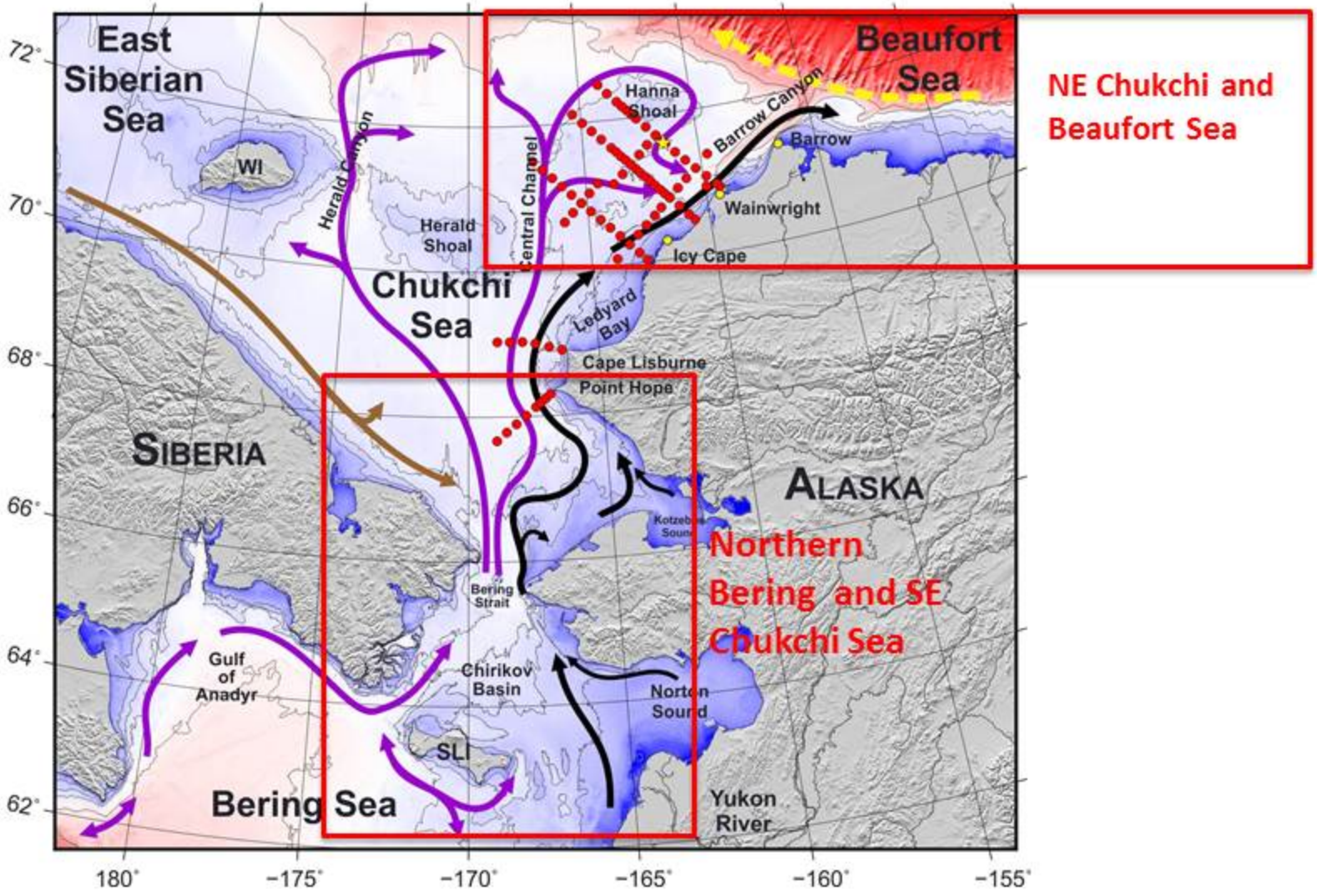
HAB 2020 Healy cruise
Chief Scientist: Robert Pickart/ WHOI; co-PI, Donald Anderson/WHOI
August 1-30, 2020
Dutch-Dutch

- Repeat *Alexandrium* and *Pseudo-nitzschia* sampling during HLY1901 (August 2019)
- Compare of 2018 and 2019 cyst and cell distributions
- Comprehensive toxin and microsatellite analysis of Chukchi, Beaufort and Bering Sea *Alexandrium* cultures – determine origin and connectivity of HAB populations
- NSF-funded HAB cruise planned for 2020



Science access during subsistence whaling: April-May and Sept-Oct periods

-need to interface with coastal communities through new Arctic Waterways Safety Committee to interface with Alaska Eskimo Whaling Commission, Eskimo Walrus Commission, and other parties; see http://www.arcticwaterways.org/



[modified from S. Danielsen map 2015]

Thank you for your attention.

Questions and comments?

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

http://arctic.cbl.umces.edu , http://www.arctic.noaa.gov/dbo
http://pag.arcticportal.org
http://neptune.gsfc.nasa.gov/csb/index.php?section=270
http://arcticdata.io *(Arctic Data Center, then use DBO as search term)*
http://ambon-us.org/, https://mbon.ioos.us/
http://www.ChukchiEcosystemObservatory

BOEM Bureau of Ocean Energy Management
NASA
North Pacific Research Board Arctic Program
NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce
NSF
PAG