Arctic MBON (AMBON) Update-2017

Arctic Marine Biodiversity Observing Network

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- On behalf of all AMBON Pis:

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A demonstration observing network to monitor biodiversity in the Arctic from microbes to whales

1. Successes and challenges within AMBON

- **Successes**
  - Completion of 2015 AMBON field program
  - Near completion all 2015 data analyses (few examples to follow)
  - Integration of data collections for AMBON science presentations
  - Inclusion of results in national and international science presentations
  - NSF support provided for AMBON 2017 field program

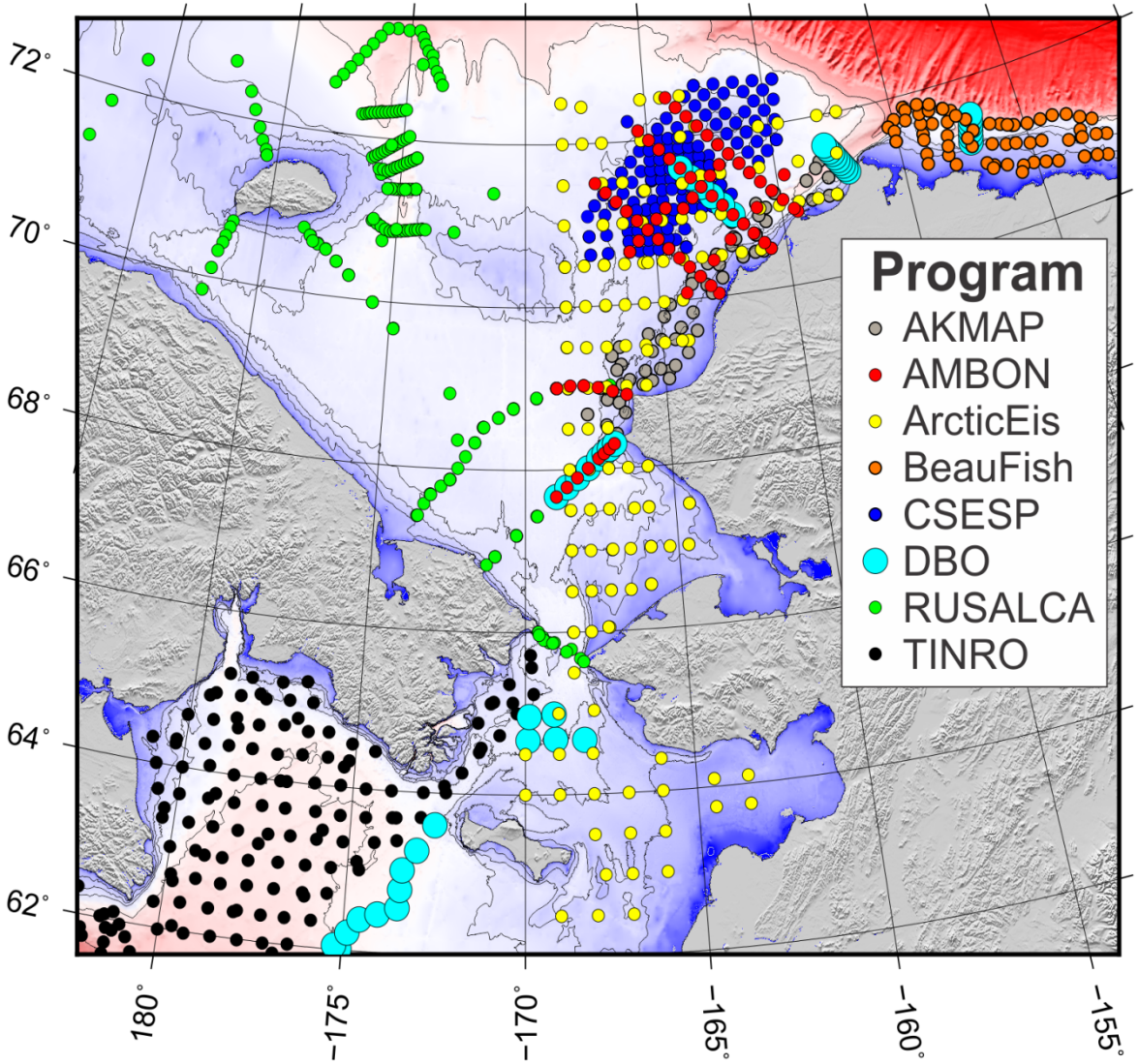
- **Challenges**
  - Due to withdrawal of Shell Exploration & Production Co. funding, reduction in program effort
  - Cancellation of 2016 field program, development of new field support for 2017

AMBON Goals

1. Apply end-to-end approach (microbes to whales) in biodiversity observations
2. Continue existing time-series and close current gaps in taxonomic coverage
3. Integrate and synthesize efforts with past and ongoing research programs in the Chukchi Sea.
4. Develop metrics for a sustainable observing network for the Arctic and other regions (demonstration project)

Arctic biodiversity from microbes to whales

The Arctic Chukchi Sea

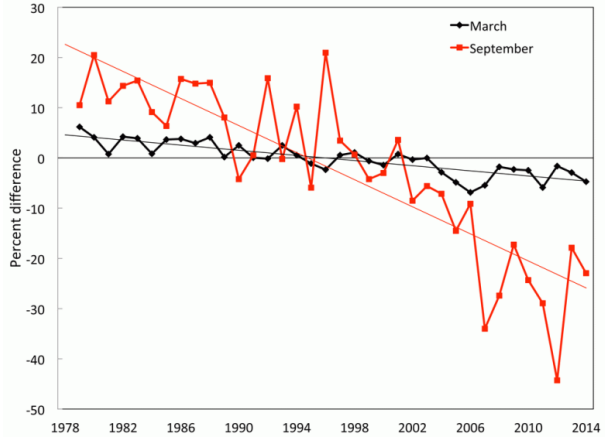


South-north gradient

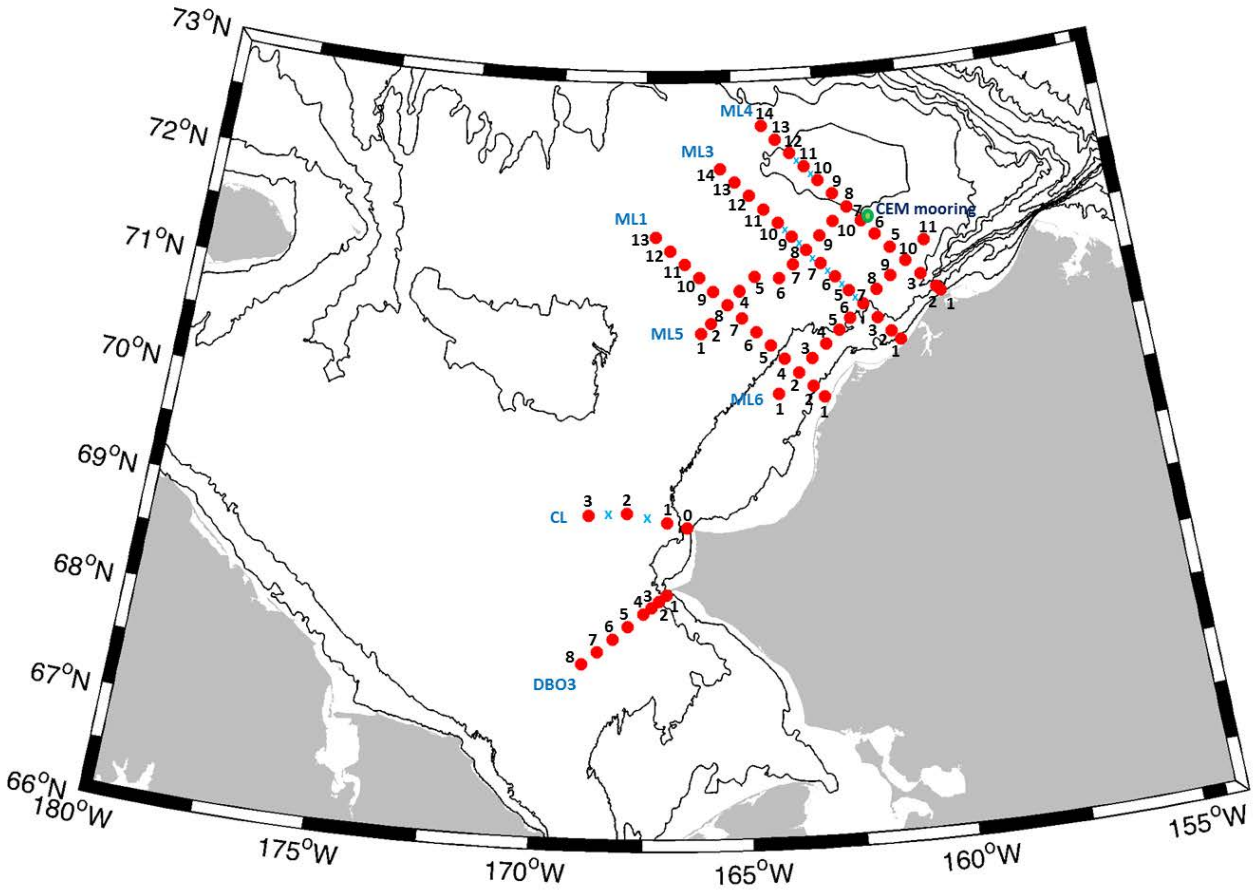
Distinct water masses

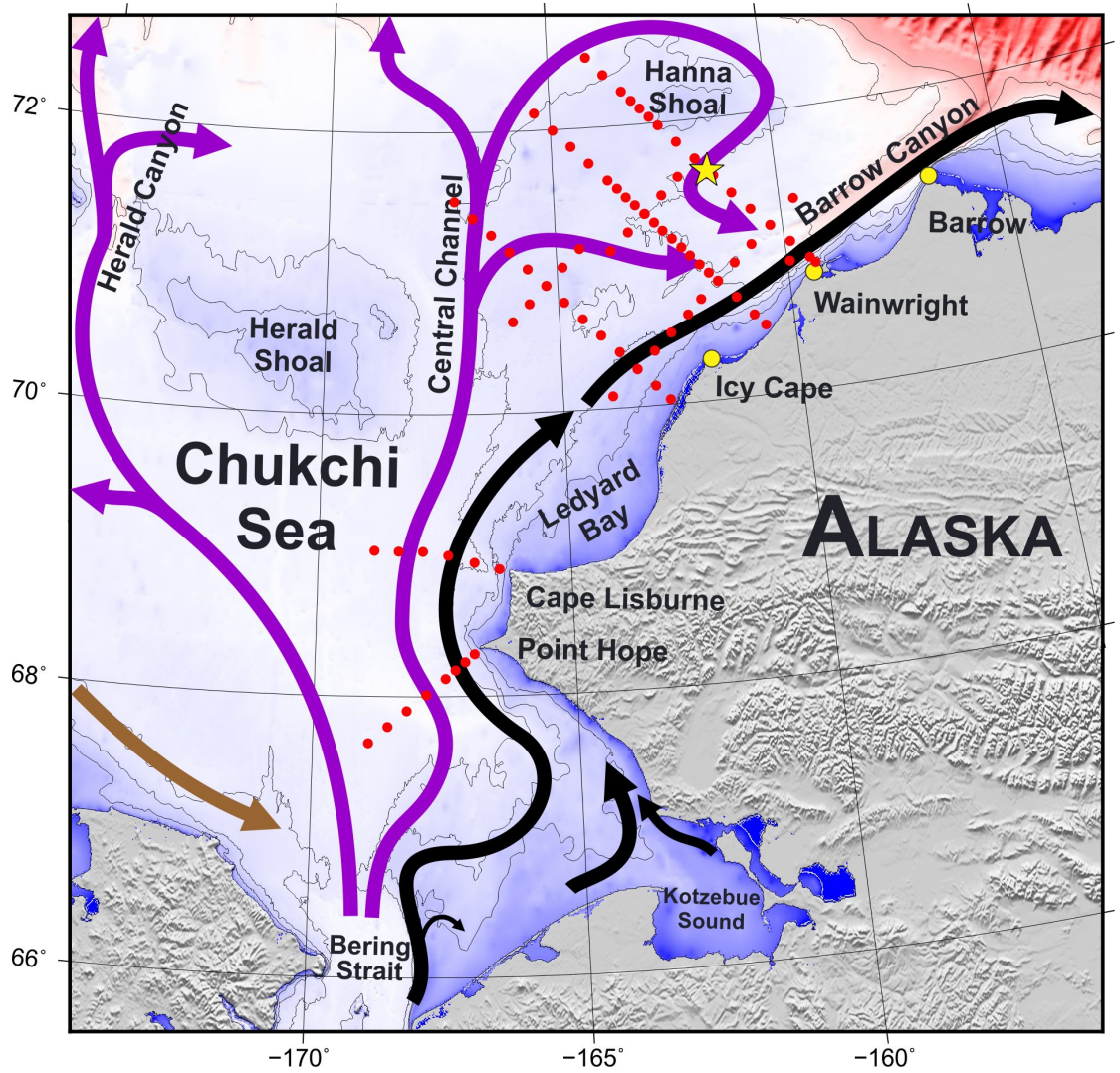
Region of dramatic changes

Historical data



AMBON 2015 and 2017 August cruise track





- Physics
- Plankton
- Benthos
- Fish
- Birds & Mammals

Funded by NOAA, BOEM, and Shell through US NOPP (National Ocean Partnership Program), plus NSF

What the end-to-end approach means

Environment

Hydrography (synoptic measurements, link to long-term moorings)

Chlorophyll *a* (water column, sediment)

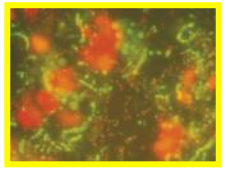
Nutrients (nitrate+nitrite, ammonia, silicate, phosphate)

Sediment (grain size, organic content, $\delta^{13}C$ and $\delta^{15}N$ of organic fraction)

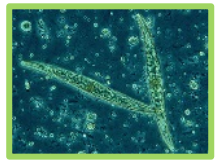
End-to-end approach

Biodiversity

Microbes – water column and sediment microbes



Phytoplankton – species composition



Zooplankton – zooplankton diversity

Benthos – infauna, epifauna, meiofauna

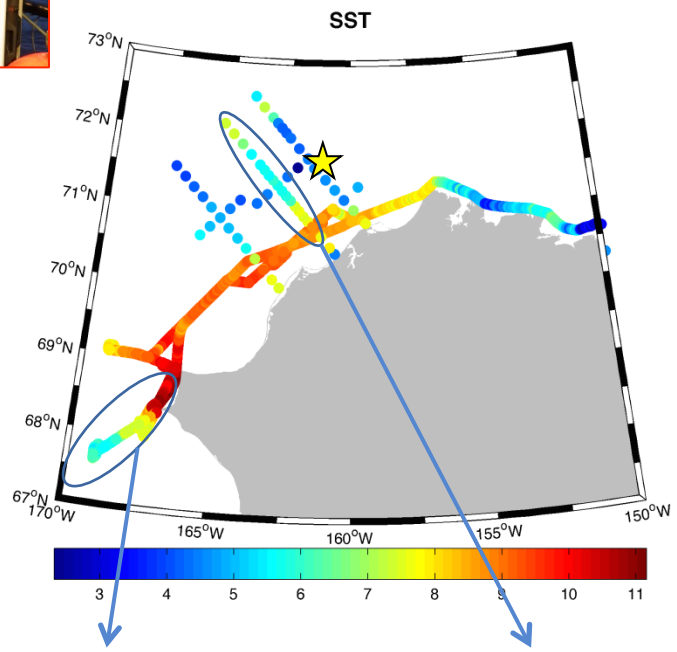
Fish – demersal and pelagic fish diversity

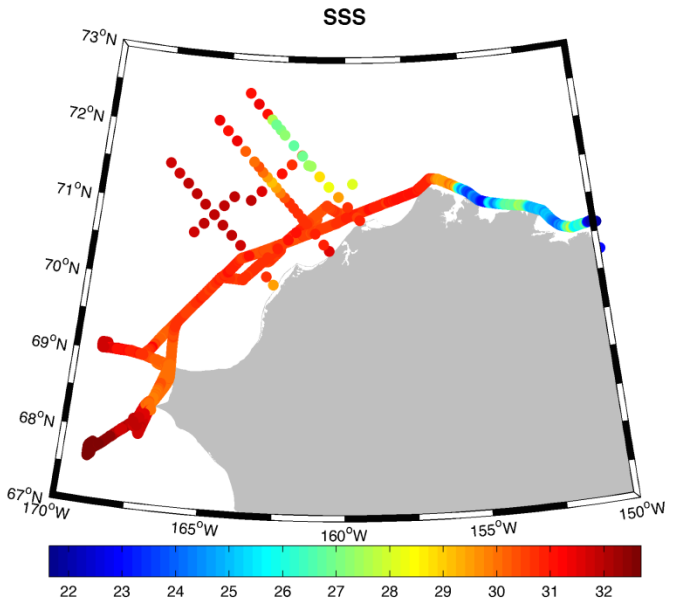
Seabirds – seabird observations

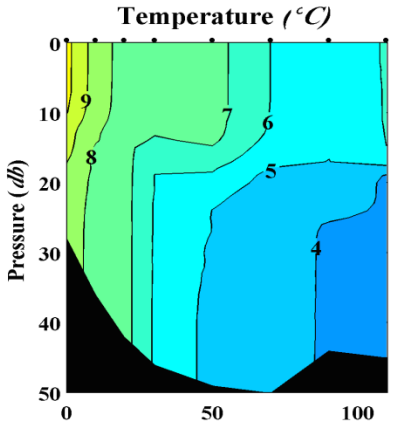
Marine mammals – seal and whale observations

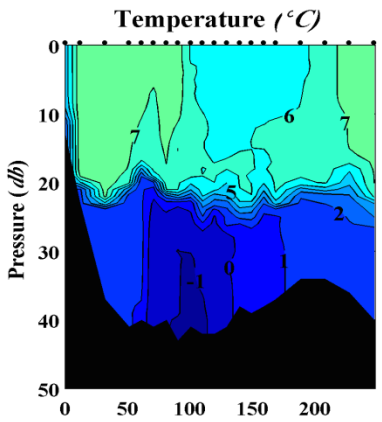
Hydrography

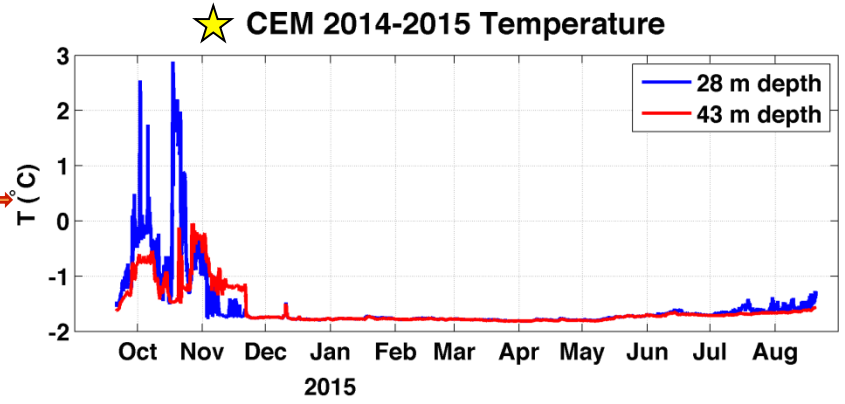
2015









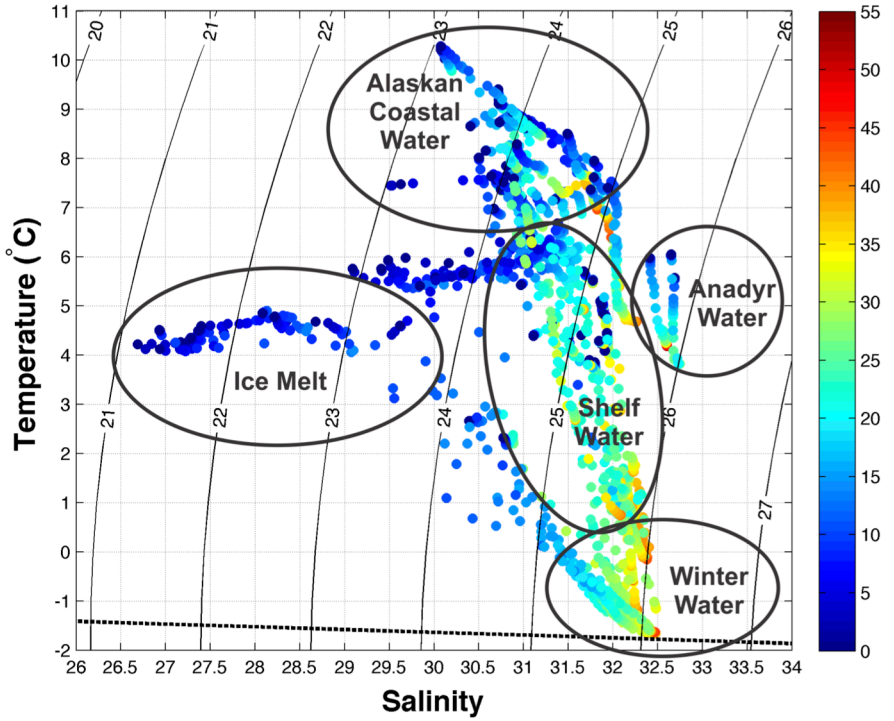


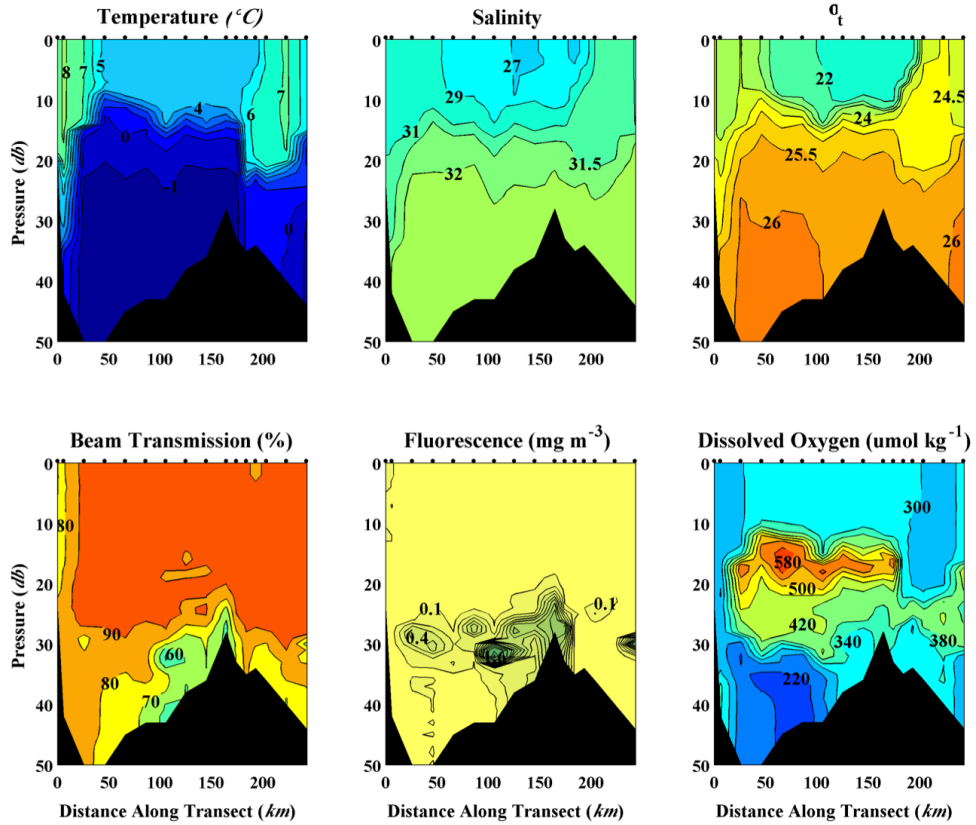
Inshore-offshore gradients

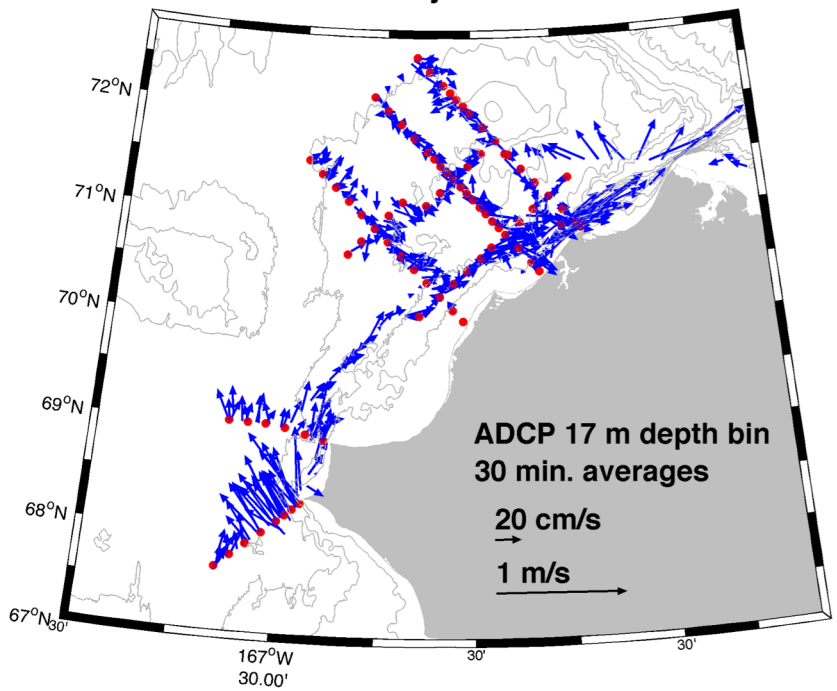
Vertical stratification

Long-term data records (mooring)

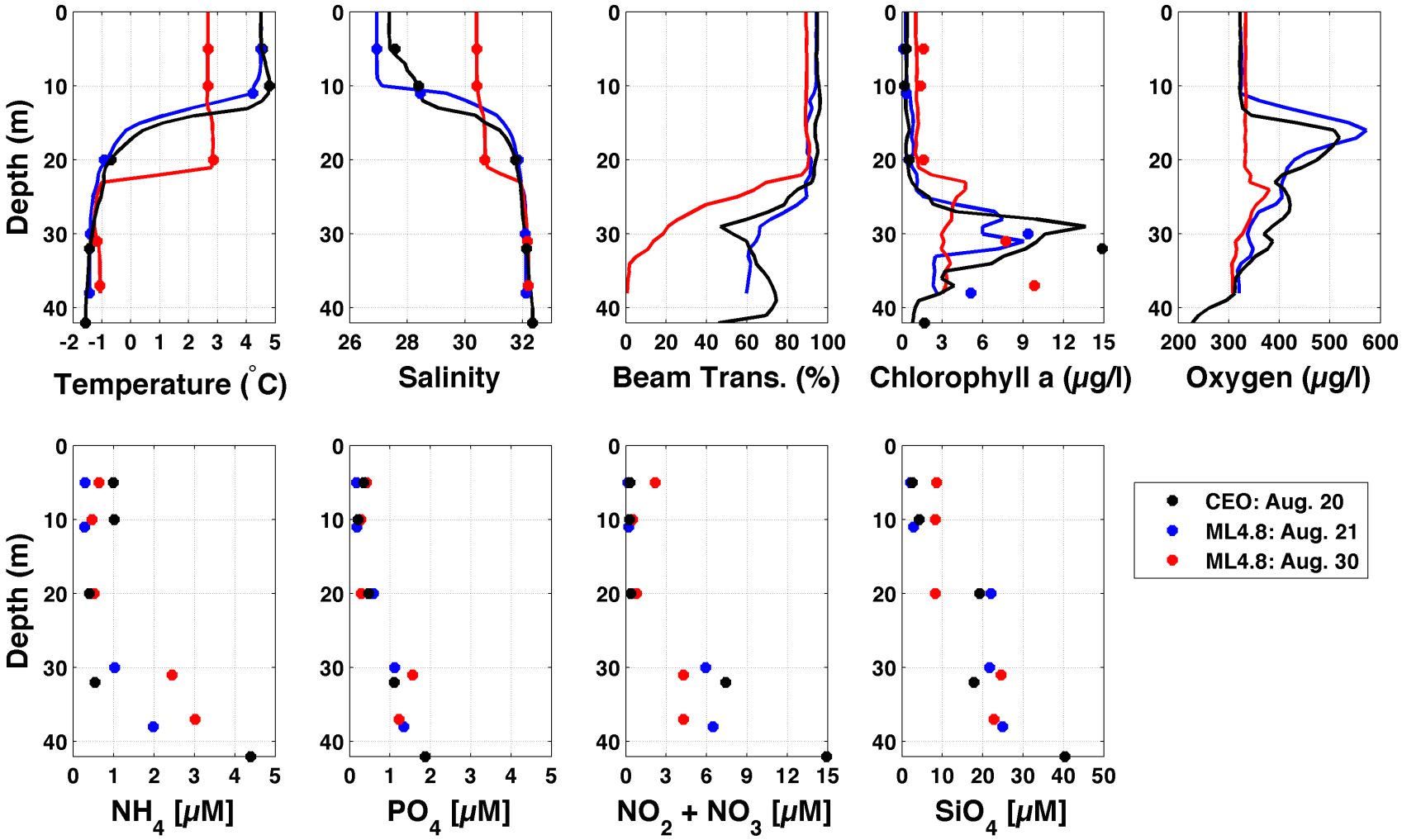
- Nice quasi-synoptic hydrographic transects (T, S, PAR, BAT, ChlF, DO, U/V)
- 5 distinct water masses
- Some stations occupied before and after storm

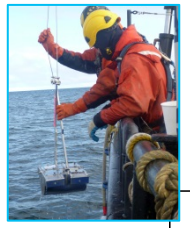






AMBON sampling at Chukchi Ecosystem Observatory (CEO) mooring before and after August 2015 storm

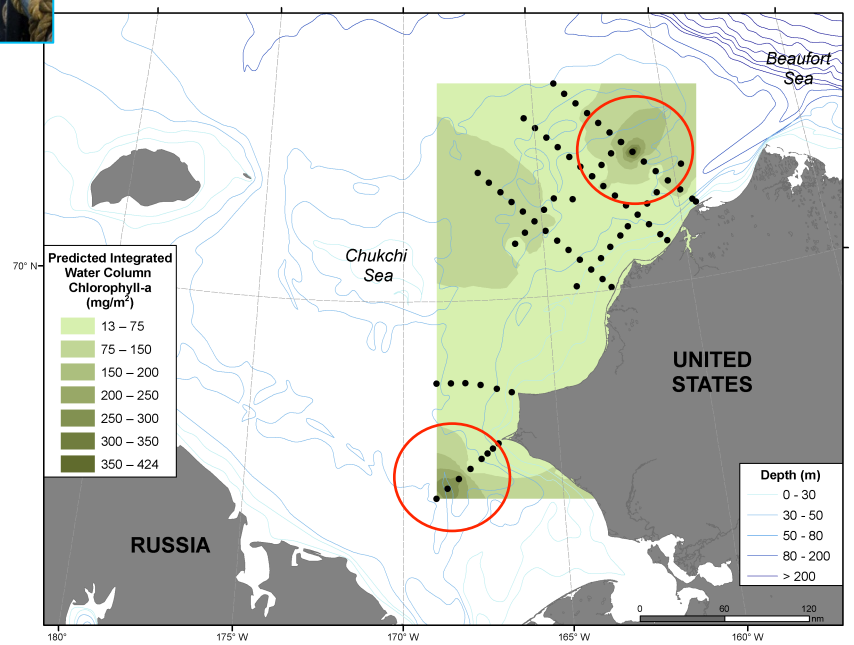




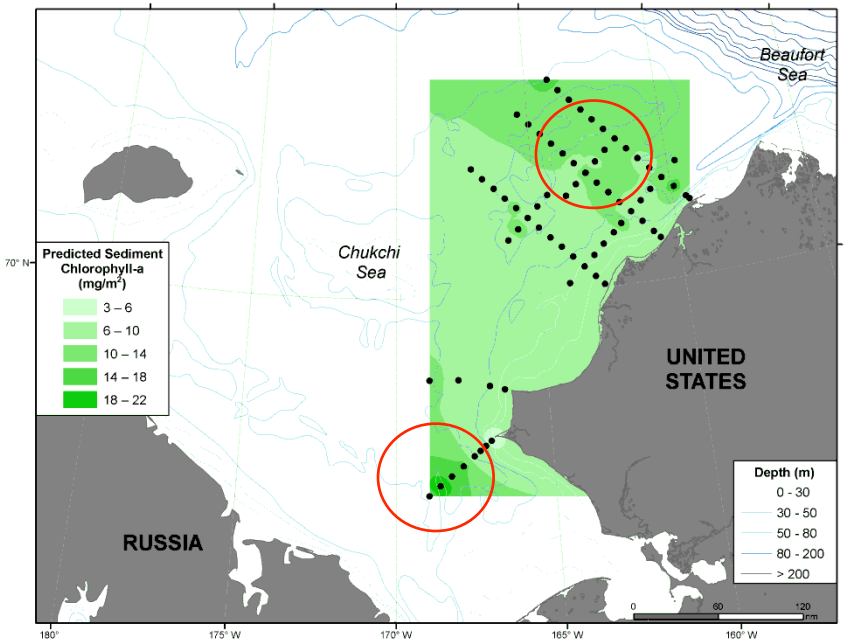
Pelagic-benthic coupling

2015

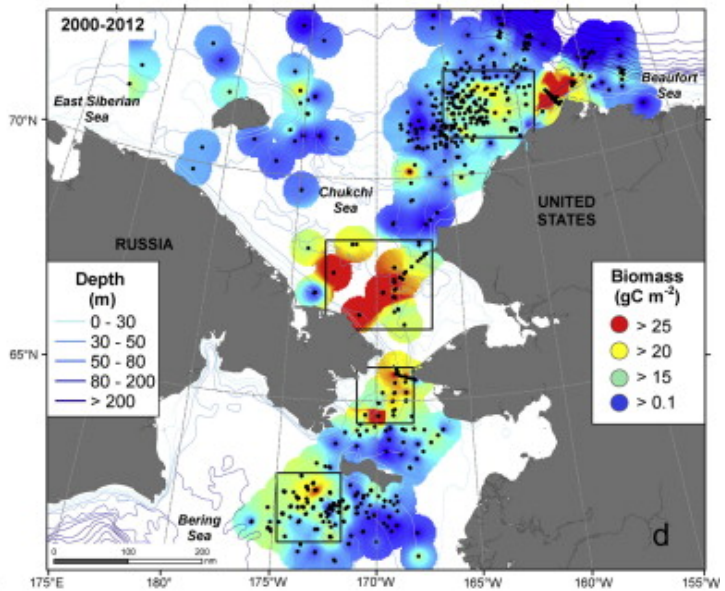
Integrated chl *a*



Sediment chl *a*



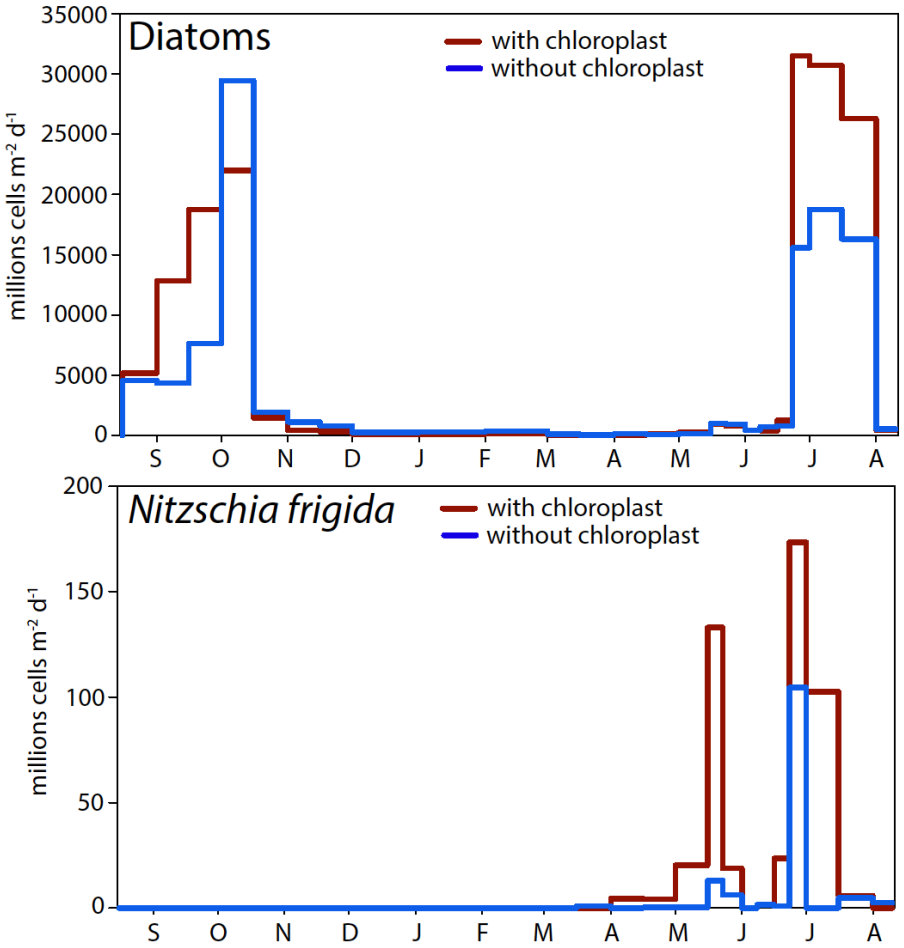
- Hotspot regions



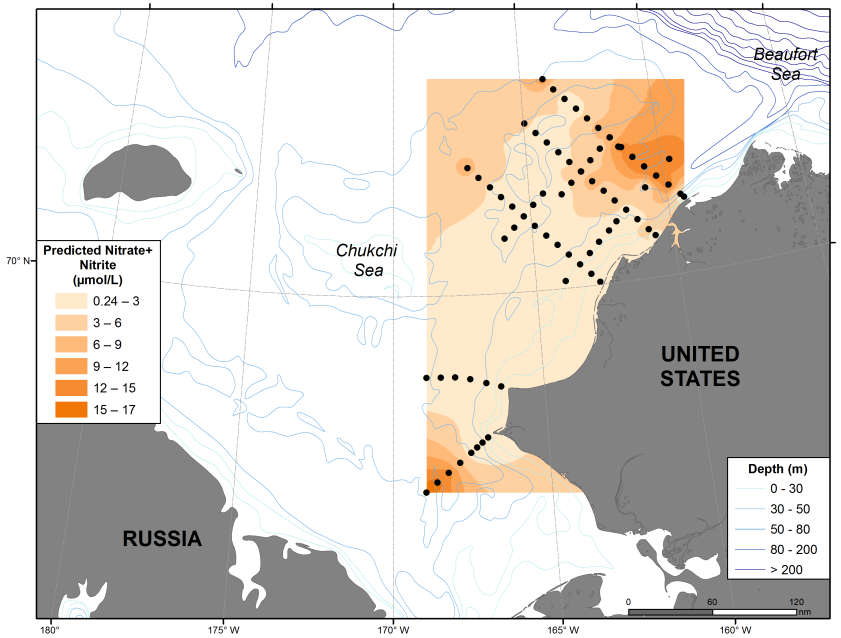
Grebmeier et al. 2015, Prog. Oceanogr.

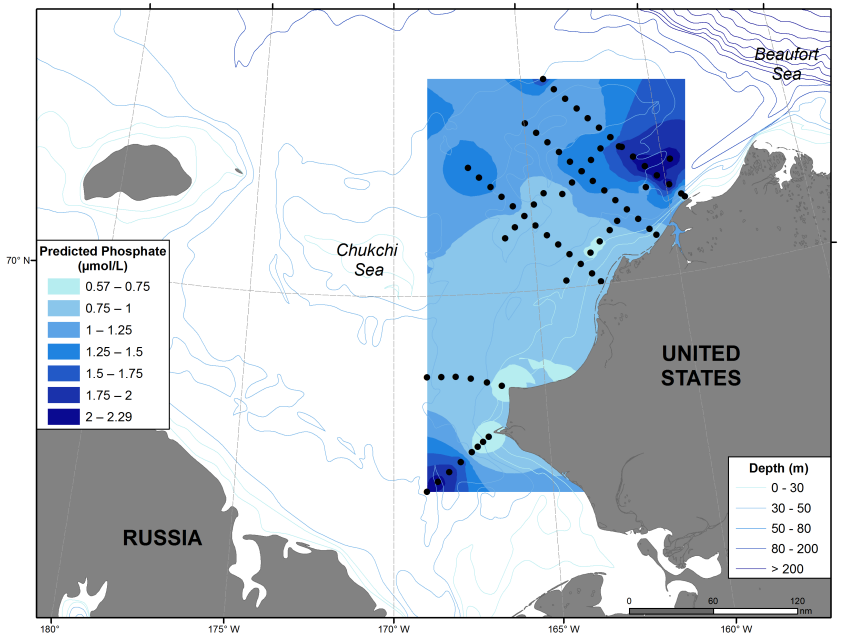
Other emerging stories: CEO and AMBON

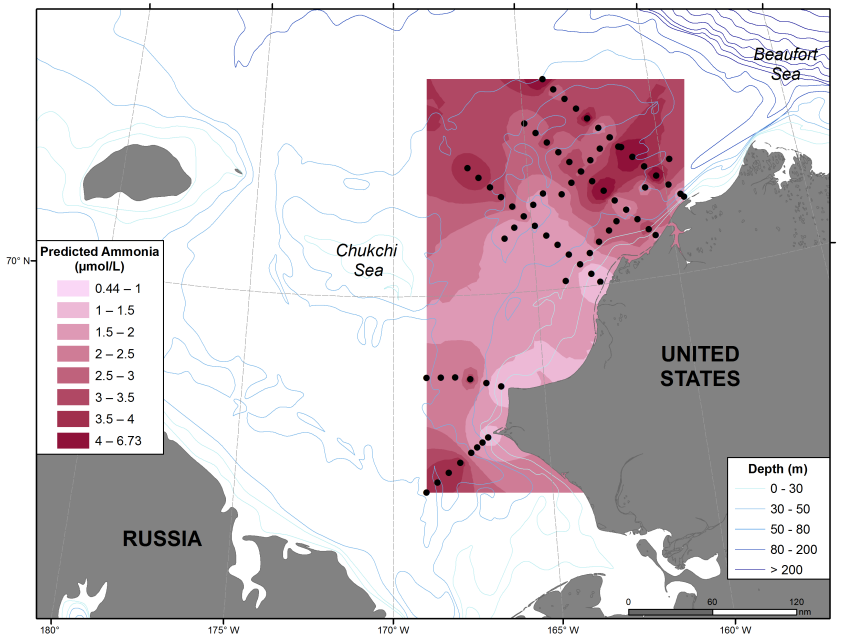
- Lots of sunlight under thick ice in May/ June 2016
- Very little chlorophyll fluorescence at 33 m depth in May 2016; increases through June and July
- Very large diatom export in June and July
- Light and appearance of ice algae *Nitzschia frigida* in May & June indicates ice release due to snow and ice melt.

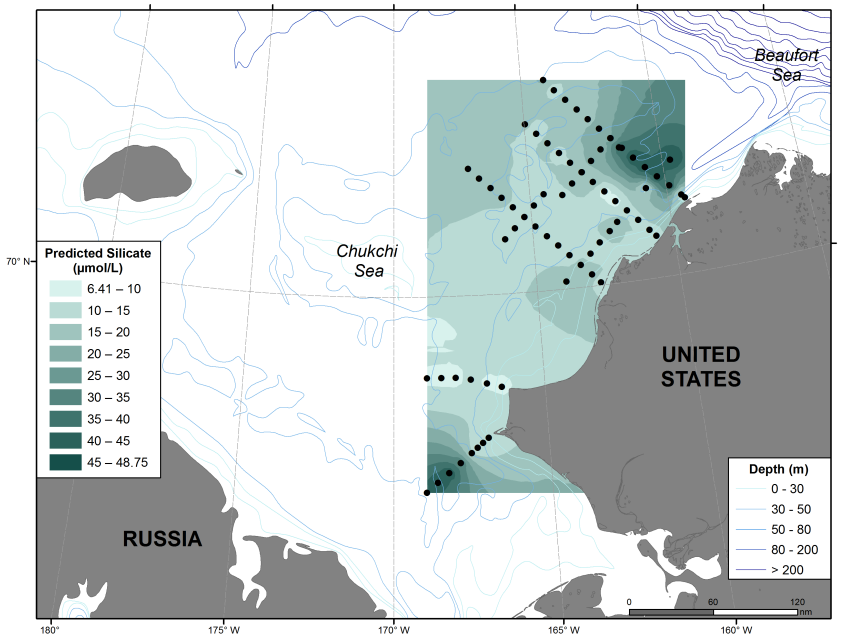


Bottom water nutrients– AMBON15

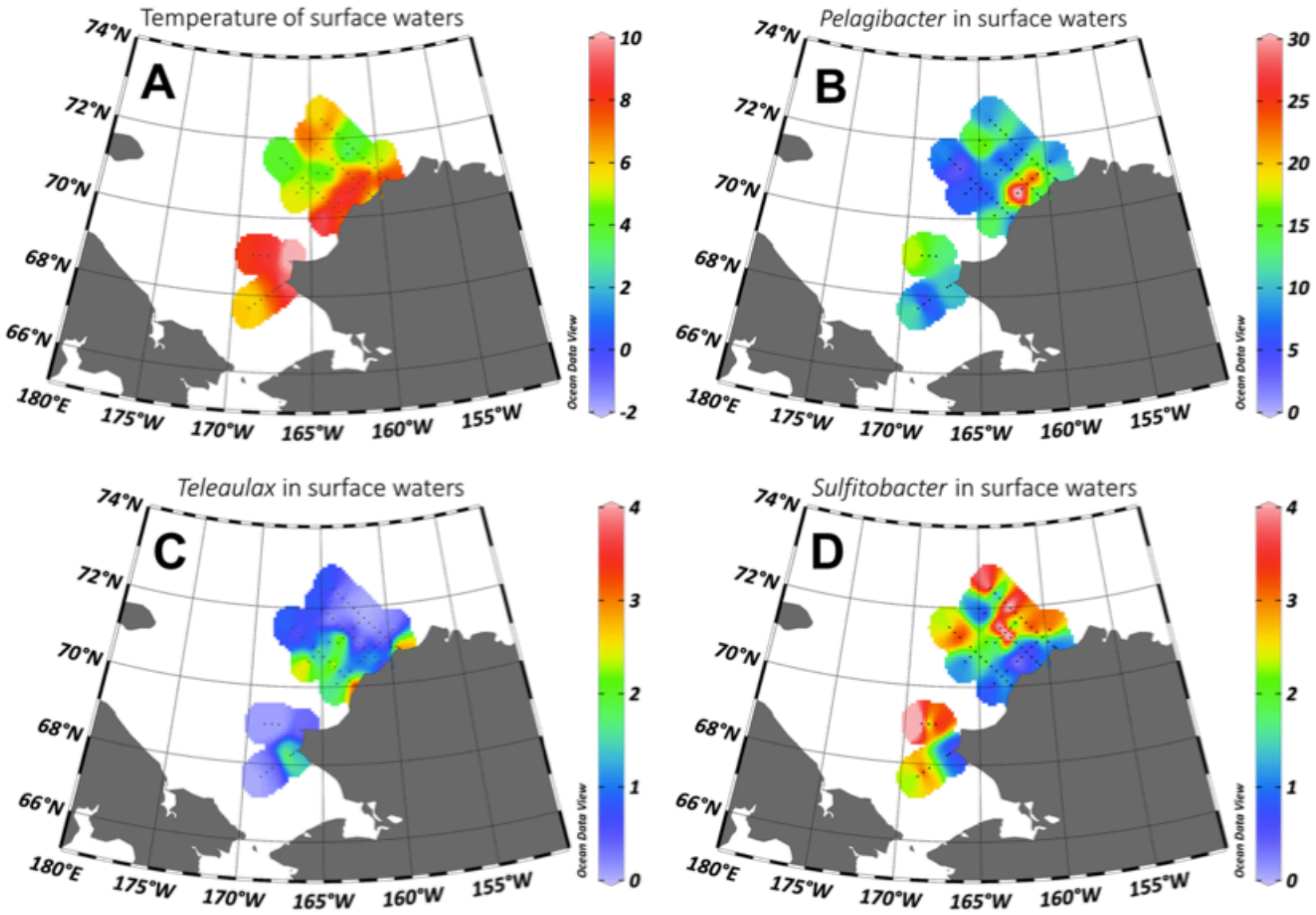






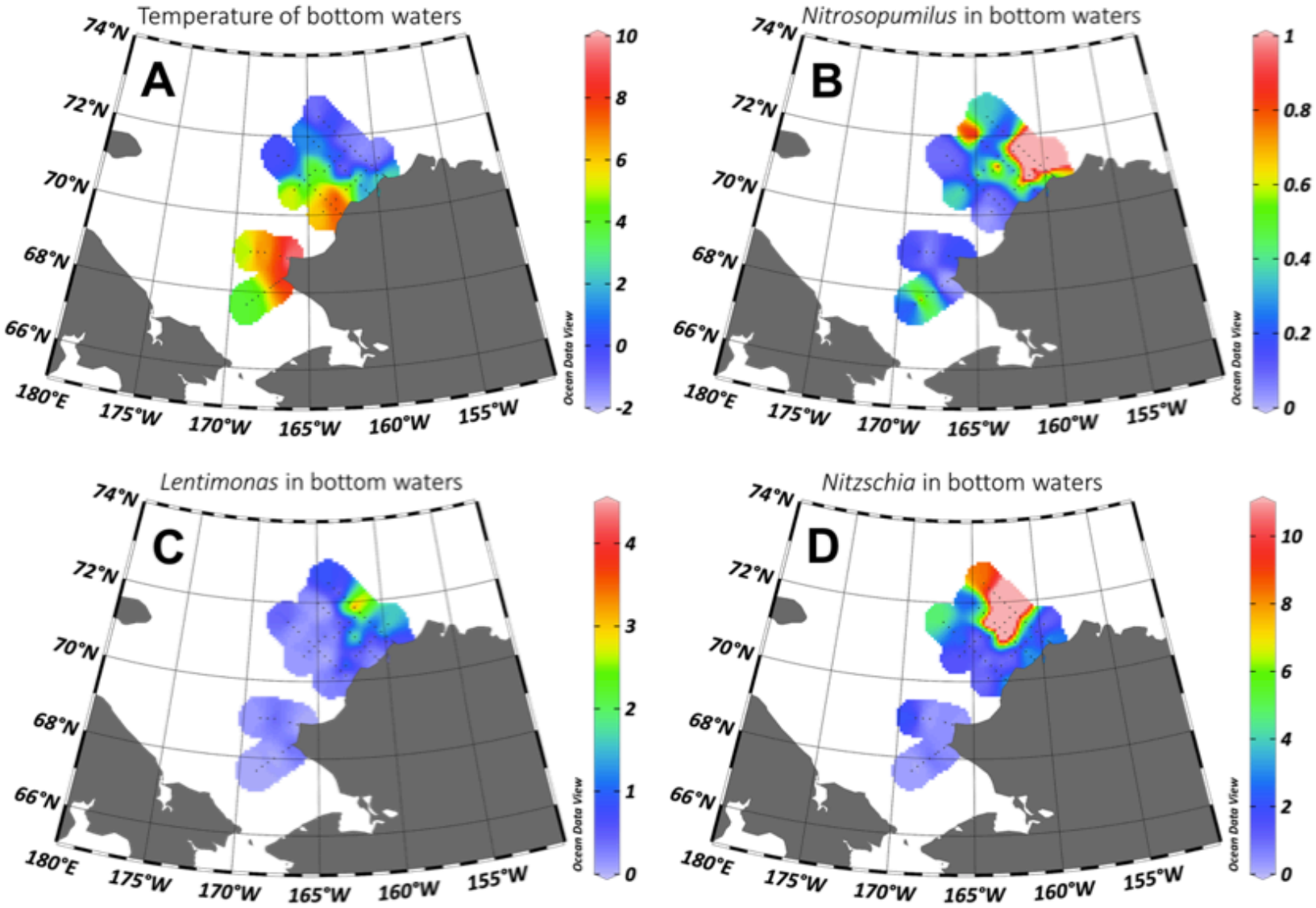


Marine Microbes



Some microbes are strongly segregated by water mass – here we see contrasting distributions of Pelagibacter and Sulfitobacter inside and outside the ACC, which features warmer, nutrient-poor waters traveling north along the Alaskan coastline.

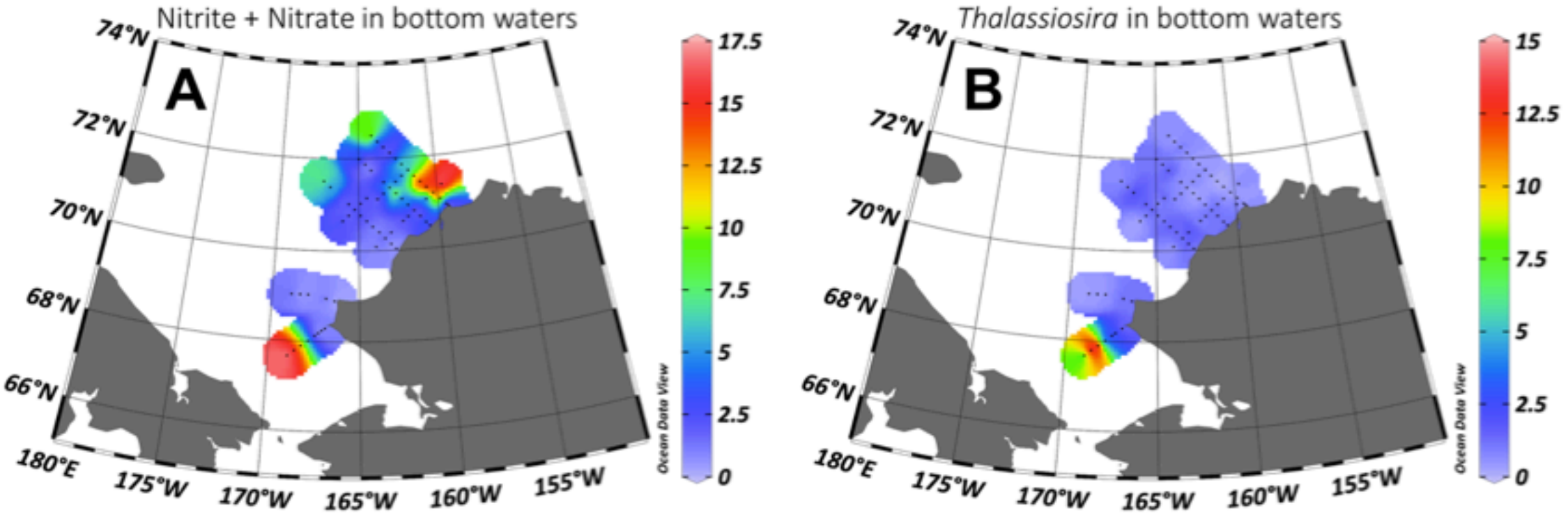
Marine Microbes



Other taxa prefer the colder, deeper Arctic Winter Water, including Nitrosopumilus, Lentimonas, and Nitzschia.

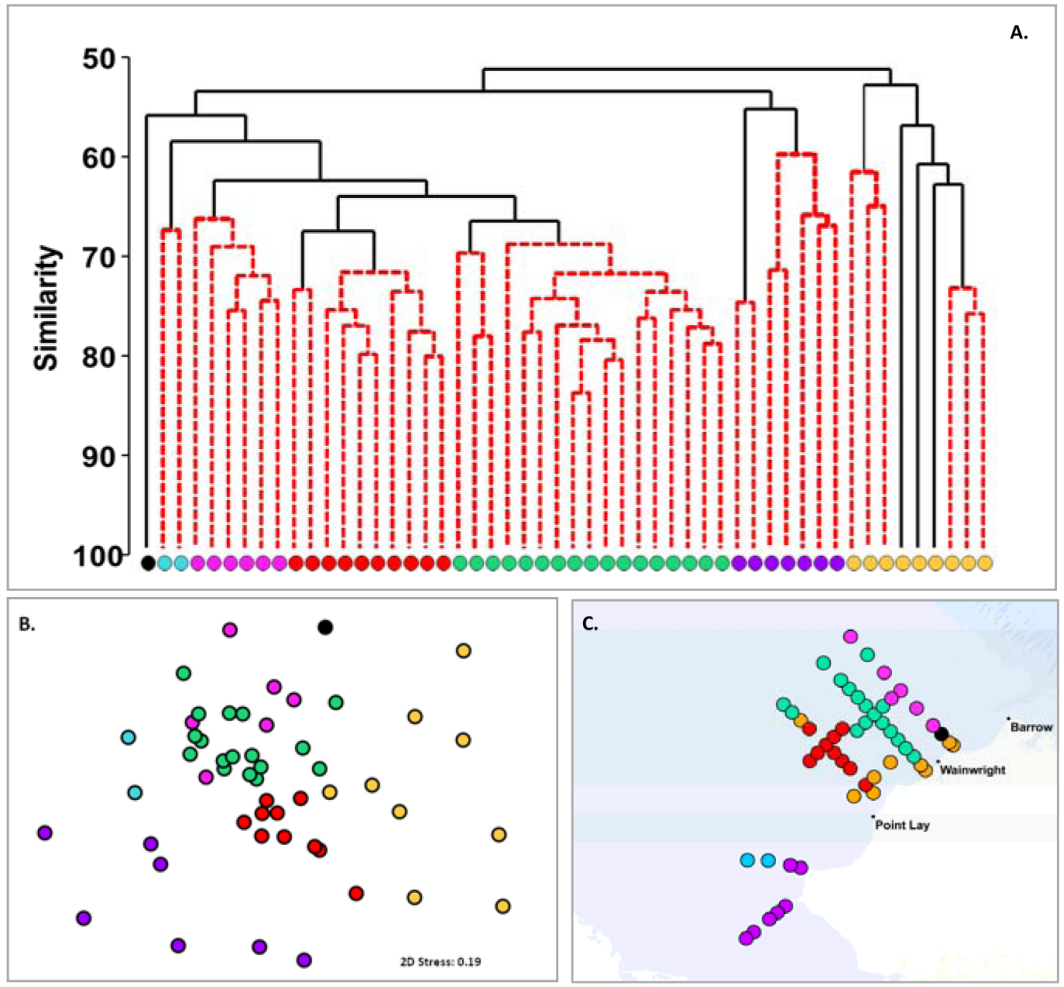
Nitrosopumilus contributes to the regeneration of nitrate-rich waters to the North, which are preferred by some taxa -- like the benthic diatom Nitzschia -- over the nutrient-deplete waters to the south.

Marine Microbes

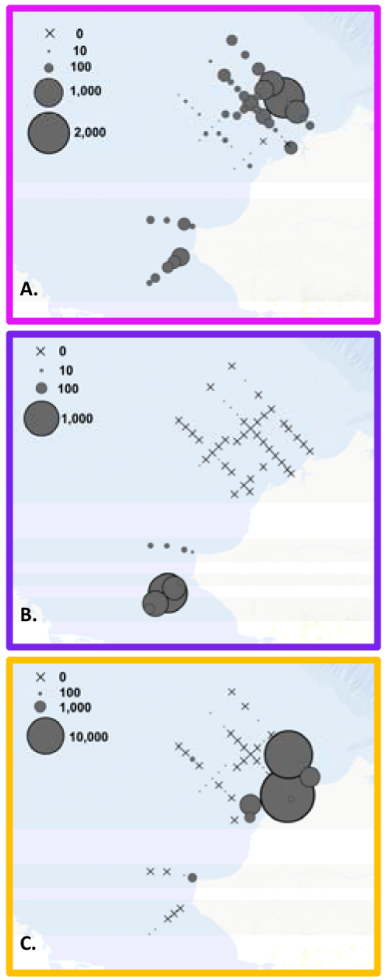


Some taxa correlate strongly with nutrient availability, given that other conditions are favorable. Here Thalassiosira is more abundant in deep, nitrate rich waters in the Southern Chukchi but absent in the north.

Zooplankton



2015 Zooplankton communities reflect underlying distribution of water masses, with 3 major groups. Boundaries and composition differ between years



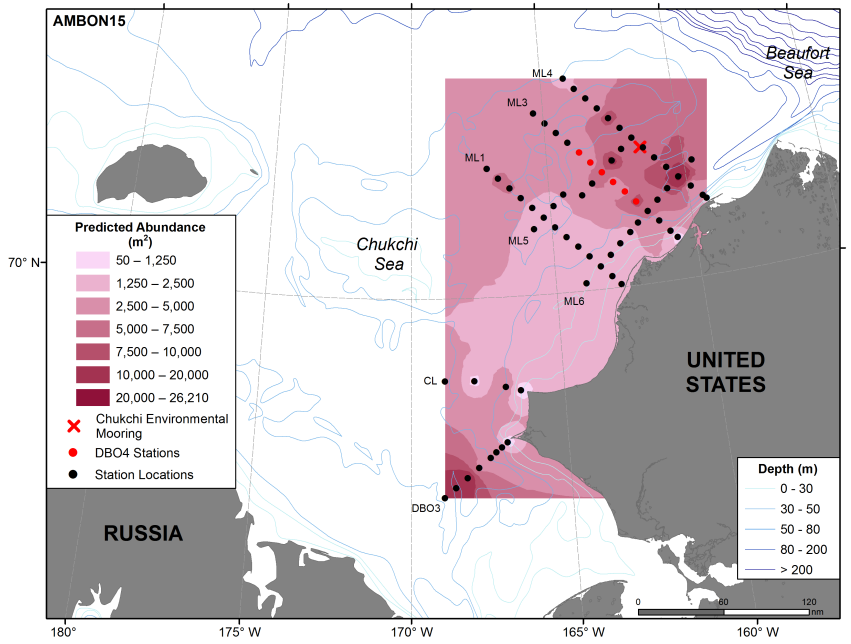
Calanus glacialis
IndVal: 0.86
Mean temperature (°C): 1.1
Mean salinity: 31.1
Mean depth (m): 43.4

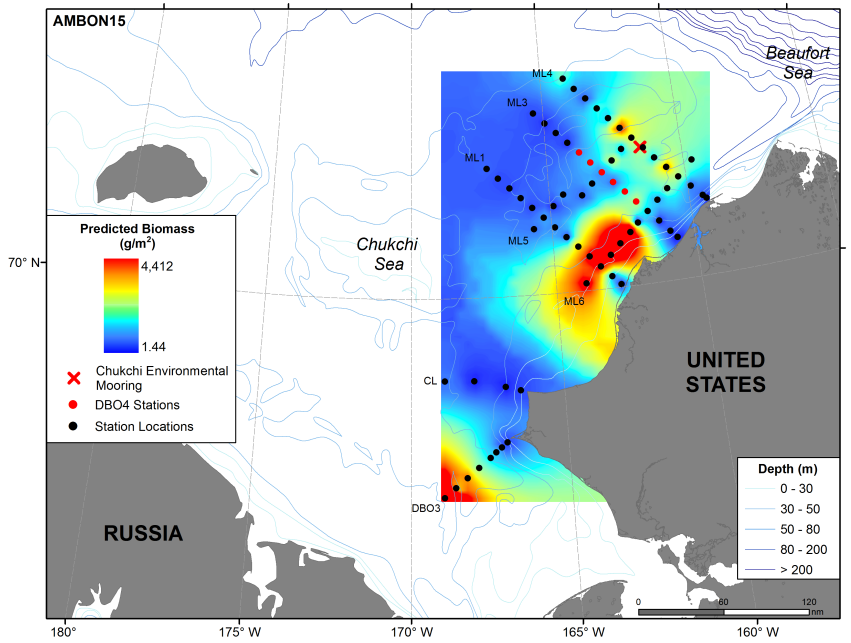
Eucalanus bungii
IndVal: 0.94
Mean temperature (°C): 6.9
Mean salinity: 31.7
Mean depth (m): 43.6

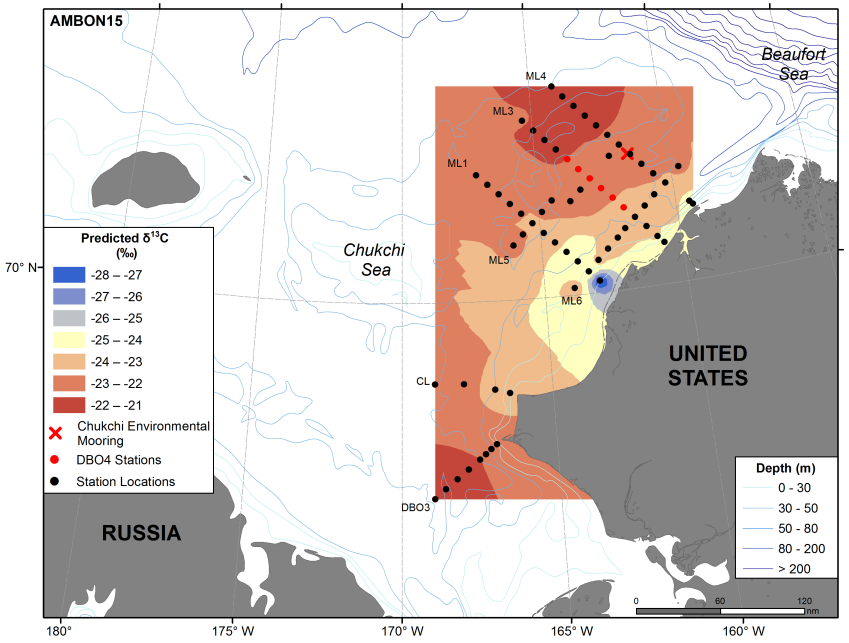
Echinodermata larvae
IndVal: 0.86
Mean temperature (°C): 7.0
Mean salinity: 30.9
Mean depth (m): 27.9

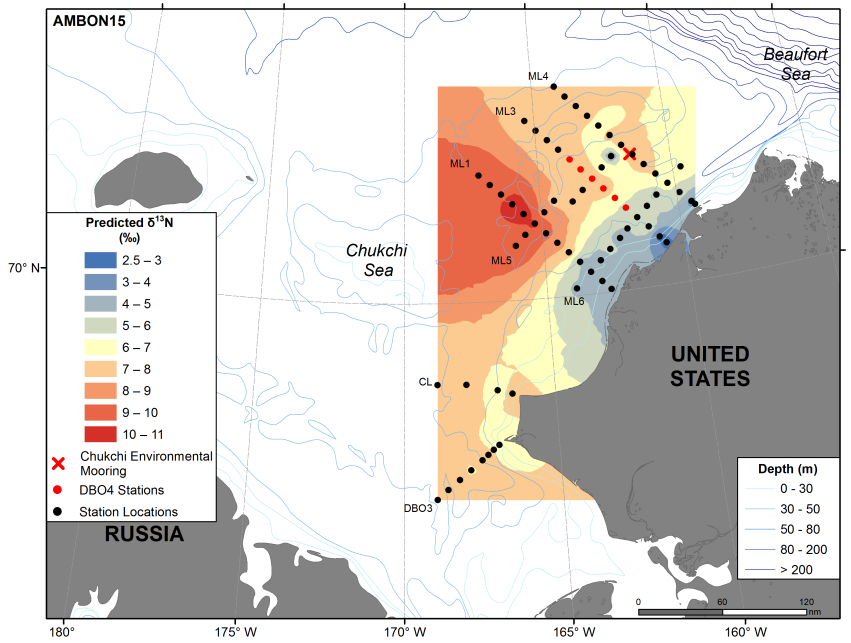
Indicator taxa for each 2015 community group with their associated average environmental parameters. (Colors correspond with left figure)

Macrofaunal Abundance and Biomass and Sediment Parameters – AMBON15





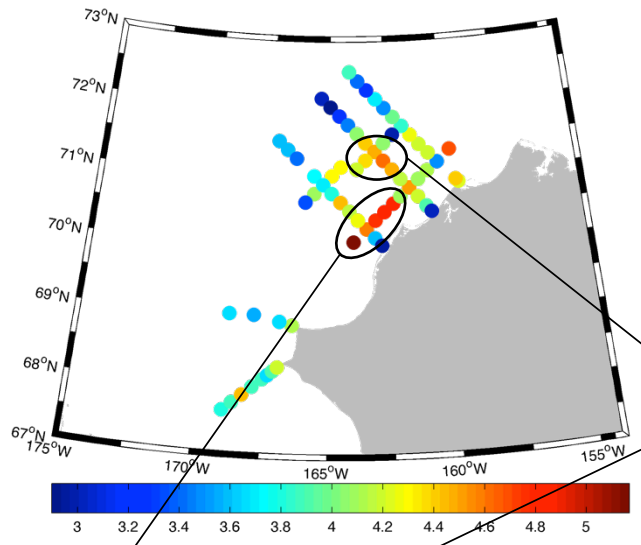




Epifauna

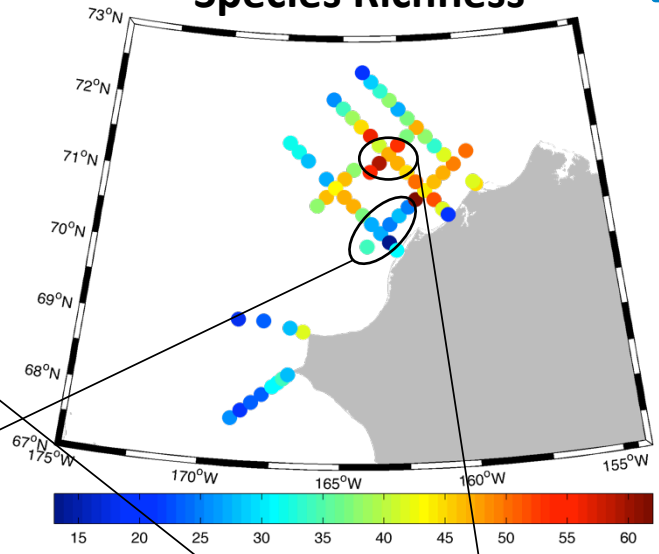
2015

Biomass



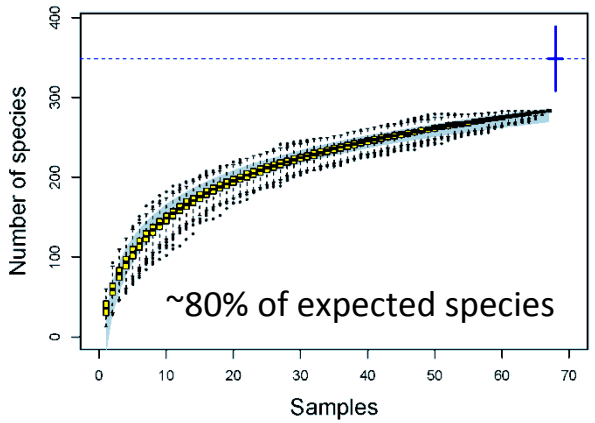
Biomass (log_{10} g wet weight 1000 m^{-2})

Species Richness



Species richness per station

High biomass – low diversity

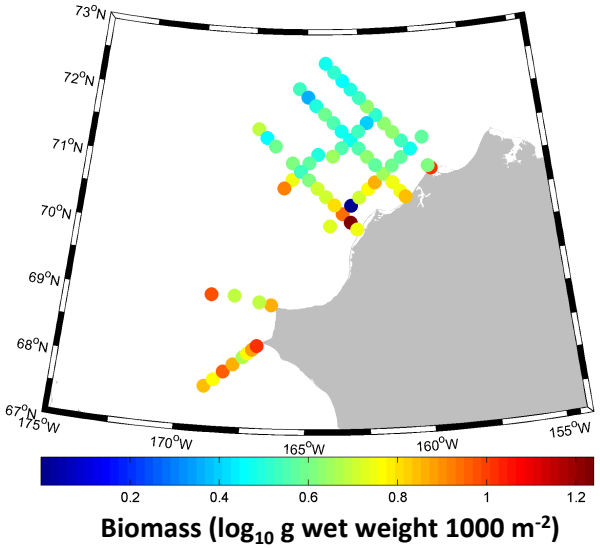


High biomass – high diversity

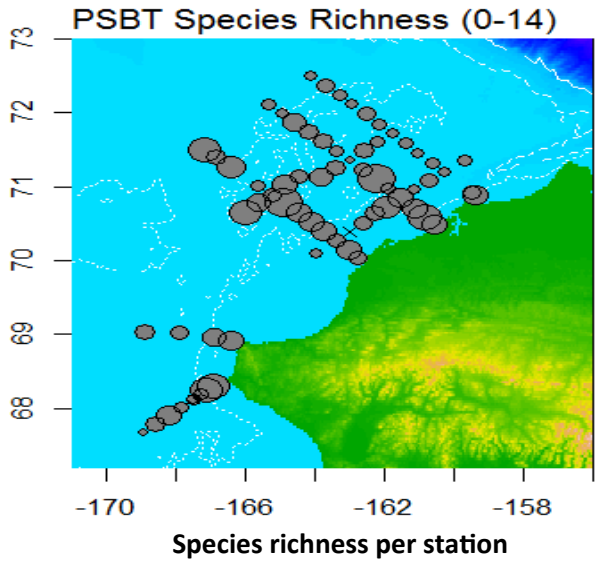
Demersal fish

2015

Biomass



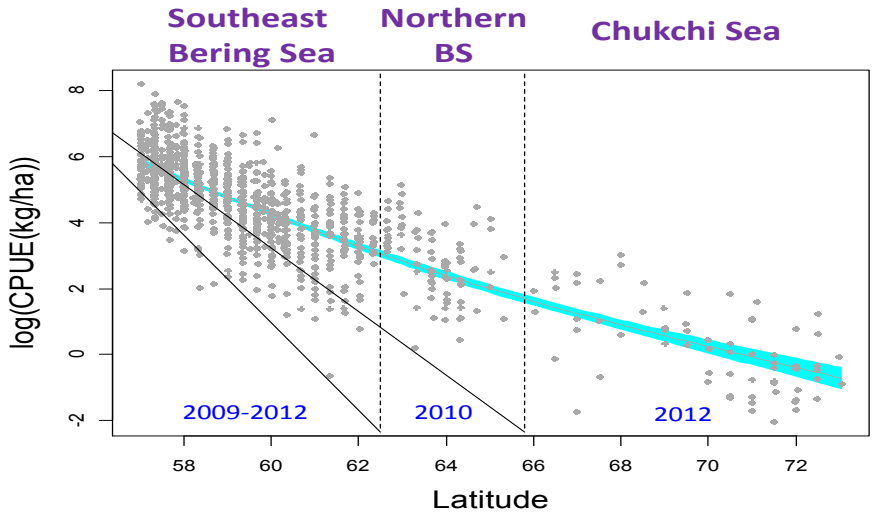
Alpha-diversity

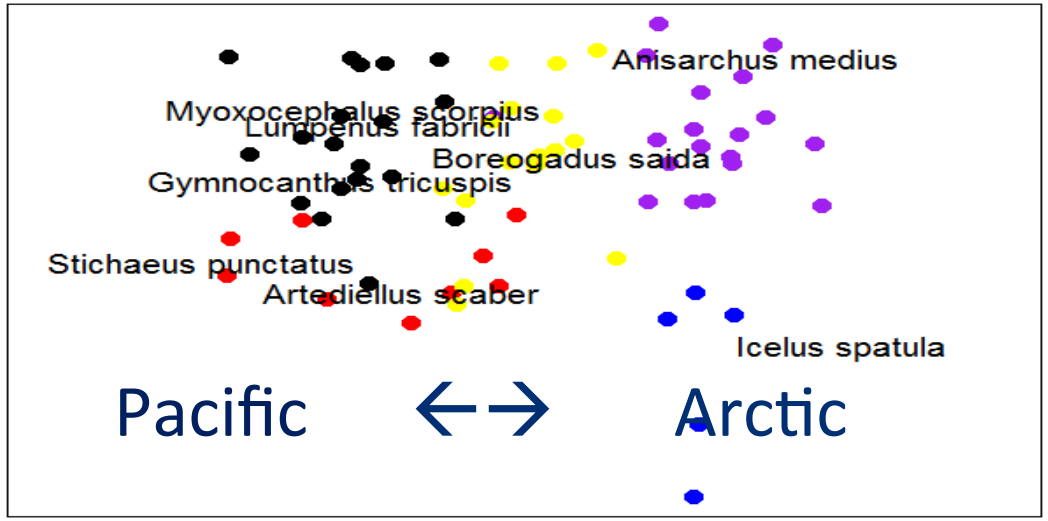


Challenge: Defining appropriate metrics for fish biodiversity, including functional groups and trophic guilds that might include invertebrates

- Highest biomass in coastal regions
- Higher diversity in Pacific-influenced waters

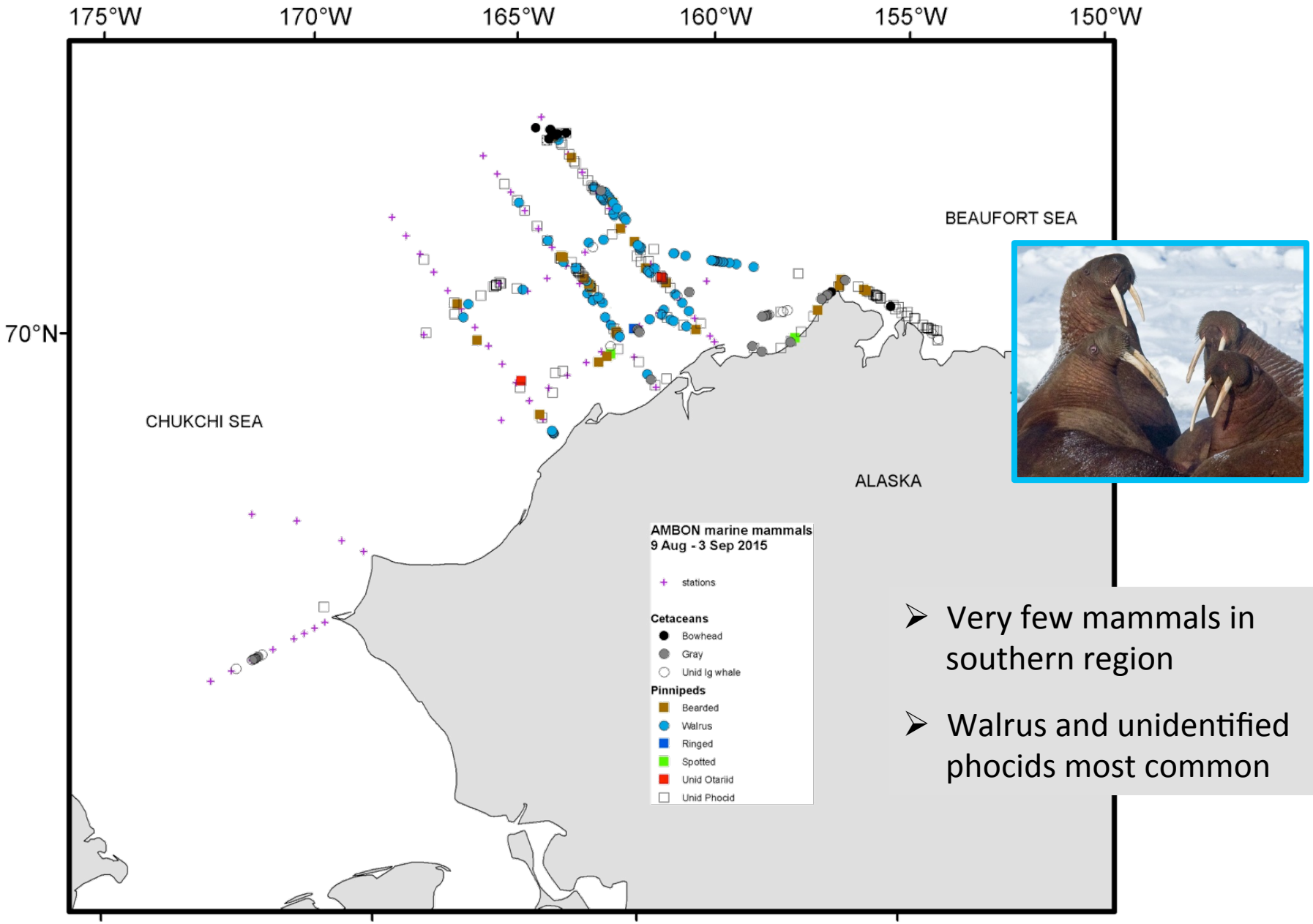
- Sculpins, pricklebacks, cods, sandlance among fish most commonly collected





Marine Mammals

2015

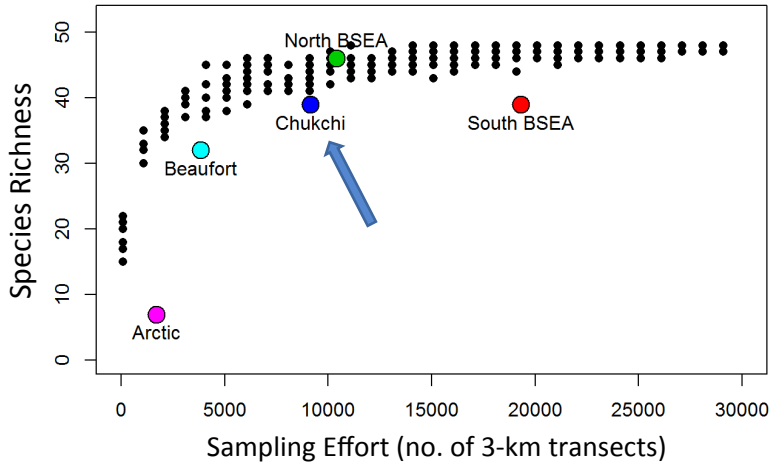


- Very few mammals in southern region
- Walrus and unidentified phocids most common

Seabirds

2015

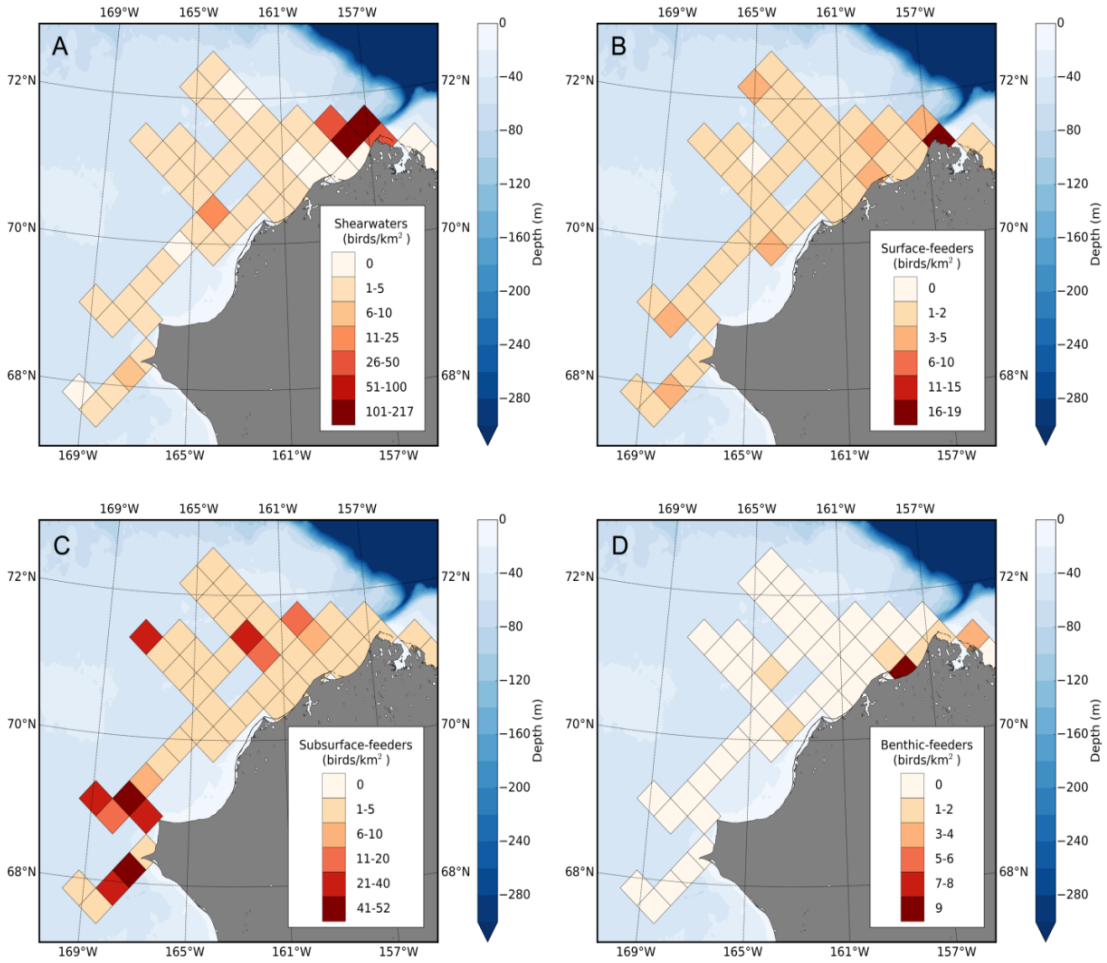
- 10,914 individuals
- 32 species
- Most abundant:
  - Shearwaters
  - Least and crested auklets
  - Phalaropes (2 species)
  - Murres (2 species)
  - Kittiwakes



Chukchi vs nearby regions: Species Richness vs Sampling effort. Predicted based on random sampling of all data, & actual for each region (North & South Bering, Beaufort, Arctic Basin)

Shearwaters

Surface Foragers



Subsurface Foragers

Benthic Foragers

Seabird density (birds/km²) & distribution

AMBON: Companion and Leveraged Projects in Chukchi Sea 2015 and 2017

- **DBO (NSF) and DBO-NCIS (NOAA) efforts**
  - Distributed Biological Observatory (DBO; http://www.arctic.noaa.gov/dbo/); three time series lines in the Chukchi Sea (2012-2017), NSF Arctic Observing Network Program
  - DBO-Northern Chukchi Integrated Study (NCIS); August-September 2017, NOAA Arctic Research Program
  - DBO endorsed by the Pacific Arctic Group, an international network that coordinates Pacific Arctic regional marine science activities (http://pag.arcticportal.com)
  - North Pacific Research Program ASGARD project, DBO3 and DBO4 in the Chukchi Sea
    ASGARD: Arctic Shelf Growth, Advection, Respiration and Deposition Rate Experiments (University of Alaska Fairbanks)
  - Chukchi Ecosystem Observatory (CEO) (http://chukchiecosystemobservatory.org)

2. Successes and challenges working “Cross-MBON”

- **Successes:**
  - Cross connection of biodiversity goals among MBONs
  - Lower to Upper trophic level data collections
  - National and International biodiversity partners (next slide)
  - Submitted NASA proposal (Maria Kavanaugh lead) to include AMBON in MBON seascape effort
- **Challenges**:
  - Cross-link of geospatial mapping and product development from temperate and polar MBONs
  - Satellite observations via DBO network (NASA DBO), but no core NASA support for AMBON
  - Dr. Nancy Foster Scholarship application for AMBON supported graduate student to help build relationships across MBONs (not successful)

Integration

- Joining Other Chukchi Sea data streams - AOOS
- International Arctic partners (CBMP, PAG, ESSAS, etc)

AOOS
Alaska Ocean Observing System

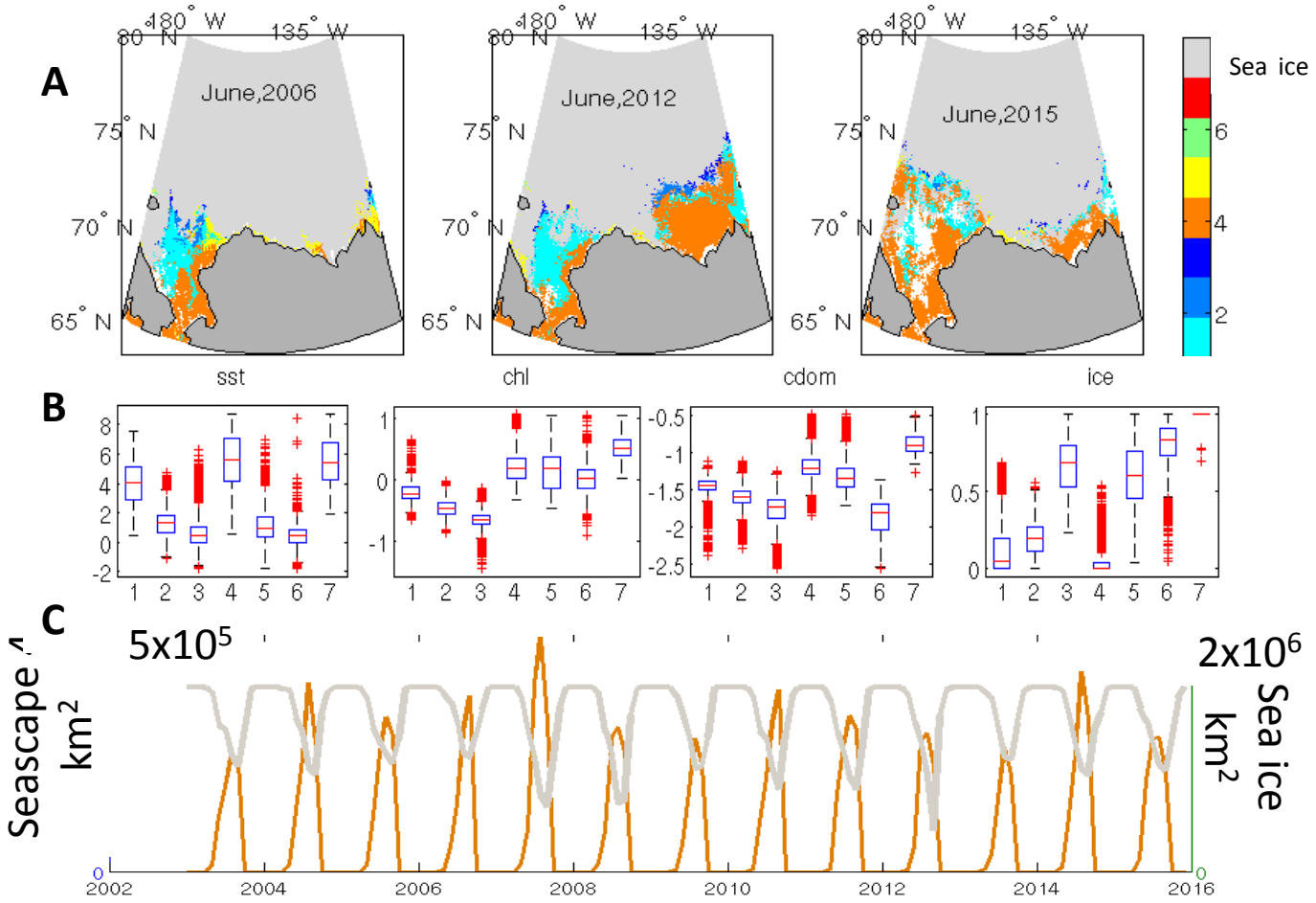
- Coordinate with other MBONs
  - Florida Keys and Monterey Bay Sanctuaries MBON
  - Channel Island MBON
- National operational marine biodiversity observation network
- Essential Biodiversity Variables (EBV)
- Common methodologies

IOOS
Integrated Ocean Observing System

- GeoBON Working Group 5; OBIS

Arctic biodiversity from microbes to whales

Dynamic seascapes in the Arctic (under development)



Kavanaugh, Otis , many others, in prep

A Sea ice concentration seascape

B are boxplots and represent the mean states of the seascapes that are color coded in A. The Y axis is concentration or mean SST, and the X axis is a categorical variable corresponding to the particular seascape (which were classified according to those four variables: chl-a, cdom, sst, %ice in addition to normalized fluorescent line height, a local to regional indicator of nutrient stress.

C Time series of sea ice concentration annually

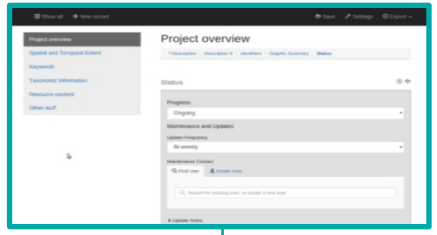
3. AMBON Data management

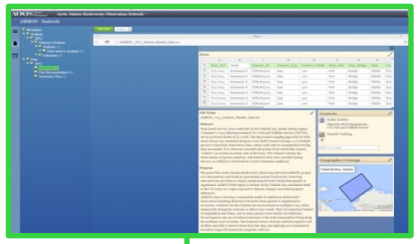
OBJECTIVES

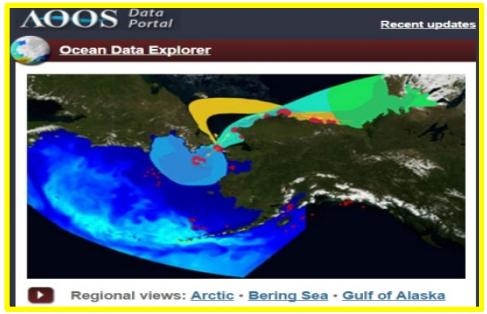
- Support data management, coordination, and implementation
- Provide services for data ingestion, QA/QC, metadata generation, data sharing, and final transfer to national archive
- Develop tools to access, query, and visualize information relevant to AMBON PIs and the larger scientific community

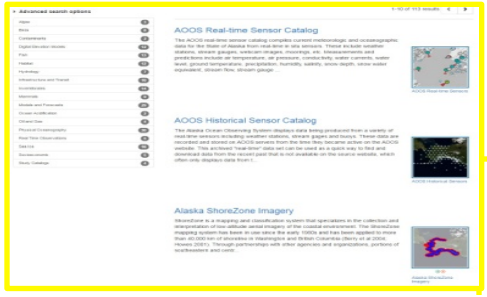
Axiom DATA SCIENCE

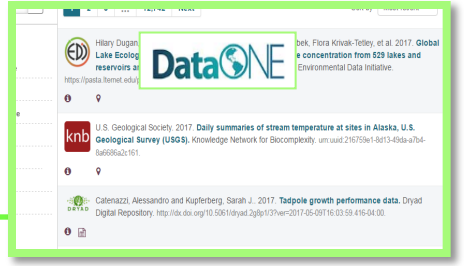
AMBON Data Lifecycle











DATA CREATION & QUALITY CONTROL
Scientists

DATA DESCRIPTION
Metadata Editor

DATA STORAGE
Workspace

ARCHIVE & PRESERVATION
Repository submission pathway

DATA ACCESS & DISCOVERY
Data portals & search catalogs

REUSE & TRANSFORMATION
Workspace Ipython (next gen) & data analysts

Axiom DATA SCIENCE

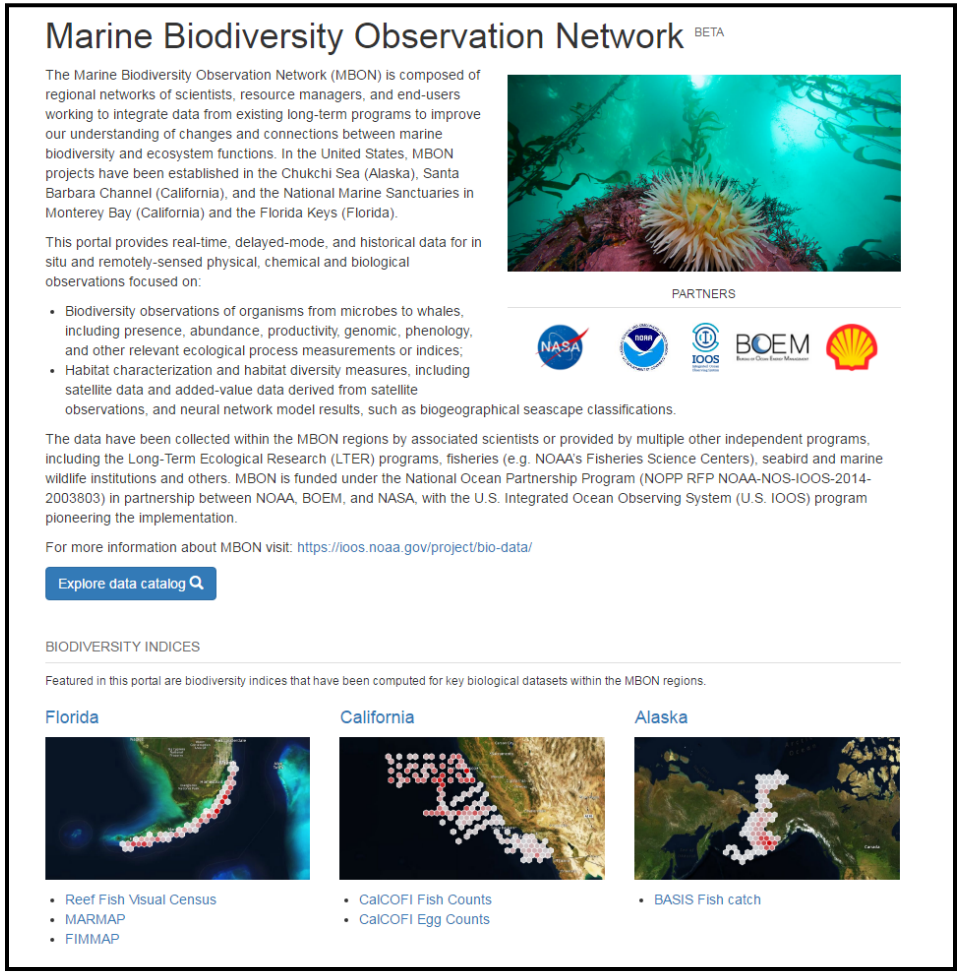
MBON Data Portal

https://mbon.ioos.us

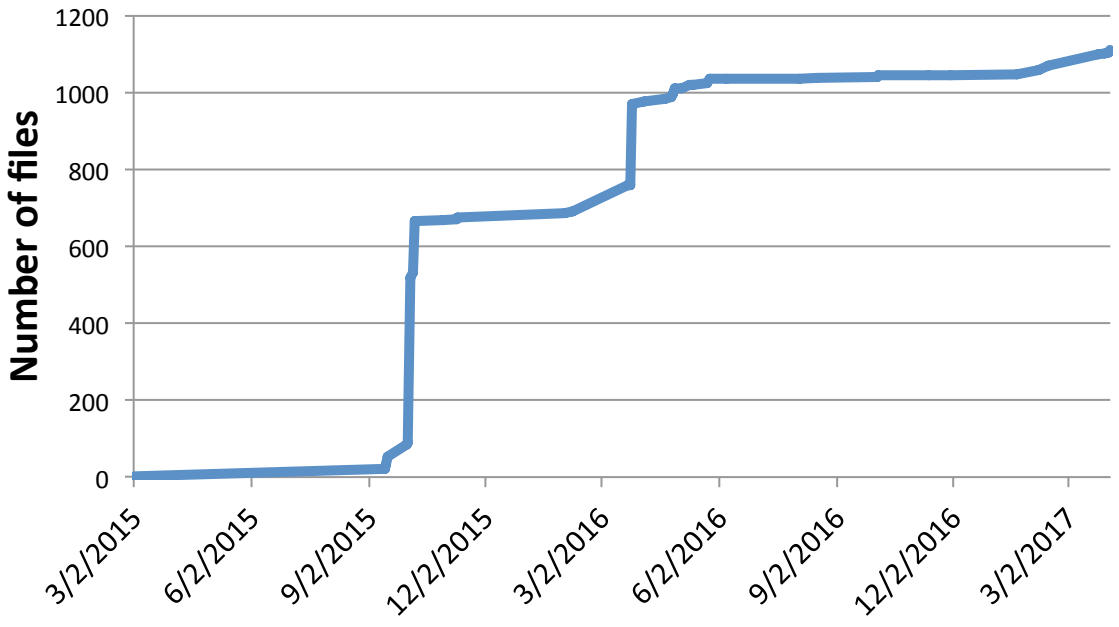
- Catalog with biological, environmental, geographic data access

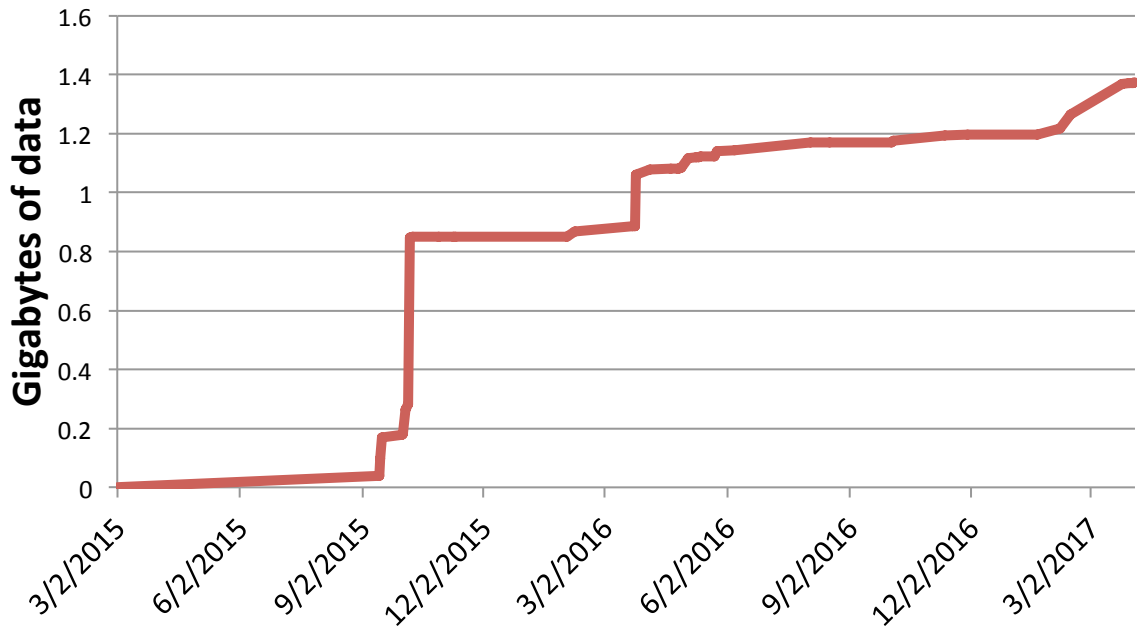
- Workspace: gateway for public data sharing through IOOS data portal

- AMBON 2015 draft metadata published to portal



AMBON Workspace Status

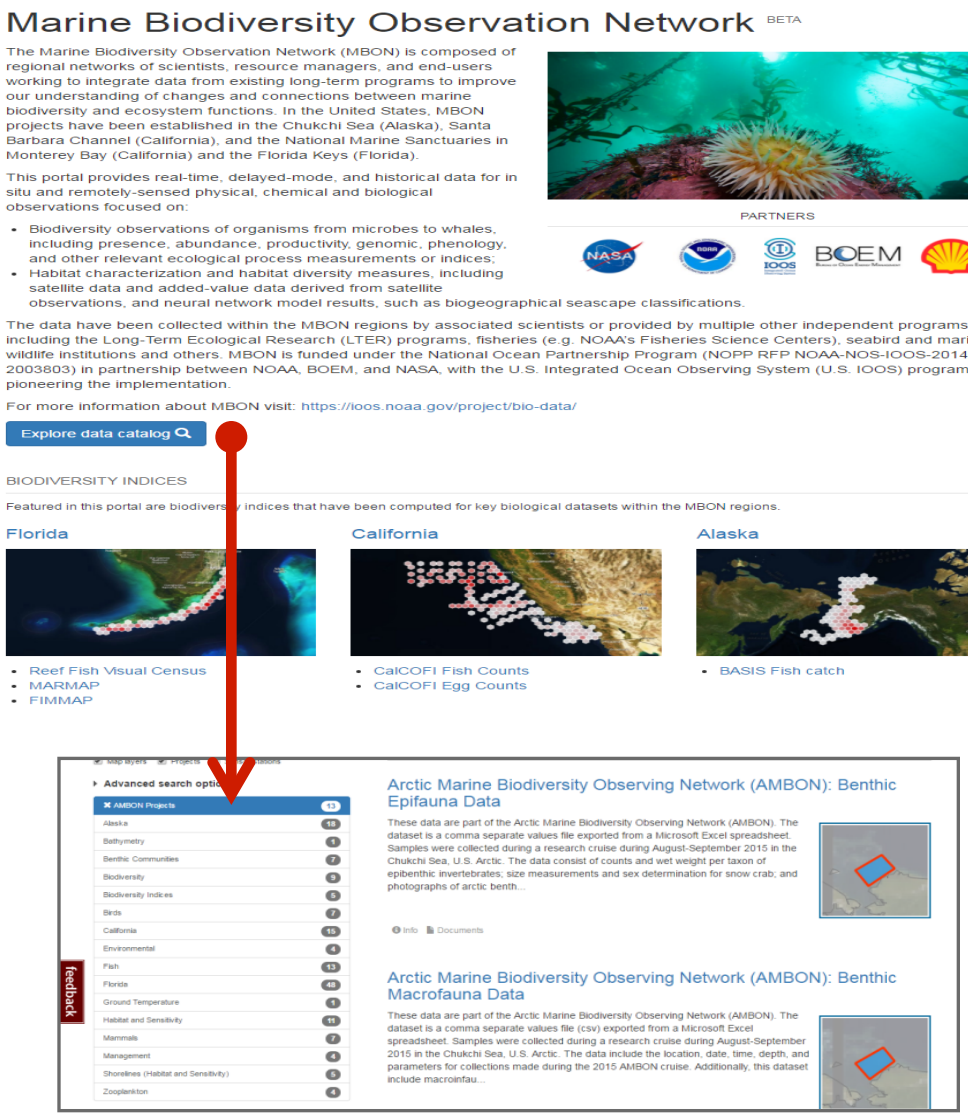




- Complete 2015 data with descriptive metadata: 9 projects
- Provisional 2015 data with basic metadata: 4 projects

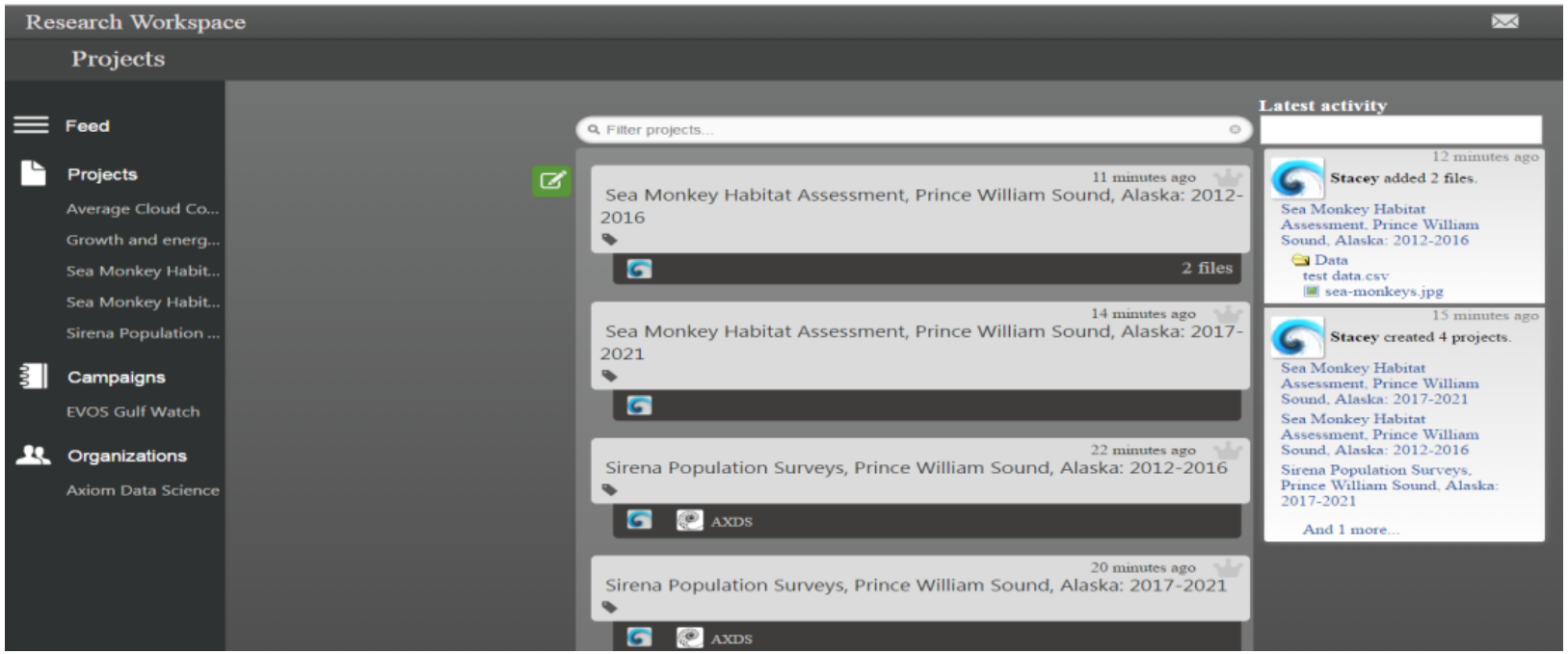
Data Discovery & Archive

- Workspace: gateway for public data sharing through MBON data portal
- Final datasets for 9 projects publically accessible in preservation formats through portal
- Automated pathway from Workspace to national archives via DataONE- *July 2017*



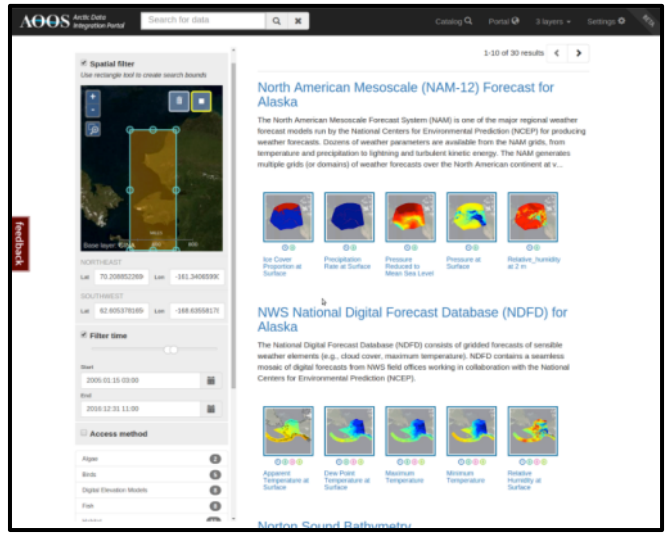
Research Workspace

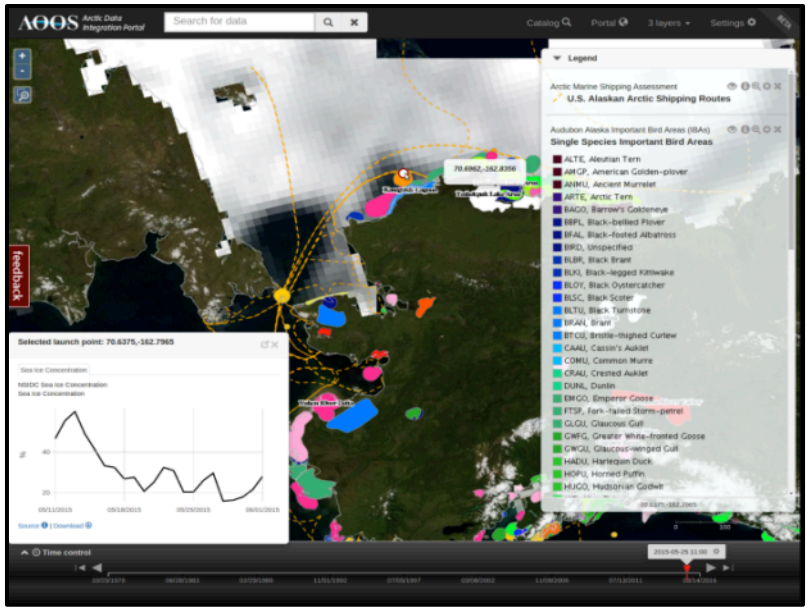
- Expanded capabilities for data organization & sharing
- User dashboard and settings for collaboration
- ISO 19110/19115-2 standards metadata editor
- Data sharing to >1 group without replication

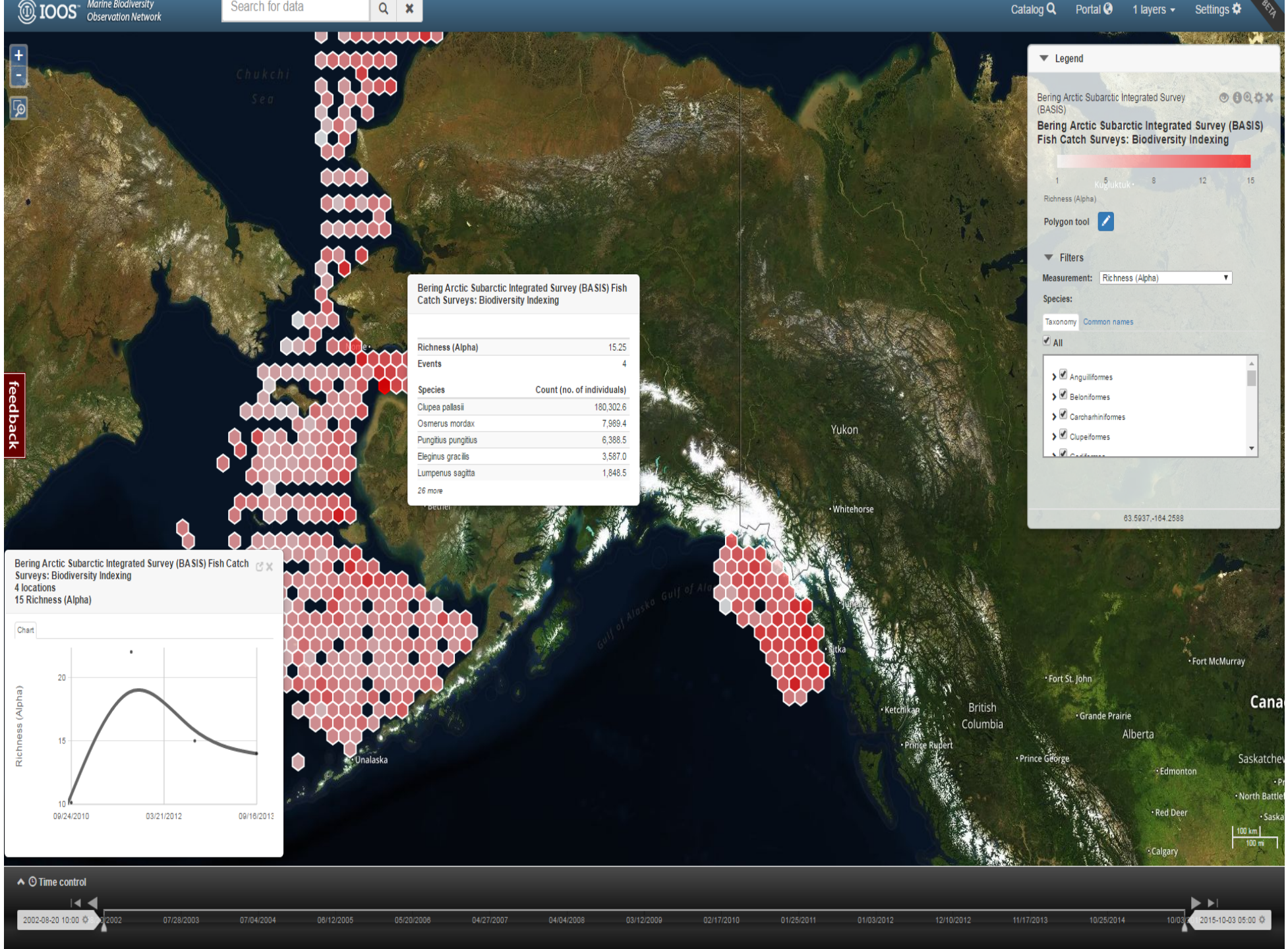


Data Visualization

- Interactive mapping of data through portal
- Stack & integrate visualizations of different data types
- Spatial/temporal data parsing
- Biodiversity indices mapped by region






IOOS Marine Biodiversity Observation Network
Search for data
Catalog
Portal
1 layers
Settings
BETA
feedback
Chukchi Sea
Gulf of Alaska
Yukon
Whitehorse
Unalaska
Ketchikan
Prince Rupert
Prince George
British Columbia
Alberta
Grande Prairie
Fort St. John
Fort McMurray
Edmonton
Red Deer
Calgary
Legend
Bering Arctic Subarctic Integrated Survey (BASIS)
Bering Arctic Subarctic Integrated Survey (BASIS) Fish Catch Surveys: Biodiversity Indexing
1
5
8
12
15
Richness (Alpha)
Polygon tool
Filters
Measurement: Richness (Alpha)
Species:
Taxonomy
Common names
All
Anguilliformes
Beloniformes
Carcharhiniformes
Clupeiformes
63.5937,-164.2588
Bering Arctic Subarctic Integrated Survey (BASIS) Fish Catch Surveys: Biodiversity Indexing
Richness (Alpha) 15.25
Events 4
Species
Count (no. of individuals)
Clupea pallasii 180,302.6
Osmerus mordax 7,989.4
Pungitius pungitius 6,388.5
Eleginus gracilis 3,587.0
Lumpenus sagitta 1,848.5
26 more
Bering Arctic Subarctic Integrated Survey (BASIS) Fish Catch Surveys: Biodiversity Indexing
4 locations
15 Richness (Alpha)
Chart
Richness (Alpha)
20
15
10
09/24/2010
03/21/2012
09/16/2013
100 km
100 mi
Time control
2002-08-20 10:00
07/28/2003
07/04/2004
06/12/2005
05/20/2006
04/27/2007
04/04/2008
03/12/2009
02/17/2010
01/25/2011
01/03/2012
12/10/2012
11/17/2013
10/25/2014
2015-10-03 05:00

Marine Biodiversity Observation Network BETA

The Marine Biodiversity Observation Network (MBON) is composed of regional networks of scientists, resource managers, and end-users working to integrate data from existing long-term programs to improve our understanding of changes and connections between marine biodiversity and ecosystem functions. In the United States, MBON projects have been established in the Chukchi Sea (Alaska), Santa Barbara Channel (California), and the National Marine Sanctuaries in Monterey Bay (California) and the Florida Keys (Florida).

This portal provides real-time, delayed-mode, and historical data for in situ and remotely-sensed physical, chemical and biological observations focused on:

- Biodiversity observations of organisms from microbes to whales, including presence, abundance, productivity, genomic, phenology, and other relevant ecological process measurements or indices;
- Habitat characterization and habitat diversity measures, including satellite data and added-value data derived from satellite observations, and neural network model results, such as biogeographical seascape classifications.

PARTNERS

The data have been collected within the MBON regions by associated scientists or provided by multiple other independent programs, including the Long-Term Ecological Research (LTER) programs, fisheries (e.g. NOAA's Fisheries Science Centers), seabird and marine wildlife institutions and others. MBON is funded under the National Ocean Partnership Program (NOPP RFP NOAA-NOS-IOOS-2014-2003803) in partnership between NOAA, BOEM, and NASA, with the U.S. Integrated Ocean Observing System (U.S. IOOS) program pioneering the implementation.

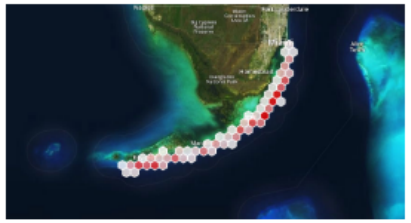
For more information about MBON visit: https://ioos.noaa.gov/project/bio-data/

Explore data catalog

BIODIVERSITY INDICES

Featured in this portal are biodiversity indices that have been computed for key biological datasets within the MBON regions.

Florida

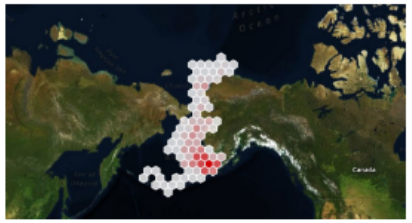


- Reef Fish Visual Census
- MARMAP
- FIMMAP

California

- CalCOFI Fish Counts
- CalCOFI Egg Counts

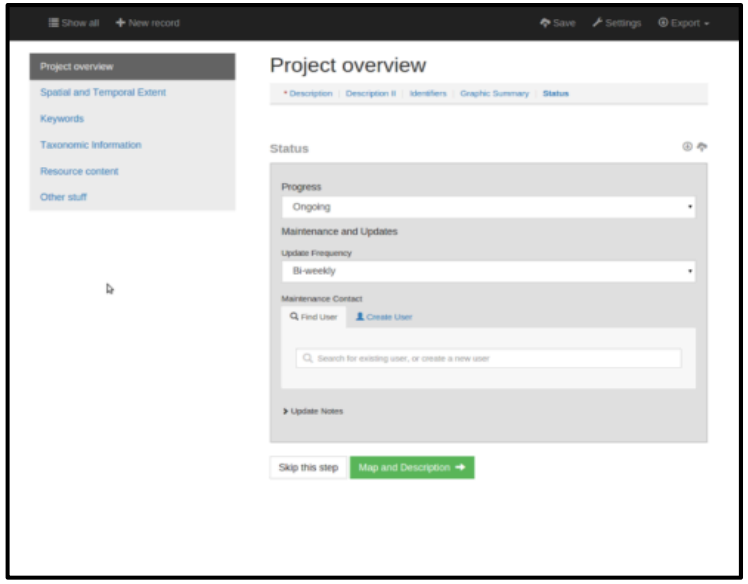
Alaska

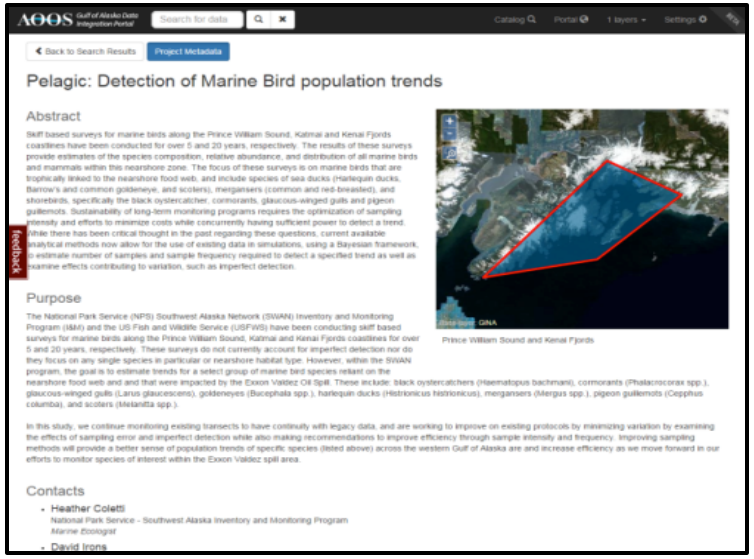


- BASIS Fish catch

What's New? Metadata Editor 2.0

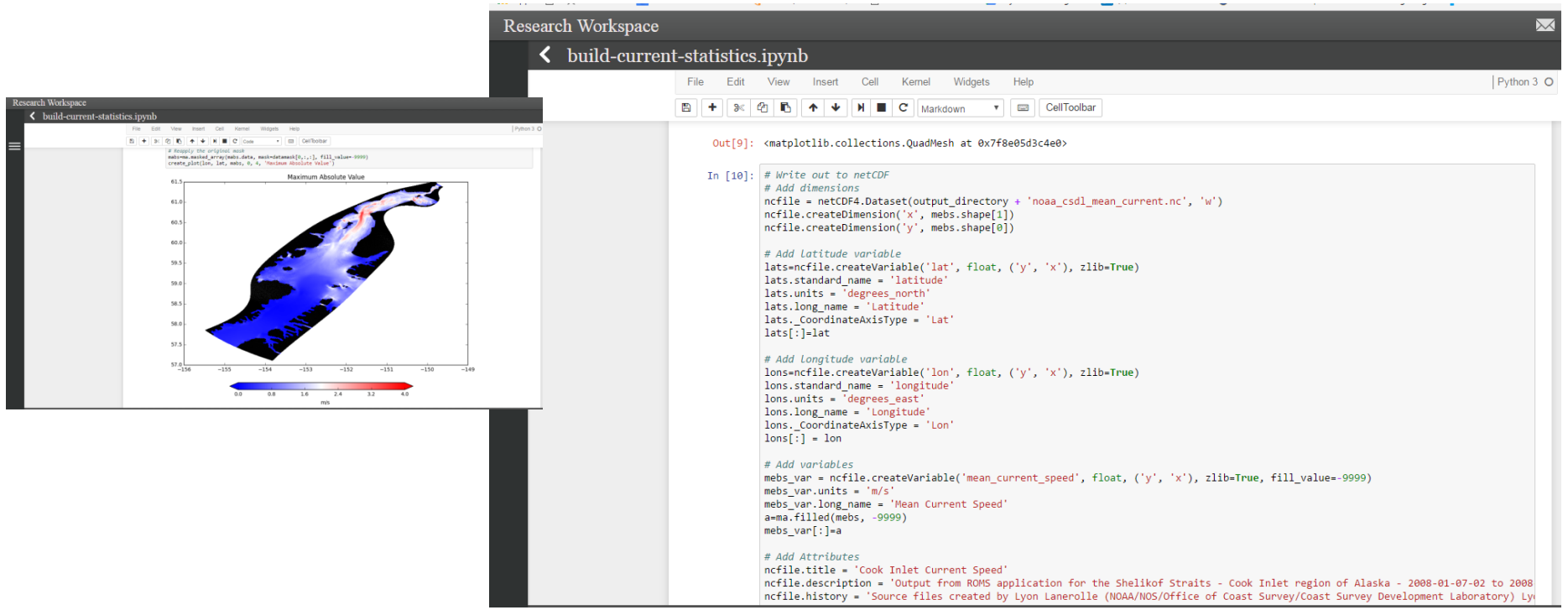
- Integrated within Workspace
- Meets ISO 19115 standards
- Accesses controlled vocabularies; automates attribute fields
- Metadata published alongside data to search catalog
- Exportable as XML record





Jupyter (iPhython) notebook

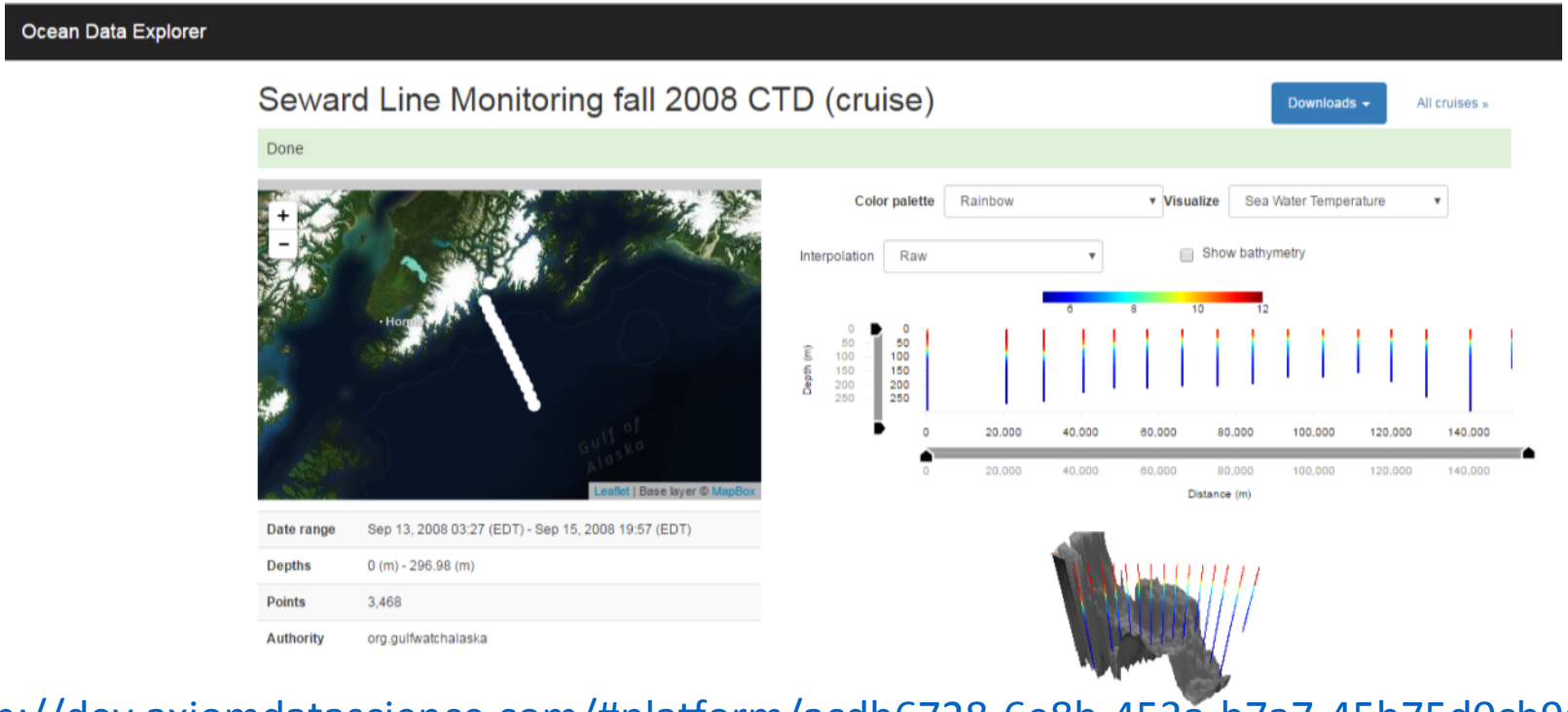
- Create and share live code, equations, explanatory text
- Interactive and reproducible computing
- Allows public users to interact natively with any data stored in the AOOS catalog



http://rw.axiomdatascience.com/file/3772/build-current-statistics.ipynb

New Charting Interface for Portal

- Several methods for spatial interpolation
- 3D bathymetry display
- Spatial data query
- Filtering on Y axis



http://dev.axiomdatascience.com/#platform/acdb6728-6e8b-453a-b7a7-45b75d0cb9ab
http://dev.axiomdatascience.com/#platform/c5a71905-21e9-4889-9887-d51ba6ddf24e

Recommended Next Steps

- Finalize 2015 data & metadata in Workspace
- Migrate metadata to ISO standard (Axiom)- *spring 2017*
- Consider timing of data publishing to AMBON website, MBON portal and/or DataONE
- Prepare for 2017 data & metadata submissions

4. Outputs and outreach for AMBON

- **Outputs**
  - Visual products for AMBON public website
  - Raw data and metafile submissions to AMBON data portal and then to MBON common data portal
  - Coordination with Chukchi Ecosystem Observatory (CEO, S. Danielson/UAF) time series mooring

- **Outreach**
  - Annual presentations at the Alaska Marine Science Symposium
  - Inclusion of results in science presentations for 2016 Oceans meeting and 2017 Arctic Science Summit Week
  - CEO website video (http://chukchiecosystemobservatory.org)

BOEM
Bureau of Ocean Energy Management

SCIENCE NOTES

Science for Informed Decisions

April 8, 2016

Dear Reader:

This month's Science Note presents new findings from the 2015 field season of the Arctic Marine Biodiversity Observing Network study, or AMBON. Last August, researchers began monitoring biodiversity in the Arctic Chukchi Sea from an ecosystem perspective, looking at microbes, whales and everything in between. BOEM is supporting this study to enhance environmental impact assessments and develop better metrics for cumulative impact analysis and a broader perspective of the ecosystem. To learn more, please enjoy reading this month's Science Note, and feel free to send us your feedback at boempublicaffairs@boem.gov.

Sincerely,
William Y. Brown
Chief Environmental Officer, Bureau of Ocean Energy Management

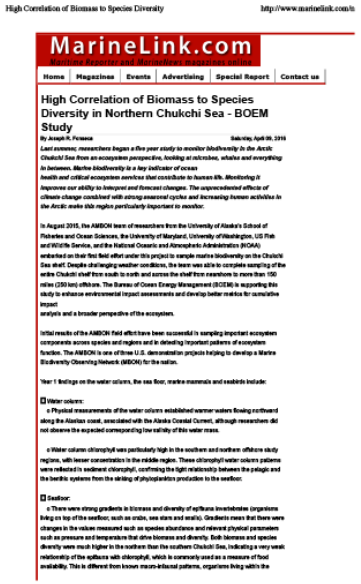
Arctic study finds high correlation of biomass to species diversity in northern Chukchi Sea

Initial research of Chukchi shelf examines water column, bottom fish, invertebrates, walruses, and seabirds

University and federal researchers sort through crabs, sea stars and mussels collected from the Chukchi Sea seafloor in 2015 for the AMBON partnership study. Photo credit: Katrin Iken, University of Alaska Fairbanks

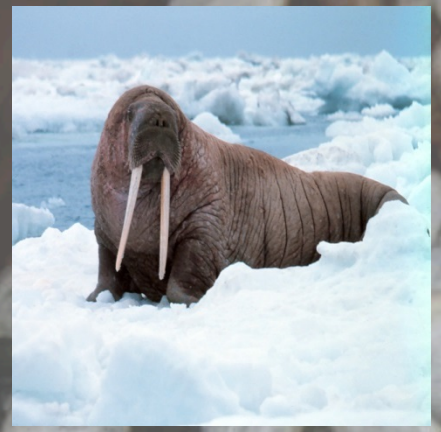
Last summer, researchers began a five year study to monitor biodiversity in the Arctic Chukchi Sea from an ecosystem perspective, looking at microbes, whales and everything in between. Marine biodiversity is a key indicator of ocean health and critical ecosystem services that contribute to human life. Monitoring it improves our ability to interpret and forecast changes. The unprecedented effects of climate change combined with strong seasonal cycles and increasing human activities in the Arctic make this region particularly important to monitor.

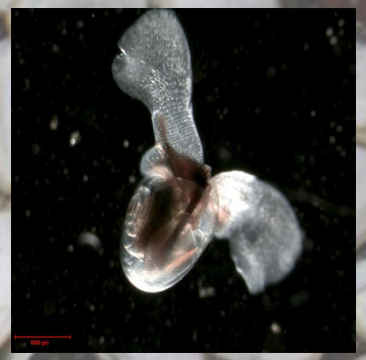
In August 2015, the AMBON team of researchers from the University of Alaska's School of Fisheries and Ocean Sciences, the University of Maryland, University of Washington, US Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration (NOAA) embarked on their first field effort under this project to sample marine biodiversity on the Chukchi Sea shelf. Despite challenging weather conditions, the team was able to complete sampling of the entire Chukchi shelf from south to north and across the shelf from nearshore to more than 150 miles (250 km) offshore. The Bureau of Ocean Energy Management (BOEM) is

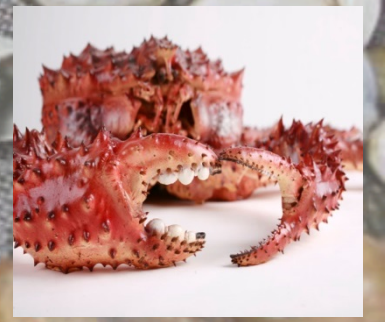


Outreach Efforts: Press release incorporated into BOEM Science Notes followed by distribution on the web and in social media

Why Biological Consequences?







a. Bering Sea fishery- 40% of all finfish and shellfish landings in the United States; over 25 million pounds of subsistence foods
b. Important prey items (e.g., bivalves, pteropods)
c. Many that produce calcium carbonate shells
d. Export production that supports a benthos is causing under saturation

Some Studies to Date

a. pteropods- which can account for ~40% of a salmon's diet (Aydin et al.2005)
b. Long et al. 2013- tanner and red king crab
c. Walleye pollock (Hurst et al. 2012)
d. Bivalves show reduced growth over 11 week lower pH exposure (Goethel 2017, M.S. thesis)

www.adfg.alaska.gov

Acknowledgements

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BOEM
Bureau of Ocean Energy Management

Cathy Coon

Louis Brzuzy