

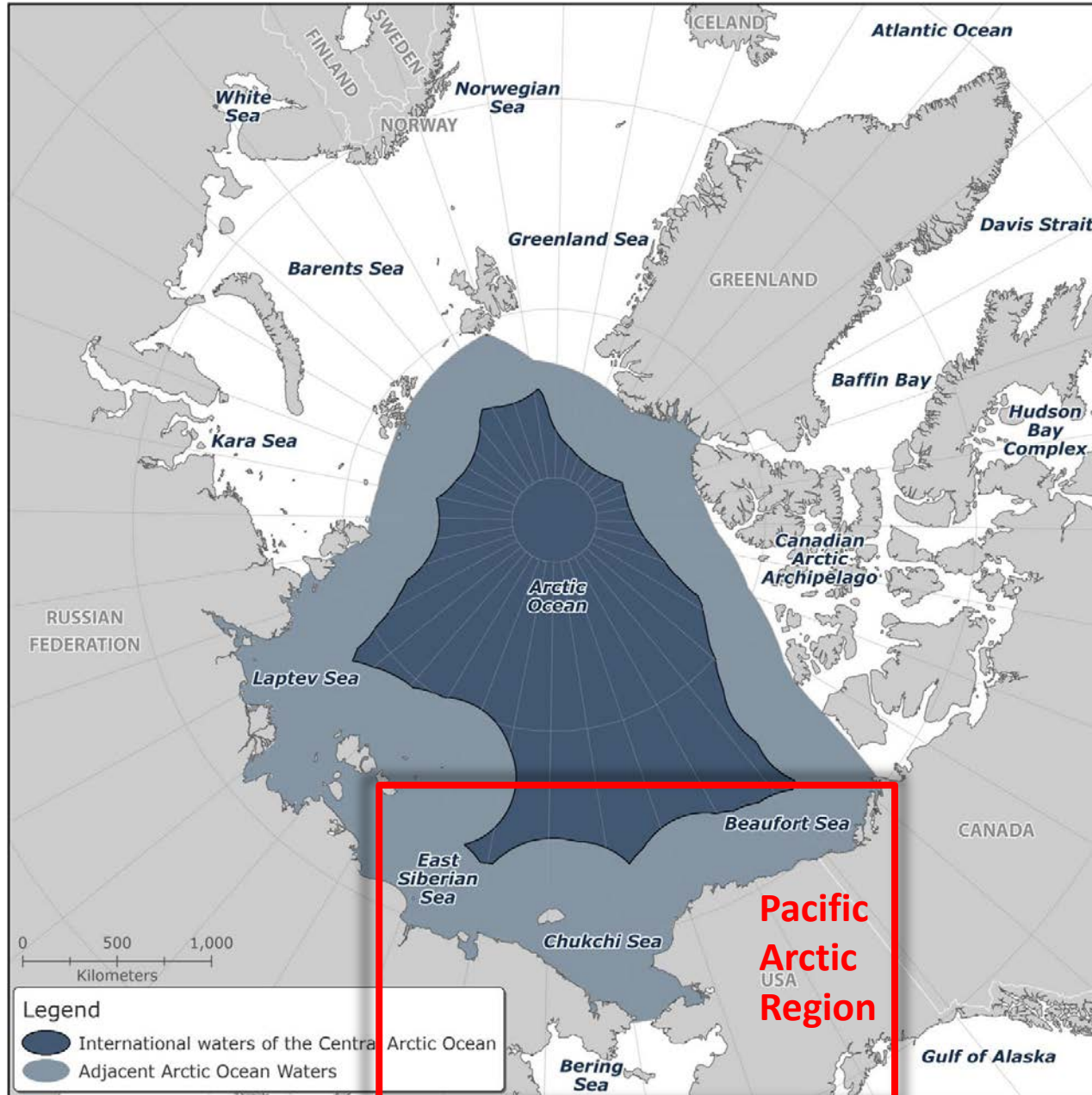
**Pacific Arctic Region Synthesis Activity for
ICES/PICES/PAME Working Group on Integrated Ecosystem
Assessment of the Central Arctic Ocean (WGICA)
and
Activities of the Pew CAO Round-table Discussions**

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University of Maryland Center for Environmental Science, Solomons, MD, USA

Pacific Arctic Group
ASSW 2018
June 18, 2018
Davos, Switzerland



Pacific Arctic Region and the Central Arctic Ocean

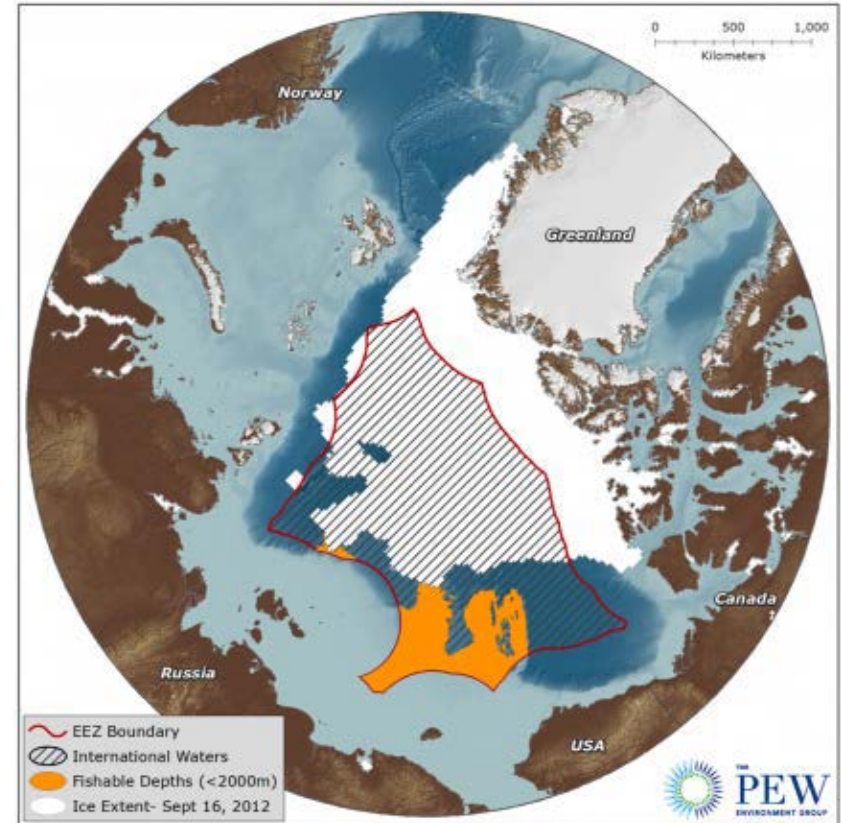
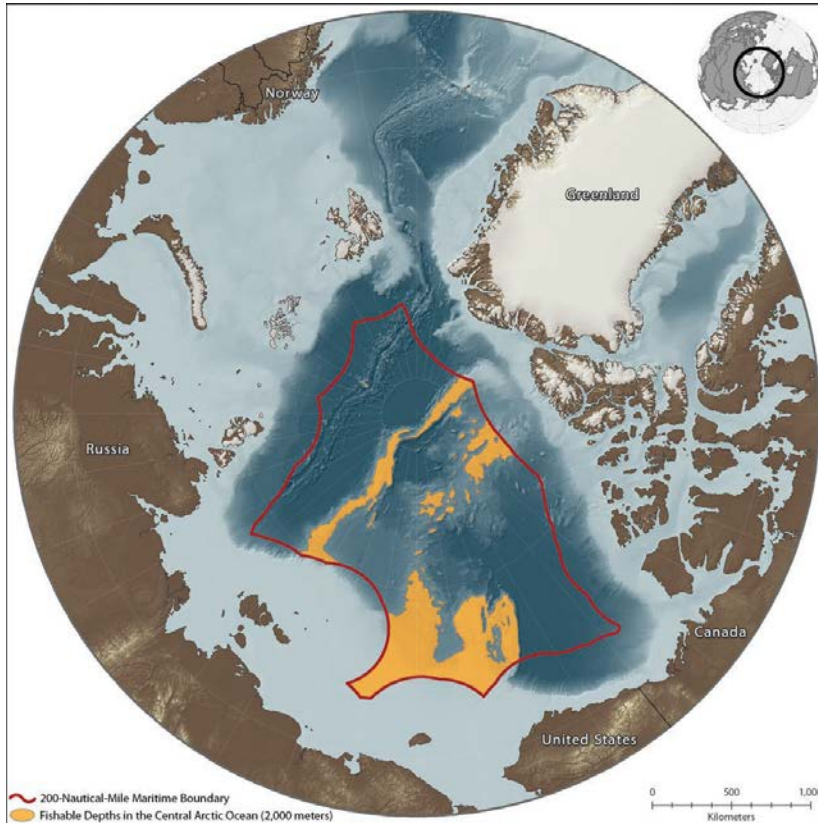


The international waters of the Central Arctic Ocean (CAO) and adjacent seas. The CAO defined as waters north of the Exclusive Economic Zone (EEZ) boundaries of the five arctic coastal states. The polygons include regional shelf seas directly adjacent to the CAO, but boundaries are just a schematic.

[Van Pelt et al. 2017]

Central Arctic Ocean: Territorial and International Areas

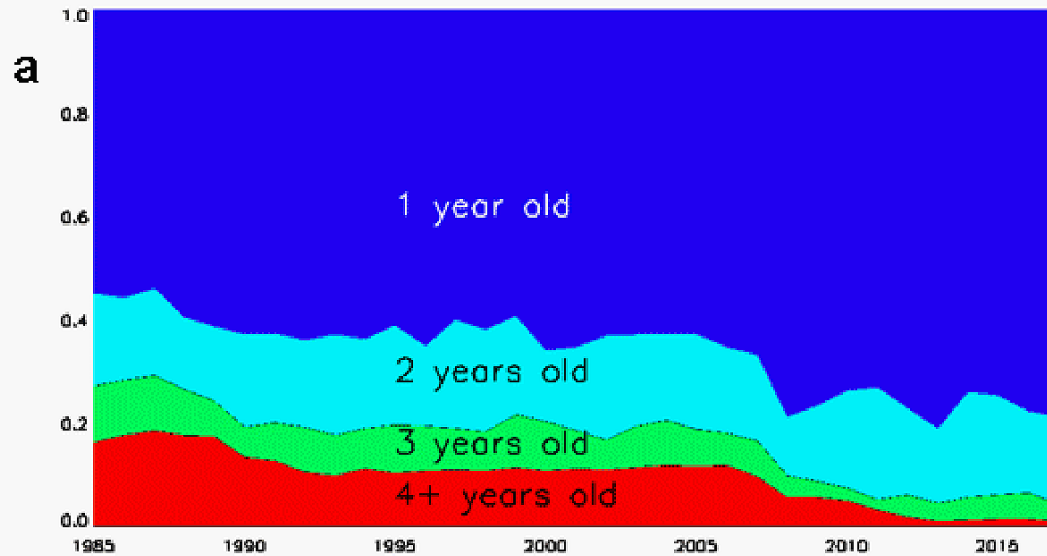
Fishable depths were derived from IBCAO v3 bathymetry (www.ngdc.noaa.gov/mgg/bathymetry/arctic/).



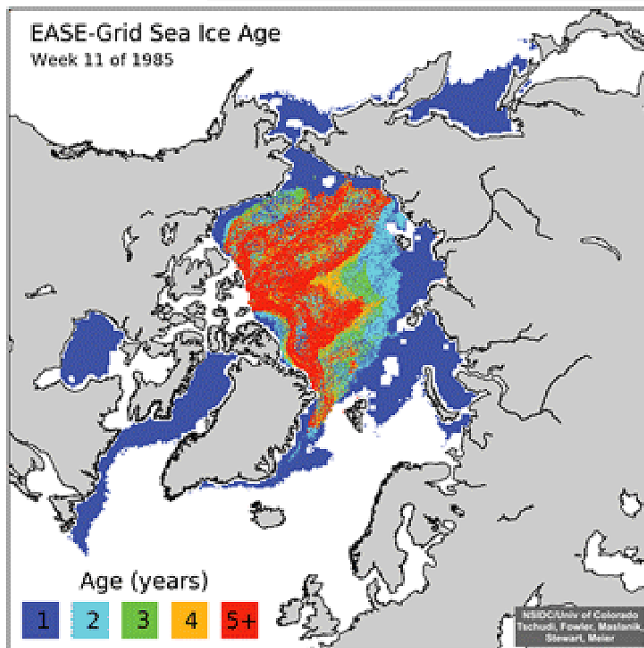
Twenty-two percent (614,000 square kilometers) of the Central Arctic Ocean is made up of ridges and continental shelves at fishable depths of 2,000 meters or less (PEW Foundation)

International waters of CAO north of 200 nm Exclusive Economic Zones (EEZs)

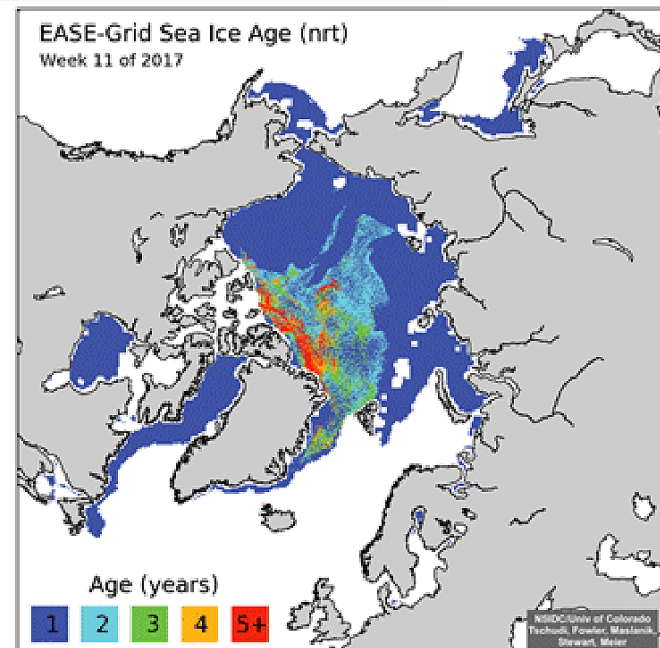
Sea ice age in the Arctic Ocean



b

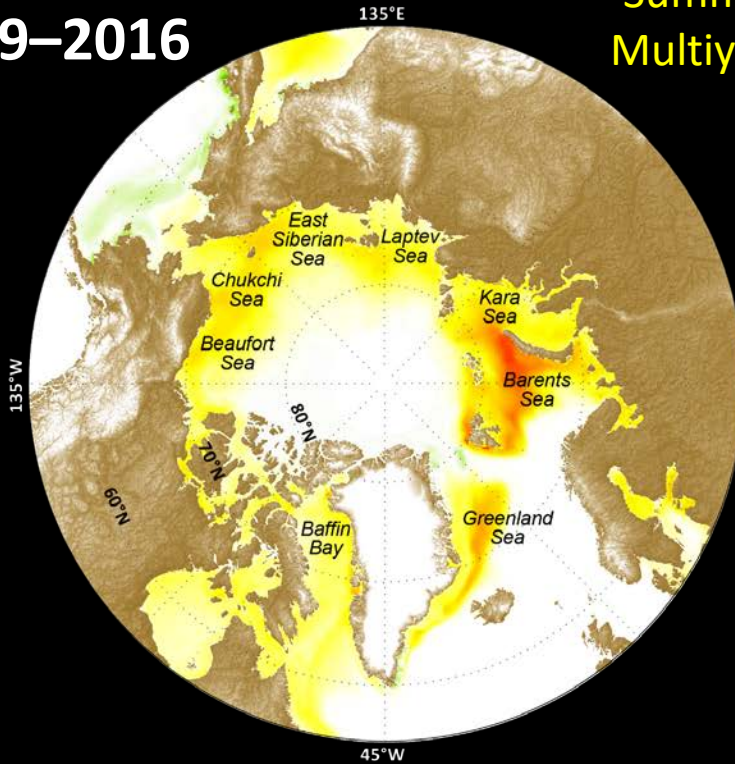


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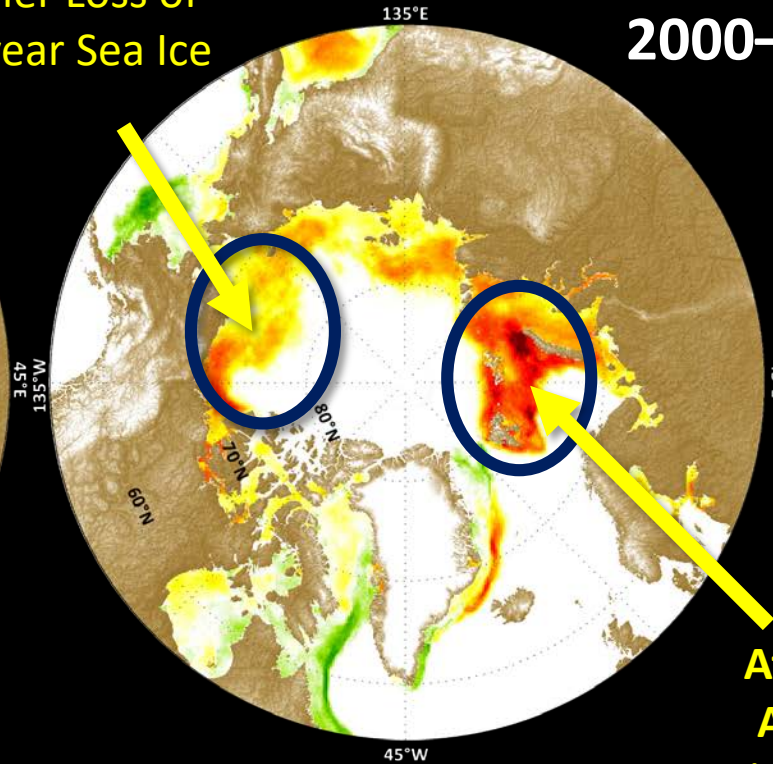
Pan-Arctic Trends in Annual Sea Ice Persistence 1979-2016

1979–2016



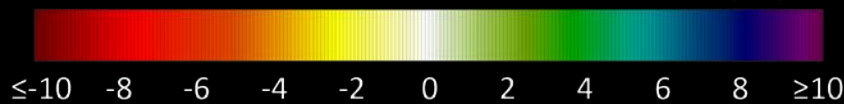
Pacific Arctic:
Summer Loss of
Multiyear Sea Ice

2000–2016

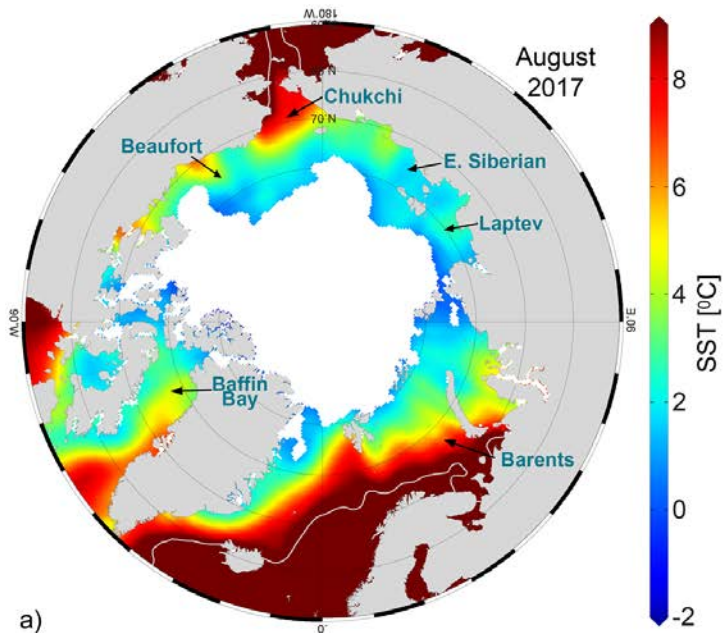


Atlantic Arctic:
Winter Loss
of First-Year
Sea Ice

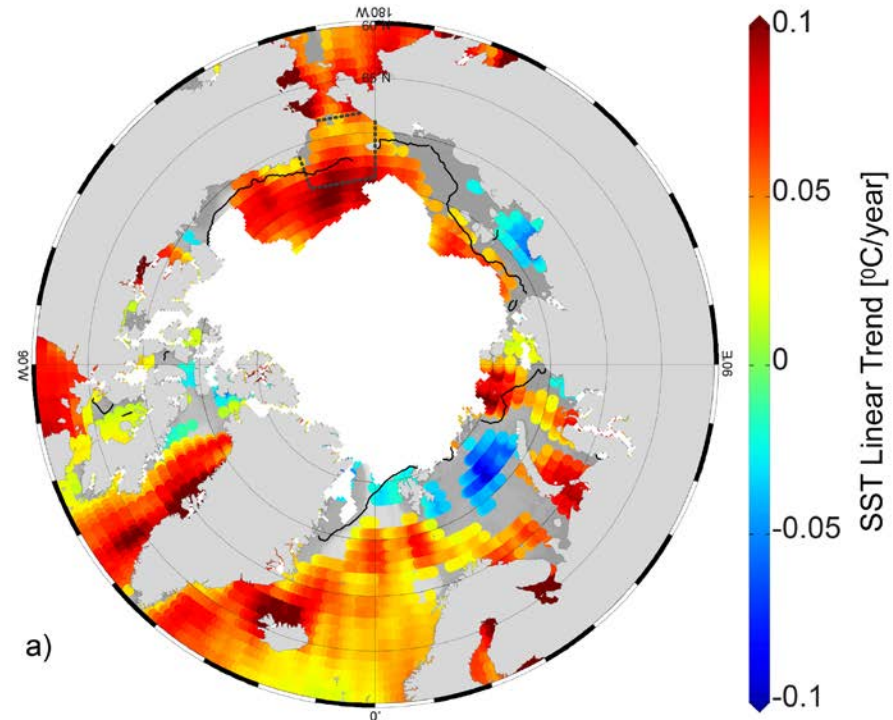
Trends in Annual Sea Ice Persistence (days/year)



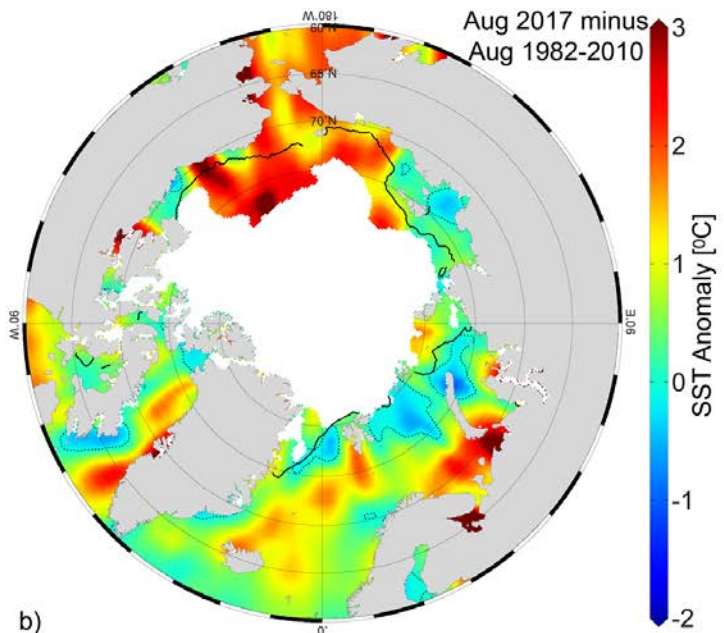
Arctic Ocean Sea Surface Temperature Change



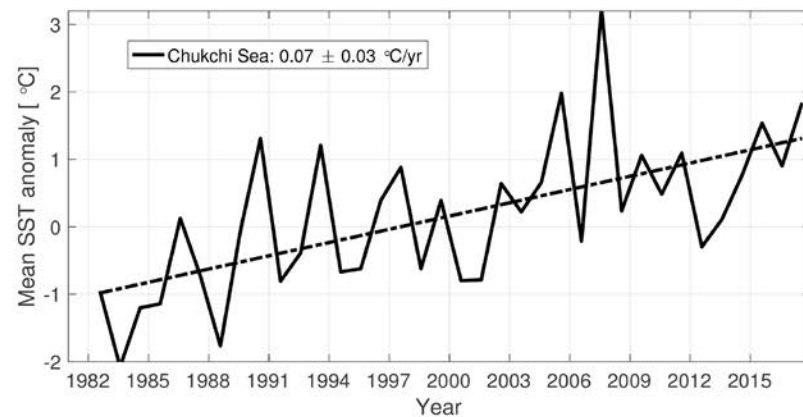
a)



a)



b)

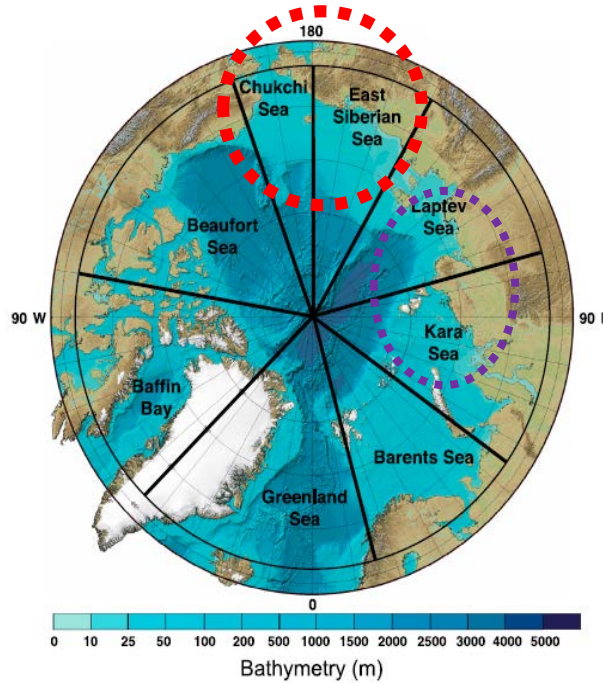
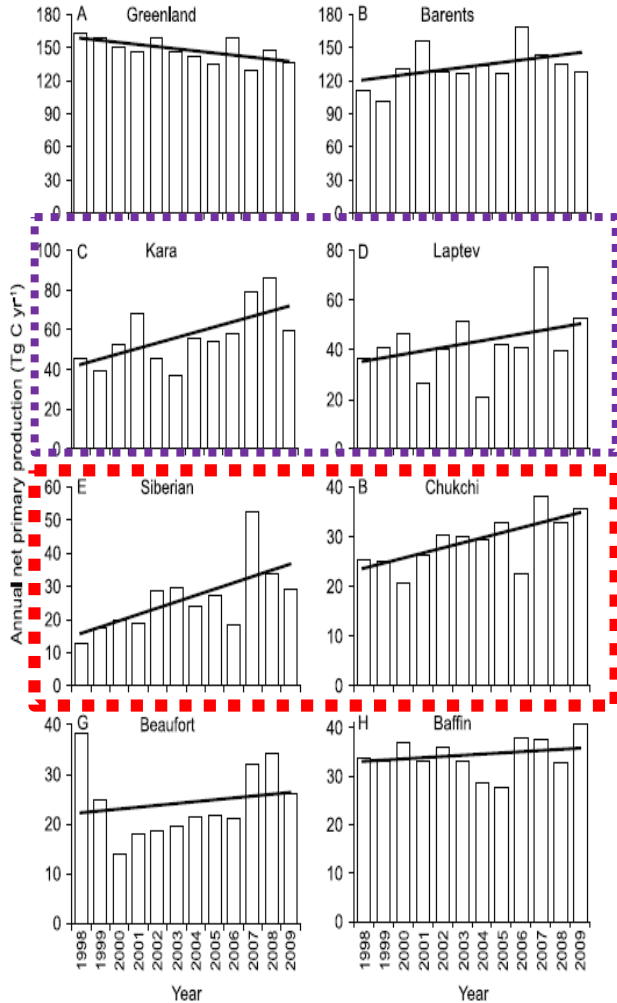


b)

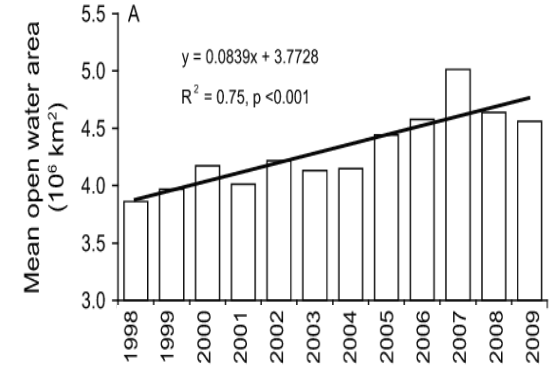
[Timmermans et al. 2017]

Increase in primary production

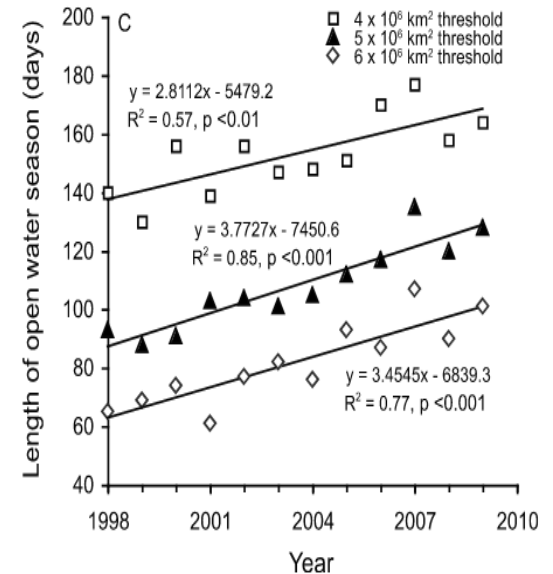
Annual primary production



Open water area

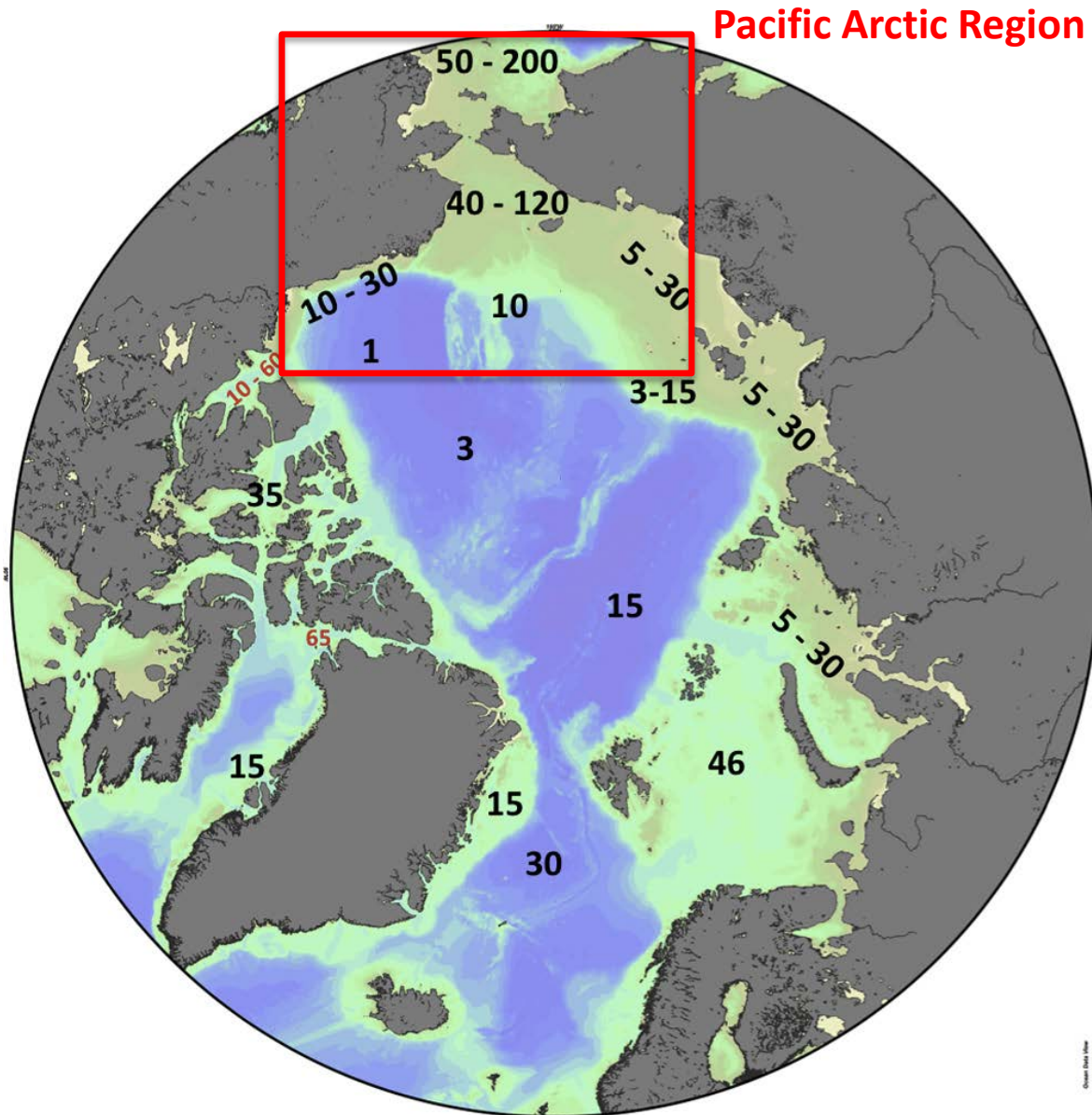


Duration of the open water season



Arrigo and van Dijken, 2011]

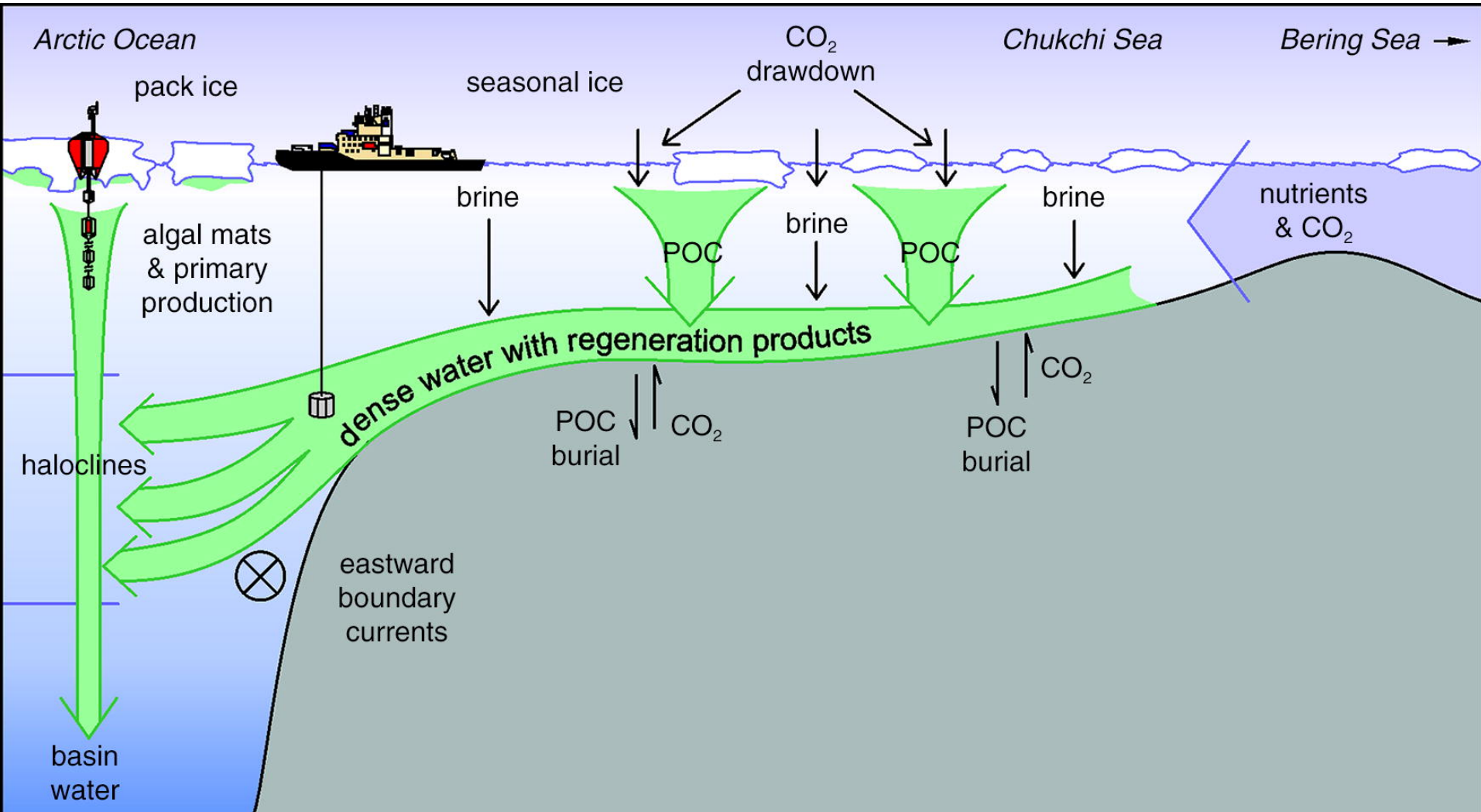
Coarse spatial distribution of annual NCP (g C yr⁻¹) across different sectors of the Arctic Ocean



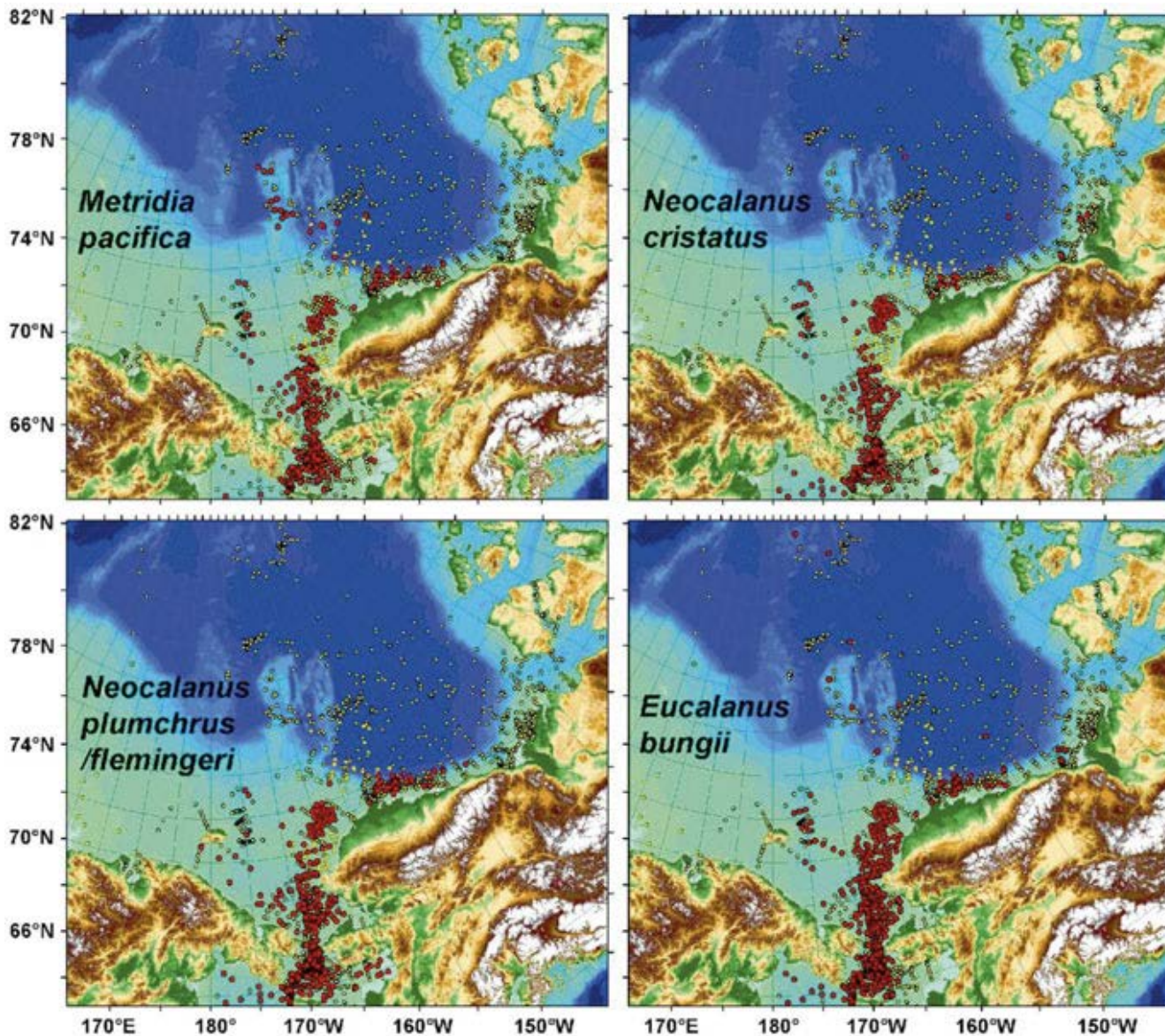
Coarse spatial distribution of annual NCP (g C yr⁻¹) across different sectors of the Arctic Ocean based on the estimations of Codispoti et al. (2013, black numbers) and additional data from Tremblay et al. (2002a, 2008) and Forest et al. (2011) (red numbers).

[Tremblay et al. 2015]

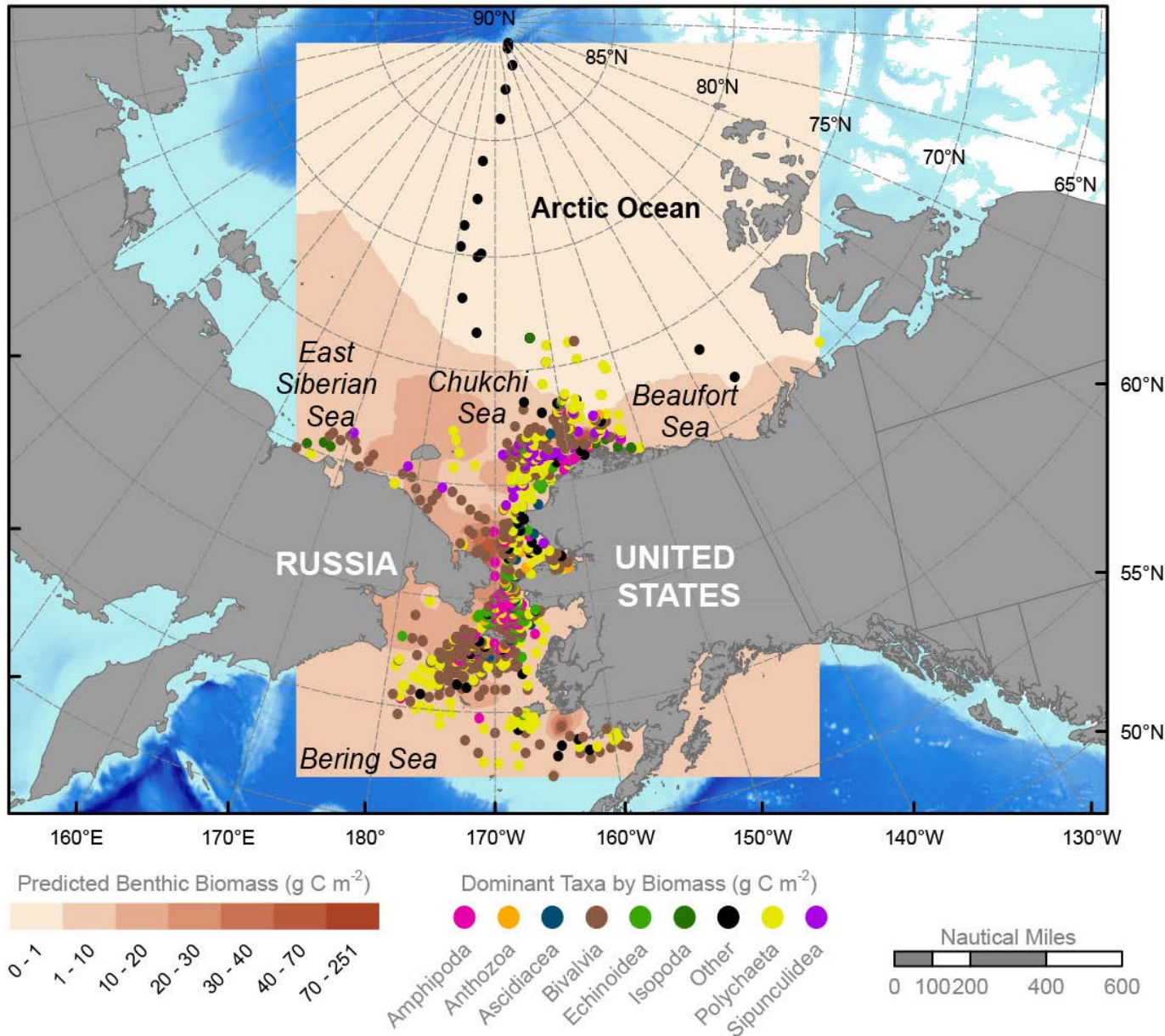
Continental shelf pump and slope exchange



Historical patterns of advection of Pacific zooplankters into the Arctic Ocean

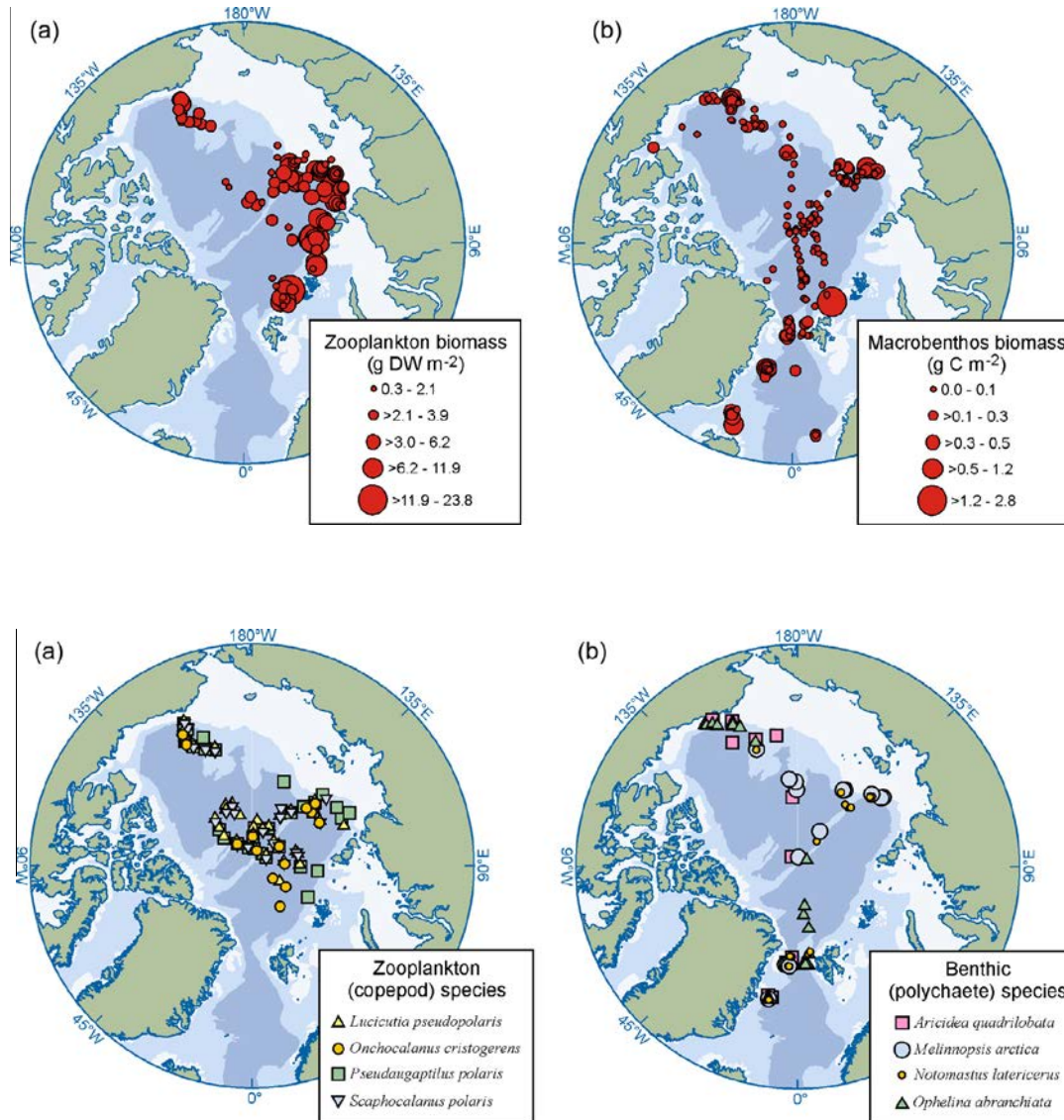


Distribution of macroinfaunal station biomass (g C m^{-2}) and dominant infaunal over four decades (1970-2012) in the Pacific Arctic



- Limited biogeochemical and biological studies on the outer continental shelf and slope regions of the East Siberian and Chukchi Seas as well as Chukchi Borderland and Arctic basin

Limited pelagic & benthic data in shelf-slope and deep basin regions of Arctic Ocean

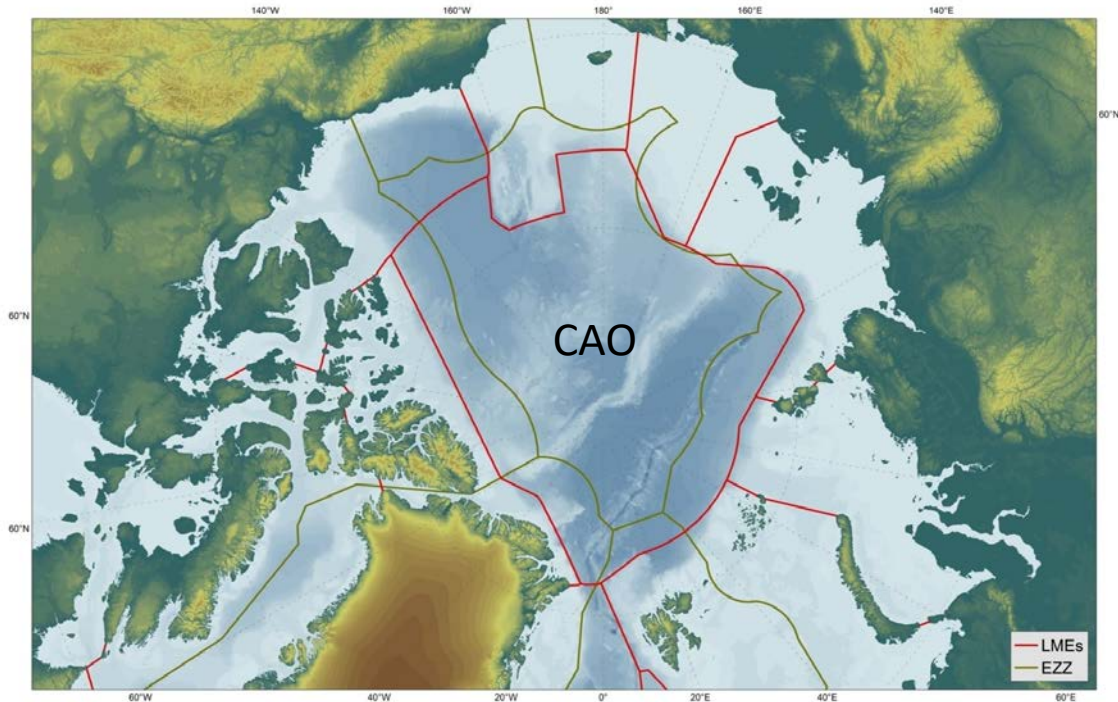


Map of contemporary marine fish data sources



- Green squares indicate data from benthic trawl monitoring efforts
- Blue squares indicate data from benthic trawl surveys
- red triangles indicate data from pelagic trawl monitoring efforts
- fish communities in waters below 1,500 m as well as mid-water realm are poorly known due to a lack of commercially important species

International Science Organizations Involvement in Central Arctic Ocean Evaluation



Large Marine Ecosystems
(red)

Territorial Boundaries
(green)

Central Arctic Ocean (CAO)

- International Council for the Exploration of the Sea (ICES), the North Pacific Marine Science Organization (PICES) and the Arctic Council’s Protection of the Arctic Marine Environment (PAME) and Conservation of Arctic Flora and Fauna (CAFF) representatives in the Working Group on Ecosystem Assessment of the Central Arctic Ocean (WGICA)
- Scientific Experts on Fish Stocks in the Central Arctic Ocean (FiSCAO)-agreement at 5th FiSCAO meeting, Ottawa, Canada, October 2017; recognized value Indigenous Knowledge
- CAFF Circumpolar Biodiversity Monitoring Program (CBMP Marine)-recent “State of the Arctic Marine Biodiversity Report, 2017”



TOWARDS AN INTERNATIONAL SCIENTIFIC COORDINATING MECHANISM FOR THE HIGH SEAS REGION OF THE CENTRAL ARCTIC OCEAN (CAO)

Arctic Science Summit Week 2017

Henry Huntington (USA) and Peter Harrison,
Canada

[PEW Charitable Trust, academic/research

Three “dialogue” meetings to encourage international arctic science community discussion for ecosystem approach to minimize unregulated fisheries in CAO

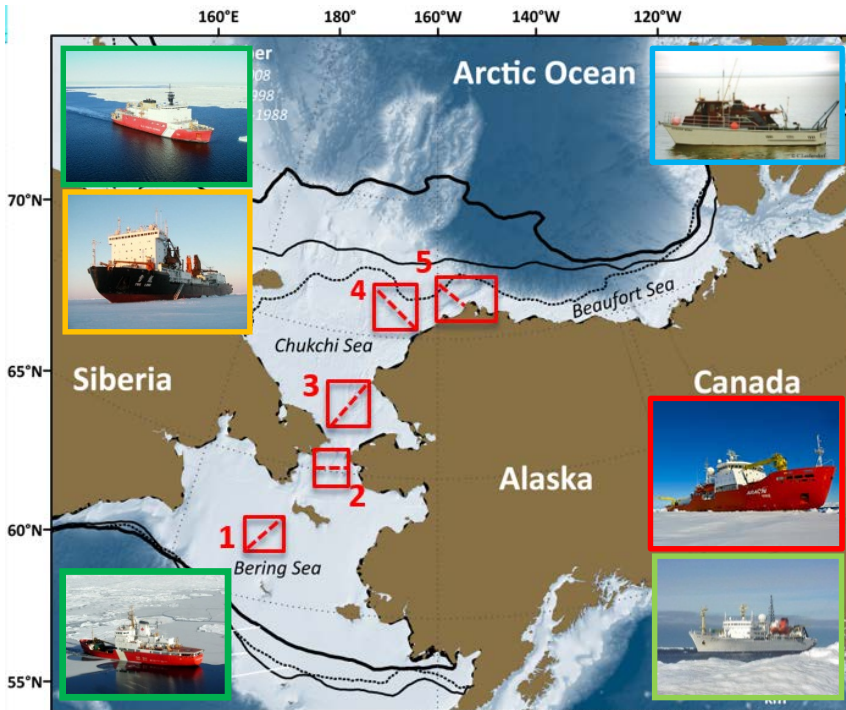
- use of “precautionary principle”
- consensus of 5 Arctic Coastal States (Canada, Denmark (Greenland), Norway, Russia, United States) on role of healthy marine ecosystems and sustainable fisheries for food and nutrition; work towards prevention of unregulated high seas fishing in the CAO
- expanded collaboration of Arctic and non-Arctic jurisdictions (+5: China, Japan, Korea, European Union, Iceland)
- promote scientific research - Integrate scientific, local, traditional knowledge
- establish joint program of scientific research, cooperation with relevant scientific bodies
- foci on increased science understanding of CAO using ecosystem approach



PAG Observational Activities

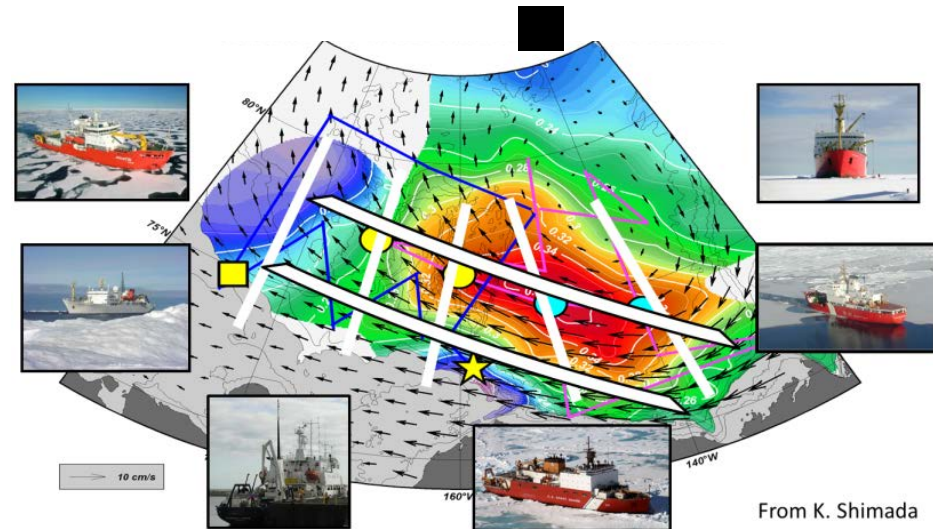
- PAG continues to develop and implement long-term monitoring activities, with a focus on:
 - ✓ **Distributed Biological Observatory (DBO)**
 - ✓ **Pacific Arctic Climate Ecosystem Observatory (PACEO)**

Distributed Biological Observatory (DBO)



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

Pacific Arctic Climate Ecosystem Observatory (PACEO)



From K. Shimada

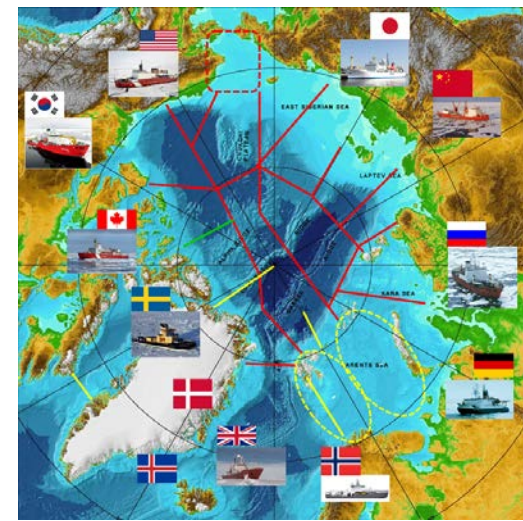
Background color: dynamic height at 100dbar relative to 800dbar from Mirai and Louis S. St-Laurent 2008 cruises (Oceanic Beaufort Gyre)

Black vectors: average sea ice motion vectors for Nov. 2007- Apr. 2008 (Sea Ice Beaufort Gyre)

Symbols: Mooring array in 2012-2013 (TUMSAT/KOPRI/NIPR & WHOI)



Synoptic Arctic *Survey*



An international initiative for: A coordinated multi-ship operation in the Arctic Ocean in the course of one summer season in one year.

To obtain synoptic view of its: Ecosystem
Hydrography
Biogeochemistry incl. carbon storage

To remedy the spotty data coverage in the Arctic

To pave the way for large-scale assessments

To create the observational fundament for future observing programs

To leave a legacy for future generations

-a developing multi-national, one season “spoke and wheel” pan-Arctic/cross-Arctic survey

SAS SSG: Leif Anderson, Are Olsen , Øyvind Paasche (leads), Jackie Grebmeier, Sung-Ho Kang, Takashi Kikuchi, Heidemarie Kassens, Azetsu-Scott, Kumiko; further information at www.synopticarcticsurvey.info

Summary and Future Directions

- dramatic reductions in the proportions of multi-year sea ice in the Central Arctic Ocean (CAO) relative to first year ice, significant seasonal declines in sea ice extent, and warming water column temperatures
- these changes have regional to global implications with respect to climate change, light penetration and availability, productivity, northward migration of biological organisms and biodiversity, as well as future development of commercial fisheries
- the 5 Arctic states, along with the 5 other non-Arctic states, signed an international agreement in November 2017 to monitor and regulate potential fisheries that could develop in the CAO beyond national boundaries
- there is an agreed need by multiple planning groups for a coordinated, multi-national and interdisciplinary organization to develop a program to provide an interannual time series suite of climate, ecosystem and fisheries data from shelf-to-basin and into central Arctic Ocean that would allow for joint analysis and assessment via approved mechanisms and management goals

Thank you for your attention.

Questions and comments?

Support provided by the US national and ongoing international science partners in the Pacific Arctic Group. Additional support for science planning activities through the International Arctic Program of the PEW Charitable Trusts and international host academic and research institutions.