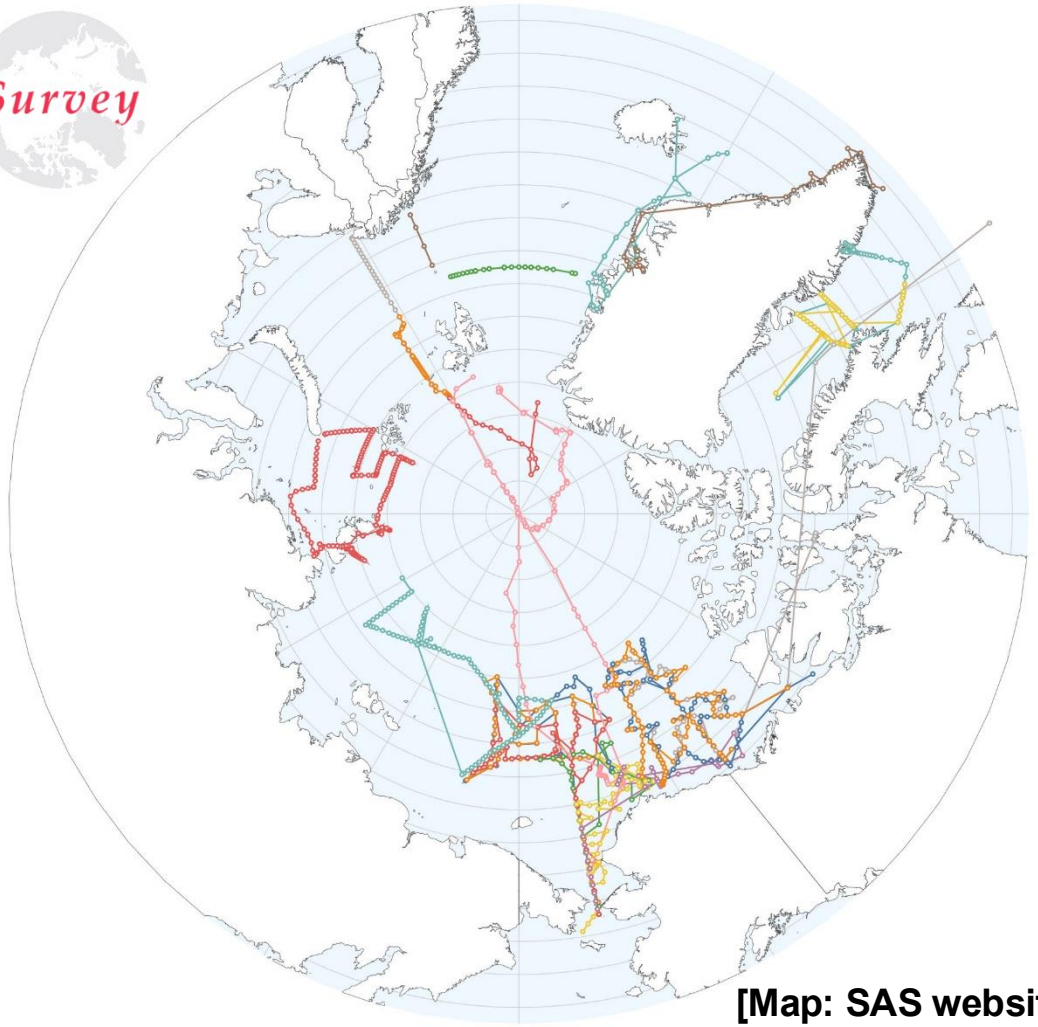
HD/MEQ/FUTURE Workshop (W3)
Present and Future Pressures and Human Activities in the Arctic Ocean and Pacific Gateways
PICES-2025 Annual Meeting
November 9, 2025 (9:00 - 17:50)
Workpia Yokohama, Yokohama, Japan

Towards the second expedition of the Synoptic Arctic Survey (SAS)

Shigeto Nishino (JAMSTEC)

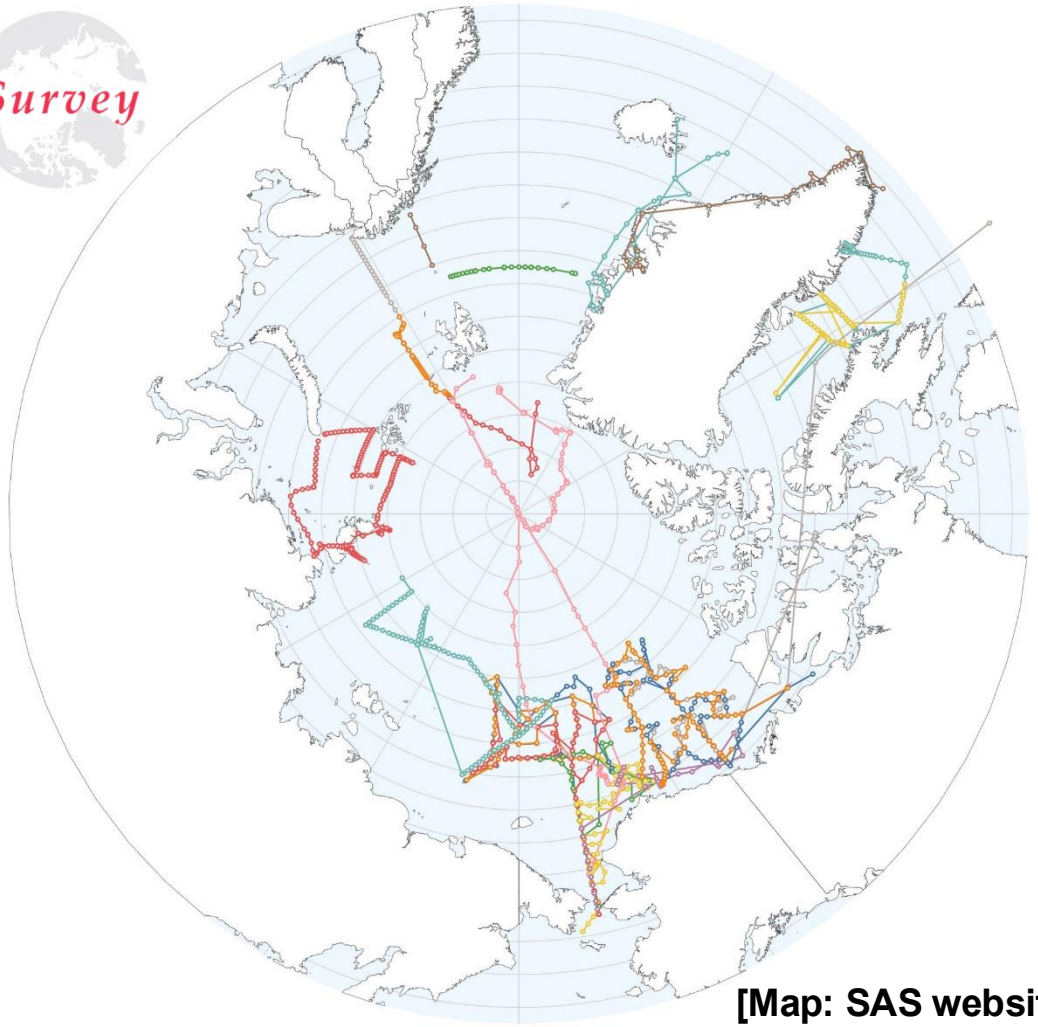
Synoptic Arctic Survey



[Map: SAS website by Maria Teresa Bezem]

- The first Synoptic Arctic Survey (SAS I), a coordinated multi-ship and multi-nation pan-Arctic program, was conducted during late summer and fall from 2020 to 2022, involving more than 25 cruises from 11 different nations.
- To understand ongoing oceanographic trends, a second ship-based sampling campaign (SAS II) is planned for around 2030.

Synoptic Arctic Survey



[Map: SAS website by Maria Teresa Bezem]

- To ensure the success of the SAS II, it is essential to establish the Science and Implementation Plan.

- In this talk, we present key science findings from the SAS I that could form the foundation of the SAS II Science and Implementation Plan, and then propose potential SAS II science topics on hydrography and biogeochemistry.

Arctic Challenge for Sustainability II (2020-2025)

Project goal: Social implementation of research results

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Atlantic-origin water extension into the Pacific Arctic induced an anomalous biogeochemical event

Shigeto Nishino ✉, Jinyoung Jung, Kyoung-Ho Cho, William J. Williams, Amane Fujiwara, Akihiko Murata, Motoyo Itoh, Eiji Watanabe, Michio Aoyama, Michiyo Yamamoto-Kawai, Takashi Kikuchi, Eun Jin Yang & Sung-Ho Kang

International SAS-I project members

Social implementation

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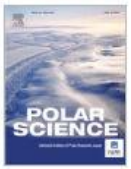

Japanese Arctic projects' contributions to the Central Arctic Ocean Fisheries Agreement

Natural scientist

Social scientists

Shigeto Nishino [a] ✉, Akiho Shibata [b], Kentaro Nishimoto [c], Osamu Inagaki [b]

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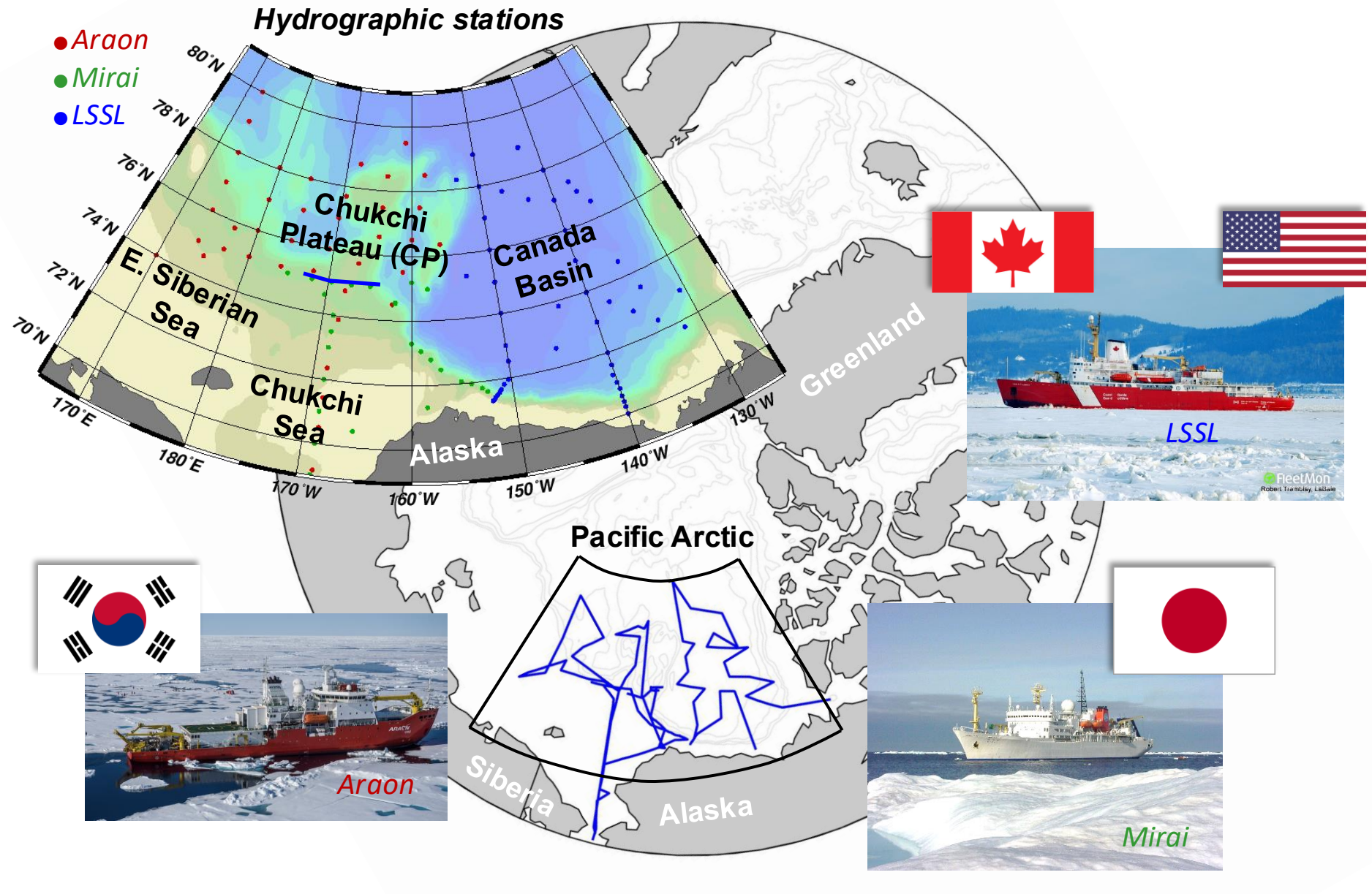
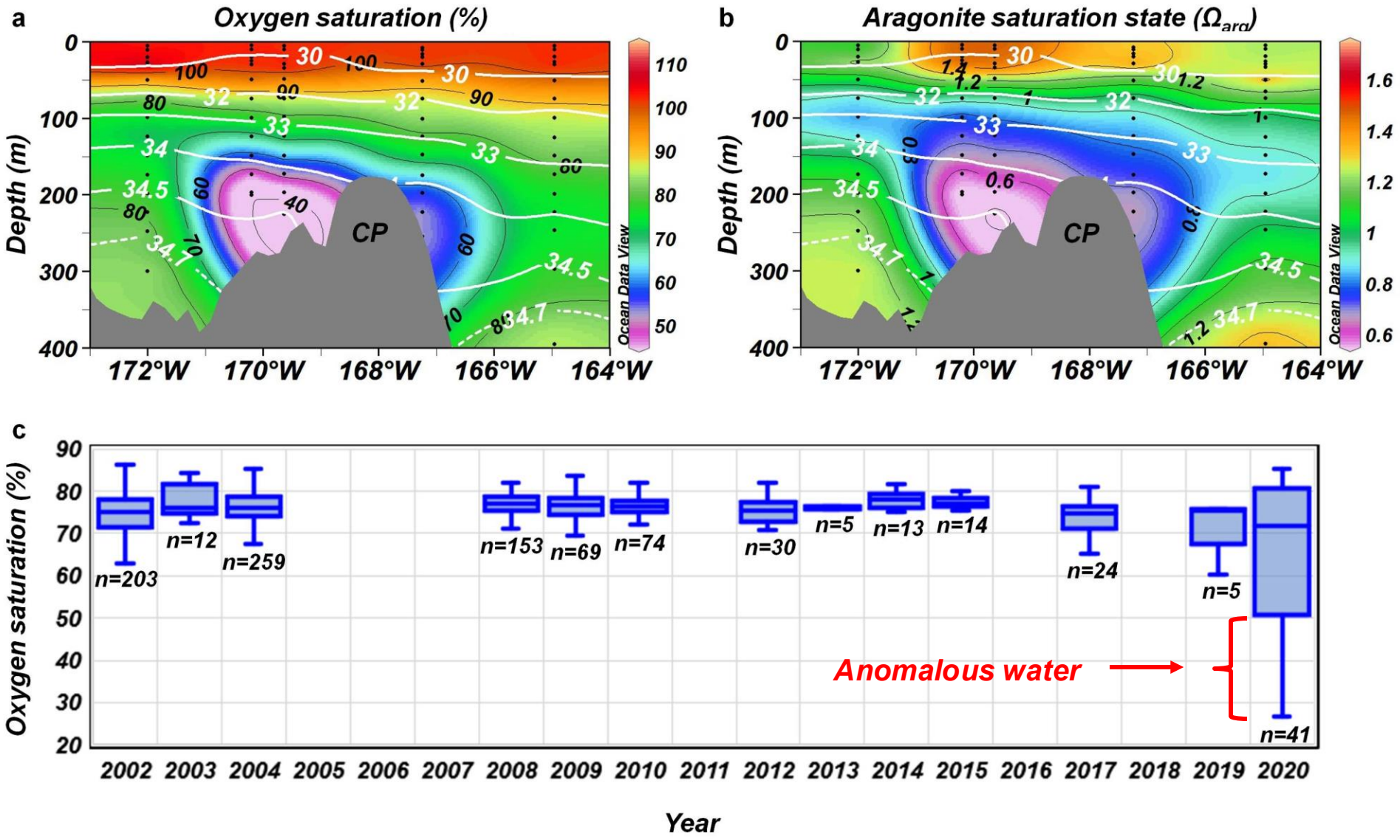
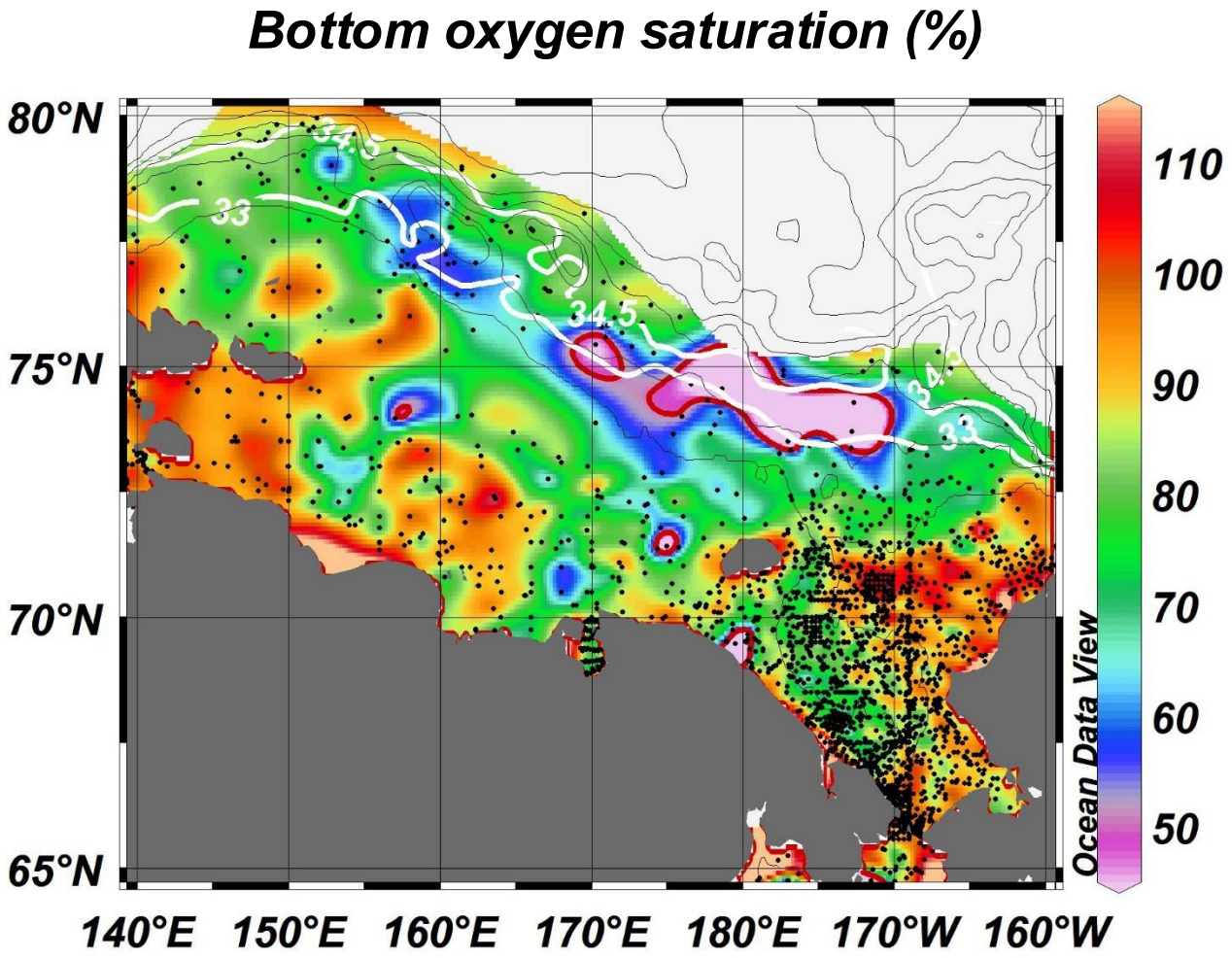
SAS I collaborative cruises in 2020 by Korea, Japan, and Canada/US



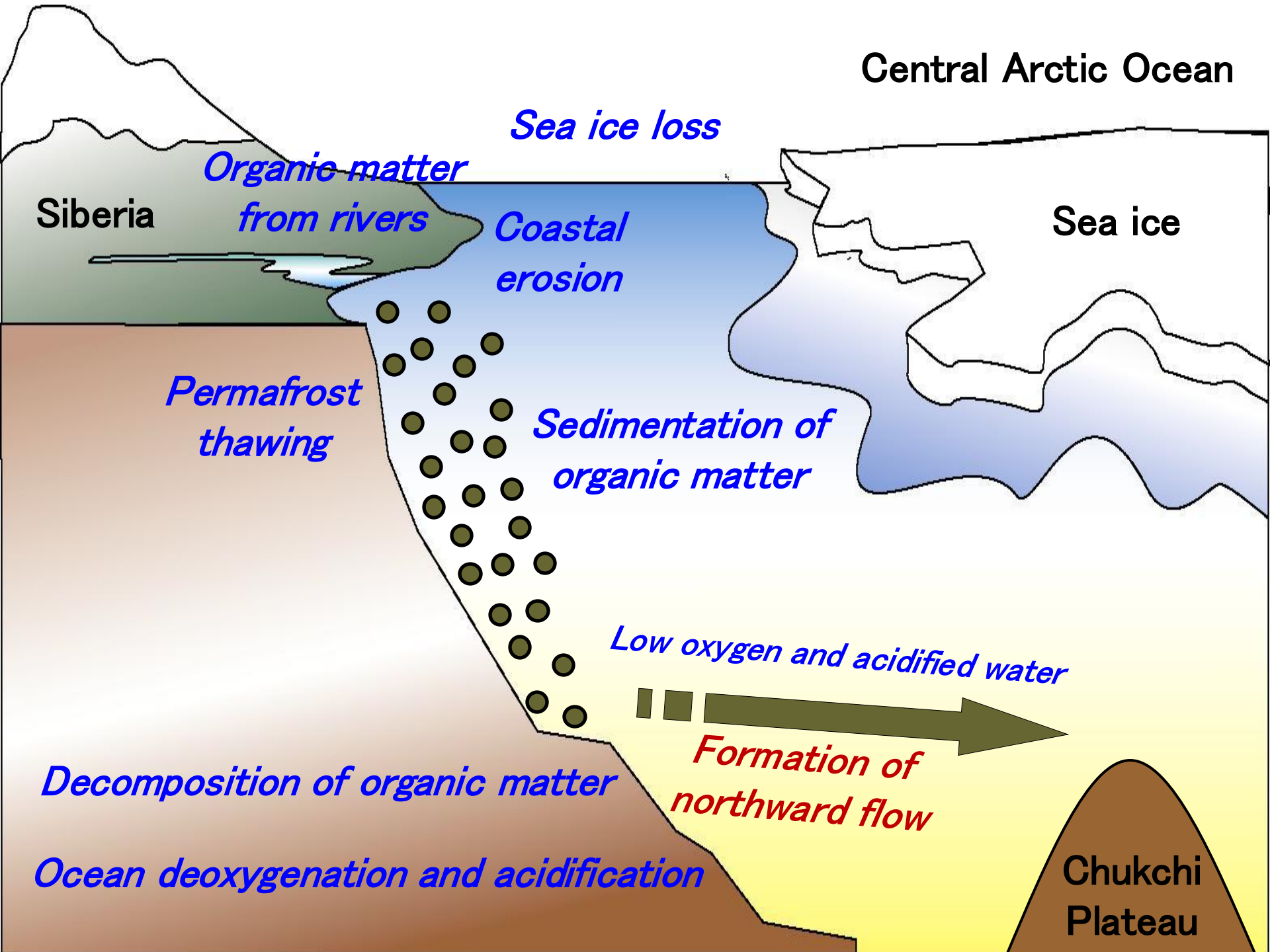
Low Oxy and highly acidified water on the Chukchi Plateau



Possible origin of the low Oxy and highly acidified water



Hydrochemical Atlas of the Arctic Ocean


Central Arctic Ocean
Sea ice loss
Organic matter
from rivers
Siberia
Coastal
erosion
Sea ice
Permafrost
thawing
Sedimentation of
organic matter
Low oxygen and acidified water
Formation of
northward flow
Decomposition of organic matter
Ocean deoxygenation and acidification
Chukchi
Plateau

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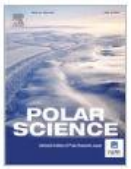

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The Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean (CAOFA)

To better understand the area's ecosystems, and to ban commercial fishing until adequate scientific information (incl. Indigenous Knowledge) is available for management measures.

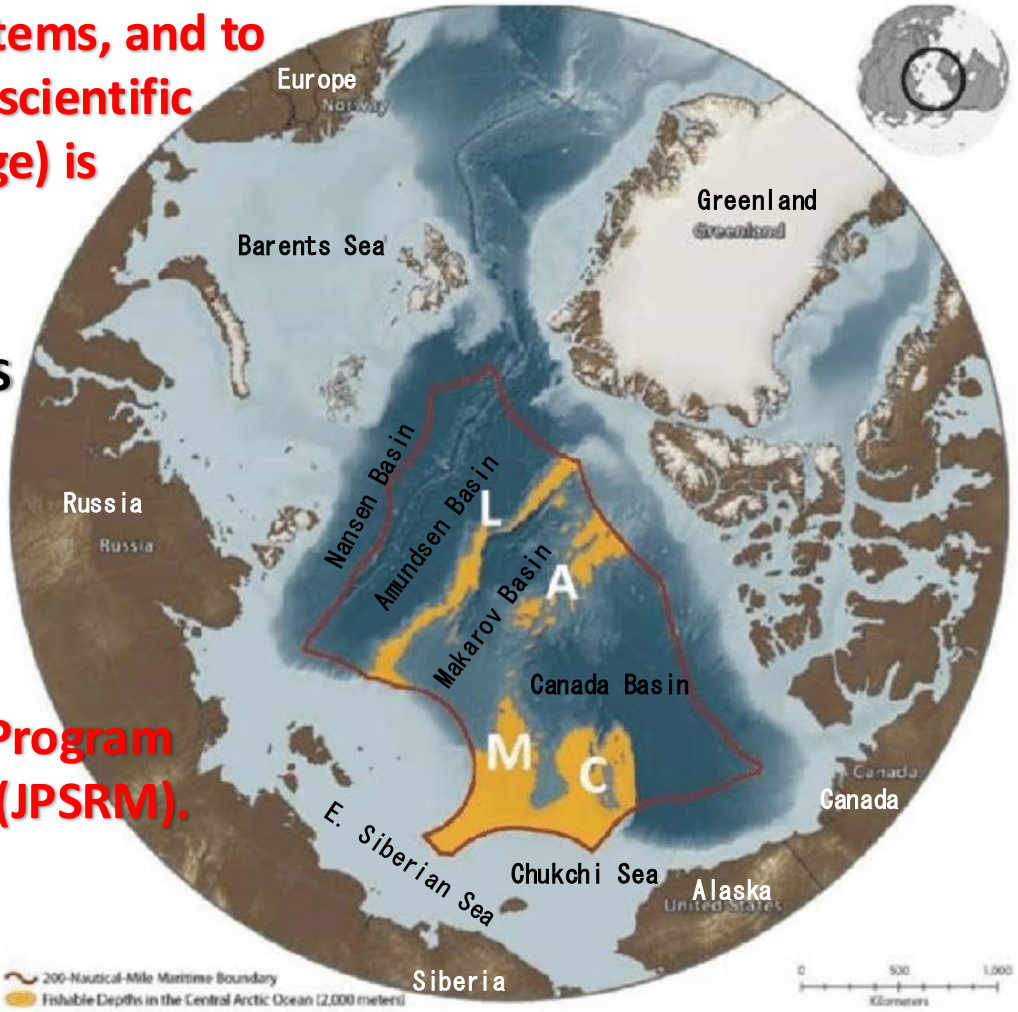
- **Signed on 3rd October 2018**
  Canada, Denmark, Norway, Russia, and US
  + China, EU, Iceland, Japan, and Korea

- **Entered into force on 25th June 2021**
  Initially be in force for 16 years,
  with possible extensions thereafter

The Parties agreed to establish a Joint Program for Scientific Research and Monitoring (JPSRM).

- **COP2 in June 2023**
  JPSRM Framework approved

- **COP3 in June 2024**
  JPSRM Implementation Plan approved



Bathymetric map of the Arctic Ocean and EEZ boundaries (red lines). Orange regions are fishable areas (< 2000 m). [WGICA 2020 Annual Report]

SAS I research findings cited in the JPSRM Implementation Plan

SAS I research findings were reflected in the JPSRM implementation plan by proposing a most urgent monitoring site, which is at risk of ocean deoxygenation and acidification, in the Agreement Area.

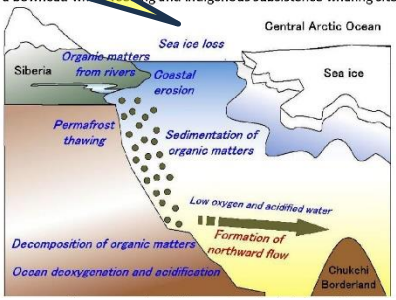
distribution around the CBL was suggested by eDNA analyses (Kawakami et al., 2023). Both are important fish species in Arctic marine food webs and are of commercial interest. However, among the Arctic high seas the CBL is experiencing the fastest rates of ocean deoxygenation and acidification, which may impact the marine ecosystem in this fishable area, due to the formation of a northward flow that transports anomalously low oxygen and highly acidified water from the East Siberian Sea (Nishino and Jung et al., 2023; Figure 1). The northward flow formation is likely caused by a change in the basin-scale ocean circulation associated with the recent sea-ice loss. Therefore, when introducing appropriate ecosystem-based management under the Central Arctic Ocean Fisheries Agreement, it will become essential to monitor the marine environment and ecosystem in the CBL region.

3.2. *Peripheral shelf/slope areas*

The ecological relationships between the Agreement Area and the adjacent shelf and slope features is poorly understood. The movement of fishes, marine mammals, seabirds, and other living marine resources between the Agreement Area and its peripheral seas is of particular importance to assessing the effects of exploratory and commercial fishing on the cultural, social, and food security needs of Arctic Indigenous peoples, local people, and communities. In addition, understanding the scope and effect of transport mechanisms for nutrients and fresh water from the nearshore to the offshore regions of the Arctic Ocean is a key factor in determining productivity for a wide variety of ecosystem components.

The area around Pt. Barrow, Alaska is one of the biological hotspots located in the peripheral shelf/slope area in the Pacific Arctic region (Grebmeier et al., 2010). Easterly winds over the Pt. Barrow area cause upwelling flows that move krill from the slope onto the shelf, and the upwelling and its subsequent relaxation establish a bowhead whale feeding and Indigenous subsistence whaling site near Pt. Barrow

SAS I findings



Synoptic Arctic Survey I (SAS I)

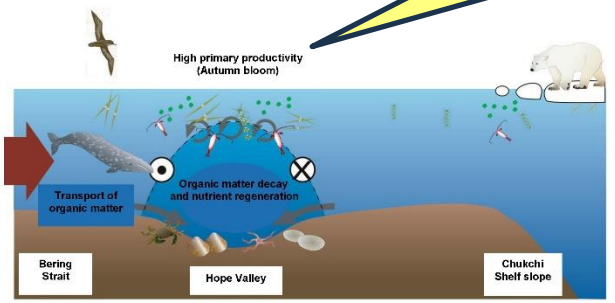
[Nishino and Jung *et al.*, 2023]

(Ashjian et al., 2010; Moore et al., 2018). Thus, the Pt. Barrow area is not only a priority geographical area but also a socio-economically and culturally focused region. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has conducted mooring observations in the Barrow Canyon since the late 1990s to monitor flow fields, including the upwelling and heat/freshwater fluxes through the canyon (Itoh et al., 2013). Recently, the mooring measurements were extended to monitor nutrient/oxygen concentrations and phytoplankton biomass/community structures. The mooring system could advance the biophysical and biogeochemical studies in the biological hotspot of the Pt. Barrow area.

The area around Pt. Hope, Alaska, is another biological hotspot located in the Pacific gateway (Grebmeier et al., 2010). Phytoplankton blooms occur not only in spring but also in autumn, with the fall bloom likely triggered by regenerated nutrients associated with the decomposition of particulate organic matter accumulated at the bottom of Hope Valley (Nishino et al., 2016; Figure 2). The zooplankton biomass in the Pt. Hope area also increases in autumn (Kitamura et al., 2017), and bowhead whales use this area for feeding during their fall southward migration (Tsujii et al., 2021). If ocean warming in the Pacific Arctic continues, Pacific cod may expand northward via the Pt. Hope area into the Chukchi Sea, as suggested by observational (Cooper et al., 2023) and model (Alabia et al., 2023) studies. However, the oxygen concentration found at the bottom of Hope Valley during autumn is as low as 100 μmol kg^{-1} (Nishino et al., 2016), which is in a range (< ~130 μmol kg^{-1}) that affects the growth and behavior of some fishes (Ekau et al., 2010). As a result, expansion of Pacific cod into the Chukchi Sea might be inhibited by the low oxygen water. Furthermore, the Pt. Hope area has already been undergoing $CaCO_3$ undersaturation during autumn and the undersaturation duration is expected to increase in the future (Yamamoto-Kawai et al., 2016). Therefore, the Pt. Hope area should be monitored as a bellwether of ecosystem degradation in the Arctic high-seas caused by ocean deoxygenation and acidification.

The Barents Sea and the northern Norwegian Sea are also considered as hot spot areas, as they are stepping stones for Atlantic fish entering the CAO (e.g., Snoeijs-Leijonmalm et al., 2023). Several recent

DBO findings



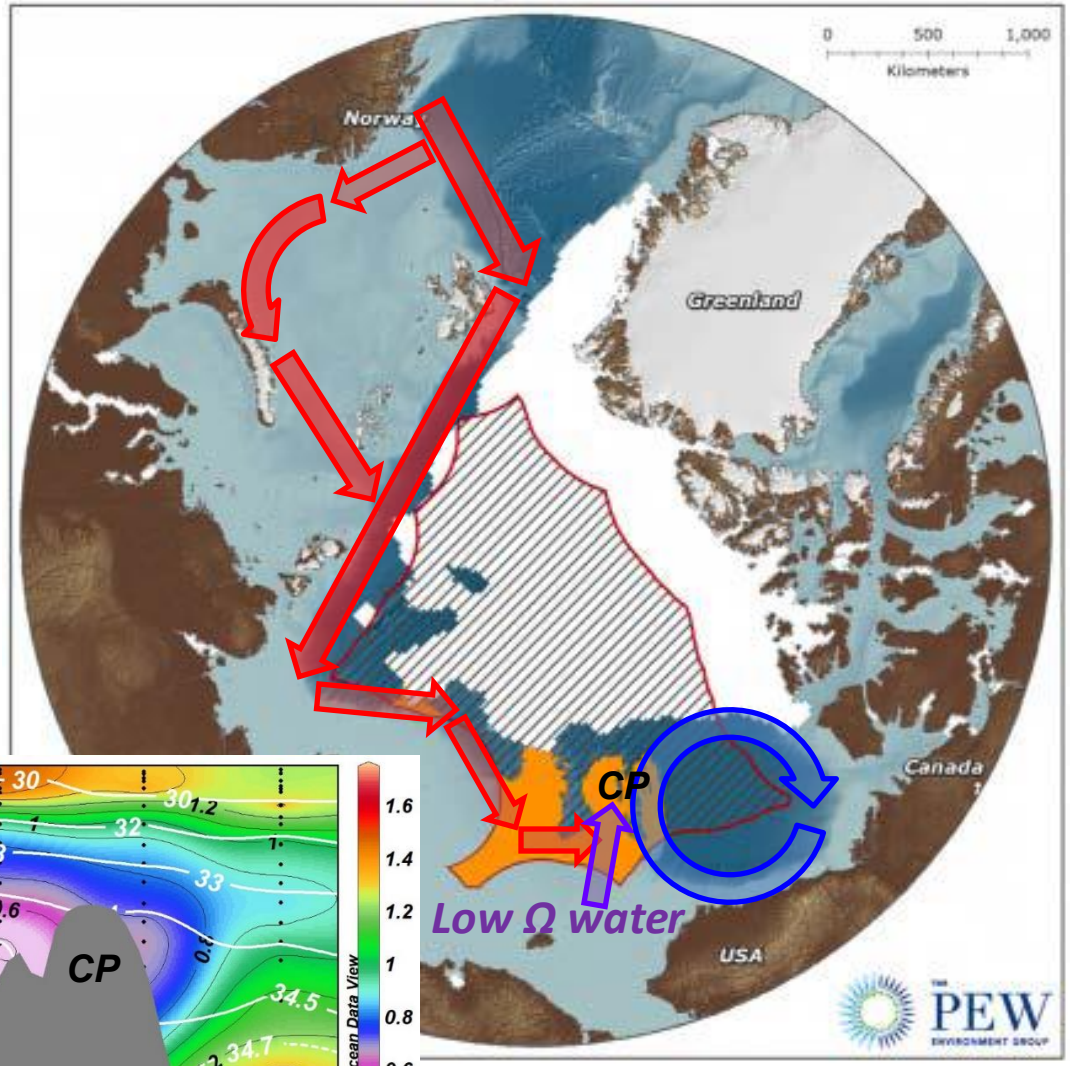
Distributed Biological Observatory (DBO)

[Nishino *et al.*, 2016]

Atlantic-origin water extension into the Pacific Arctic induced an anomalous biogeochemical event

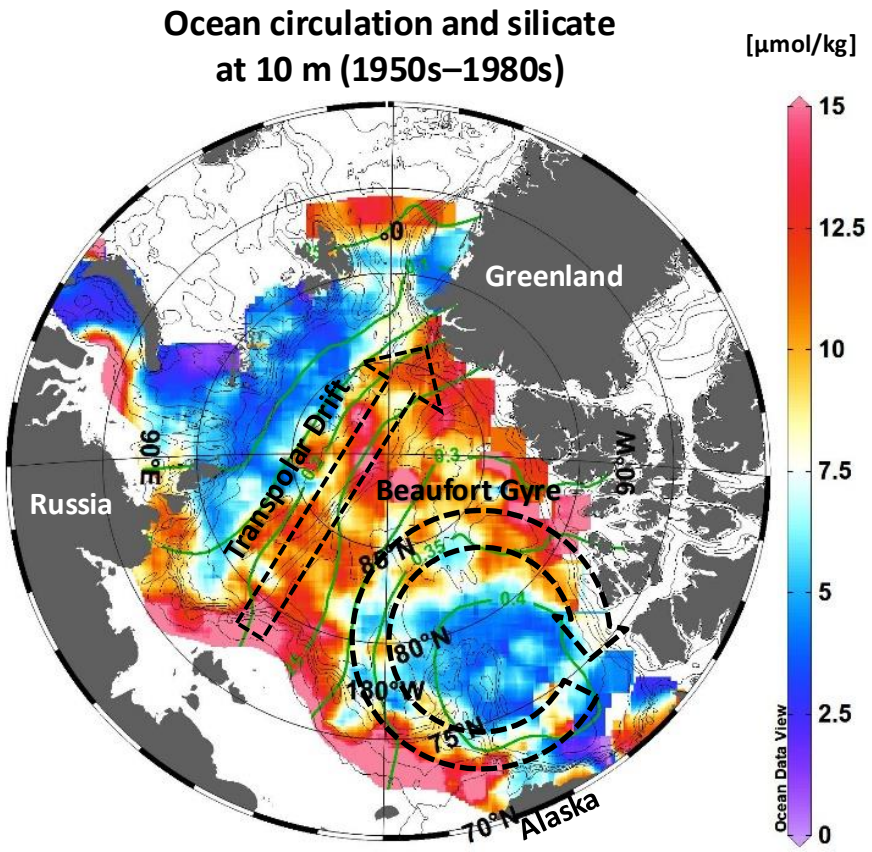
Nishino & Jung *et al*. [2023, *Nat. Commun.*] (issued a press release)

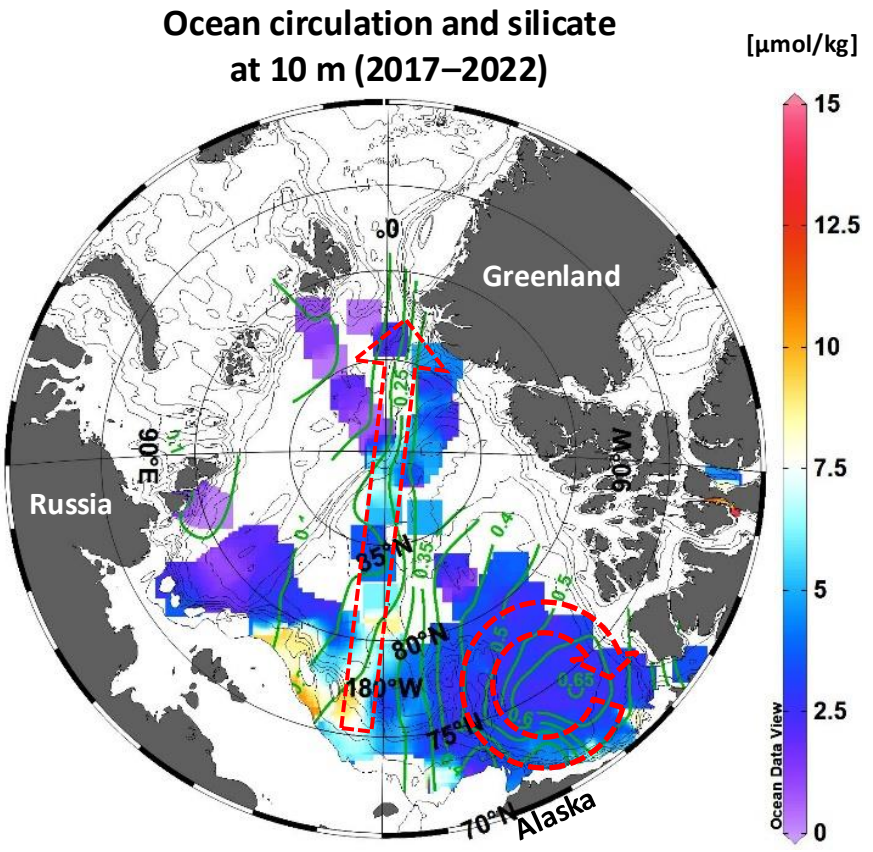
- The appearance of anomalously low oxygen and acidified water on the Chukchi Plateau (CP) is associated with a change of large-scale ocean circulation.
- The CP is a part of fishable areas less than 2000 m indicated by orange region, and the anomalously low oxygen and acidified water may impact the marine ecosystem in the fishable area.
- Thus, monitoring of marine environment and ocean acidification in this area (CP) would be important under a framework of such as the Central Arctic Ocean Fisheries Agreement (CAOFA).



SAS I (2020–2022) covered the Central Arctic Ocean

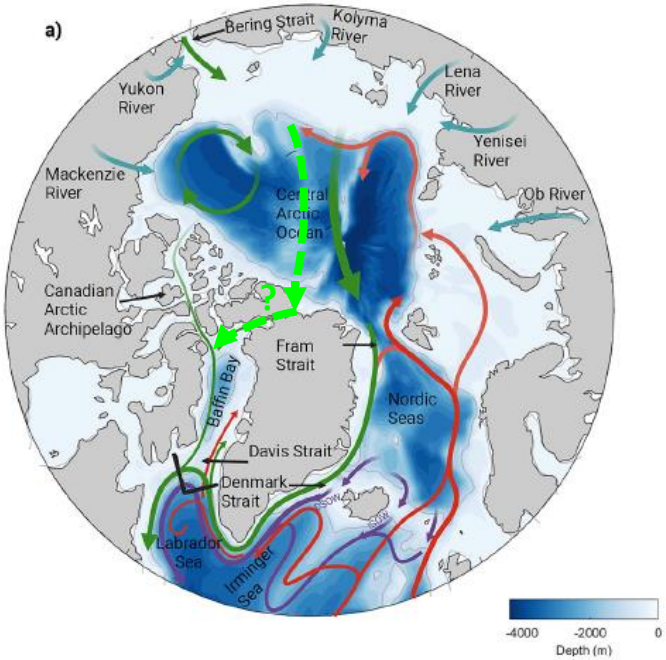
Large-scale changes in ocean circulation occurred just before the SAS I period.





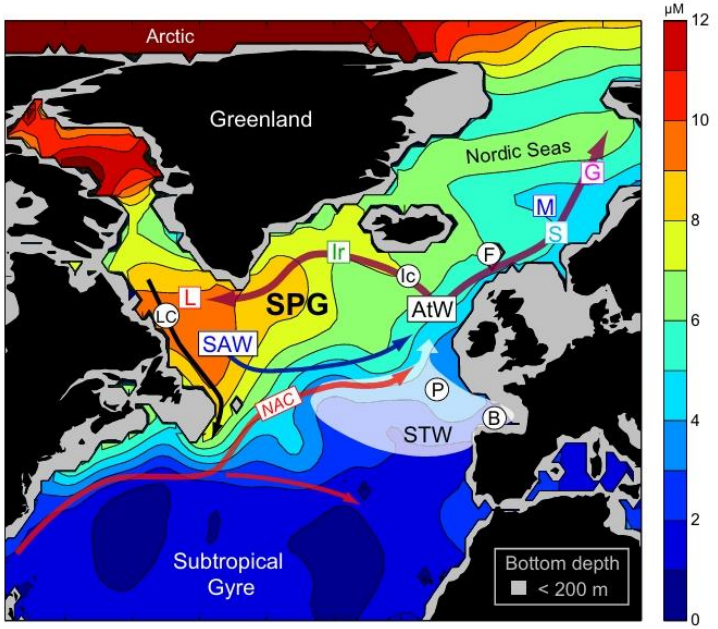
- Atlantification caused decreases of silicate concentration on the Atlantic side.
- Freshening resulted in decreases of silicate concentration on the Pacific side.
- How will ocean circulation and nutrient distribution change during the SAS II?

FW and carbon transport connecting to AMOC



[Gjelstrup *et al.*, 2024; SAS webinar]

Upper ocean (0–200 m) silicate (April)

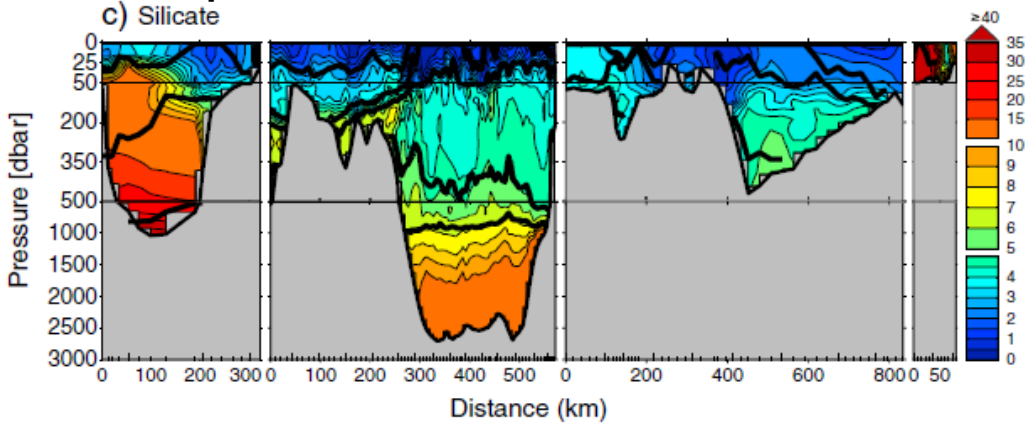


[Hátún *et al.*, 2017]

SAS II Theme:

Arctic-Atlantic Interaction

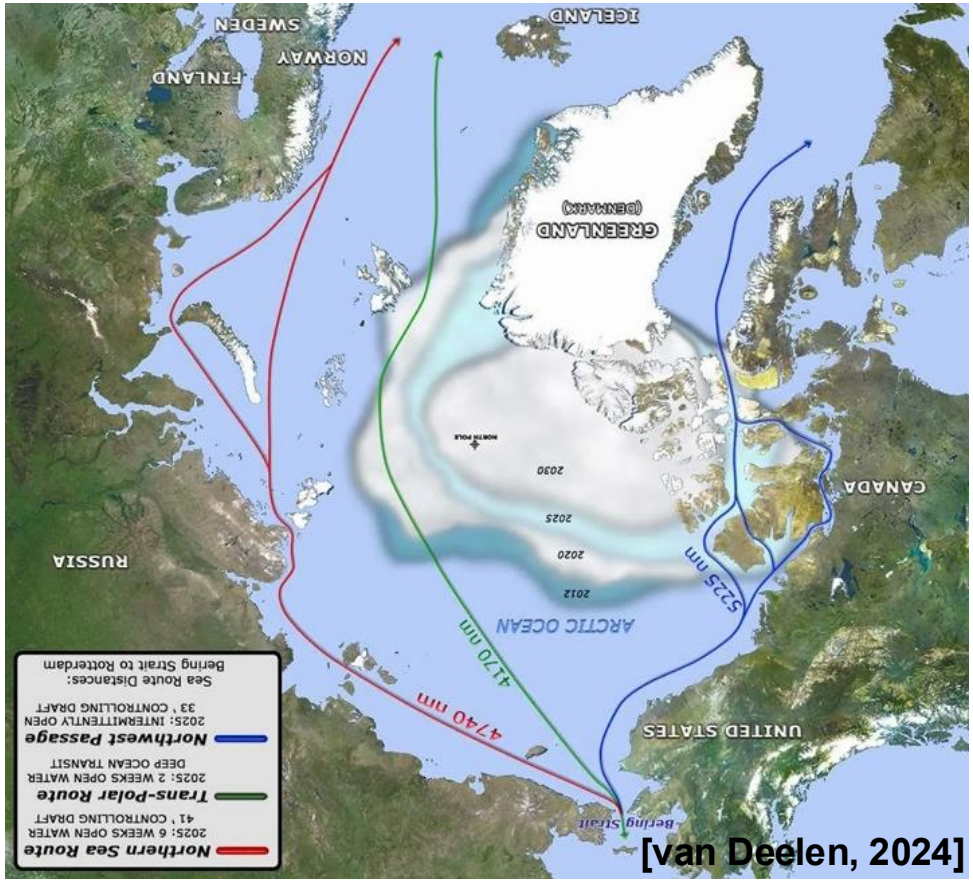
Export of nutrients from the Arctic Ocean

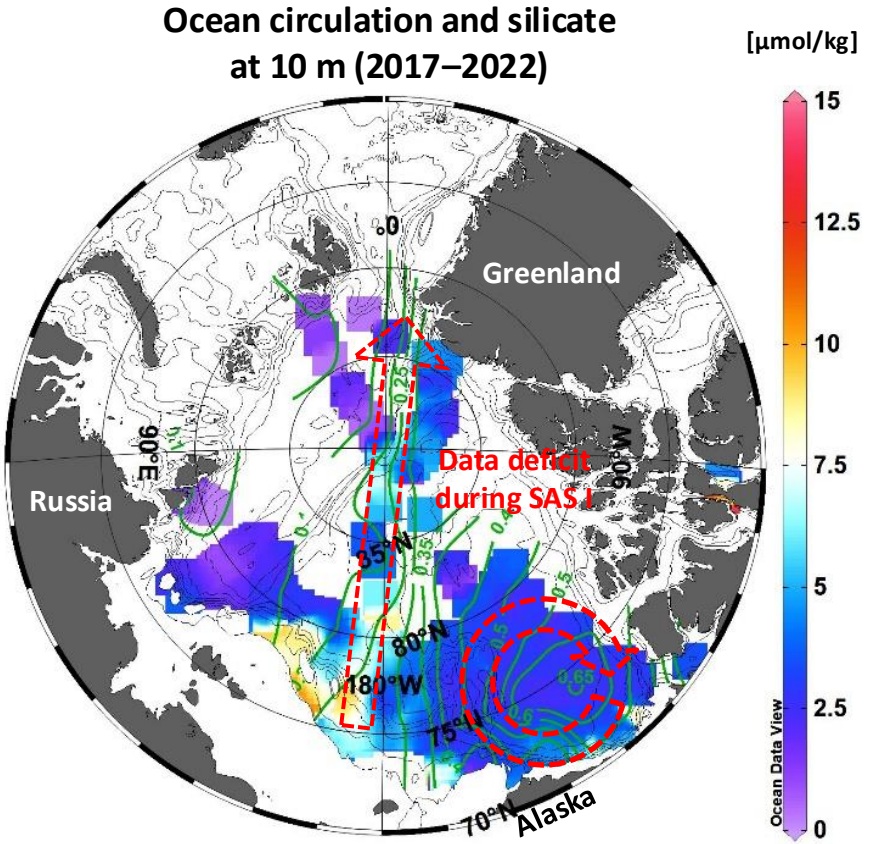


[Torres-Valdés *et al.*, 2013]

SAS II (2030) science topics on hydrography and biogeochemistry

Large-scale changes in ocean circulation occurred during the SAS I period.



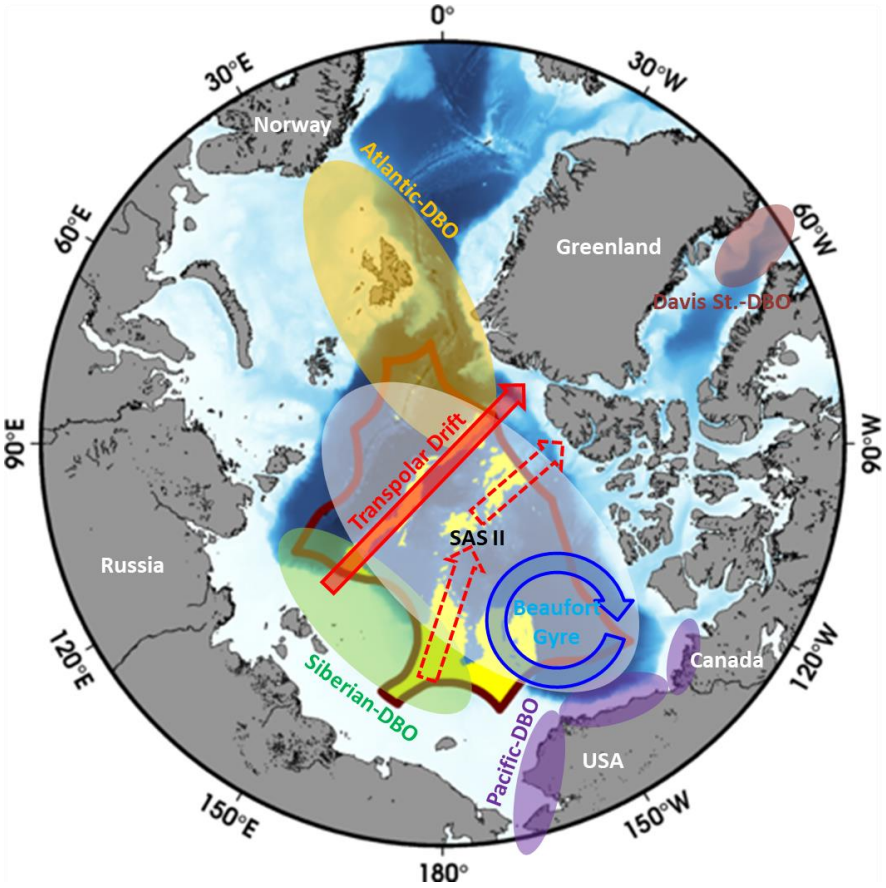


- How will ocean circulation and nutrient distribution change between SAS I and II?
- How will these changes affect the AMOC and Arctic/Atlantic biogeochemical cycles and marine ecosystems?
- Observations in a data deficit area and collaborations with DBOs are necessary.

Develop SAS II (2030) Science and Implementation Plan

- Changes in the marine environment and ecosystem in the Arctic shelves and gateways will significantly impact the Central Arctic Ocean through ocean circulation. Therefore, it is crucial to monitor the areas of the Beaufort Gyre and Transpolar Drift at least on a decadal scale, as their locations are different between before and during the SAS I period.

- These major currents transport waters toward the Central Arctic Ocean along the Chukchi Plateau (via the Beaufort Gyre) and Lomonosov Ridge or Mendeleev Ridge (via the Transpolar Drift). These regions have relatively shallow seafloors and are considered fishable areas. Thus, observations there could also provide critical data for CAOFA.



- To observe changes over the next decade, the SAS II program will enhance its observation network in collaboration with initiatives such as Pan-Arctic DBO, BGEP, NABOS, ASOF, and others, as well as CAOFA JPSRM.