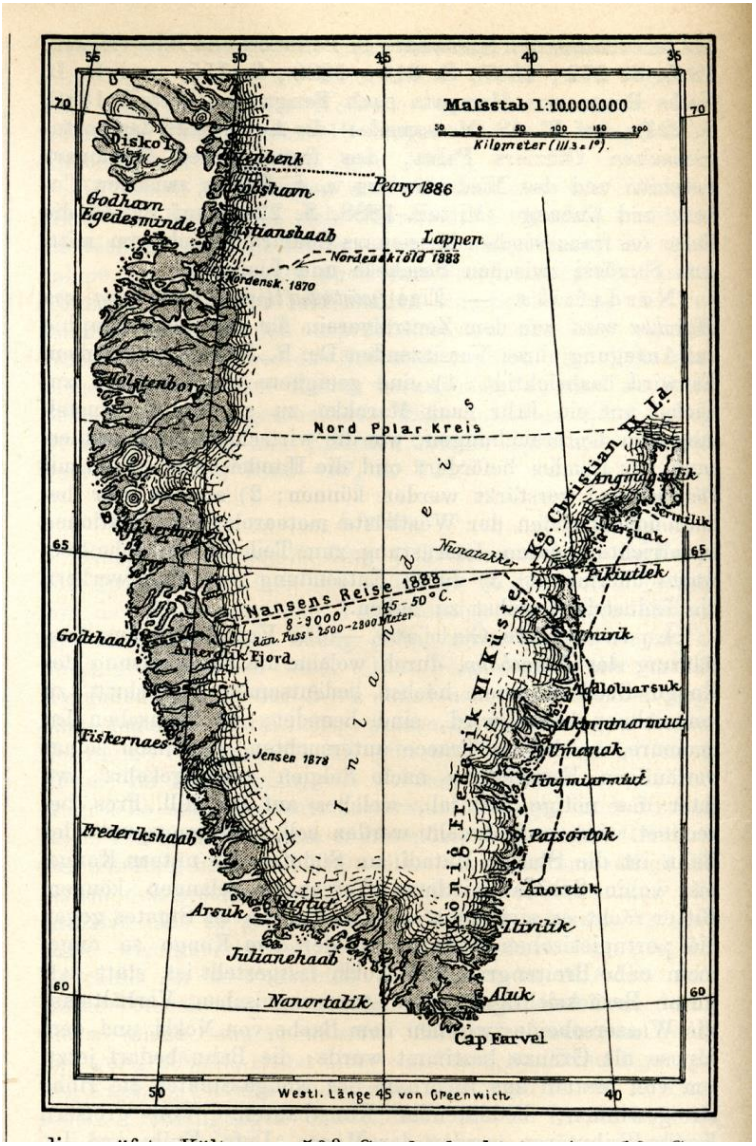
Synoptic Arctic Survey

The Synoptic Arctic Survey (SAS) – towards 2020

Øyvind Paasche, Are Olsen, Leif Anderson, Jeremy Wilkinson, Jackie Grebmeier, Takashi Kikuchi, Sung-Ho Kang, Carin Ashjian and the SAS Community.

Second International Science and Policy Conference on Implementation of the Ecosystem Approach to Management in the Arctic, Bergen, June 27, 2019

The Research Frontiers in the Arctic



«What lies hidden in Greenland's big unknown interior?

«There is no point in trying to calculate or speculate how Greenland is built in its interior; we live in the era of empiricism, let us therefore first see, often enough have a single solitary observation overthrown an entire system of dogmas and theories.»

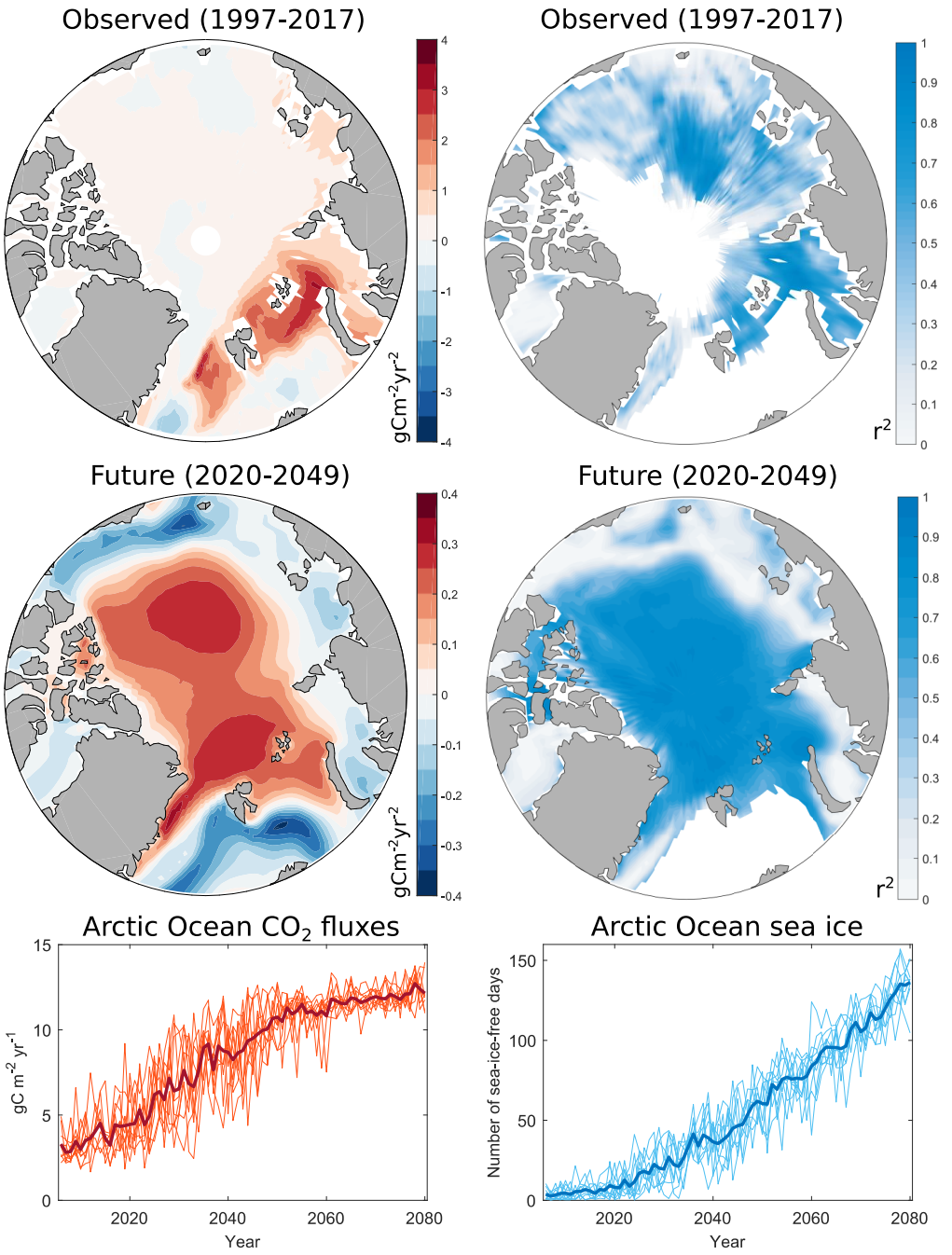
Fridtjof Nansen (1888)

The old and the new (and troublesome) Arctic

(i) The rapid transformation of the Arctic Ocean will continue for decades to come regardless of any reductions in global CO2 emissions

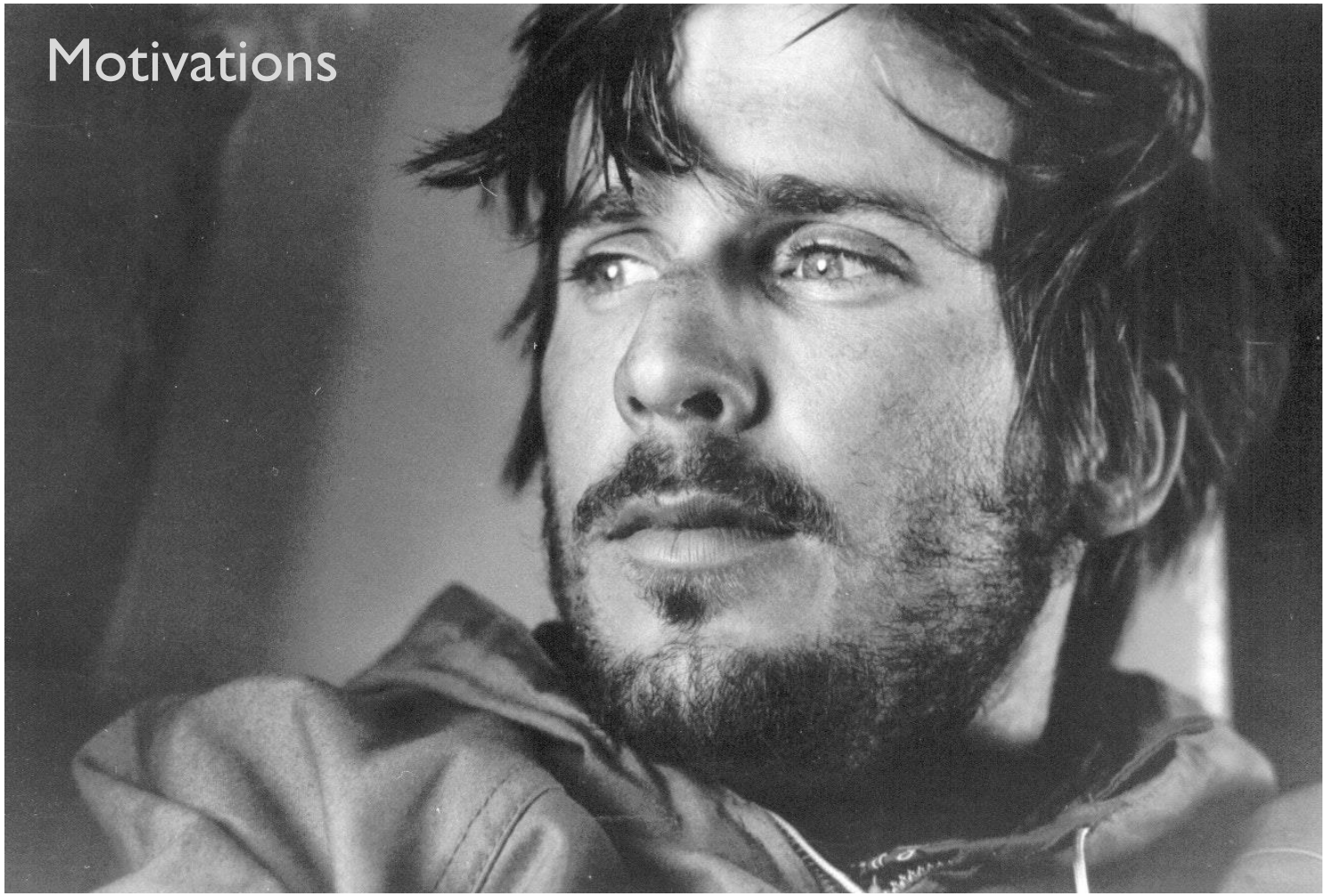
(ii)The scientific challenges arising from this makeover of the Arctic Ocean and its drivers and consequences are too large to be handled by any country alone and too complex to be properly understood through single discipline approaches.

Paasche et al., (submitted)



Eddy Carmack:

«Our current view of the Arctic Mediterranean is decidedly 'regional' because historical efforts have focused on regions with the result that we sense the parts but not the whole. A synoptic view of the Arctic Ocean is lacking and is sorely needed.»



Synoptic Arctic Survey

What is it?

Synoptic Arctic Survey is a bottom-up, researcher driven, initiative aiming at collecting empirical data in the Arctic ocean that cannot be done in any other way than through cruises! SAS will take place in 2020 (+2021) involving the coordination of many research vessels (not all ice breakers).

THE GOAL is to generate a comprehensive dataset that allow for a complete characterization of Arctic hydrography and circulation, carbon uptake and ocean acidification, tracer distribution and pollution, and organismal and ecosystem functioning and productivity.

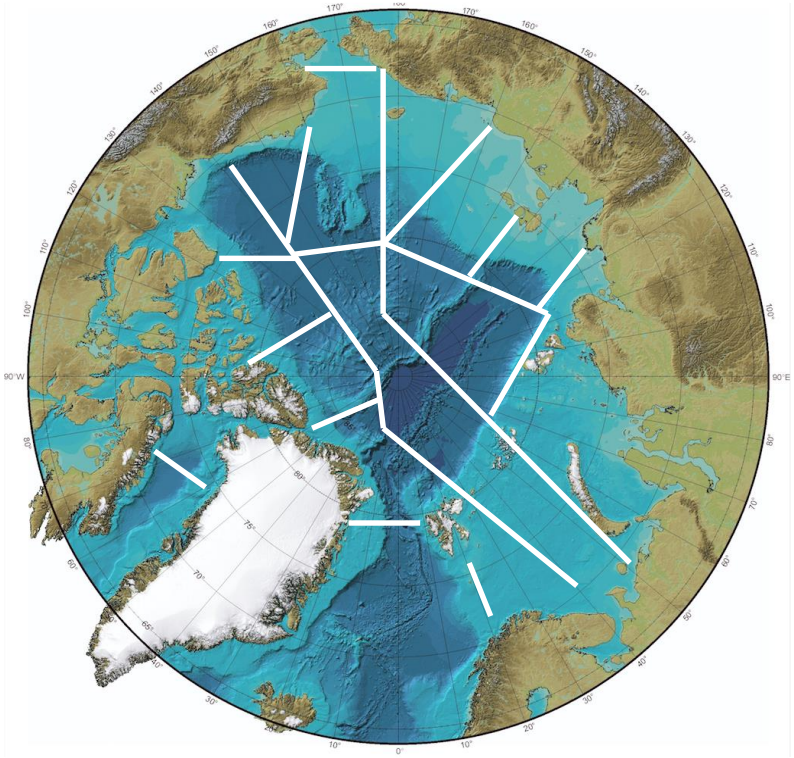
THE DATA will provide a unique baseline, which will allow us to track climate change and its impacts as they unfold in the Arctic over the coming years, decades and centuries. There can be no doubt that not only future generations of polar scientists will benefit from such a baseline, but also decision makers.

There is a historical LEGACY dating back to The Maud Expedition (1918-1925) where the acclaimed Norwegian researcher Harald Ulrik Sverdrup was in charge of the science conducted at the traverse of the Northeast Passage.

Collaborating for better observations of the Arctic Ocean

Synoptic Arctic Survey

- Coordinate **nationally funded** Arctic Ocean cruises in time and space into a set of intersecting sections
- To retrieve the **full three–dimensional *structure*** of the Arctic, the distribution of *important chemical elements*, and *ecosystem properties* based on data from a single year
- Ultimate vision: **the first of repeated decadal suveys of the Arctic Ocean**
- Creating **a backbone** for Arctic Ocean research



An international, researcher driven, initiative

Leif Anderson, Are Olsen, Øyvind Paasche, Takashi Kikuchi, Carin Ashjian, Peter Schlosser, Jim Swift, Heidimarie Kassens, Sebastian Gerland, Jeremy Wilkinson, Jackie Grebmeier, Eddy Carmack, Melissa Chierici, Kumiko Azetsu-Scott, Jeremy Mathis, Jackie Grebmeier, Vidar Lien, Lise Lotte Sørensen, Jens Hölemann, Andrey Novikhin, Kyoung-Ho Cho, Sung-Ho Kang, Karen Edelvang, Motoyoh Itoh, Oleg Titov, Michio Yamamoto-Kawai, Vladimir Ivanov, Colin Stedmon, Bill Williams +++

UNIVERSITAS BERGENSIS

JAMSTEC

AWI

LAMONT-DOHERTY EARTH OBSERVATORY
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY

NORSK·POLARINSTITUTT

GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

Fisheries and Oceans Canada

NOAA

SCRIPPS INSTITUTION OF OCEANOGRAPHY UCSD

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

HAVFORSKNINGSINSTITUTTET

KOPRI
Korea Polar Research Institute

ΠΨΗΡΟ

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

UNIVERSITAS GOTHOBURGENSIS 1891

BEDFORD INSTITUTE OF OCEANOGRAPHY
BIO
INSTITUT OCÉANOGRAPHIQUE DE BEDFORD

ARCTIC RESEARCH CENTRE

UNIVERSITY OF MARYLAND CENTER FOR ENVIRONMENTAL SCIENCE 1925

UArctic IASC

2014 Idea conceived, Japan-Norway Marine Science week

2015 First international SAS workshop, Washington DC

2016 St. Petersburg

Gothenburg, develop SAS Science and Implementation plan

2017 First draft of Science Plan completed

First national group formed, Sweden

2018 National meeting Japan

National meeting Norway

UK, submitted 'highlight topic to NERC'

"National" meeting Canada

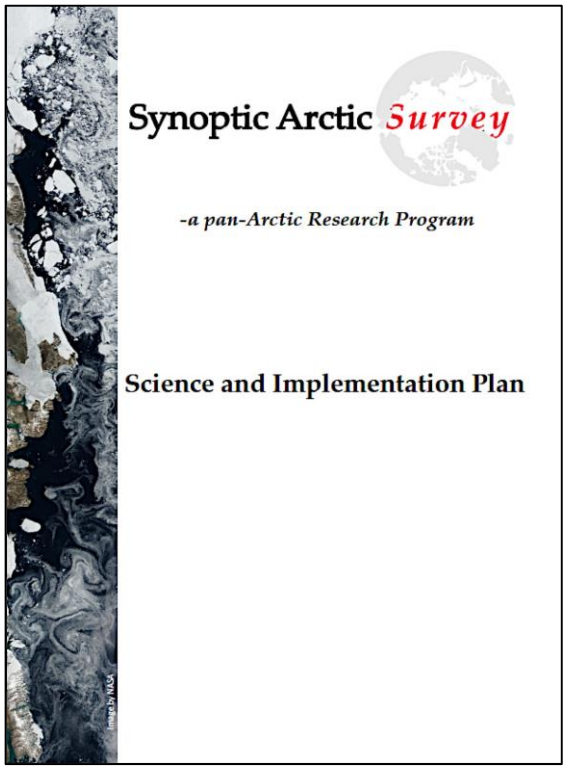
National meeting Denmark

Science Plan Complete

SAS Planning meeting - USA

Germany + Russia

Establish SSG, fall 2018



2020 Planned year of the Synoptic Arctic Survey (SAS–2020)

The Synoptic Arctic Survey (SAS) – International Planning and Coordination Workshop

May 15-16, 2019
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts, USA

There will be an open coordination and planning workshop to continue planning the Synoptic Arctic Survey (SAS) project on May 15-16, 2019 at the Woods Hole Oceanographic Institution in Woods Hole, MA, USA. The SAS is a developing international program envisioned to mount a coordinated, multi-nation, oceanographic field based effort on a Pan Arctic scale quasi-synoptically over two summer seasons (2020-202) to achieve the baseline understanding of the fundamental structure and function of the linked Arctic carbon-ecosystem-physical systems that will permit detection of ongoing and future changes. The goals of the workshop include planning coordinated field sampling, international data sharing, education including graduate student participation, post field-season data synthesis, public outreach, and involvement of indigenous communities and identifying additional measurements (e.g., atmospheric measurements) or approaches (e.g., modeling) that would contribute to accomplishing the goals of the SAS. The SAS is a ground-up effort and wide participation, including all professional levels of scientists, graduate students, and science managers across multiple disciplines and indigenous community members, in the planning is welcome!

Synoptic Arctic Survey

Funded by:

NSF IASC

Links

SAS Agenda

SAS Workshop Travel Information

SAS Science Plan

SAS Home Page

Ashjian Intro Goals

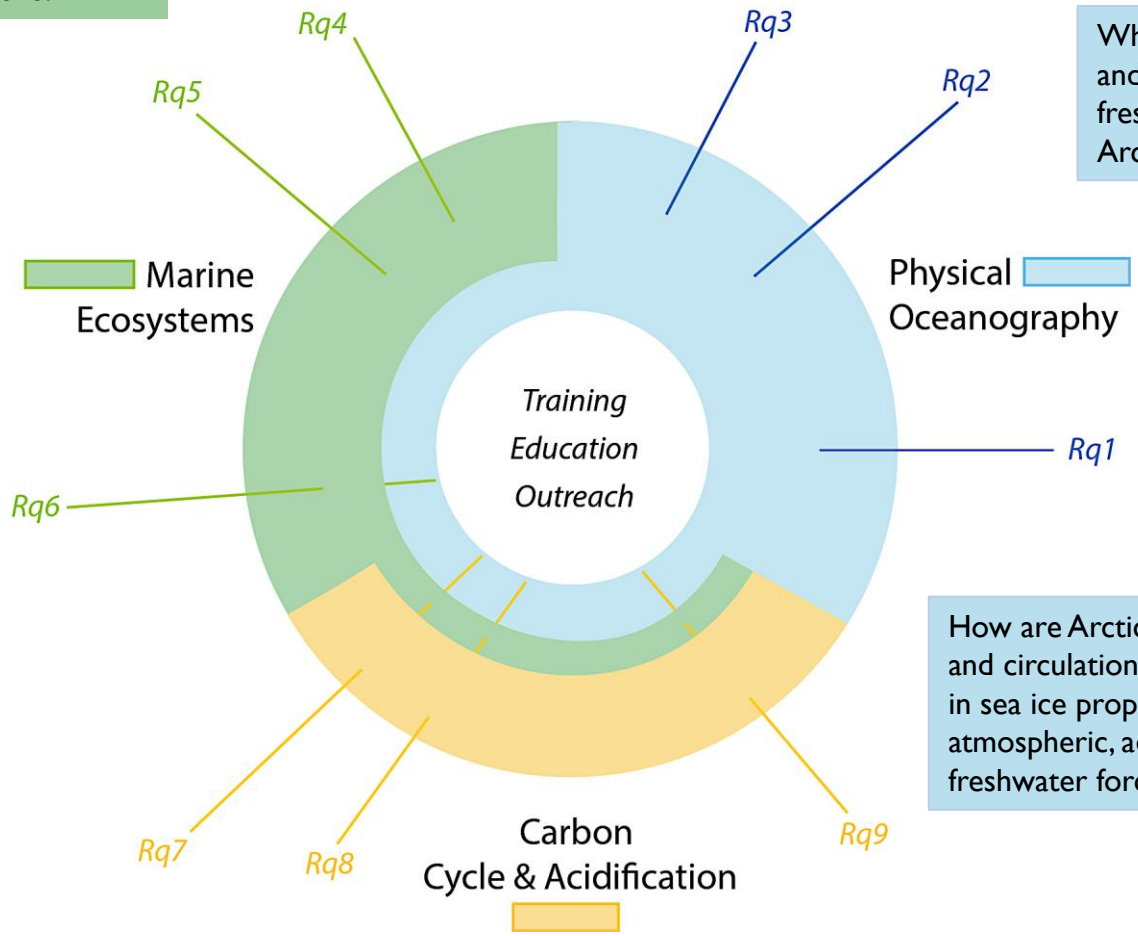
What are the present state and major ongoing transformations of the Arctic marine system?

How does primary production and associated availability of nutrients vary between Arctic regions?

What are the changes in water mass sources, sinks and transformations?

What are the states of, and changes in, heat and freshwater budgets in the Arctic regions?

Does northward range expansion of subarctic species vary regionally and are any of these species likely to establish permanent populations in Arctic regions?



How does carbon flow vary across regional ecosystems of the Arctic?

How are Arctic Ocean water masses and circulation responding to changes in sea ice properties, and atmospheric, advective and freshwater forcing?

What is the contribution of the Arctic Ocean to maintaining the global ocean carbon dioxide reservoir and uptake?

What are the input and fate of terrestrial and subsea carbon to the Arctic Ocean?

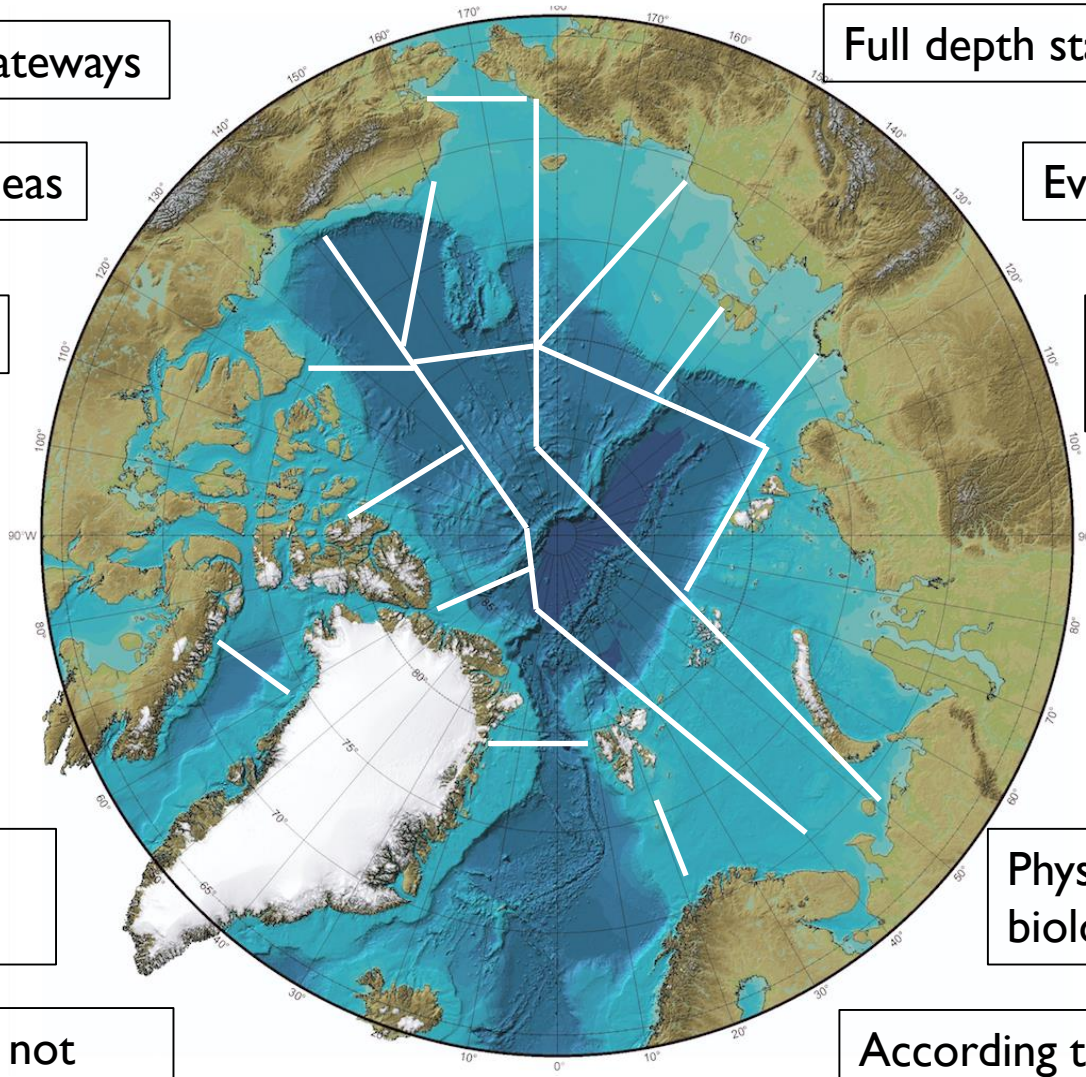
What are the magnitude, drivers, and impacts of Ocean Acidification in the different regions of the Arctic Ocean?

Synoptic Arctic Survey Observations

The gateways

The shelf seas

The deep basins



Some previously sampled regions

Some regions not previously sampled

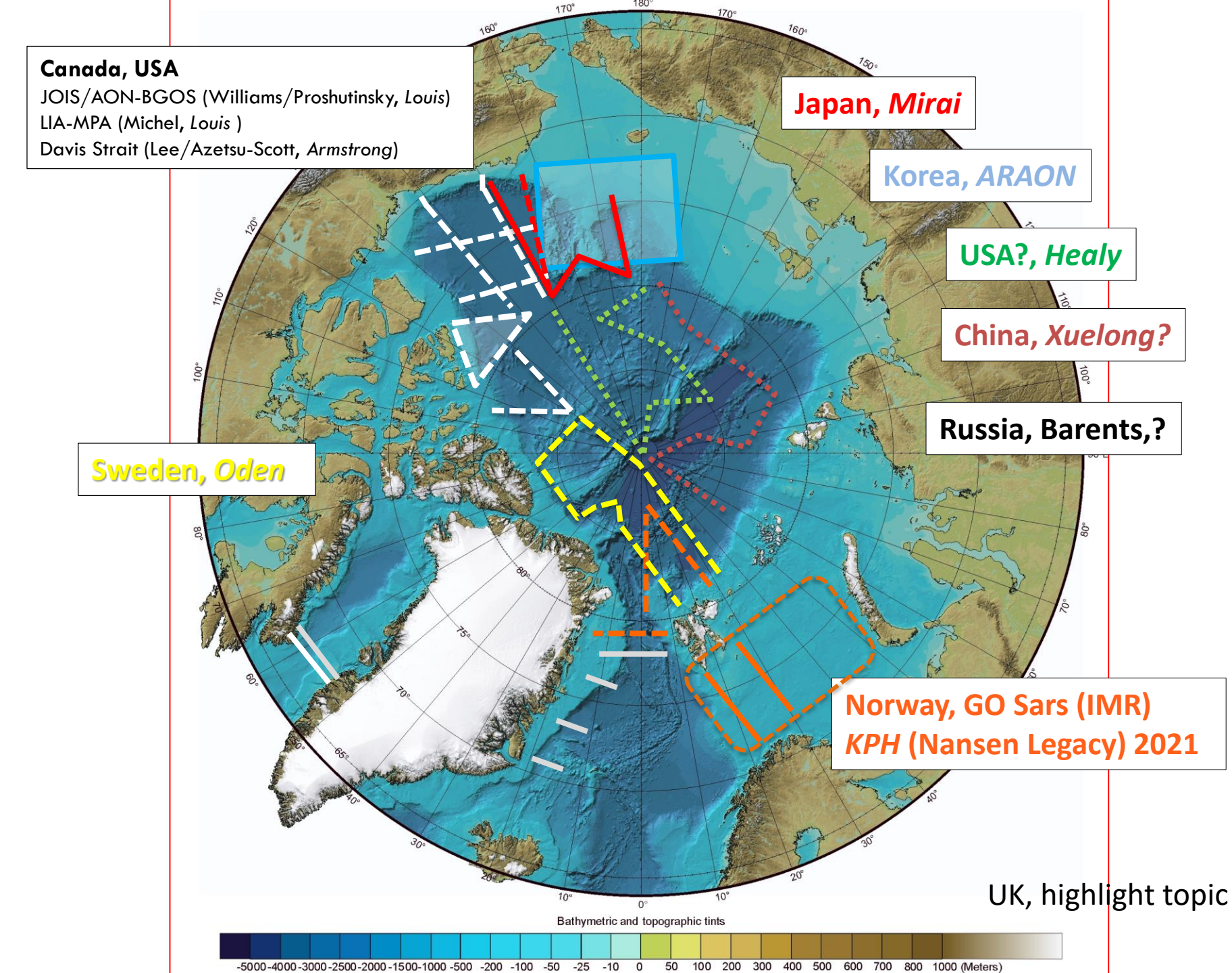
Full depth stations

Every 20 nm

Closer over ridges and shelf slopes

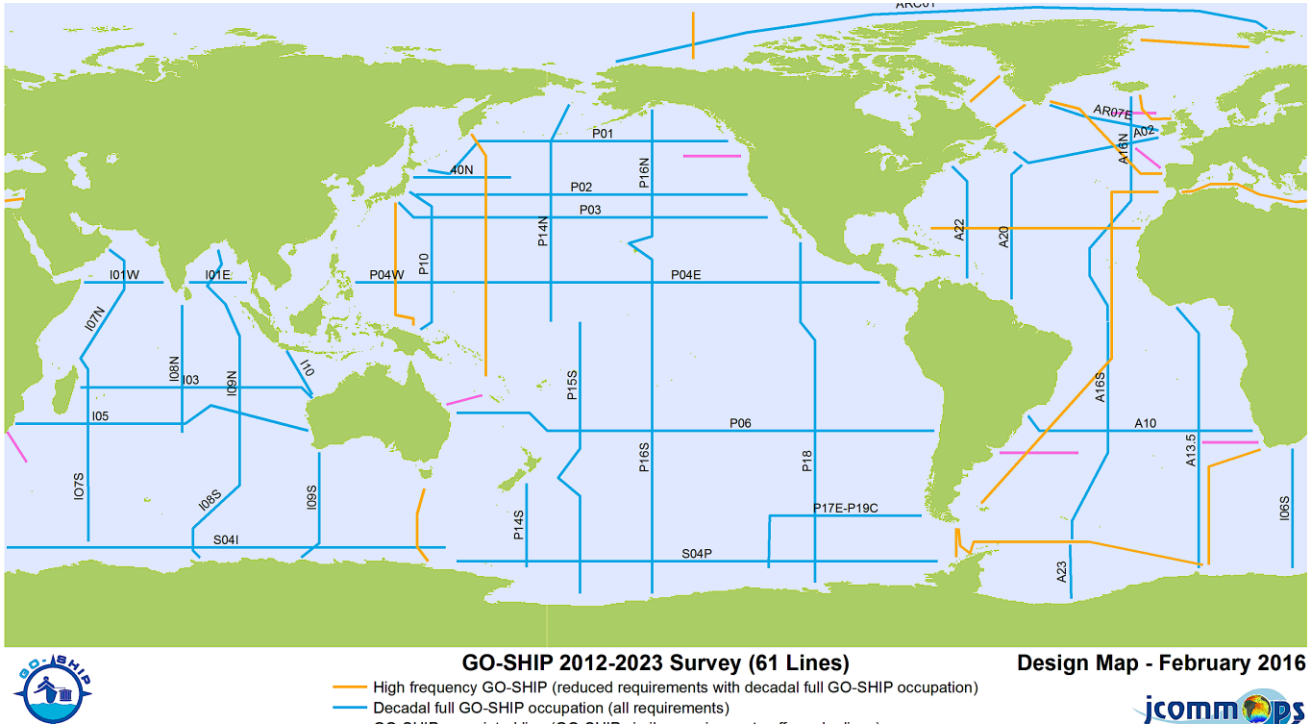
Physical, chemical and biological measurements

According to latest protocols


Canada, USA
JOIS/AON-BGOS (Williams/Proshutinsky, Louis)
LIA-MPA (Michel, Louis)
Davis Strait (Lee/Azetsu-Scott, Armstrong)
Japan, Mirai
Korea, ARAON
USA?, Healy
China, Xuelong?
Russia, Barents,?
Sweden, Oden
Norway, GO Sars (IMR)
KPH (Nansen Legacy) 2021
UK, highlight topic
Bathymetric and topographic tints
-5000 -4000 -3000 -2500 -2000 -1500 -1000 -500 -200 -100 -50 -25 -10 0 50 100 200 300 400 500 600 700 800 1000 (Meters)

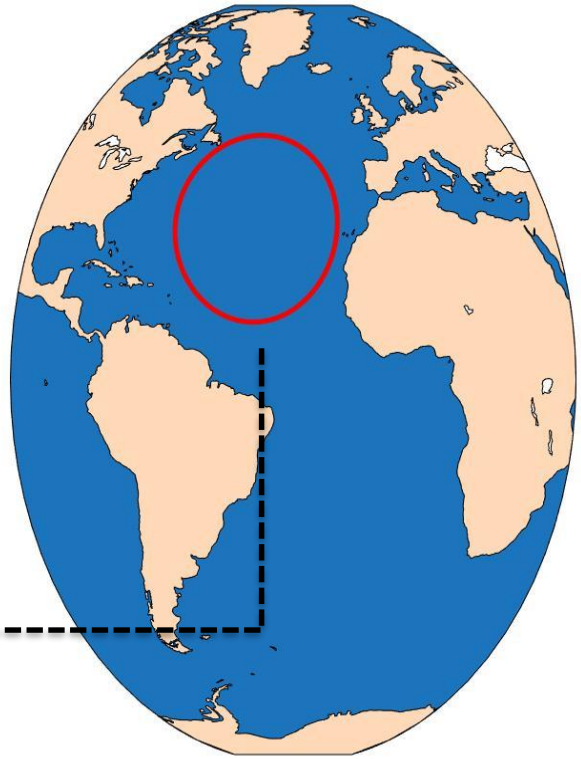
Global Ocean Ship-Based Hydrographic Investigations Program

The GO-SHIP Panel was established in 2007 by the IOCCP and CLIVAR to develop a strategy for a sustained global repeat hydrography program and to revise the 1994 WOCE hydrographic program manual.



- Decadal global ocean coverage of a set of level 1 variables, measured according to strict protocols.
- Heat, Carbon, OA, Oxygen, ventilation rates etc.
- Data are quickly made available (e.g. at CCHDO) and synthesized into global data products (GLODAP)

SAS ambition – to create an Arctic GO-SHIP

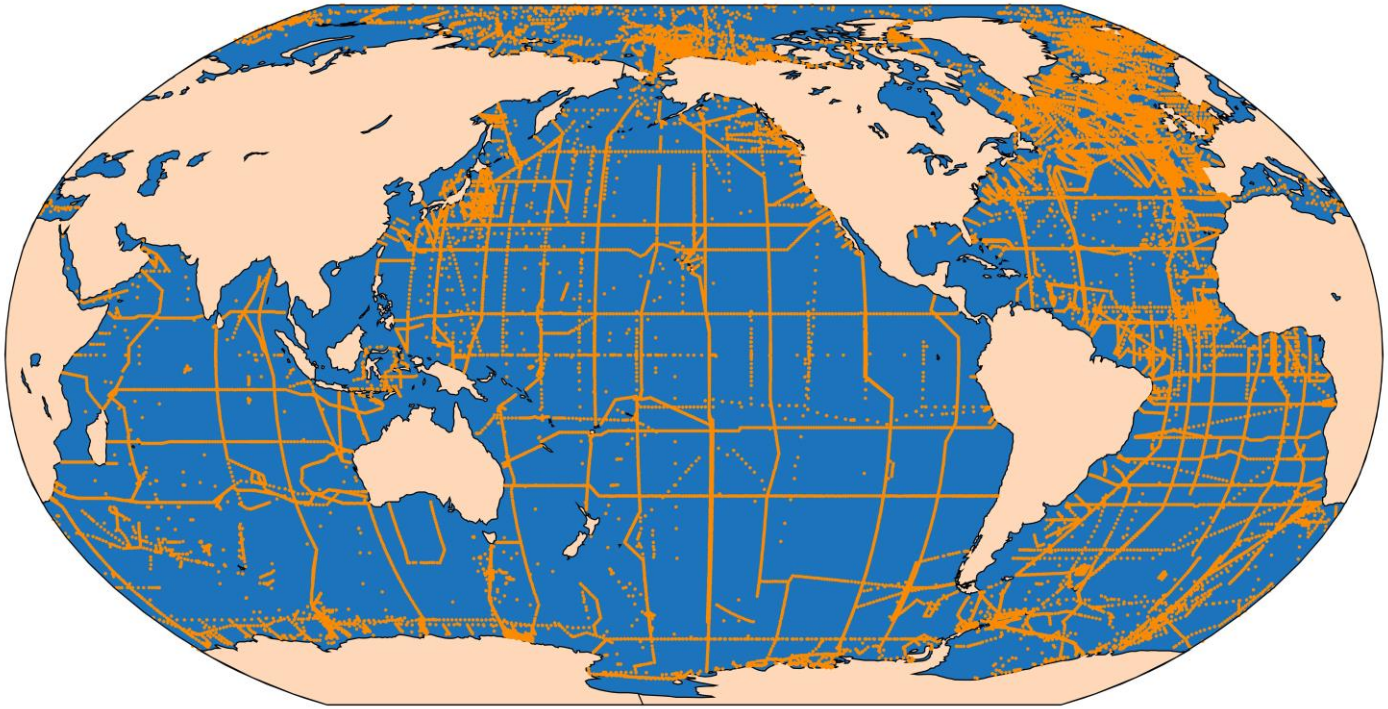


- Adopt a GO-SHIP model for Arctic ship-based field work
- Given: the large variability, the large number of available ships, the large interest in Arctic research, and the small size of the Arctic Ocean
- This should and can be done during a single year,
- repeated every decade,
- and have an ecosystem sampling program

NB: The circle represents the size of the Arctic Ocean, smaller than you might think

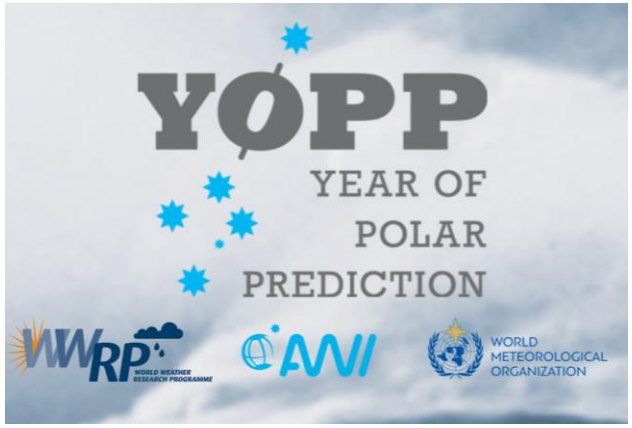
Data Synthesis

- Merged, homogenized, consistent data products are much more useful than individual data sets.
  - At some point a SAS data product should be prepared.
  - For hydrography and biogeochemistry; should be patterned after GLODAP,
    - securing internal consistency using crossover checks on deep data.
    - Therefore, we must ensure that the individual cruises overlap in space.



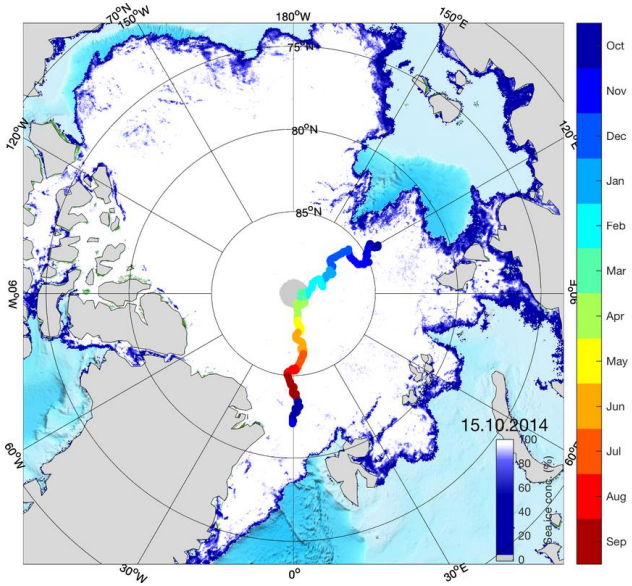
Global coverage of GLODAPv2.2019, with data from 840 cruises (Olsen et al. ESSD, 2019)

Synergy with other large community initiatives



YOPP is the flagship activity of PPP with the aim of enabling a significant improvement in environmental prediction capabilities for the polar regions and beyond, by coordinating a period of intensive observing, modelling, verification, user-engagement and education activities.

Core phase : May 2017 to June 2019.



MOSAiC
International Arctic Drift Expedition

The primary objective of MOSAiC is to develop a better understanding of these important coupled-system processes so they can be more accurately represented in regional- and global-scale models.
Starting Sept 2019, ending Oct. 2020

SAS2030 → UN's Decade of Ocean Science

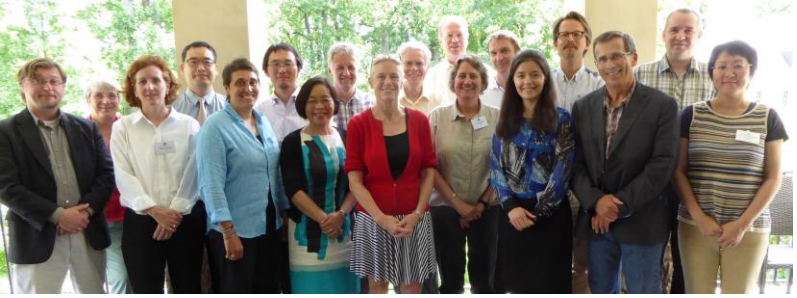
The United Nations has proclaimed a **Decade of Ocean Science for Sustainable Development (2021-2030)** to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in creating improved conditions for sustainable development of the Ocean.

Restricted Distribution

IOC/EC-LI/2 Annex 3
Paris, 18 June 2018
Original: English

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (of UNESCO)

Fifty-first Session of the Executive Council
UNESCO, Paris, 3–6 July 2018



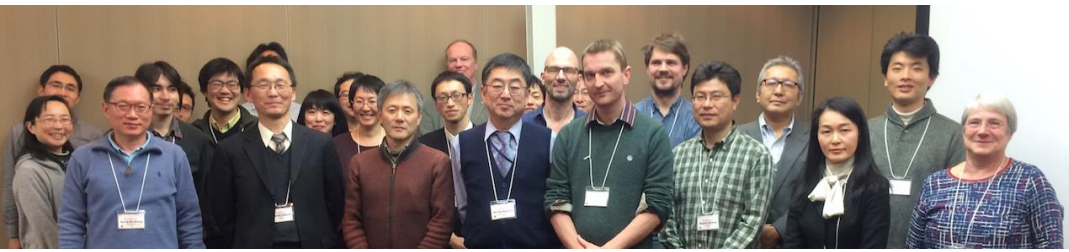
First international SAS workshop, Washington DC (2015)

St. Petersburg, German Consulate (2016)

Gothenburg, start develop SAS Science and Implementation plan (2016)

First national group formed, Sweden (2017

National meeting Japan and Norway (2018)

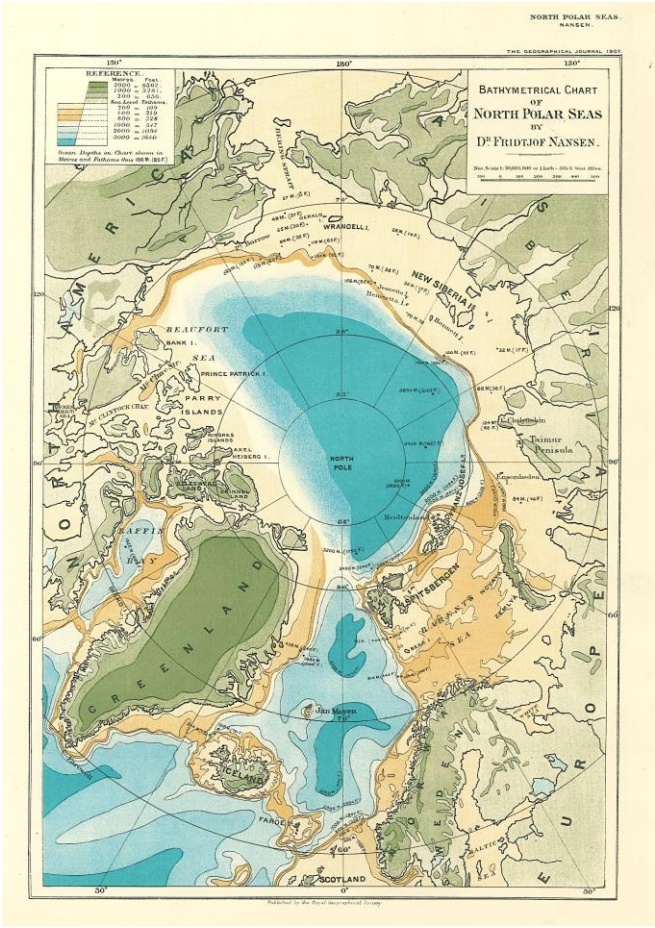


Thank you for your attention

«Because of its [The Arctic] remoteness, the severity of its climate, and the logistic problems which these two factors impose, efforts at scientific study must be made on a geographic rather than a on strictly disciplinary basis. It is for this reason that interdisciplinary and international collaboration is here even more important than elsewhere, …»

Proceedings of the Arctic Basin Symposium, October 1962.

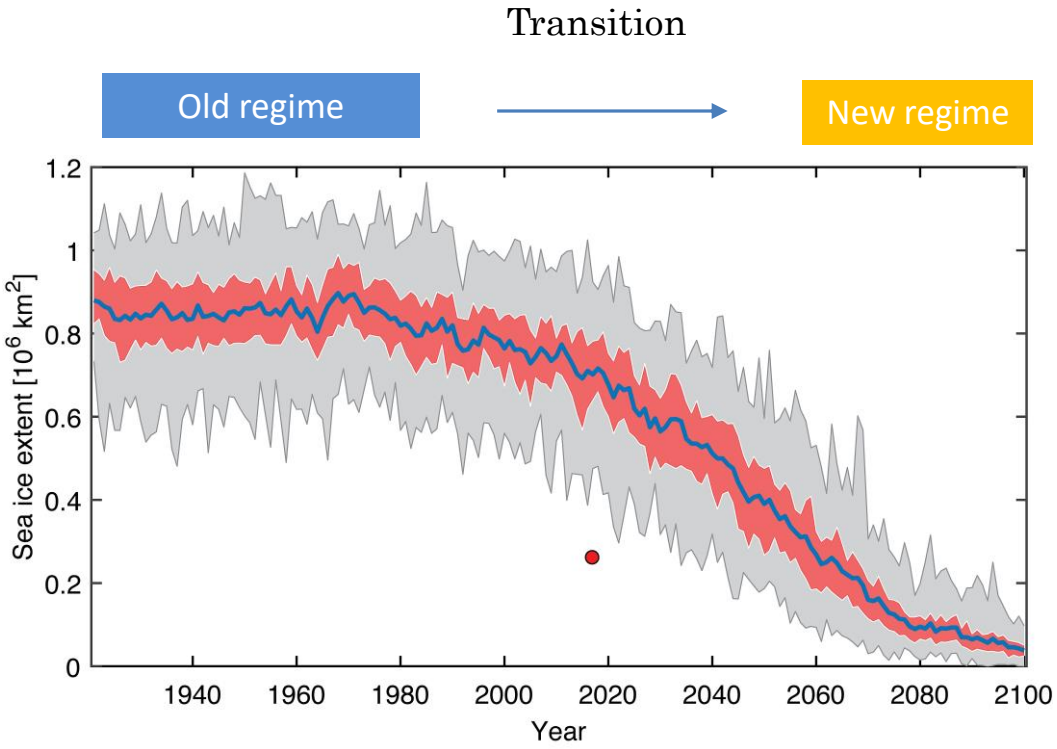
https://synopticarcticsurvey.w.uib.no



The Great Arctic Transition

A winter ice-free Barents Sea will/can be reached@:

- 2223*l and 2036*q (extrpl)
- 2061-2088 (CESM-LE)
- 2028 (GFDL)
- 2061 (MPI-ESM)
- 2063 (NorESM1)



Onarheim & Årthun (2017)

Paper submitted.

Developing the Synoptic Arctic Survey

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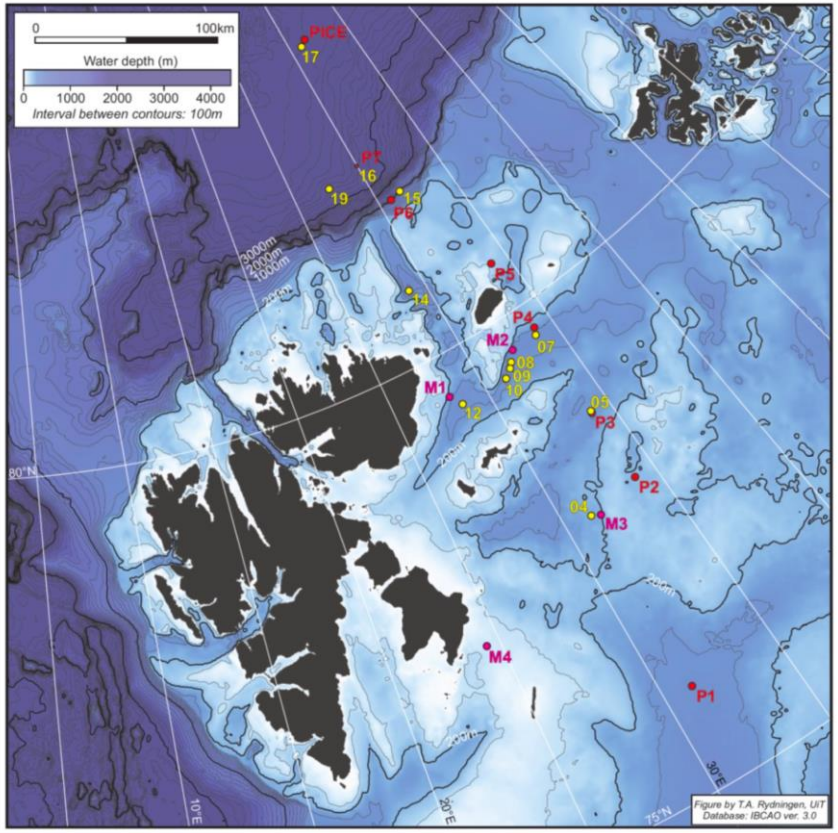
The Norwegian Contribution

GO Sars

Crown Prince Haakon

The Norwegian Contribution

The Nansen Legacy transect; cruise map 2018



www.nansenlegacy.org

Cruise plans Nansen legacy, RV *Kronprins Haakon*:

2019/20: Seasonal studies of biological communities, interactions and biogeochemical processes

Transect P1 to P-Ice (76-83°N, ~30-35°E)

4-27 August 2019

28 Nov-17 Dec 2019

March 2020 (dates to be confirmed)

May 2020 (dates to be confirmed)

2019/20 Moorings and physical processes (dates to be confirmed)

12-27 November 2019 (mooring service/A-TWAIN)

January 2020 (physical processes, dates to be confirmed)

August (mooring service and physical processes, dates to be conformed)

2021: Prolonged transect further into the Arctic basin

M1-M4: Moorings
Yellow points: Geological cores
P1-P7-P ice: Process stations
Additional moorings north of Svalbard + A-TWAIN moorings on northern shelf break

the Nansen LEGACY

The Norwegian Contribution

The Barents Sea Ecosystem Survey
The Fugløya-Bjørnøya transect (seven stations) and the Vardø Nord transect (eight stations).

The Institute of Marine Research (IMR) Monitoring Programme samples two standard transects in the Barents Sea: the Fugløya-Bjørnøya transect (seven stations) and the Vardø Nord transect (eight stations). The Fugløya-Bjørnøya transect is split into two sections: North ("15") and South ("16"), which are each sampled three to six times a year with WP-2 nets from 100 m and/or bottom to the surface. The data in this report are from bottom-to-surface hauls (100-0 m).

Water temperatures along the Fugløya-Bjørnøya transect range from 4°C to 9°C, with the seasonal high in August and the seasonal low in February. Peak zooplankton biomass is found from June to August in the northern section and from May to July in the southern section. Zooplankton biomass has been steadily decreasing over the duration of the time-series, most noticeably in the northern section. This is also seen in the weakening (reduced magnitude) of the peak biomass period in the northern section and to a lesser extent in the southern section.

This is a cooperation between Institute of Marine Research (IMR) in Norway (Contact person Randi Ingvaldsen, randi.ingvaldsen@imr.no) and Polar Research Institute of Marine Fisheries and Oceanography (PINRO) in Russia.

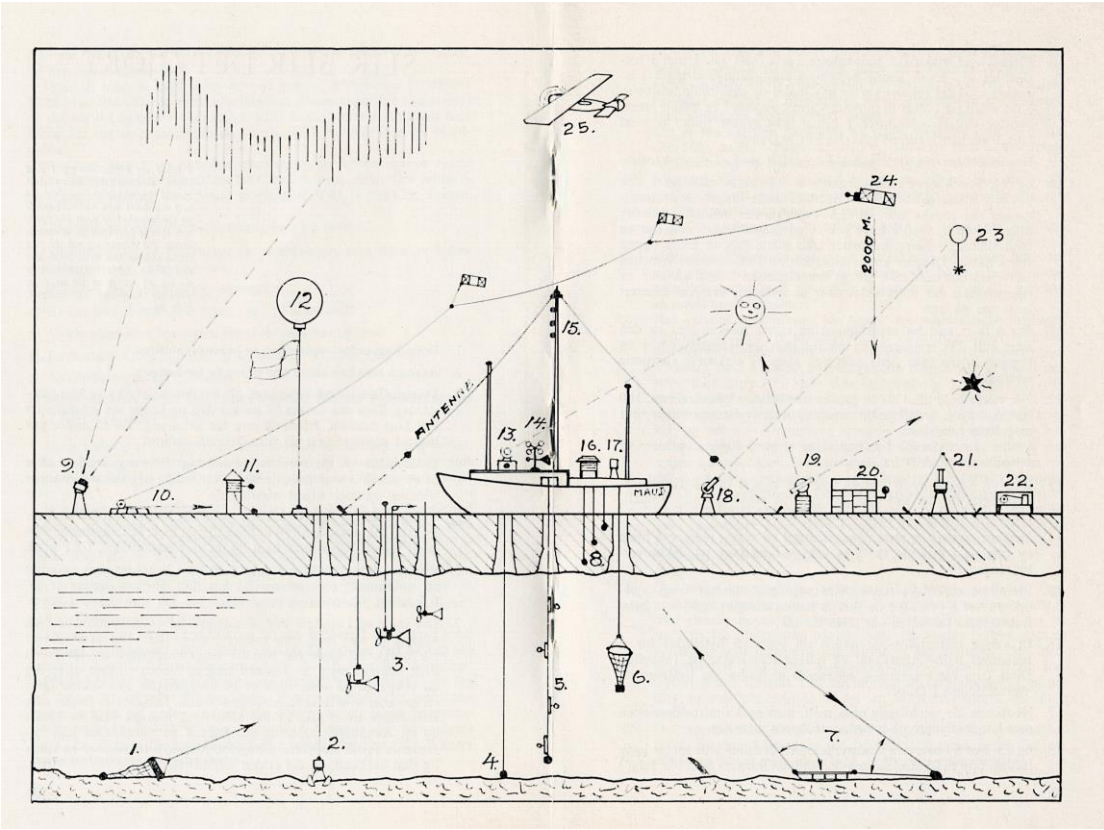
Main objective of the network:
1. Describe water mass distribution and properties
2. Document ocean climate variability as part of long time series
3. Relate ocean climate variability to variation in recruitment, growth, condition and size of commercial fish stocks Observations are taken by IMR from research vessels.

The programme is carried out in cooperation with Russia (PINRO) coordinated under the Joint Norway-Russia Fisheries Commission. The current meter moorings are shifted once a year.

Motivations

From no change→ to all about change→legacy

«The field for future exploration is tremendous»
Scientific work of the Maud 1922-1925; Harald U. Sverdrup, 1926.



The Maud Expedition (1918-1925) –
The Oceans (1942)


Harald Ulrik Sverdrup (1888-1957)
1 Sverdrup = 10^{-6} m^3 water per sec.

The measurements

Variable	Sampling	
Physical and chemical measurements		
Pressure	CTD	
Temperature	CTD	
Salinity	CTD + Niskin	
Dissolved Oxygen	CTD + Niskin	
Nutrients (NO_3/NO_2, PO_4, SiO_3)	Niskin	Physical-Chemical
CFCs and SF_6	Niskin	
Dissolved Inorganic Carbon	Niskin	
Total Alkalinity	Niskin	
pH	Niskin	
$\delta^{18}O$ of H_2O	Niskin	
Methane	Niskin	
Dissolved Organic Carbon (DOC)	Niskin	
Particulate Organic Carbon (POC)	Niskin	
Water column ecosystem measurements		
Chlorophyll	Niskin	
Primary production	Incubation	
Viruses	Niskin	
Bacteria	Niskin	
Phytoplankton composition	Niskin	
Microzooplankton	Niskin	
Meso-and Macro- zooplankton	Bongo nets, Multinet, Optical Instruments, Acoustics	Bio-Eco
Icthyoplankton	Aluette or Tucker Trawls, Acoustics	
Fish	Trawls, Acoustics	
Marine mammals	Passive acoustics, Visual observations	
Other Carbon transformation rates	Selected process studies (e.g., grazing, reproduction, sinking, respiration)	
Benthic measurements		
Meio- and Macro- fauna	Box Core or Multicore or other corers	
Epifauna	Benthic camera, Beam trawl	
Other Carbon transformation rates	Selected process studies (e.g., grazing, reproduction, sinking, respiration)	
Other		
Epontic Communities	Under-ice imaging, ice cores, sub-ice sampling	
Seabirds	Visual Observations