The Synoptic Arctic Survey (SAS) – towards 2020

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.»
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

- 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 surveys of the Arctic Ocean

- Creating a **backbone** for Arctic Ocean research
An international, researcher driven, initiative

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

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

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

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

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

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

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

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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 deep basins
The shelf seas
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?

Sweden, Oden

Russia, Barents,?

Norway, GO Sars (IMR)
KPH (Nansen Legacy) 2021

UK, highlight topic
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.

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.
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.

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\textsuperscript{*} (extrpl)
- 2036\textsuperscript{*}\textsubscript{q}
- 2061-2088 (CESM-LE)
- 2028 (GFDL)
- 2061 (MPI-ESM)
- 2063 (NorESM1)

Onarheim & Årthun (2017)
Developing the Synoptic Arctic Survey

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The Norwegian Contribution

GO Sars

Crown Prince Haakon
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 confirmed)

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 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

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

From no change→ to all about change→legacy

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

Harald Ulrik Sverdrup (1888-1957)
1 Sverdrup = 10^{-6} m³ water per sec.
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<td>Salinity</td>
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<tr>
<td>Dissolved Oxygen</td>
<td>CTD + Niskin</td>
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<td>Niskin</td>
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<td>Niskin</td>
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<td>Dissolved Inorganic Carbon</td>
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<td>pH</td>
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<td>Niskin</td>
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<td>Aluette or Tucker Trawls, Acoustics</td>
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<td>Passive acoustics, Visual observations</td>
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<td>Selected process studies (e.g., grazing, reproduction, sinking, respiration)</td>
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<td>Benthic measurements</td>
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<td>Meio- and Macro- fauna</td>
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