The International Synoptic Arctic Survey (SAS): Updates on 2021-2022 Field Program

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Pacific Arctic Group Virtual Business Meeting
November 24-25, 2020

https://synopticarcticsurvey.w.uib.no/
International Contributions to SAS: Pacific Arctic

- Earlier sea ice retreat, atmospheric changes, and northward advection of warming Pacific water into the region; opening light to region earlier

- SAS will have multiple transects into the basin in 2020-2022 as a pan-Arctic effort to better understanding status and trends in physical drivers, the carbon components, and ecosystem response

- Ecosystem pelagic & benthic components, including paired trawls and acoustics for fisheries (ship dependent)

- Twenty-two percent of the Central Arctic Ocean (CAO) is made up of ridges and continental shelves at fishable depths ≤2,000 meters

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

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Addressing Arctic Challenges Requires a Synoptic Ocean Survey

A coordinated effort involving trailblazing science—and icebreaking ships—from many nations is needed to fill gaps in our understanding of the Arctic Ocean and how it's changing.

In this 2007 photo, the Swedish icebreaker *Oden* (left) runs a seismic cable in the wake of the Russian nuclear-powered icebreaker *50 Let Pobedy*, which is plowing through heavy ice north of Greenland. The Synoptic Arctic Survey team plans to launch a coordinated multinational campaign using icebreaker ships to gather data in the Arctic Ocean beginning in 2020. Credit: Leif Anderson

[Paasche et al. 2019 Eos, Nov]
What are the present state and major ongoing transformations of the Arctic marine system? (specifically the ecosystem and carbon system)

• Describe the present state of the Arctic Ocean to provide the foundation against which future states can be compared to quantify change.

• Three key foci:
  1) Physical drivers of importance to the ecosystem and carbon cycle,
  2) Ecosystem response, and
  3) Carbon cycle and ocean acidification

• Envisioned to repeat each decade
The short-term results of the SAS project will provide a unique baseline of the Arctic Ocean (slopes and basin) summer conditions to which both historic and future observations can be compared.

A synoptic picture with SAS data sets are a prerequisite for detecting changes of the many components of the Arctic Ocean system, be it the physics, biology or chemistry components.

ASSW21 SAS session (#17)-abstract submission open; see link for summary of session to includes updates on field results and future planned activities, including synthesis.
Atlantic Water core temperature (defined by potential temperature maximum) and associated salinity from 1980 to 2015 over the Arctic slope

[Bluhm et al. 2020, FMAS]

- Increase of AW core temperature (defined by potential temperature maximum) and associated salinity from 1980 to 2015 over the Arctic slope from 1980 to 2015 (Igor Polyakov data in Bluhm et al. 2020)
Biomass distribution of mesozooplankton over slopes

- Vertically integrated dry weight biomass of mesozooplankton over slopes (20 to bottom depth of ≥1000 m) show enhanced biomass over slopes (modified from Kosobokova and Hirche, 2009, Smoot and Hopcroft, 2017)

Increase at lower slope region 1000m

[Bluhm et al. 2020, FMAS]
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

[Bluhm and Grebmeier 2011]
Macrofaunal Benthic Biomass over shelf-slope in the Pacific and Atlantic Arctic

- Macrofaunal biomass highest on upper slope downstream of Barrow Canyon within Pacific Arctic inflow to Arctic Basin

- By comparison, macrofaunal biomass highest on the lower NE Barents Sea slope of Atlantic inflow to Arctic Basin

[Bluhm et al. 2020, FMAS]
Proposed USA SAS Cruise, Aug-Sept 2021

[USCGC Healy or other international icebreaker; coordination with other ongoing cruises]


[courtesy Carin Ashjian and US SAS SSC]
nations have plans only for 2020 (Sweden, China) and others have plans or proposed plans for 2021 (Norway, Russia, US/this proposal), with survey regions synergistically encompassing much of the Arctic Ocean (Fig. 1). This proposed US effort focuses on the Canadian Basin, with linkages to the Chukchi Sea continental shelf and Beaufort Gyre system. These linkages will be provided not only through sampling along a proposed cruise track that intersects those dynamic regions but also through synergies and collaborations with scientists from China, Korea and Japan who will be working in the Pacific Arctic in 2020 and 2021. Additional coordination is planned with scientists in the Beaufort Gyre Observing System (BGOS) Program (Timmermans PI, proposed 2020-24), the Distributed Biological Observatory (DBO; Moore and Grebmeier 2018) on the Bering, Chukchi and Beaufort shelves (Cooper and Grebmeier PIs), and the year-round Chukchi Ecosystem Observatory (CEO) moorings on the NE Chukchi shelf (Danielson PI).

3. **Background**

The Pacific Arctic/Canadian Basin marine system upper water column is significantly influenced by seasonal sea ice and inflow of heat, water, nutrients and biota through Bering Strait from the northern Bering Sea/Pacific Ocean (Aagaard et al. 1981). Seasonal sea ice in Pacific-influenced waters has been declining in summer extent and temporal persistence since at least the start of the satellite record in 1979, with vast regions in this Arctic Ocean sector now essentially ice-free by mid-summer (Frey et al. 2015) and the largest Arctic Ocean sea-ice losses recorded in the Chukchi/Beaufort Sea regions (Serreze et al. 2016). Historically, the Pacific signature extended off the Chukchi Shelf into the Canada Basin and along the Chukchi Cap, diminishing to the north (Steele et al. 2004; Codispoti et al. 2005). With ongoing declines in seasonal sea ice and increases in northern transport driven by changing atmospheric patterns (e.g., Woodgate 2018), the northern extent of influence, relative volume and heat content of the Pacific Water may be increasing (e.g., Timmermans et al. 2018). Similarly, Atlantic Water at depth has been warming since the start of the century (e.g., Polyakov et al. 2012), with likely impacts on the ocean heat budget, stratification, and sea ice melt. These play important roles in shaping the hydrography, carbon dynamics, and ecosystems.

**Box 2. Essential Ocean Variables (EOVs) of the SAS**

(* indicates variable here proposed to be measured)

**Physical**

Pressure*
Temperature*
Salinity*
Velocity*
Transmissivity*
Meteorological Measurements*
Ice Characteristics
Microstructure
Seafloor Depth*
Sediment Characteristics*
Gravimetry*, Magnetometry

**Biogeochemistry**

Dissolved Oxygen*
Nutrients (NO₃/NO₂, PO₄, SiO₃)*
CDOM Fluorescence
Chlorophyll* (pelagic, benthic)
CFCs and SF₆
DIC*, DOC*, POC*
Total Alkalinity*
pH*
Methane

**Ecosystem**

Abundance/Biomass of Viruses, Bacteria, Phytoplankton, Micro- Meso-*, and Macrozooplankton, Benthic Meio-, Macro-*, and Epi-fauna, Epontic Organisms, Ichthyoplankton, Fish, Seabirds, Marine Mammals
Net Community Production from O₂-Ar* & Nutrients
Primary Production (¹³C incubations, O₂ Isotopes*)
Respiration of Different Trophic Levels*
Elemental Composition* (C, N, stable isotopes)
eDNA
Molecular Voucher Specimens*

- Essential Ocean Variables (EOVs) as part of SAS activities (*EOVs in US NSF proposal)
- Goal: Standardize select variable for all SAS cruises
- Added additional variables for atmospheric and satellite observations
- NSF proposal by US SAS Science Advisory Committee-submitted Sept 2020
- If successful, 50% ship open for other participants to submit proposals (national and international participants; also will connect with ongoing shelf science programs
- Have suggested that SAS could be a “flagship” activity of IARPC (US Interagency Arctic Research Policy Committee)
International SAS Cruises: Confirmed and Planned

Canada, USA (white lines) - collaborations: JOIS/AON-BGOS (Williams/Proshutinsky, Louis S St. Laurent (LSSL), 2020-2021); LIA-MPA (Michel, LSSL)

LIA-MPA (Michel, LSSL), 2020-2021;

Sweden, Oden – planned 2022

Canada/Denmark: Pikialasorsuaq Project and BBOS - 2021 (2022)

Denmark: Polar Dream Project (Dana, 2021)

Canada, USA (white lines) - Davis Strait (Lee/Azetsu-Scott, Armstrong), 2020 (2021)

Japan, Mirai – 2020 - 2022

Korea, ARAON – 2020 – 2022

USA, Healy – this proposal 2022

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China, Xuelong – 2020, 2021?

Russia, Germany, Switzerland – 2021

Norway, Kronprins Haakon (Nansen Legacy, 2021 or 2022-solid), G.O. Sars (IMR-dotted); leveraging existing programs

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[updated B. Williams and J. Grebmeier, Sept 2020]
Abstract
The Central Arctic Ocean remains profoundly understudied, particularly carbon cycling, ecosystem alteration, and associated changes in atmosphere, ice and ocean physics that influence those biological and biogeochemical systems. The region is expected to continue to make marked changes over the next decades, driven by ongoing climate warming, yet our understanding of key process is limited for this area. The international Synoptic Arctic Survey (SAS) seeks to quantify the present states of the physical, biological, and biogeochemical systems of the Arctic Ocean. Multiple countries have both confirmed and pending cruises as part of the 2020/2021 SAS networked activities. Key goals of the SAS are to establish the present state of the Arctic system, to document temporal changes where possible through comparison with historical data, and to quantify linkages between the adjacent shelves, slopes, and deep basins, objectives that are shared with the broader Pan-Arctic effort of the composite SAS. The SAS consists of regional shelf-to-basin ship-based surveys in 2020 and 2021 to obtain a Pan-Arctic understanding of essential ocean variables (EOVs) on a quasi-synoptic, spatially distributed basis in which no single nation bears the full burden of collecting the requisite data. The multi-country field effort will provide a strong basis for educational opportunities for early career scientists. This SAS session will outline the benchmark and important legacy for SAS activities to future, quasi-decadal assessments of rapid and evolving Arctic Ocean system change. Updates on the 2020 SAS field program results and upcoming national plans for 2021 activities will be provided during the session.
Thank you for your attention. Any questions?

http://www.synopticarcticsurvey.info/splan.html
https://web.whoi.edu/sas2019/

SAS Virtual workshop #17; abstracts due for ASSW2020 November 30 2020