Phytoplankton Blooms in the warming Chukchi Sea: Two cruises on R/V Norseman II

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R/V Norseman II in Barrow Canyon
photo by Y. Iida
Goals of the project

- Improve our understanding of phytoplankton dynamics in the Chukchi Sea
- Identify locations and quantify the magnitude of harmful algal blooms (HABs)
- Map the distribution of HAB cysts in the sediments
- Understand how the circulation, water properties, and atmospheric forcing influence these things
**Leg 1 Shipboard Sampling**

**Physical Oceanography**
- CTD
- SADCP
- Imaging FlowCytobot (underway plankton imagery)
- Whole cell water samples (Alexandrium enumeration)
- Water Filtration (Pseudo-nitzschia DNA and domoic acid detection)
- Net tows and underway water sampling (Algal Toxins)
- Invertebrate Clam/Worm collections (Food web toxin detection)
- Surface sediments (cyst mapping)
- Multi-cores (vertical cyst distribution, PET experiments)

**HABs**
- Nutrients
- Dissolved oxygen/argon ratios (O2/Ar)
- Pigment (Chlorophyll and phaeopigments) concentrations in particulate (filter) samples
- Organic carbon and nitrogen concentrations in particulate (filter) samples (POC, PN) and sediment samples (%OC, %N)
- Fast Repetition Rate Fluorometry (phytoplankton nutritional status)
- 13C and 15N uptake incubations (primary productivity rates)
- Optical properties (backscatter, chlorophyll fluorescence, particle size) from underway system

**Biogeochemistry**
Scenes from the ship
Leg 1: 19 Jul – 15 Aug 2022

Norseman II 2022-01S HABs
We sampled a massive harmful algal bloom starting southwest of St Lawrence Island.

IFCB measurements: concentration of *Alexandrium Catenella* (cells/L)
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23 Jul – 8 Aug

8 – 14 Aug

17 – 31 Aug

31 Aug – 2 Sep

Leg 1 northward

Leg 1 southward

Leg 2 northward

Leg 2 southward
23 Jul – 8 Aug

8 – 14 Aug

17 – 31 Aug

31 Aug – 2 Sep

Leg 1 northward

Leg 2 northward

Leg 1 southward

Leg 2 southward
Measurements in Bering Strait, Leg 1  28-29 July

Zooming in on Bering Strait, the highest *Alexandrium* cell counts are in the Central branch of the flow. Note that part of this branch veers into Russian waters.
Coming back south in leg 1 we encountered much higher cell concentrations, especially in Kotzebue Sound.
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Vectors depict the Alaskan Coastal Current
Coming back south in leg 1 we encountered much higher cell concentrations, especially in Kotzebue Sound.

This is likely due to the strong winds from the south that accelerated the Alaskan Coastal Current and caused it to veer to the east.

29-31 July

10-12 Aug

Vectors depict the Alaskan Coastal Current
Leg 2 Shipboard Sampling

Physical Oceanography
- CTD
- SADCP
- Oxygen and nutrients
- Oxygen/argon ratios (O2/Ar)
- Oxygen isotope ratios (16O, 17O, 18O) in collected water samples
- Pigment (Chlorophyll and phaeopigments) concentrations in particulate (filter) samples
- Total suspended solid concentrations in particulate (filter) samples
- Organic carbon and nitrogen concentrations in particulate (filter) samples (POC, PN) and sediment samples (%OC, %N)
- Fast Repetition Rate Fluorometry (to evaluate phytoplankton nutritional status)
- 13C and 15N uptake incubations (to measure primary productivity rates)
- Optical properties (backscatter, chlorophyll fluorescence, particle size) from underway system
- DON
- bulk nitrate, ammonium, urea, and amino acid uptake rates
- single cell nitrate, ammonium, urea, and amino acid uptake rates

Biogeochemistry

HABs
- Imaging FlowCytobot (underway plankton imagery)
- Whole cell water samples (Alexandrium enumeration)
- Water Filtration (Pseudo-nitzschia DNA and domoic acid detection)
- Net tows and underway water sampling (Algal Toxins)
Scenes from the ship
Leg 2: 17 Aug – 6 Sep 2022
Leg 2 sampled the northern Chukchi shelf
Leg 2 sampled the northern Chukchi shelf
Leg 2 sampled the northern Chukchi shelf

Hanna Shoal section
Between the two cruises we occupied the following DBO lines

- DBO2: 1 occupation
- DBO3: 2 occupations
- DBO4: 1 occupation
- DBO5: 3 occupations
- Bering Strait: 3 occupations
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- Bering Strait: 3 occupations

435 CTD stations
120 surface sediment grabs
15 multi-cores
47 phytoplankton net tows
Between the two cruises we occupied the following DBO lines:

- DBO2: 1 occupation
- DBO3: 2 occupations
- DBO4: 1 occupation
- DBO5: 3 occupations
- Bering Strait: 3 occupations
Monitoring the Western Arctic Boundary Current in a Changing Climate: A late-season cruise on R/V Sikuliaq

Principal Investigator: Robert Pickart, Woods Hole Oceanographic Institution

Funded by: the National Science Foundation – Office of Polar Programs, Arctic Observing Network

Beaufort Sea in November (photo by A. Pacini)
Goals of the project

- Service the long-term mooring located in the Beaufort Sea boundary current east of Pt Barrow
- Carry out a hydrographic/velocity/tracer survey of the boundary current system from Bering Strait to the Canadian Beaufort
- Provide a platform for ancillary programs, including underway biogeochemistry, HABs, oxygen isotopes in the water column and air, sediment coring, and black carbon
# Shipboard Sampling

## Physical Oceanography
- CTD
- SADCP
- Microstructure
- Mooring work

## Biogeochemistry
- Oxygen and nutrients
- Oxygen/argon ratios (O2/Ar)
- $\delta^{18}O$ and $\delta^2H$ in seawater and $\delta^{18}O$, $\delta^{17}O$, $\delta^2H$ in marine air
- DOC
- Black Carbon
- Cores for biomarkers and microfossils

## HABs
- Water Filtration (Pseudo-nitzschia DNA and domoic acid detection)
- Whole cell water samples (Pseudo-nitzschia enumeration)
- Invertebrate Clam/Worm collections (Food web toxin detection + lab experiments)
- Surface sediments (cyst mapping)
- Multi-cores (vertical cyst distribution)
mooring recovery

photo by A. Kowalski

mooring deployment

photo by A. Kowalski
CTD ops in the ice

multi-core recovery
Vibracore (4–6 m cores)
Hydrographic stations occupied on R/V Sikuliaq 1 Nov – 3 Dec 2022
Beaufort shelf/upper-slope sections
viewer is looking to the west
viewer is looking to the west

positive velocity is eastward
Beaufort shelf/upper-slope sections

Presence of winter water
Distinguishing component water masses using isotopes $\delta^{18}$O, $\delta$D (deuterium excess)
Distinguishing component water masses using isotopes $\delta^{18}$O, $\delta$D (deuterium excess)
Depth-averaged flow 0–100m
Depth-averaged flow 0–100m
Depth-averaged flow  0–100m
Depth-averaged flow 0–100m
Depth-averaged flow  0–100m

20 cm s⁻¹
Depth-averaged flow 0–100m
Depth-averaged flow  0–100m
Depth-averaged flow 0–100m
occupying Prudhoe line

S. Roberts, UAF
occupying Colville line
Advective speed ~100 km/day  open water tongue speed ~15 km/day
Autumn Barrow Canyon warm water outflow event: vectors (Nov 2018) and ice edge (Nov 2022)
On the cruise we occupied the following DBO lines

- DBO3
- DBO5
- DBO6
- Bering Strait
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171 CTD stations
69 surface sediment grabs
10 long cores
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Thank you