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

Team of Investigators: Donald Anderson, Robert Pickart, *Woods Hole Oceanographic Institution*
Miguel Goni, Lauren Juranek, *Oregon State University*
Dean Stockwell, *University of Alaska, Fairbanks*

Funded by: the National Science Foundation – Office of Polar Programs

R/V Norseman II in Barrow Canyon
photo by Y. Iida

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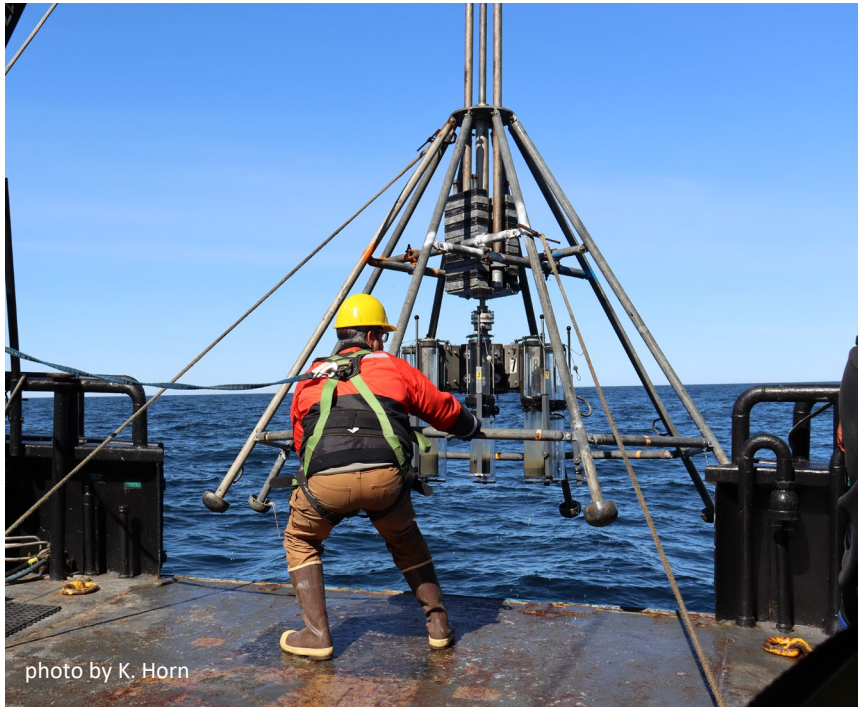
Goals of the project

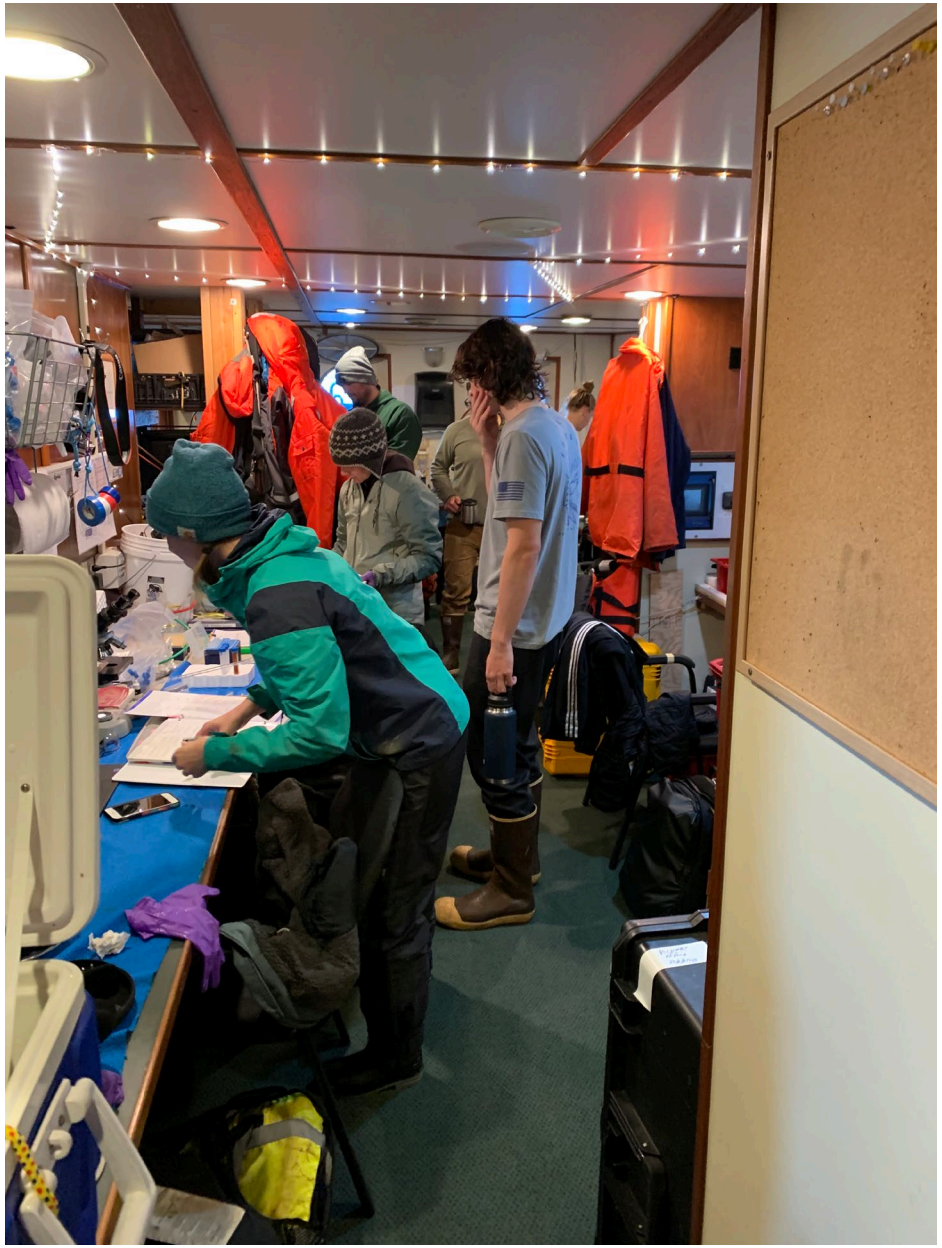
- Improve our understanding of phytoplankton dynamics in the Chukchi Sea
- Identify locations and quantify the magnitude of harmful algal blooms (HABs)
- Map the distribution of HAB cysts in the sediments
- Understand how the circulation, water properties, and atmospheric forcing influence these things

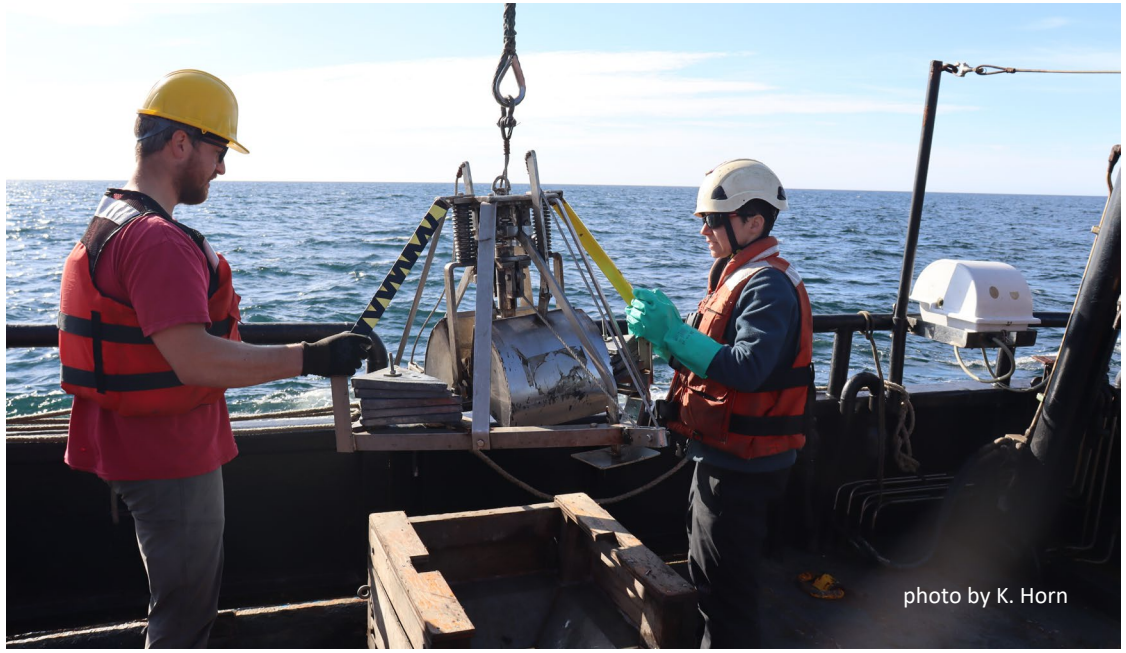
Leg 1 Shipboard Sampling

Physical Oceanography	• CTD • SADCP
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) • Invertebrate Clam/Worm collections (Food web toxin detection) • Surface sediments (cyst mapping) • Multi-cores (vertical cyst distribution, PET experiments)
Biogeochemistry	• 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

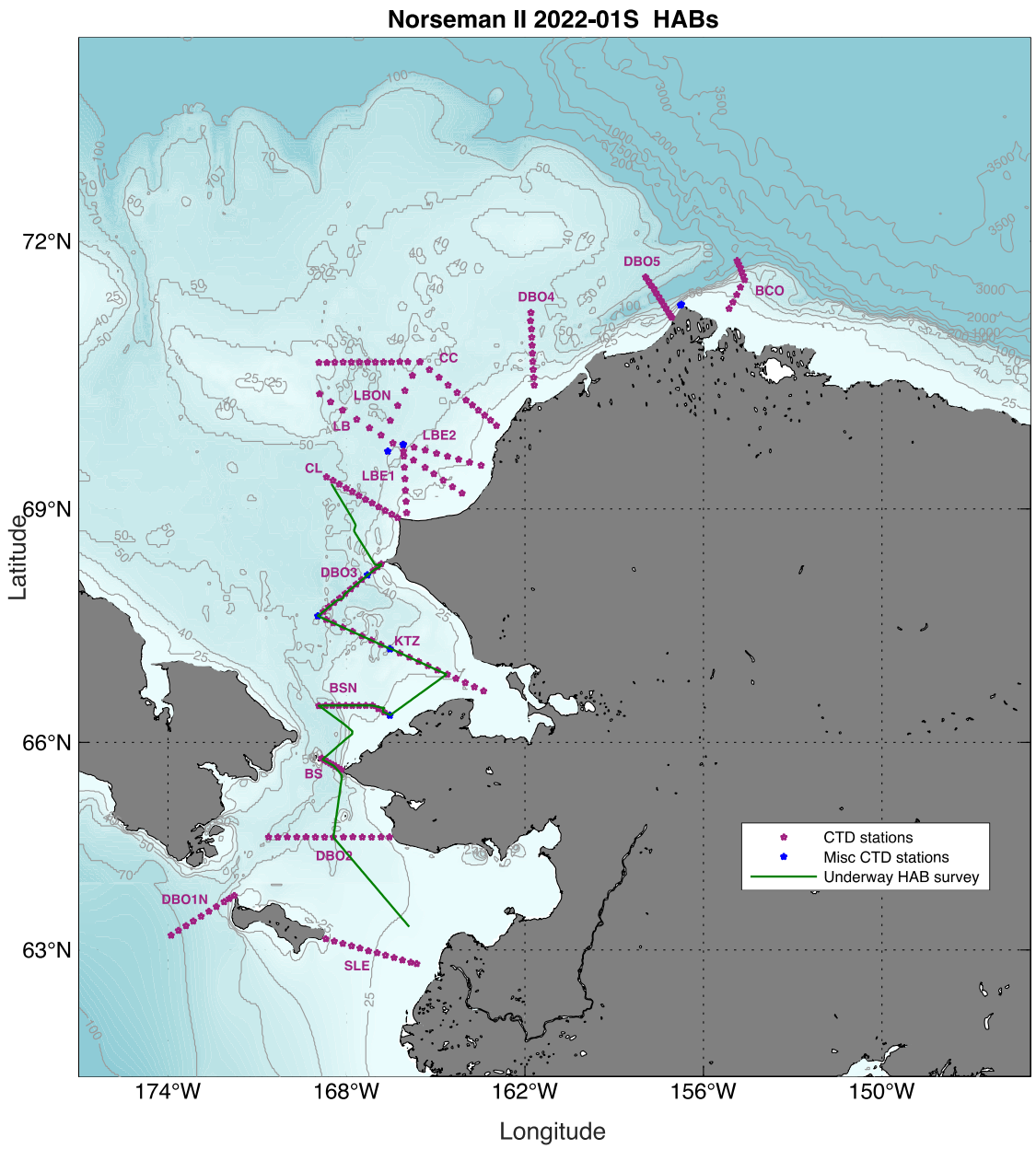
Scenes from the ship





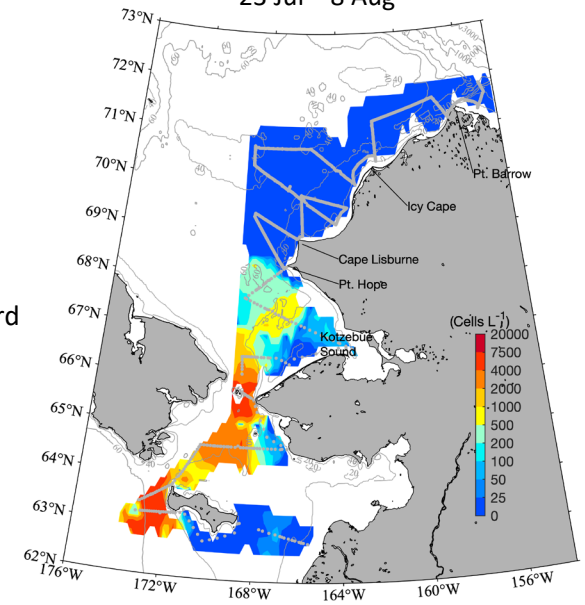


Leg 1: 19 Jul – 15 Aug 2022



23 Jul – 8 Aug

Leg 1 northward



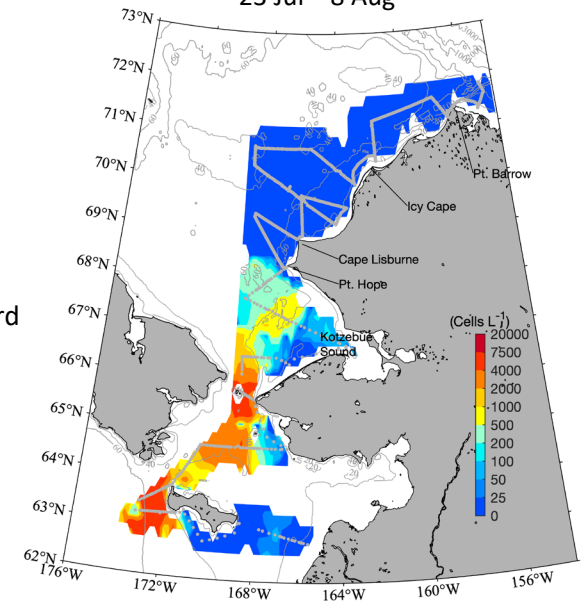
We sampled a massive harmful algal bloom starting southwest of St Lawrence Island

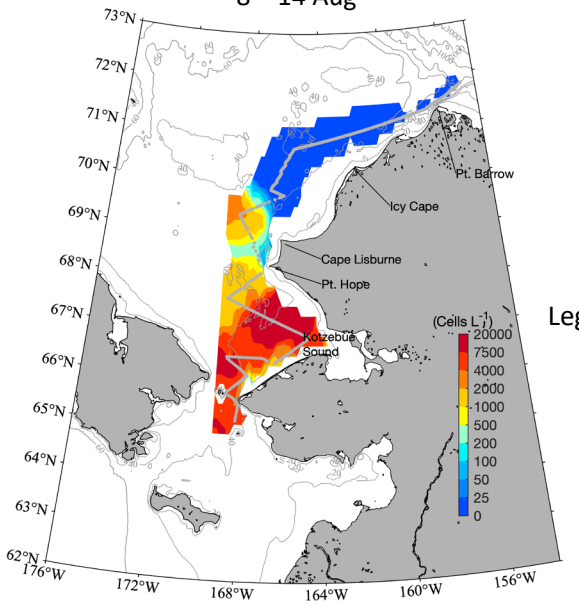
IFCB measurements: concentration of *Alexandrium Catenella* (cells/L)

23 Jul – 8 Aug

8 – 14 Aug

Leg 1 northward



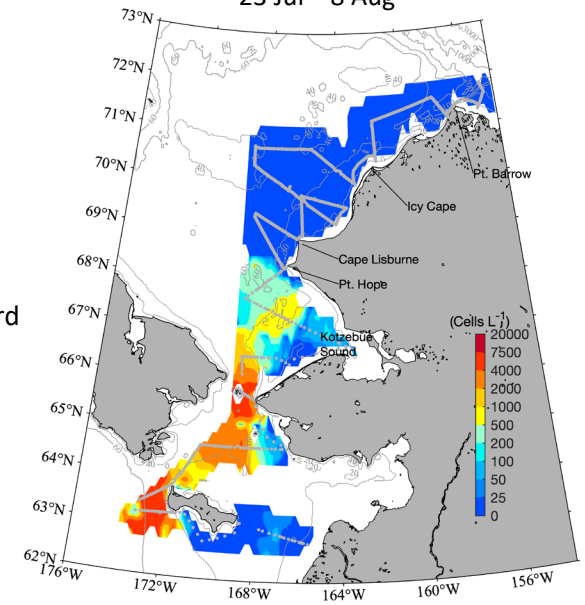


Leg 1 southward

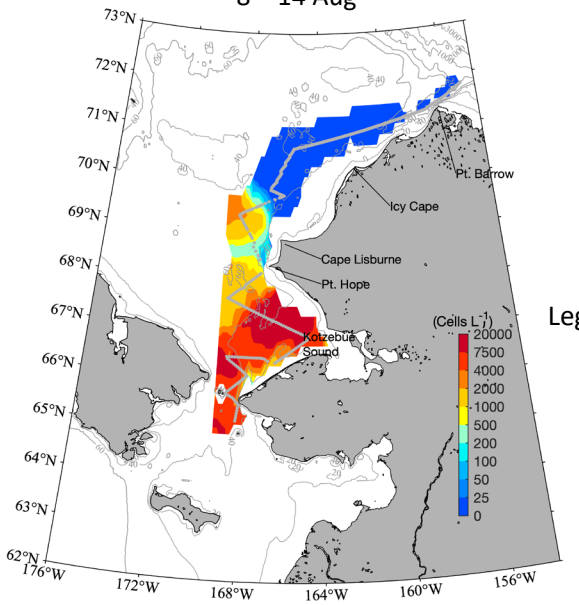
IFCB measurements: concentration of *Alexandrium Catenella* (cells/L)

Leg 1 northward

23 Jul – 8 Aug



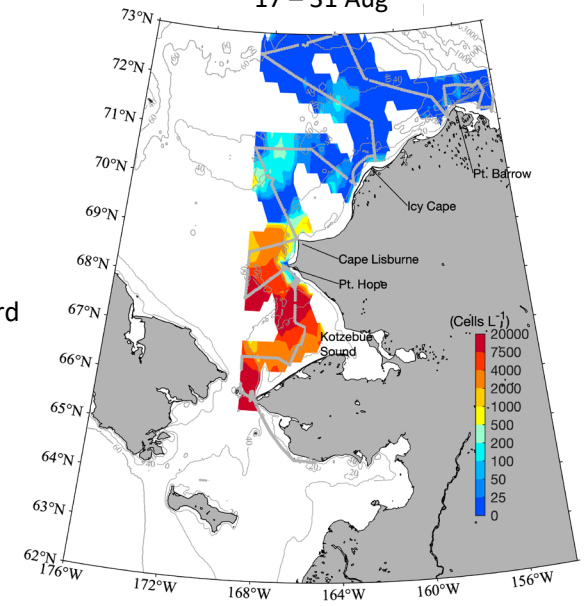
8 – 14 Aug



Leg 1 southward

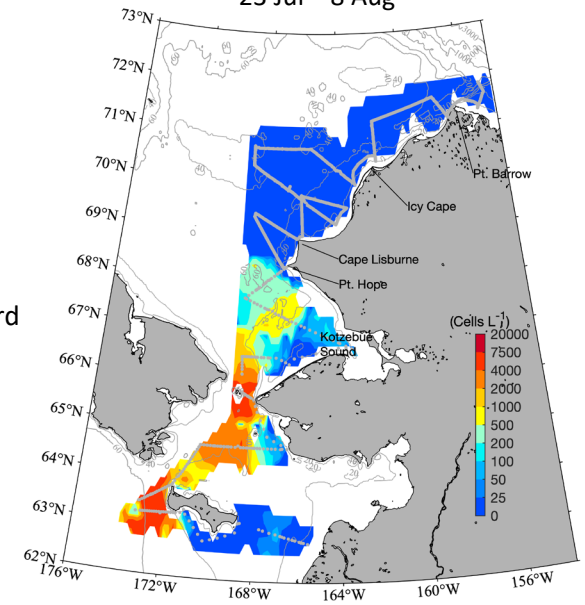
Leg 2 northward

17 – 31 Aug



23 Jul – 8 Aug

Leg 1 northward



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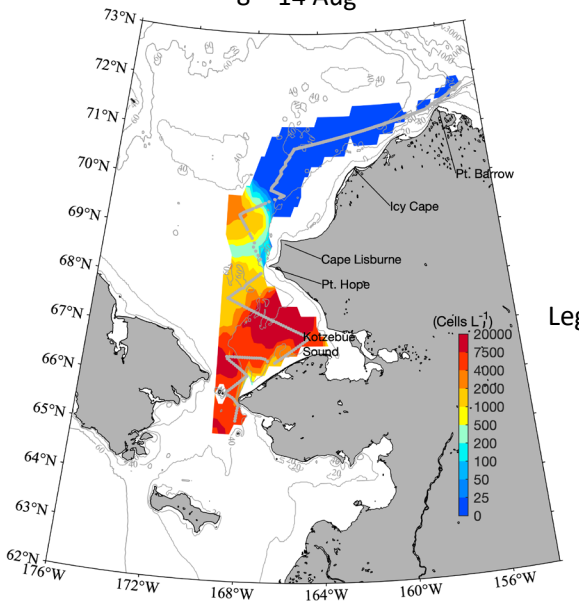
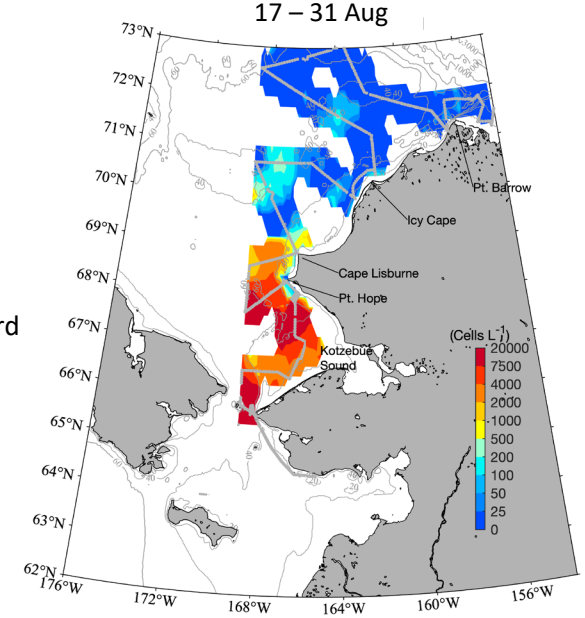


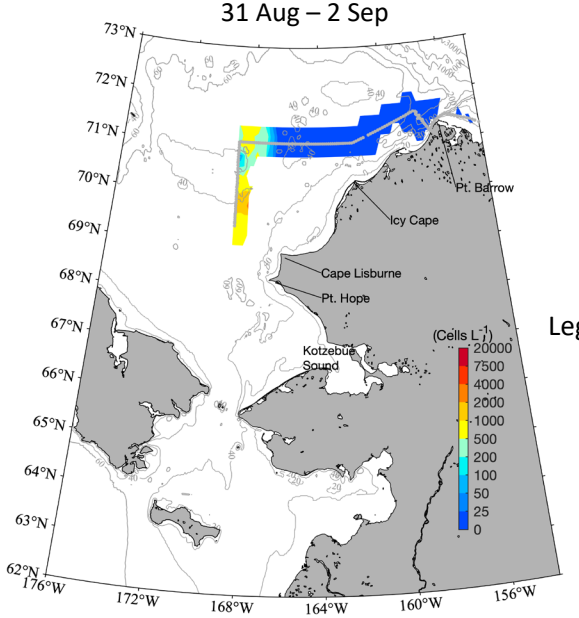
17 – 31 Aug

Leg 2 northward



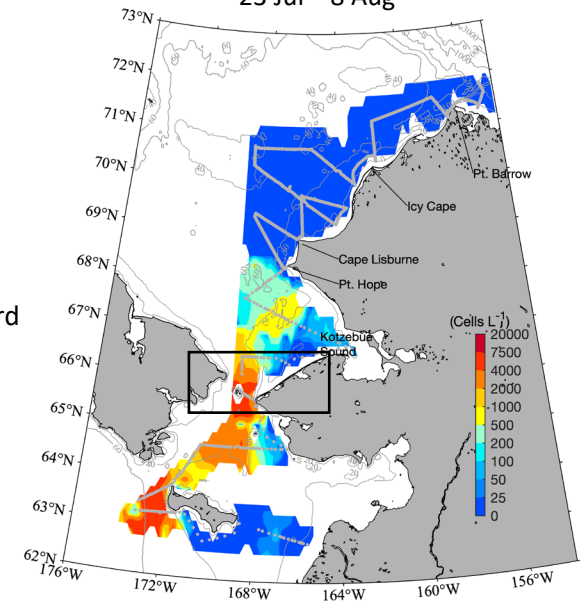
31 Aug – 2 Sep

Leg 2 southward



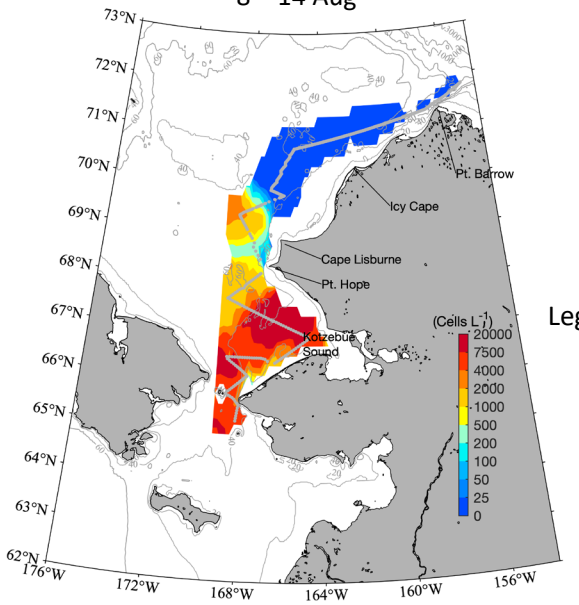
23 Jul – 8 Aug

Leg 1 northward



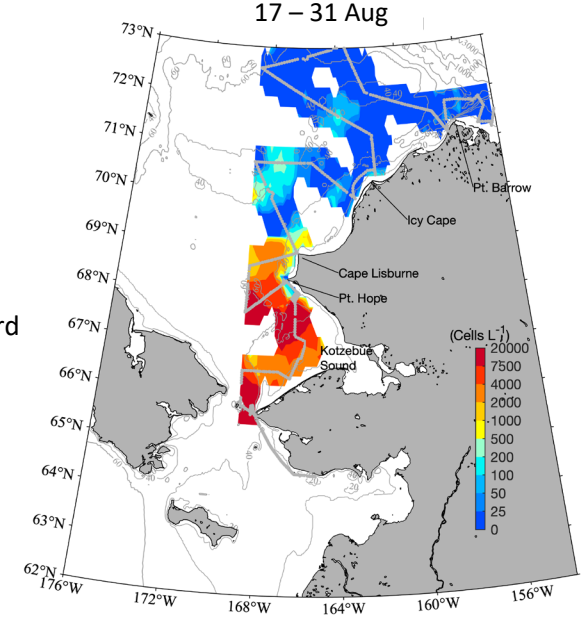
8 – 14 Aug

Leg 1 southward



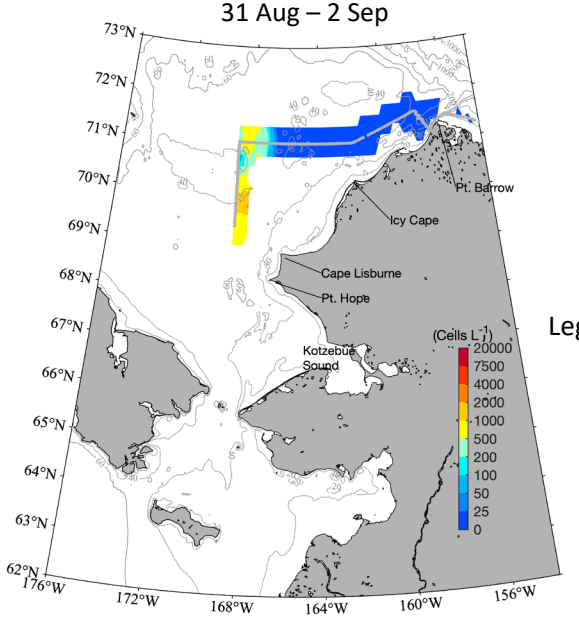
17 – 31 Aug

Leg 2 northward

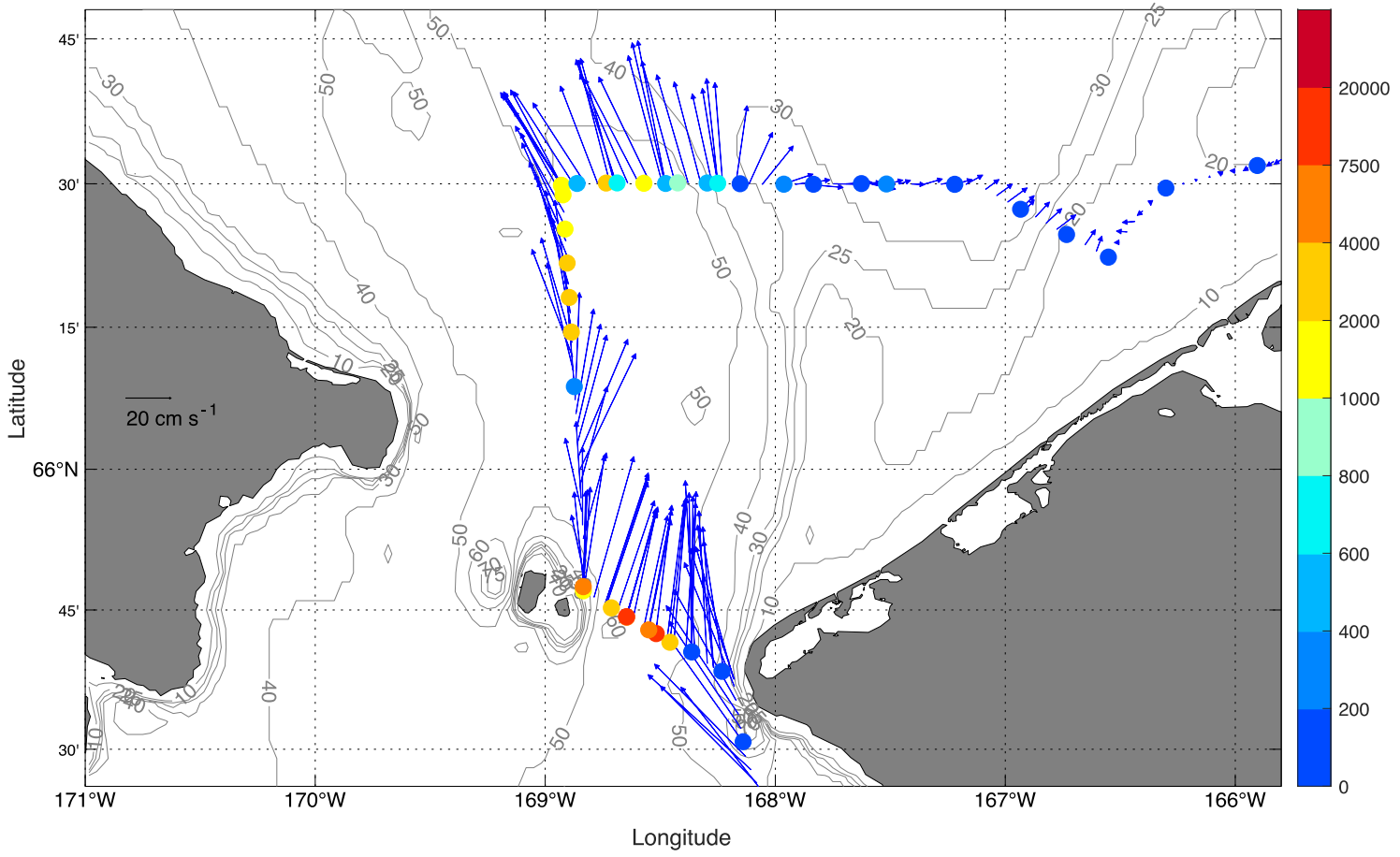


31 Aug – 2 Sep

Leg 2 southward



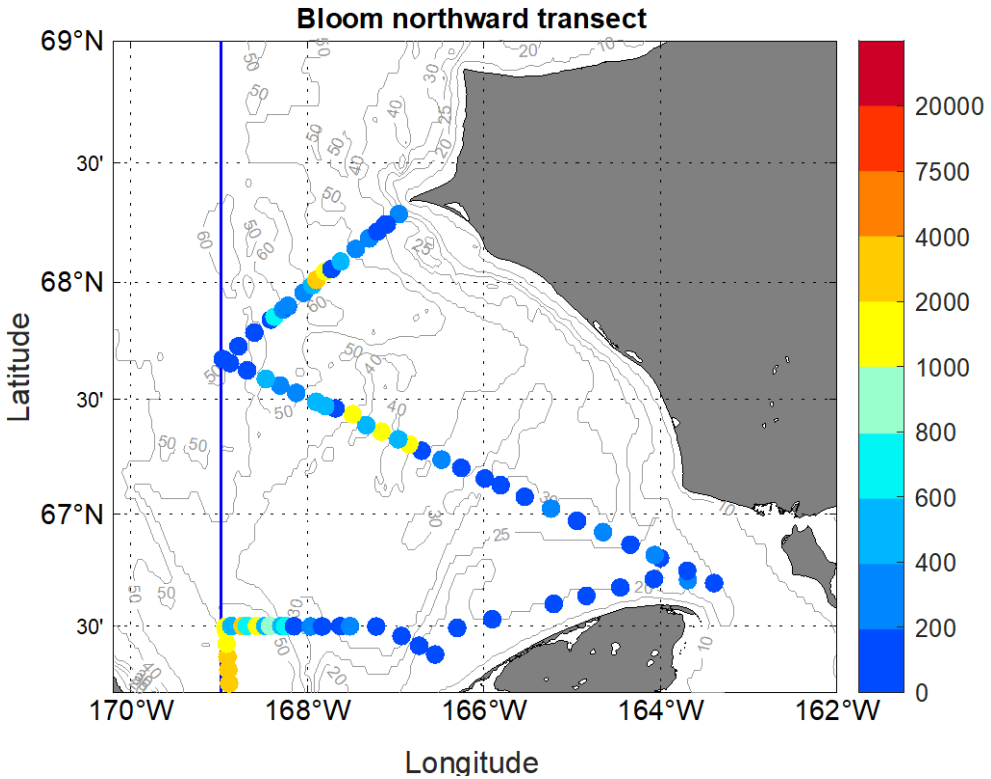
Measurements in Bering Strait, Leg 1 28-29 July



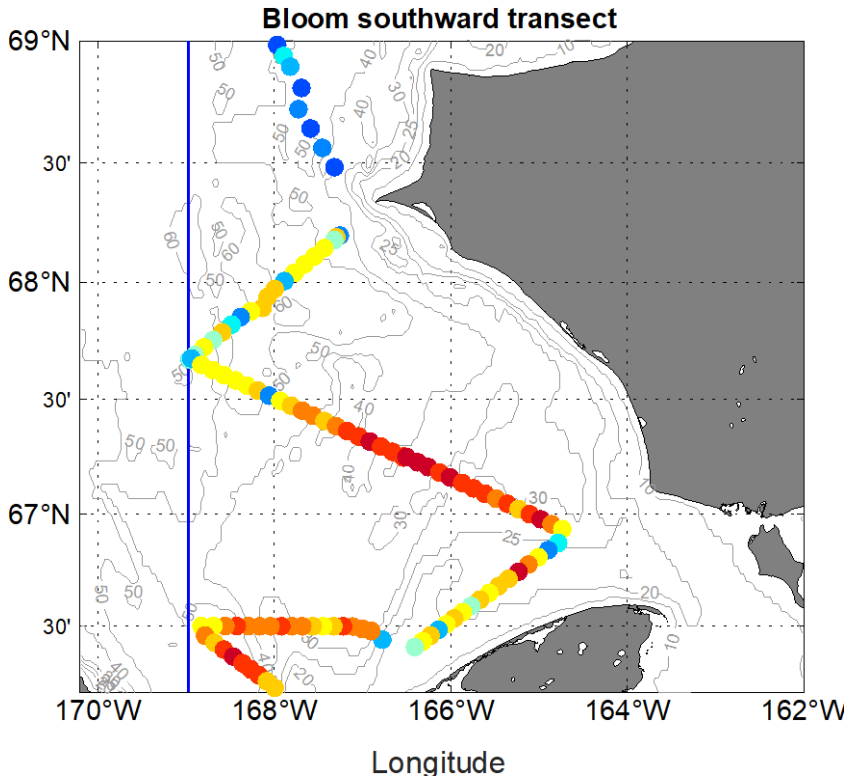
Zooming in on Bering Strait, the highest *Alexandrium* cell counts are in the Central branch of the flow. Note that part of this branch veers into Russian waters.

Coming back south in leg 1 we encountered much higher cell concentrations, especially in Kotzebue Sound.

29-31 July



10-12 Aug



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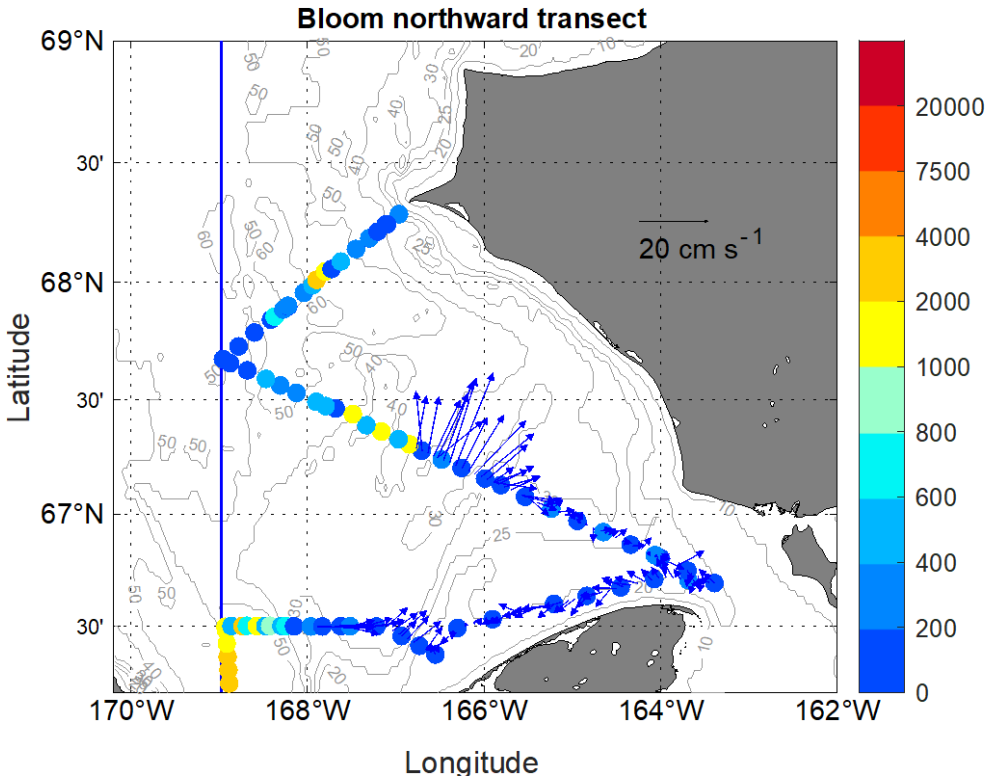

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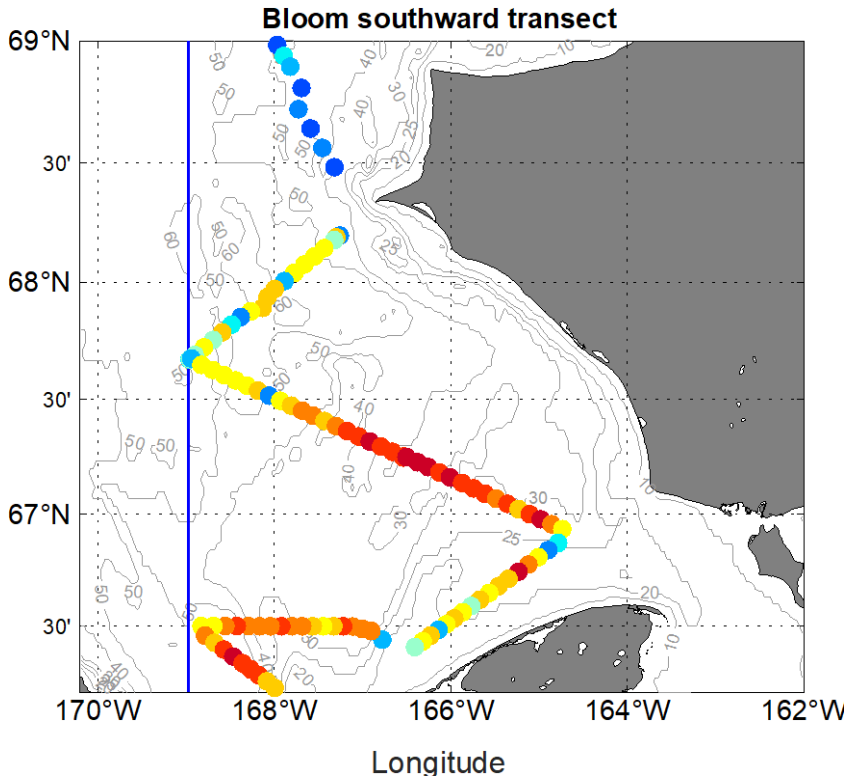
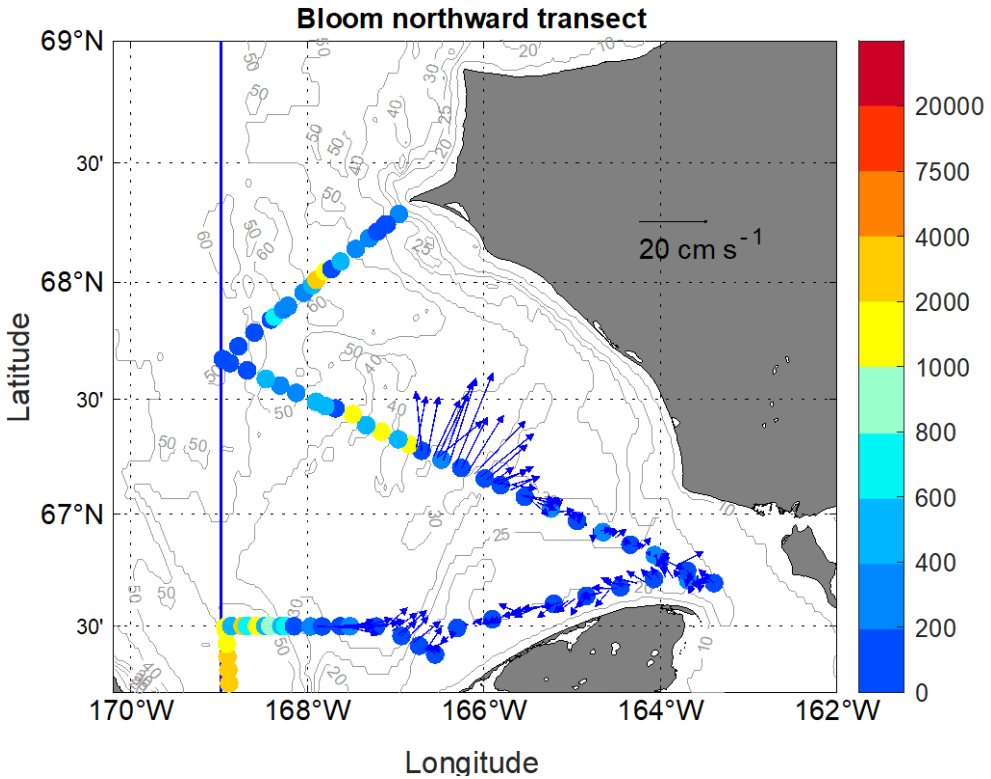


Vectors depict the Alaskan Coastal Current

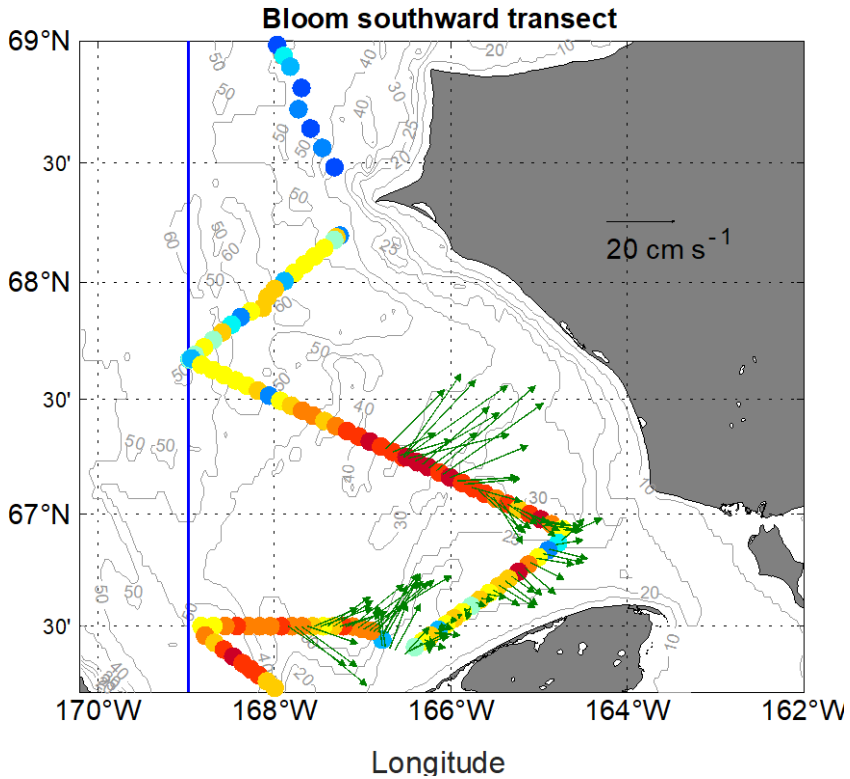
Coming back south in leg 1 we encountered much higher cell concentrations, especially in Kotzebue Sound.

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

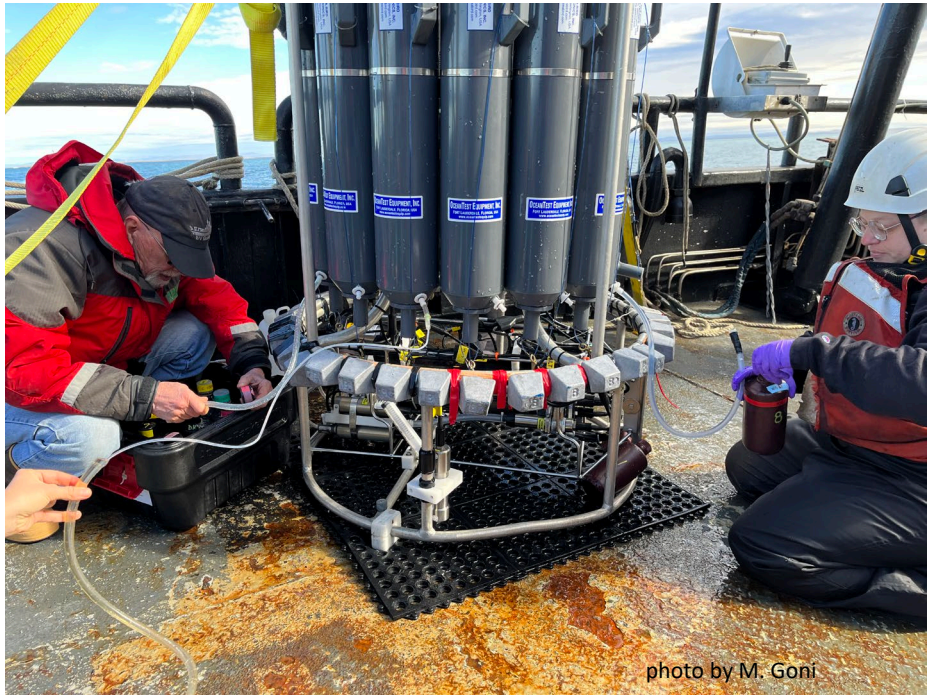


Vectors depict the Alaskan Coastal Current

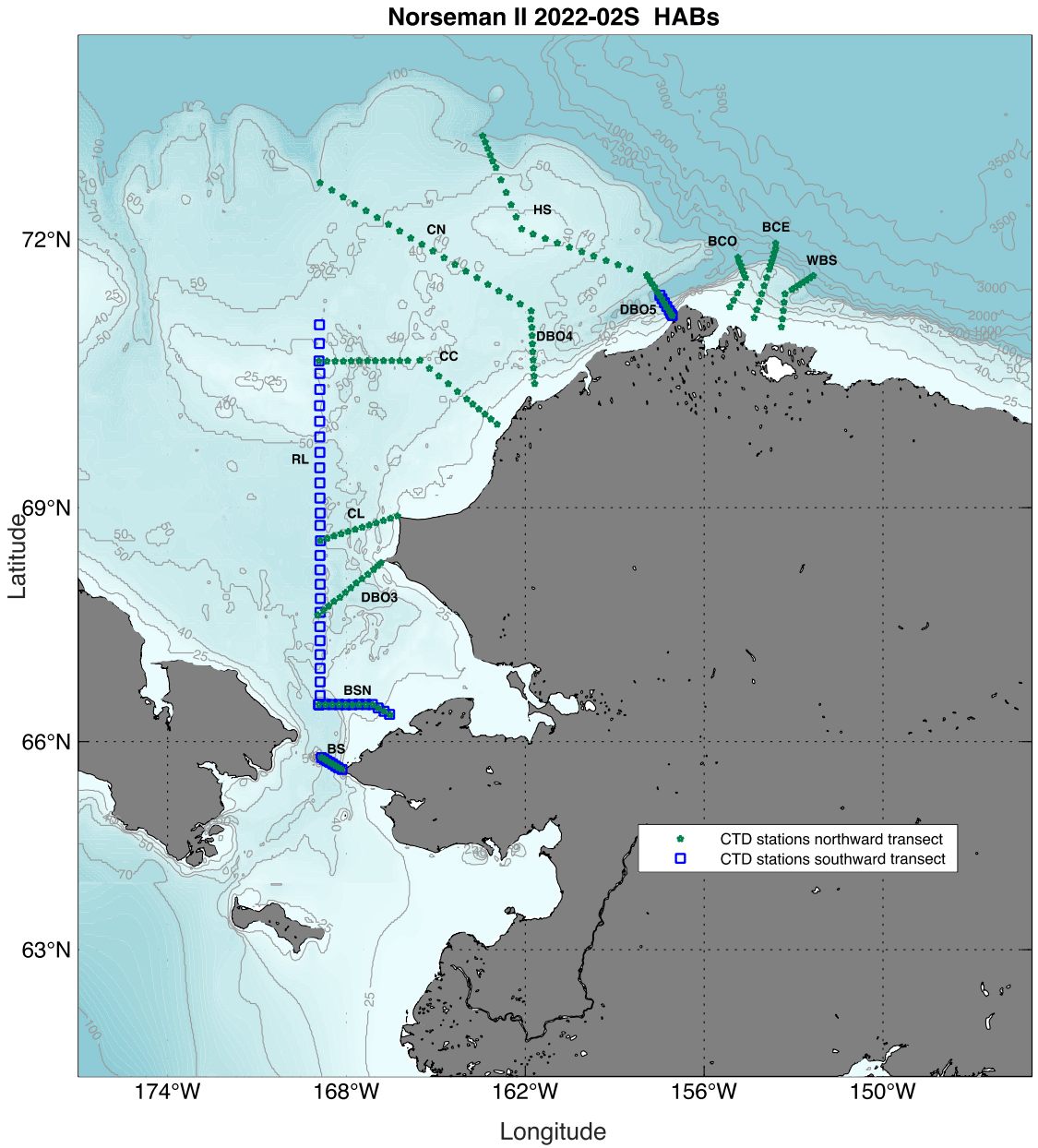
Leg 2 Shipboard Sampling

Physical Oceanography	• CTD • SADCP
Biogeochemistry	• 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
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)

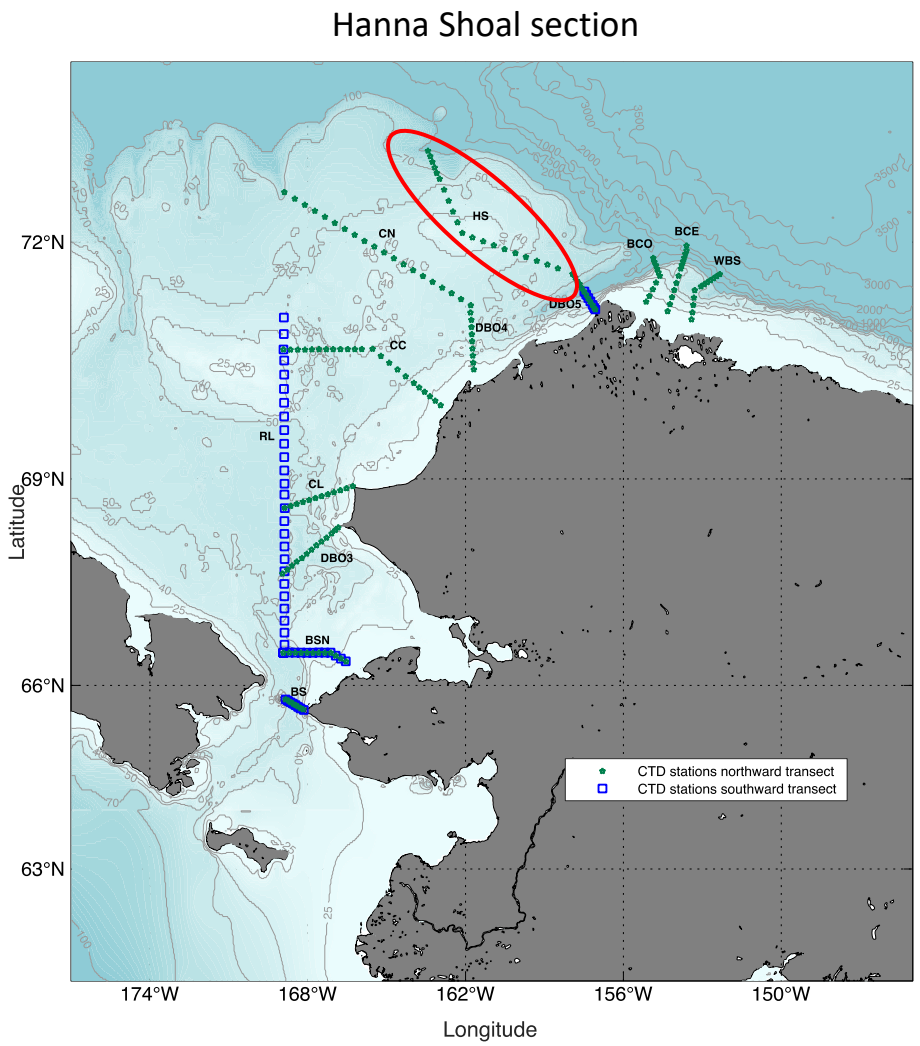
Scenes from the ship



Leg 2: 17 Aug – 6 Sep 2022

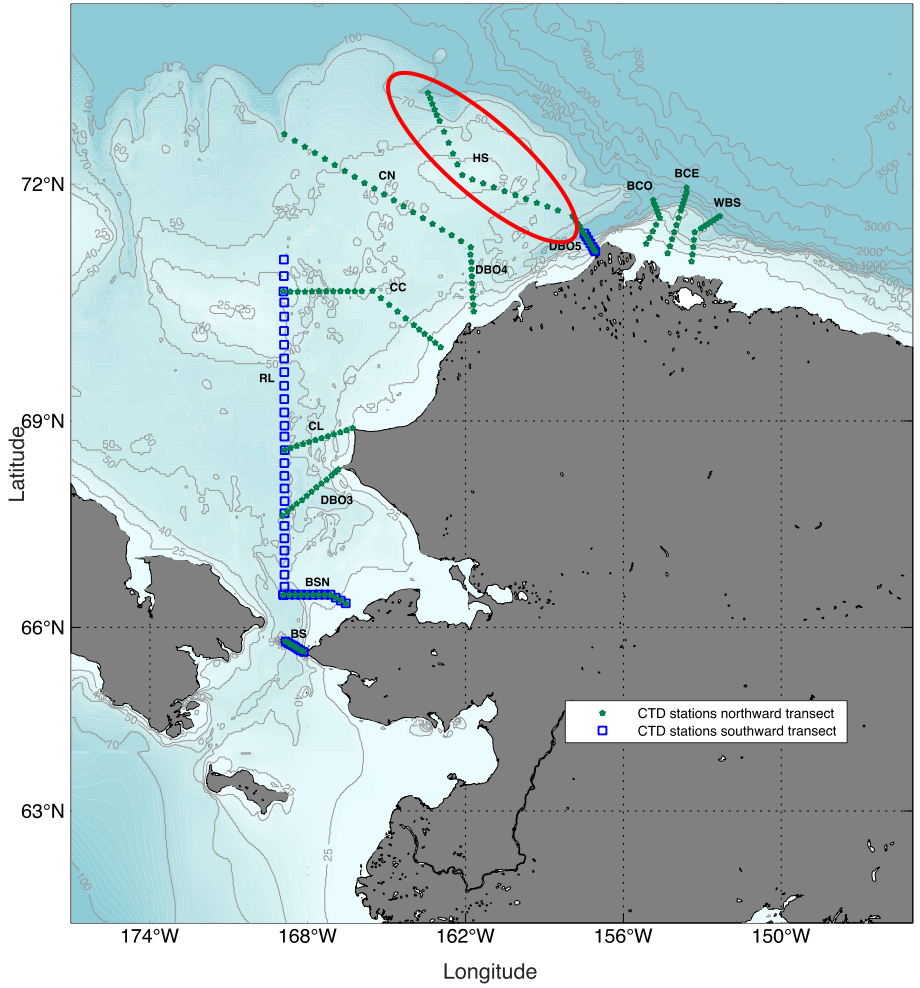


Leg 2 sampled the northern Chukchi shelf

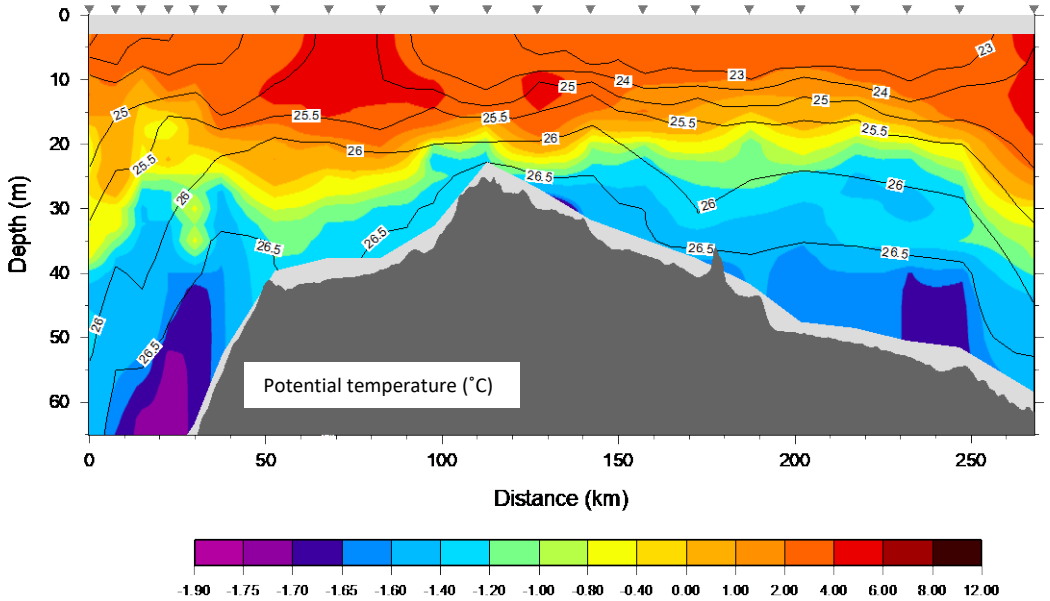


Leg 2 sampled the northern Chukchi shelf

Hanna Shoal section



Properties overlaid on Potential Density



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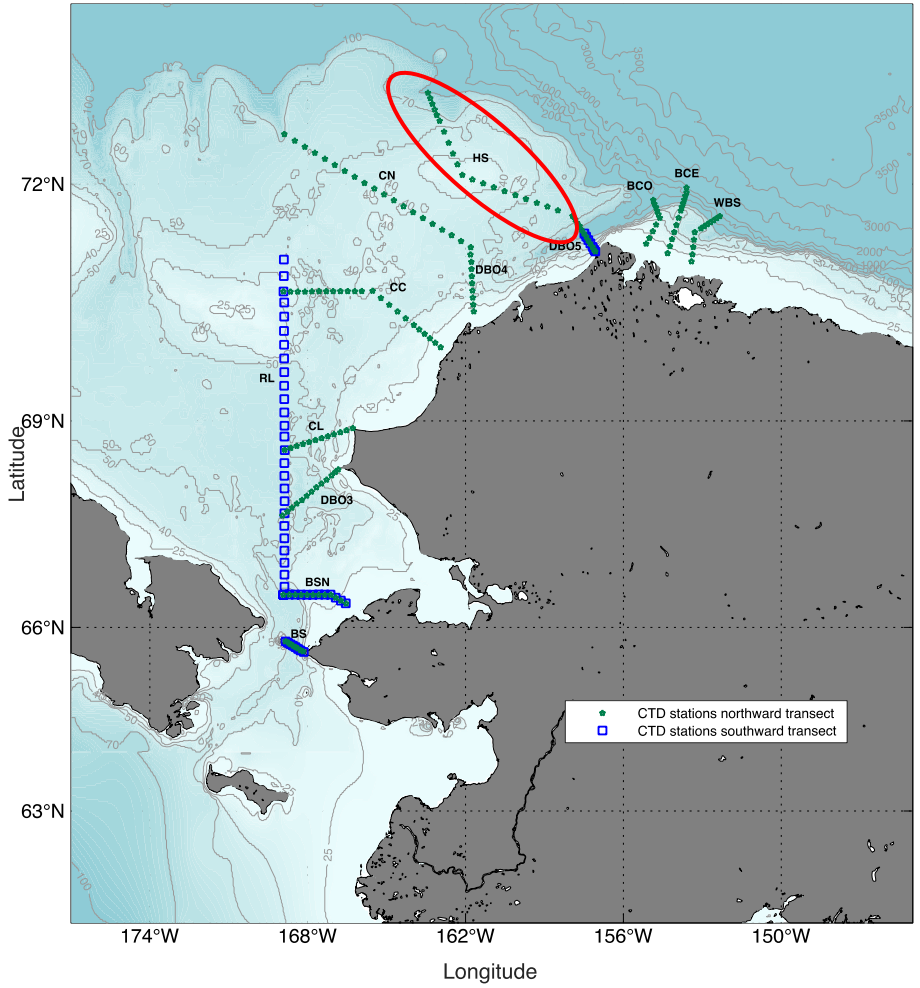

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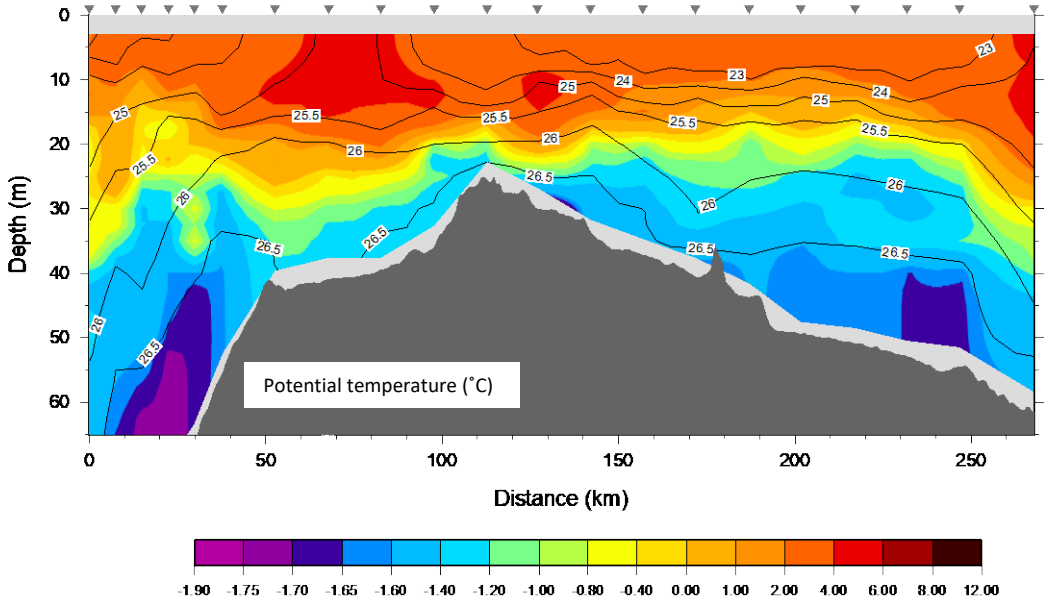
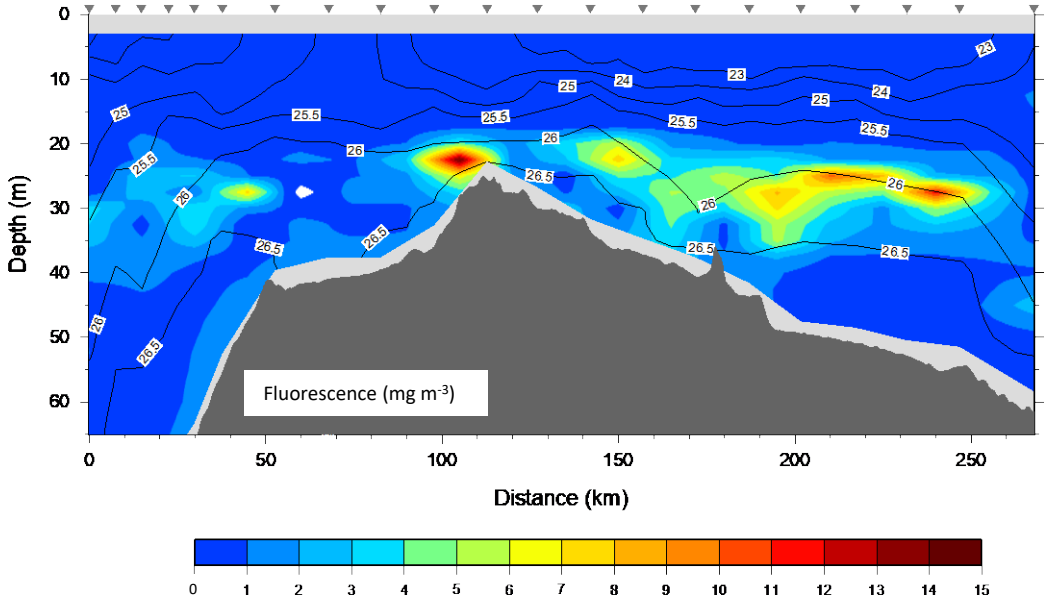
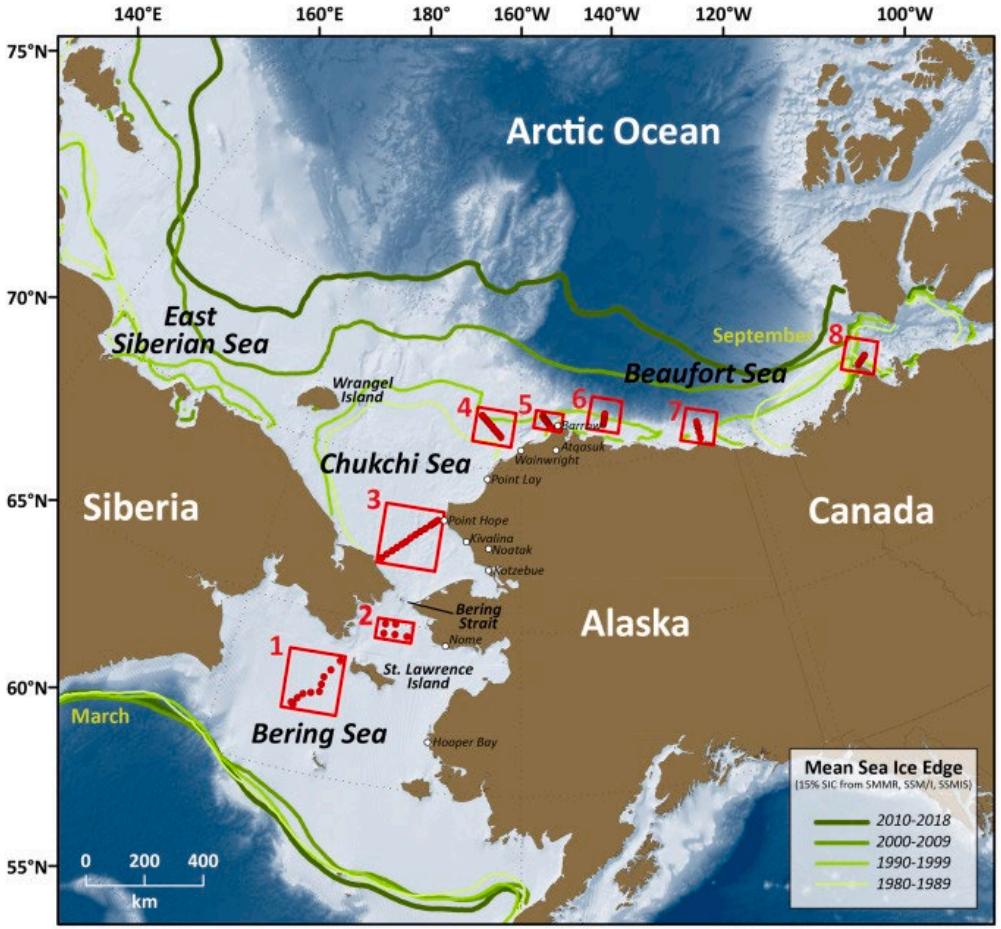




Between the two cruises we occupied the following DBO lines

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



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435 CTD stations
120 surface sediment grabs
15 multi-cores
47 phytoplankton net tows

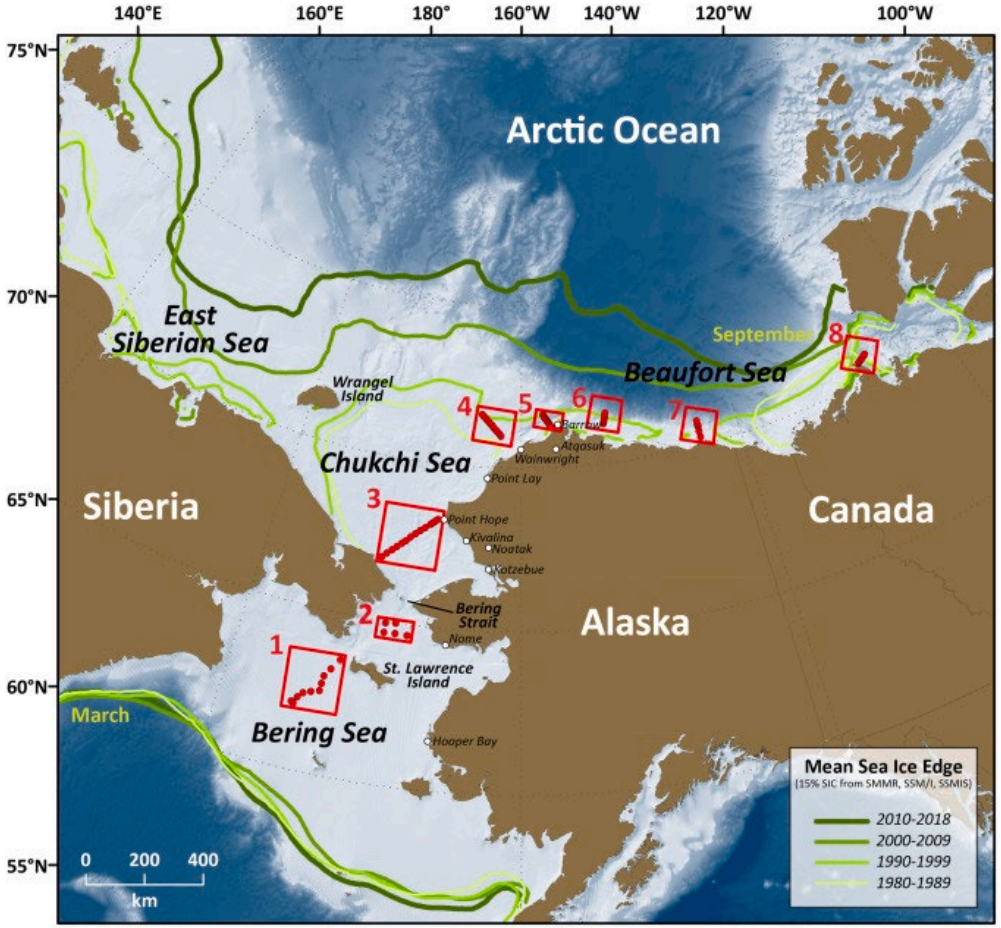

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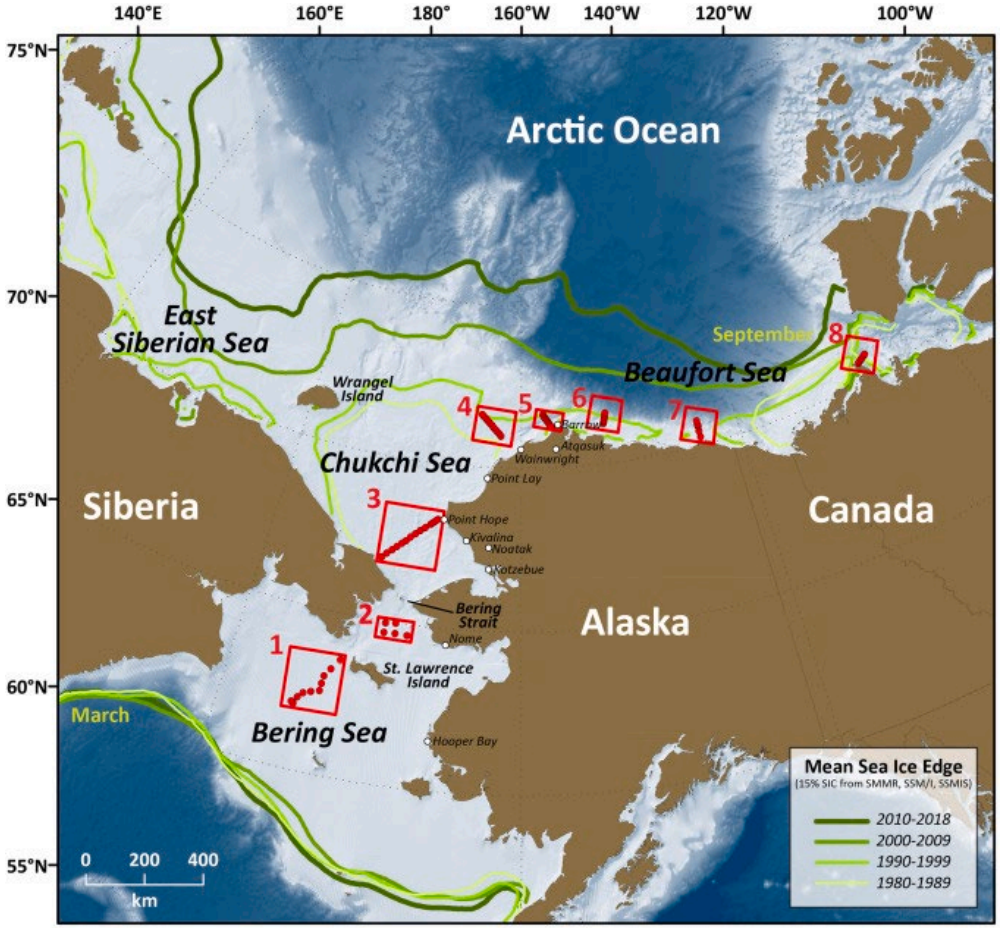
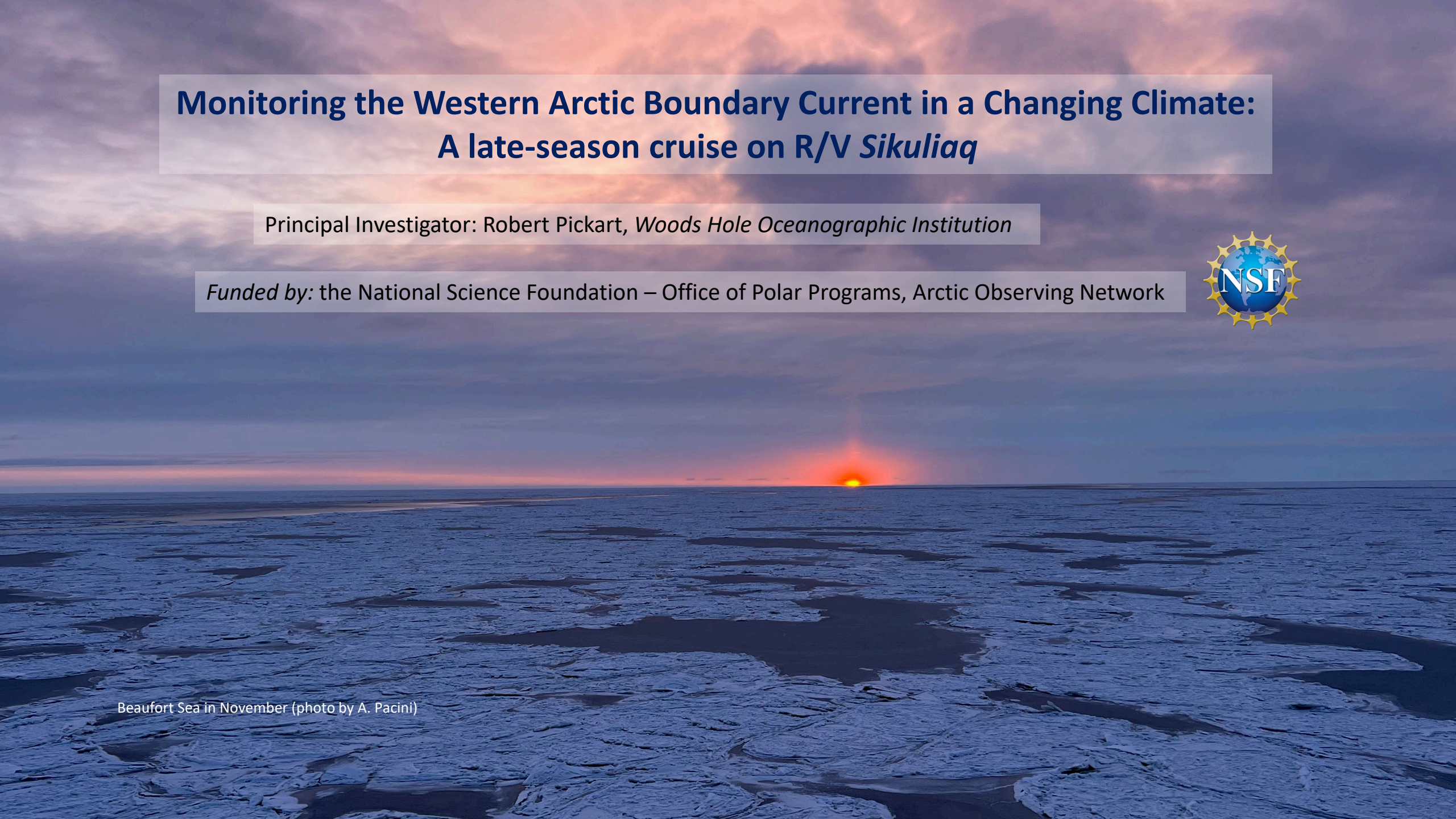
photo by M. Stuhlreyer



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)

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*

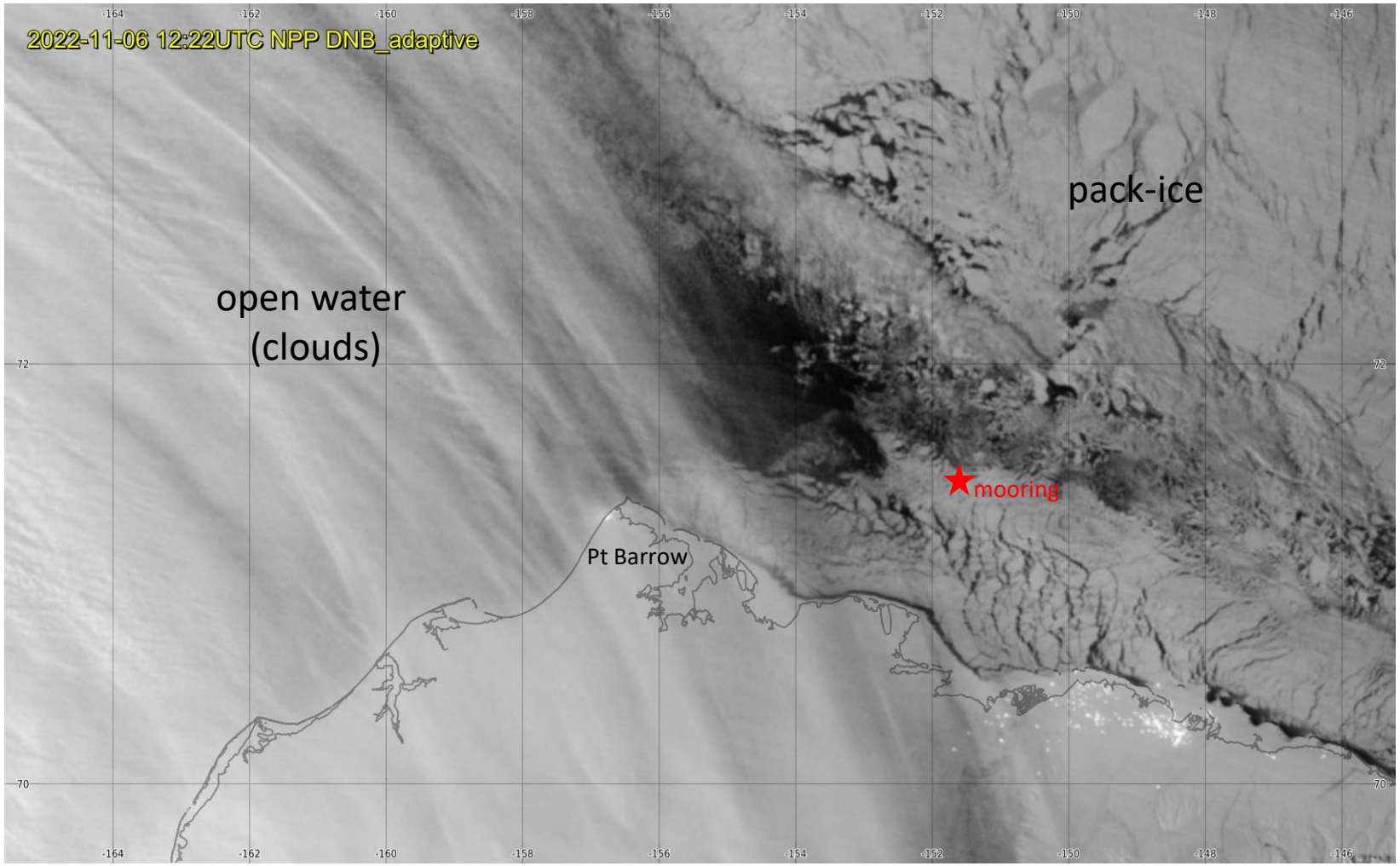
Funded by: the National Science Foundation – Office of Polar Programs, Arctic Observing Network

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

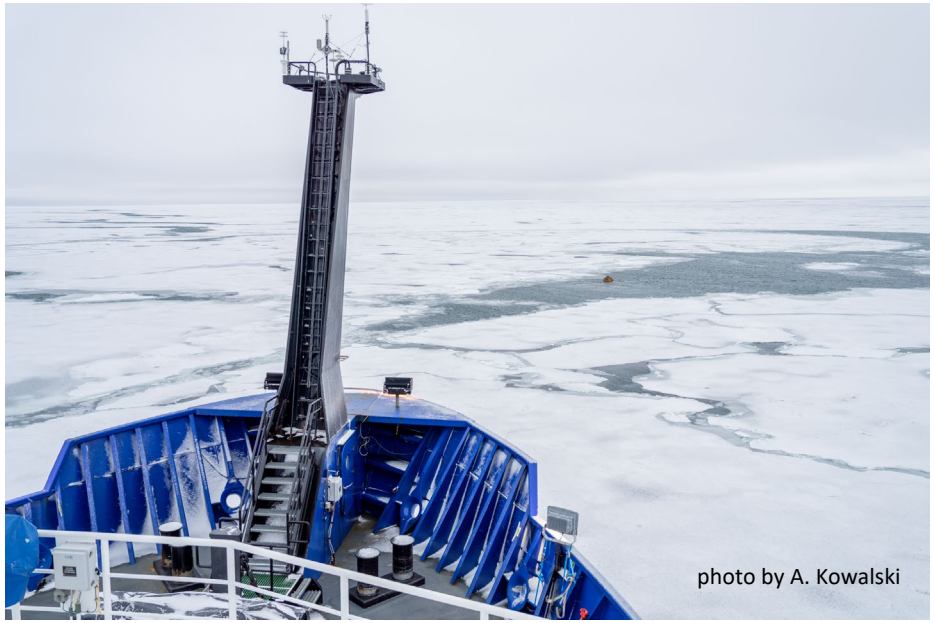
Shipboard Sampling

Physical Oceanography	• CTD • SADCP • Microstructure • Mooring work
Biogeochemistry	• Oxygen and nutrients • Oxygen/argon ratios (O2/Ar) • δ18O and δ2H in seawater and δ18O, δ17O, δ2H 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)



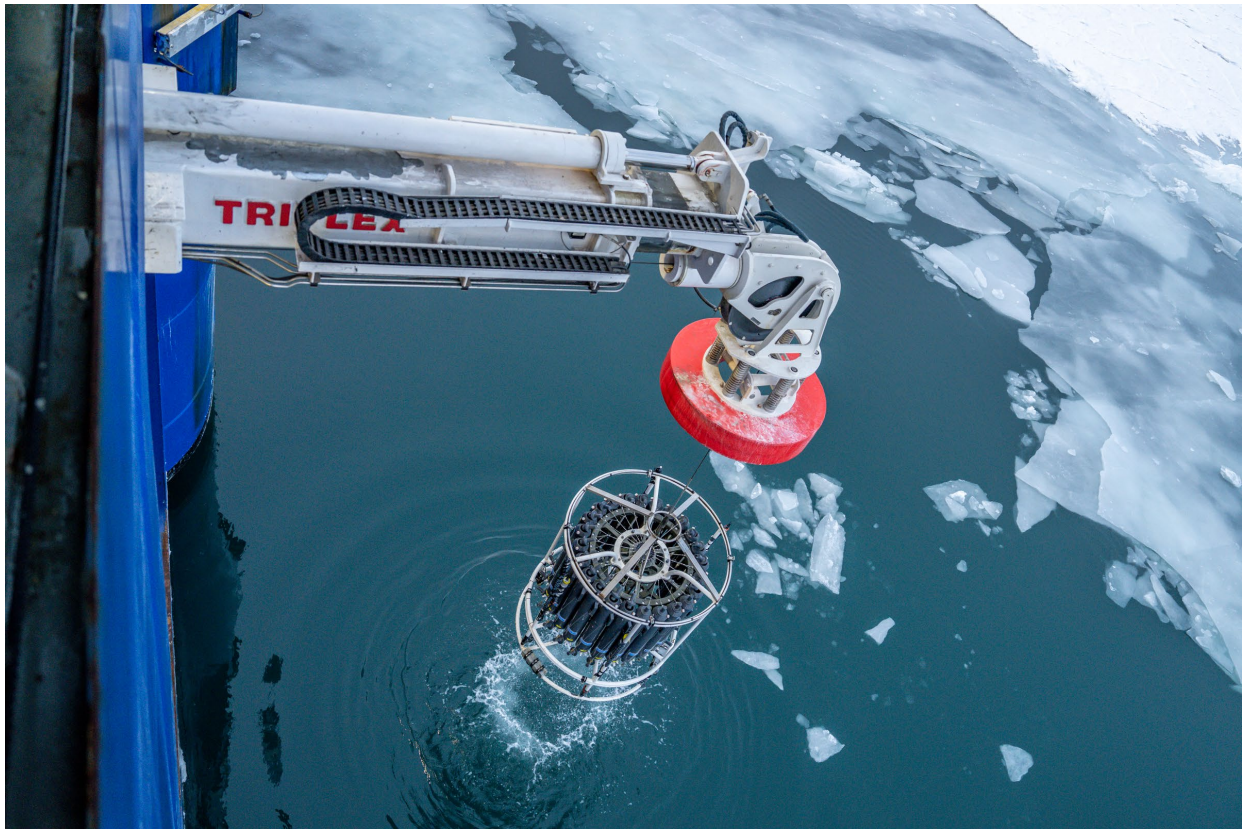
Nighttime visual image Nov 6, 2022

mooring recovery

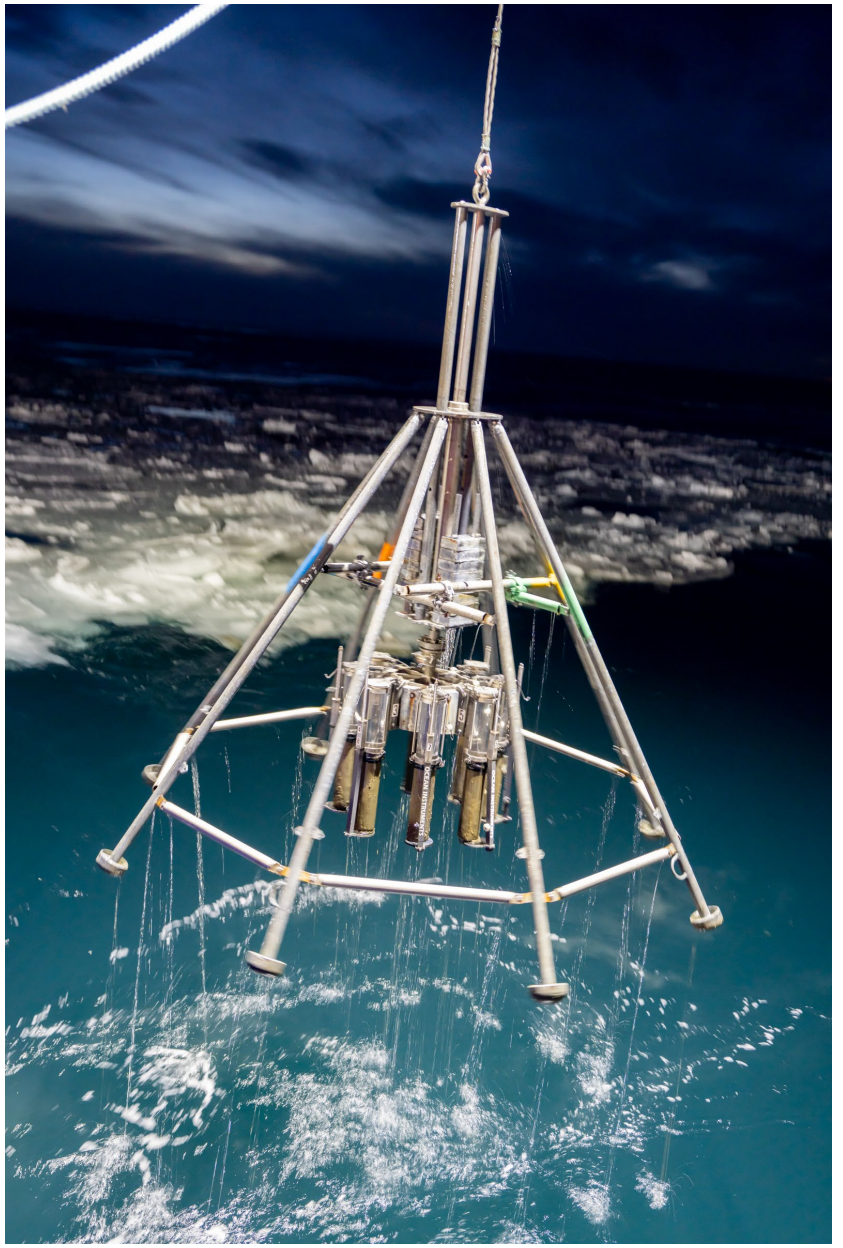


mooring deployment

CTD ops in the ice

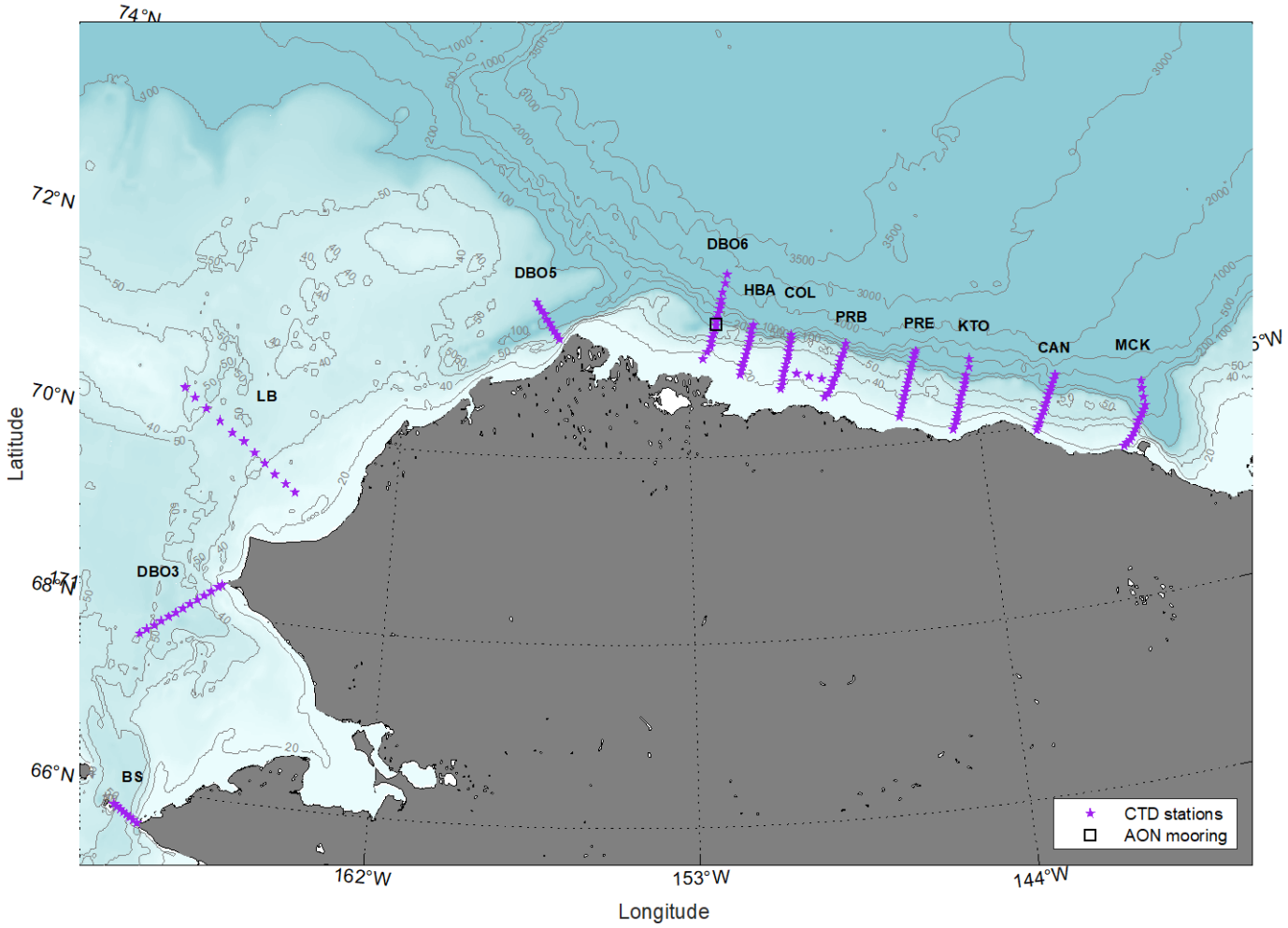


multi-core recovery

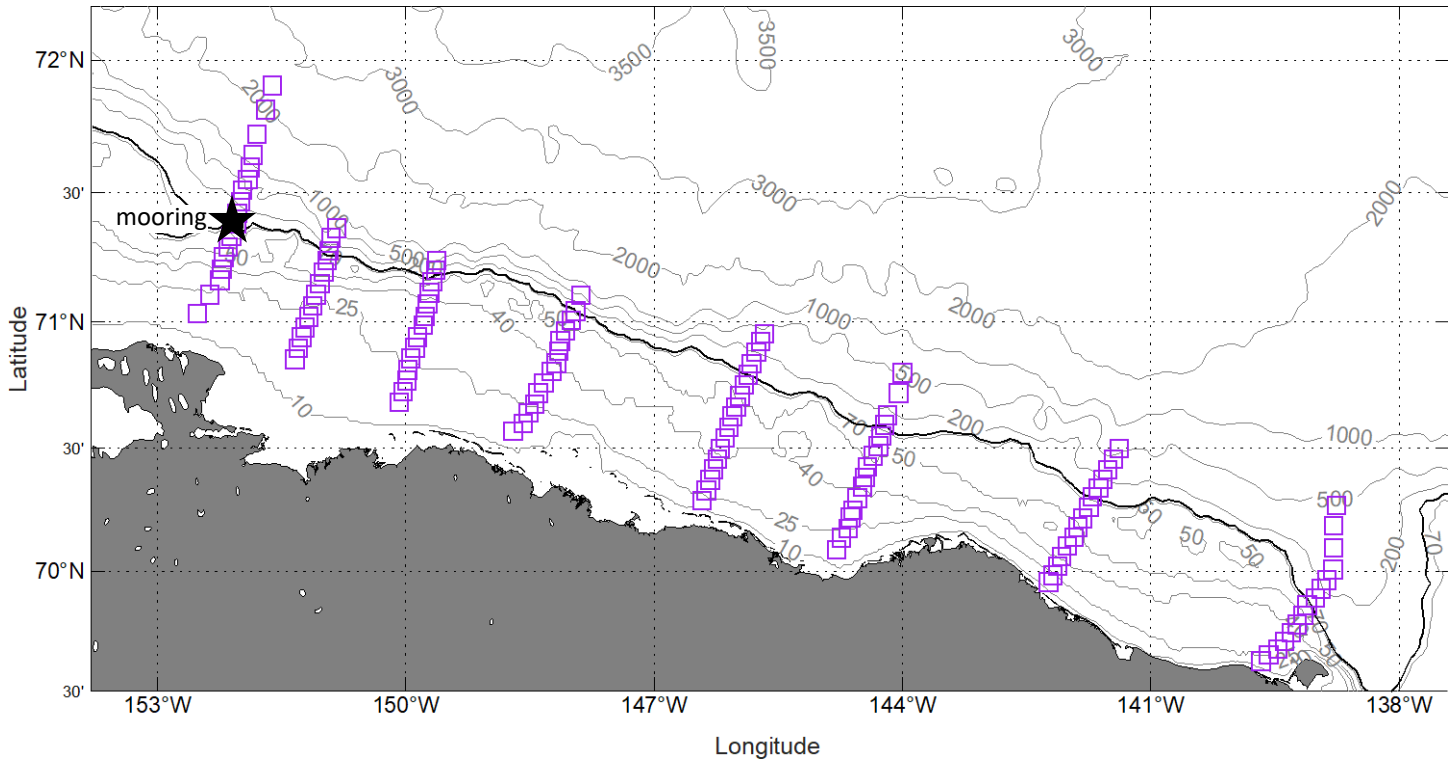


Vibracore (4–6 m cores)

Hydrographic stations occupied on R/V Sikuliaq 1 Nov – 3 Dec 2022



Beaufort shelf/upper-slope sections



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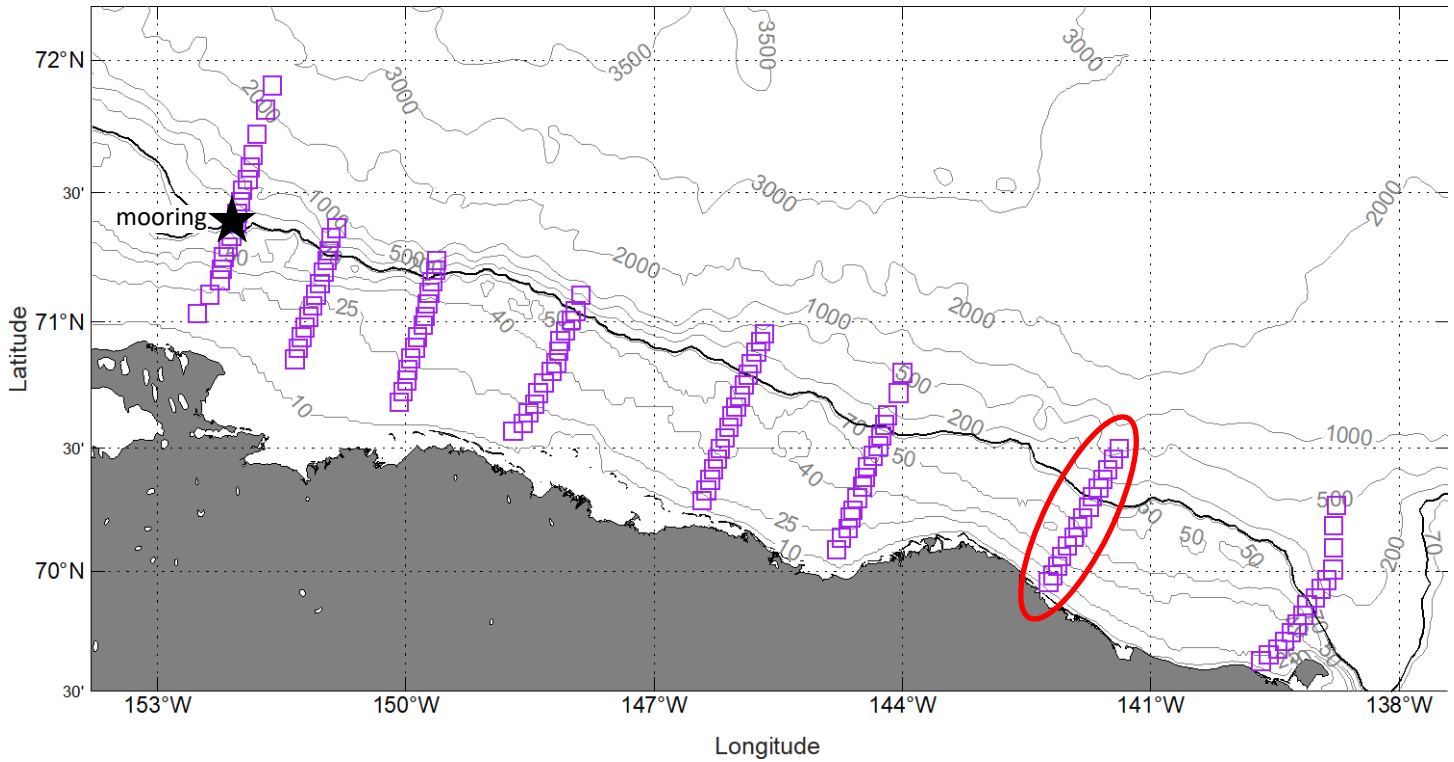
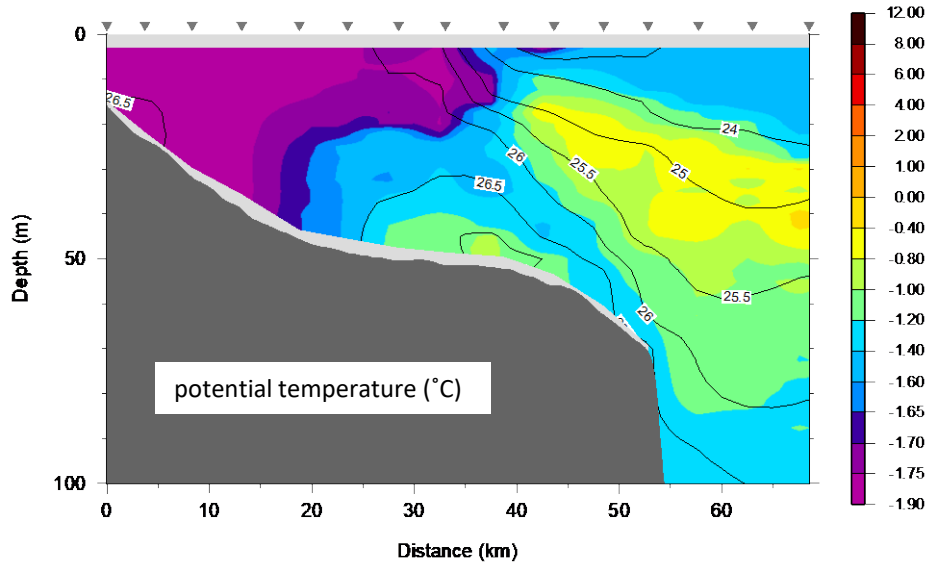
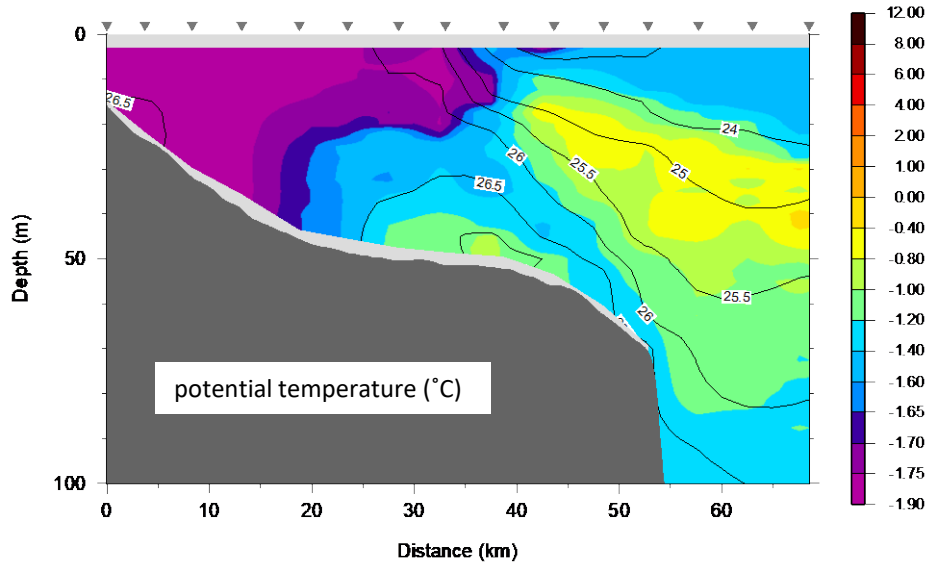
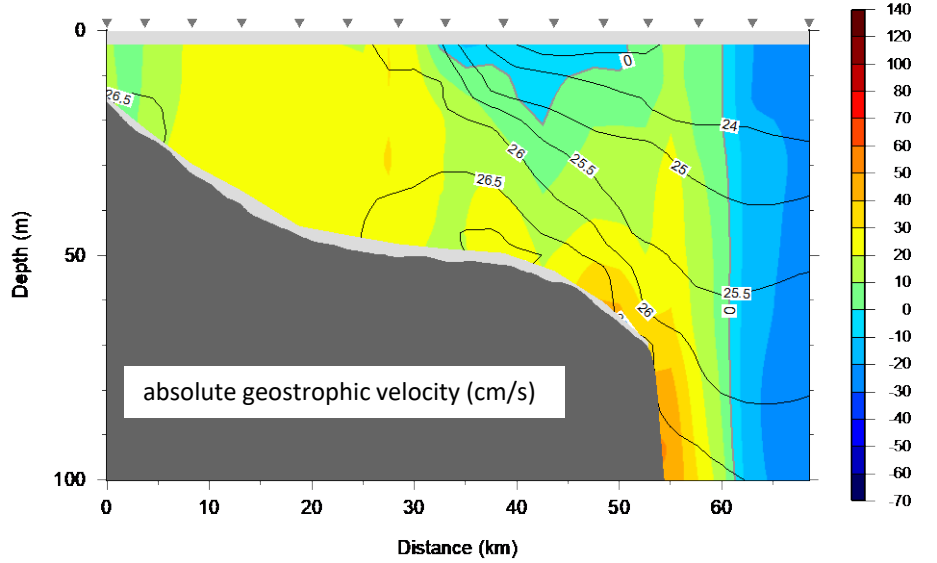




viewer is looking to the west

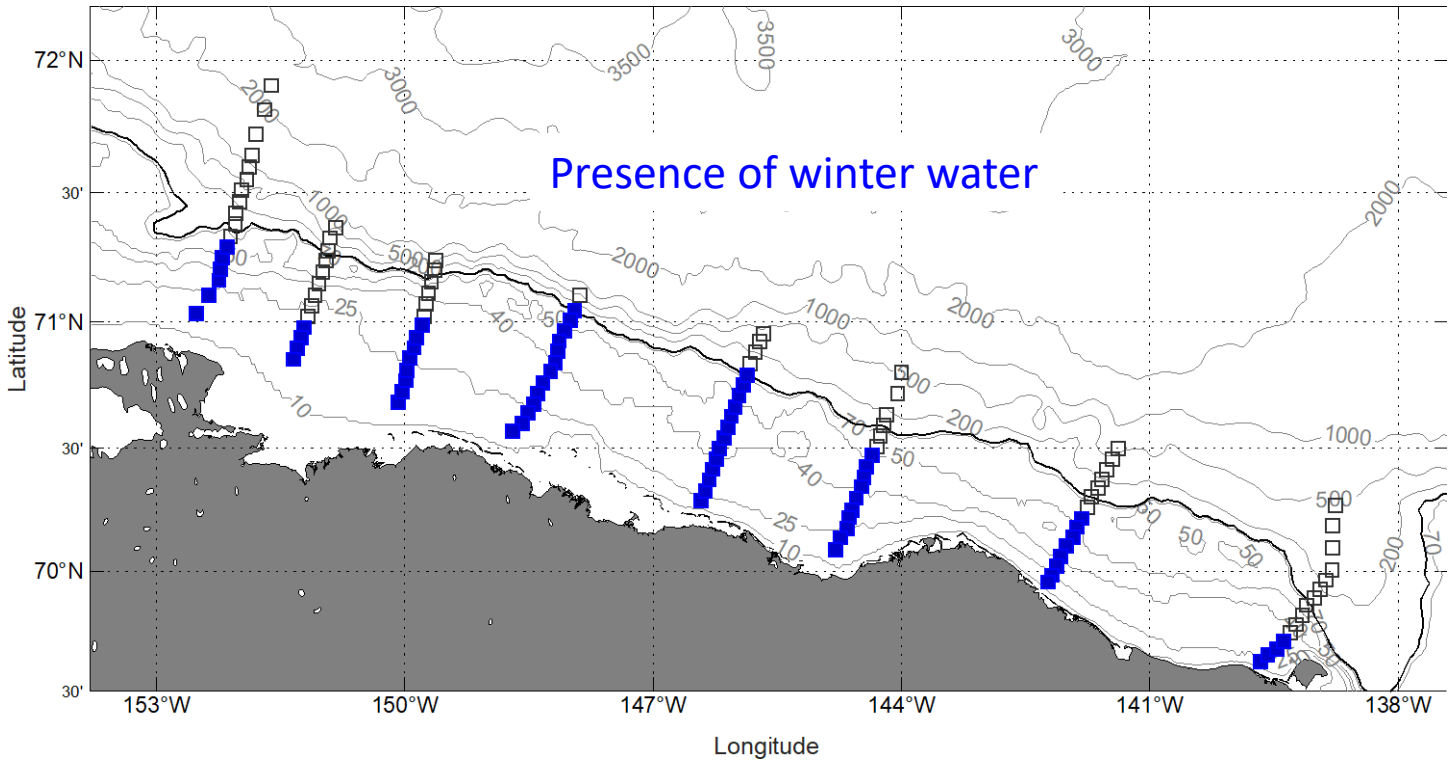


viewer is looking to the west

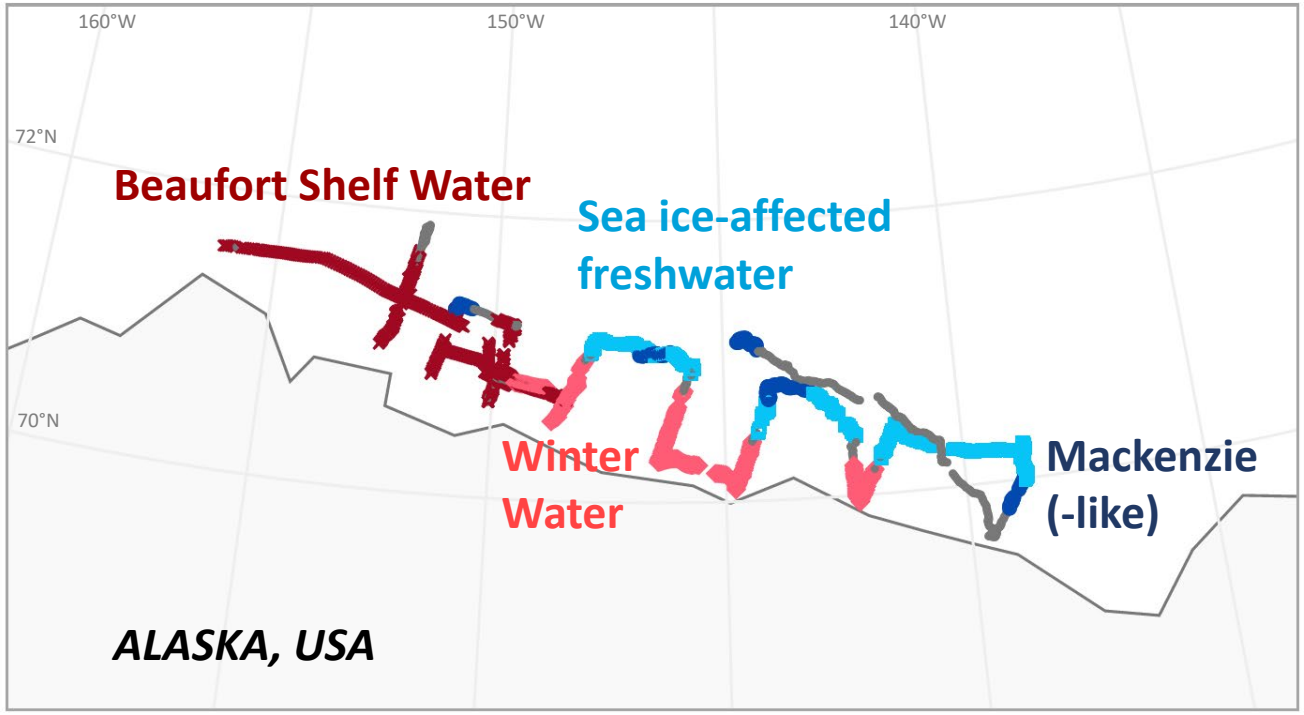


positive velocity is eastward

Beaufort shelf/upper-slope sections

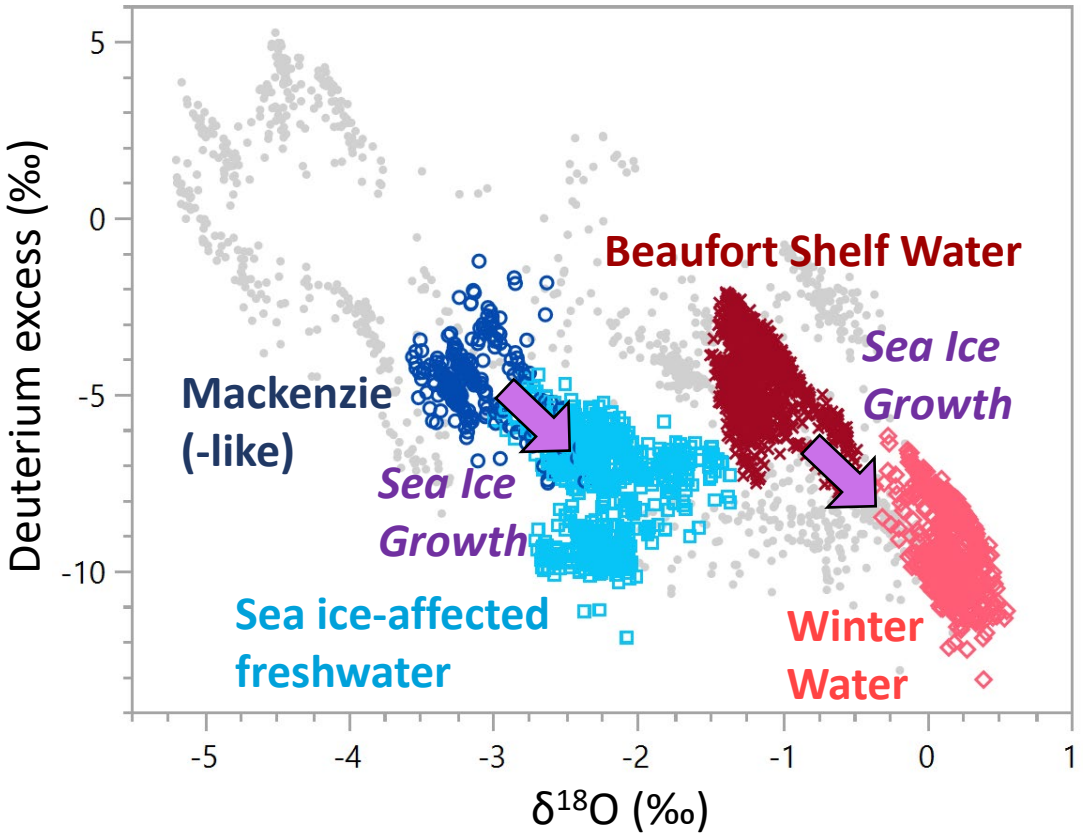


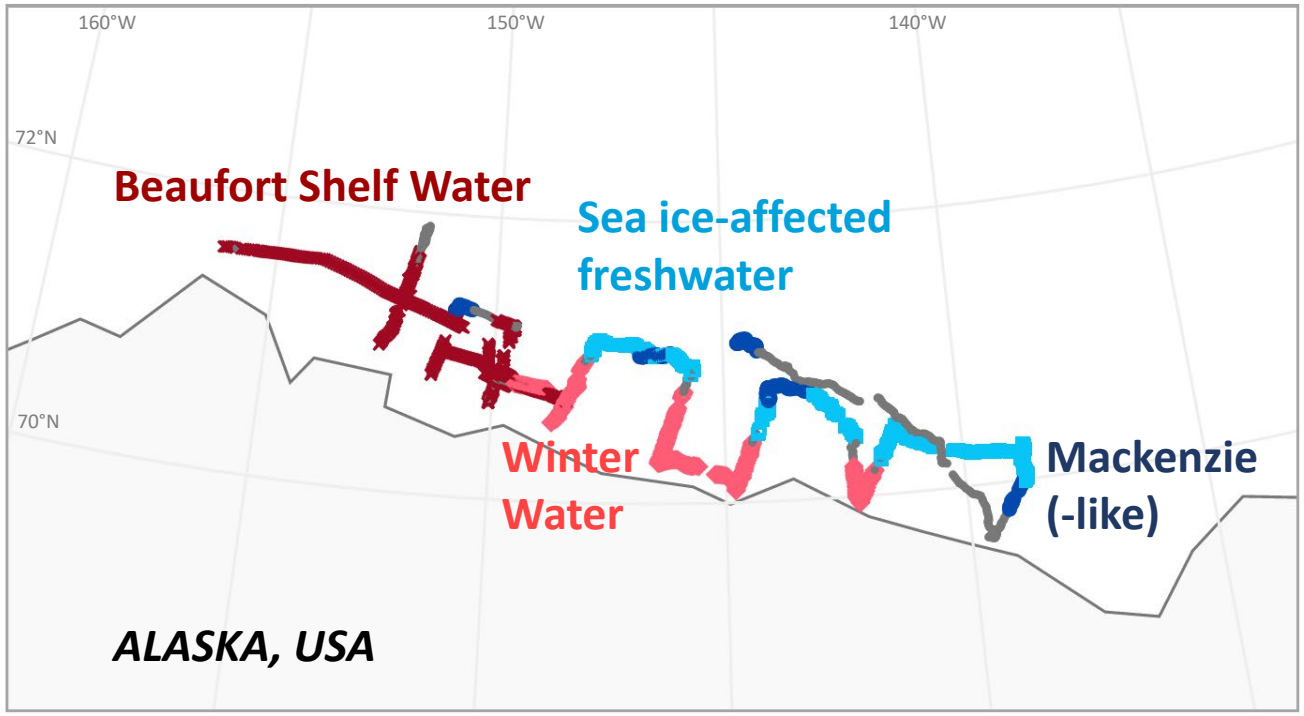
Distinguishing component water masses using isotopes $\delta^{18}O$, δD (deuterium excess)



B. Kopec; E. Klein, UAA

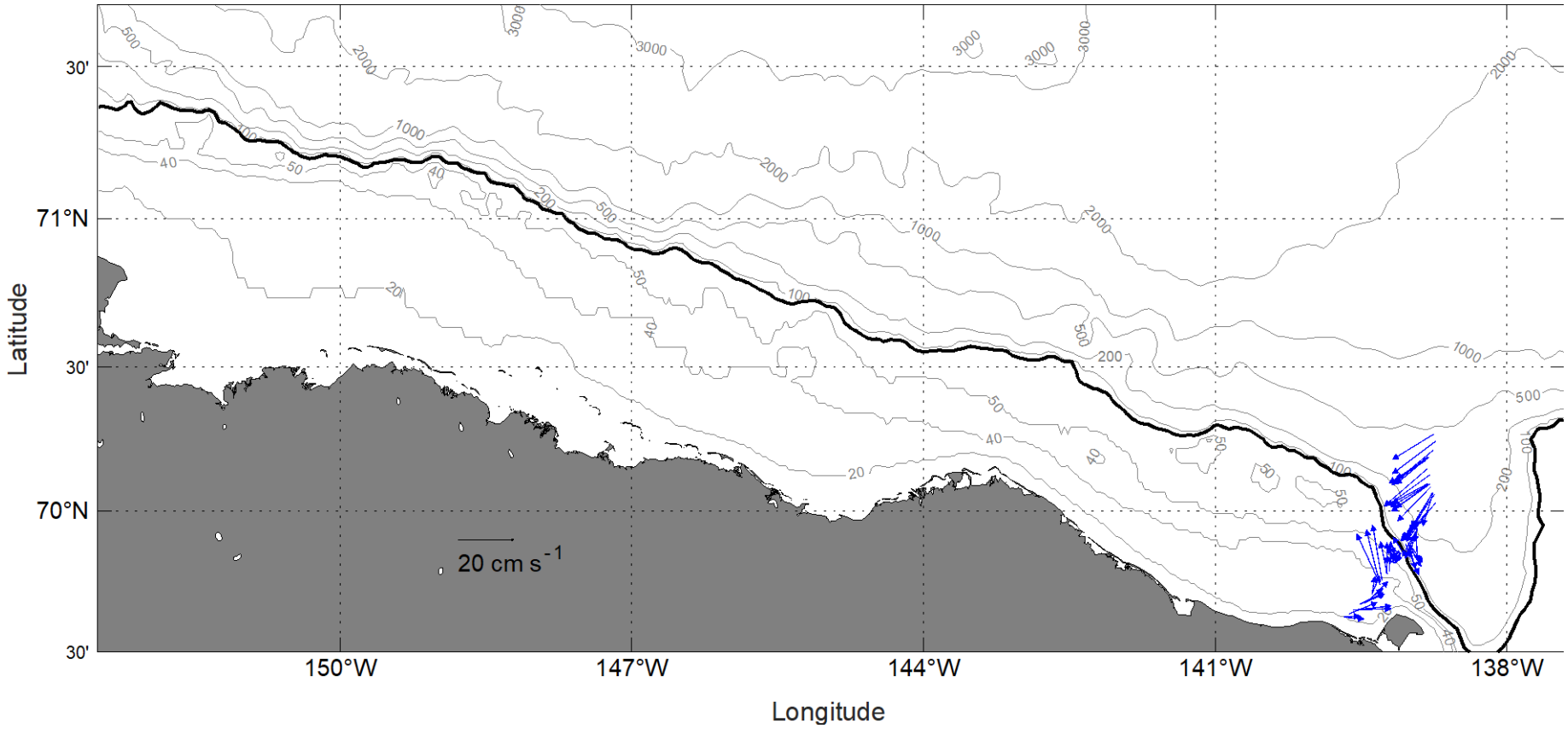
Distinguishing component water masses using isotopes $\delta^{18}O$, δD (deuterium excess)



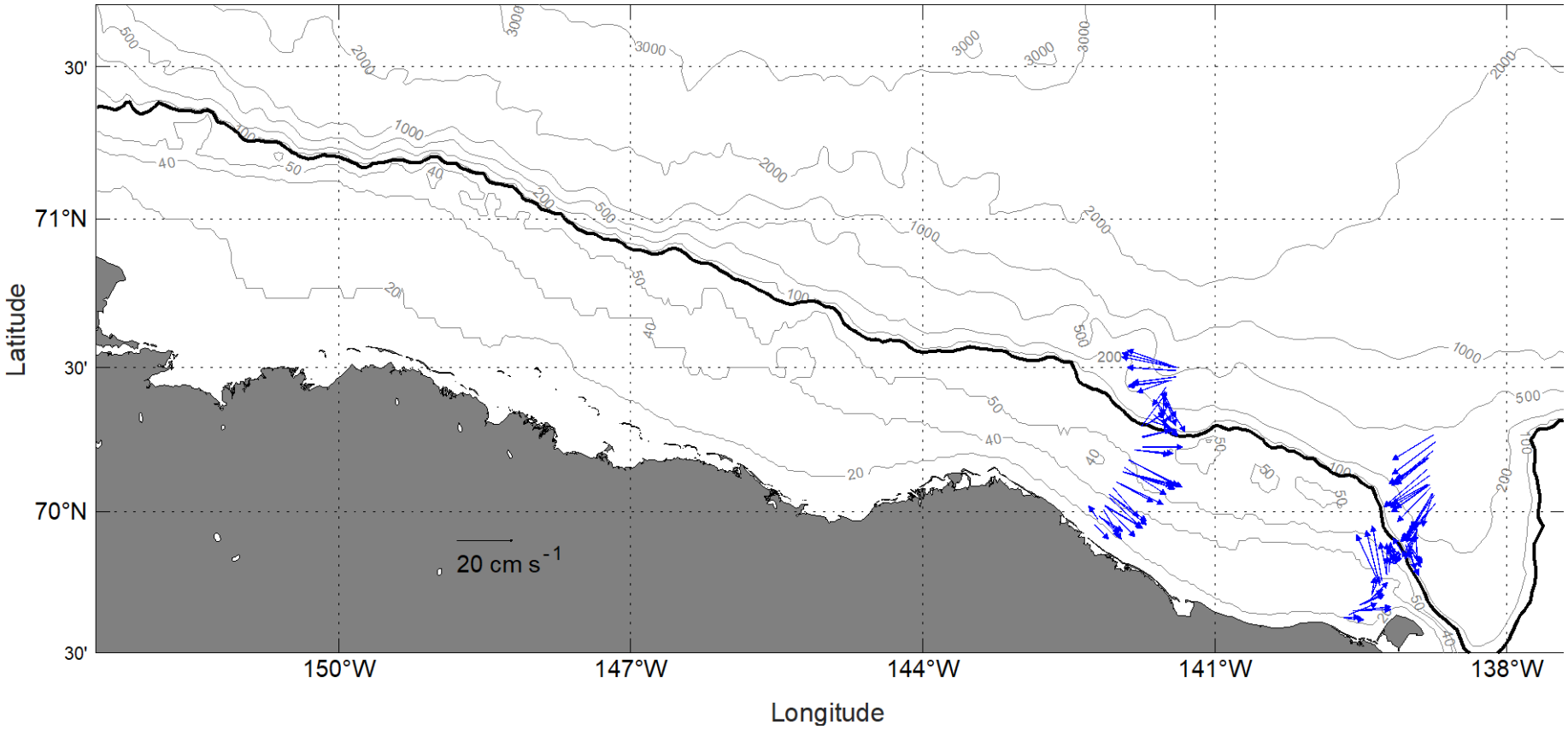


B. Kopec; E. Klein, UAA

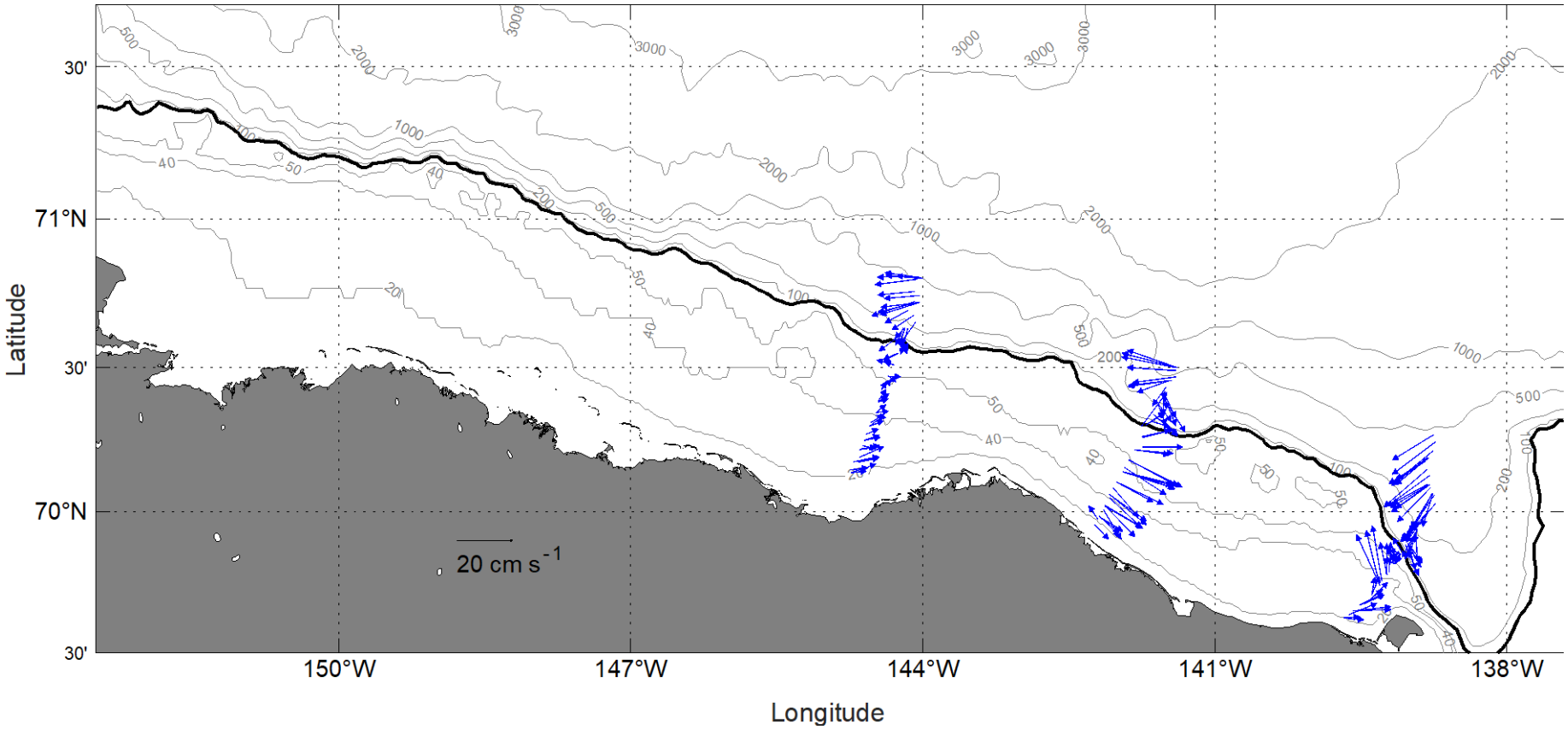
Depth-averaged flow 0–100m



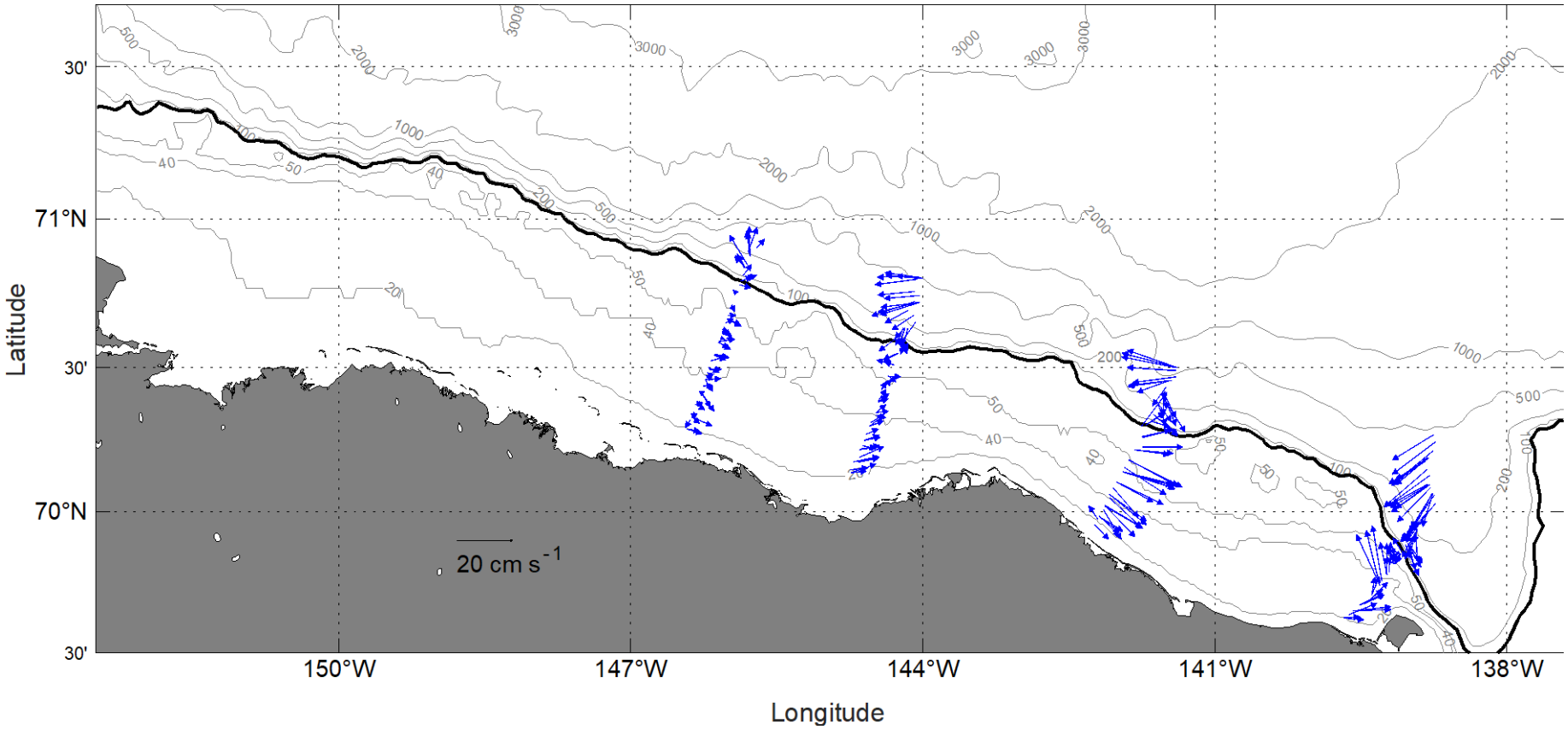
Depth-averaged flow 0–100m



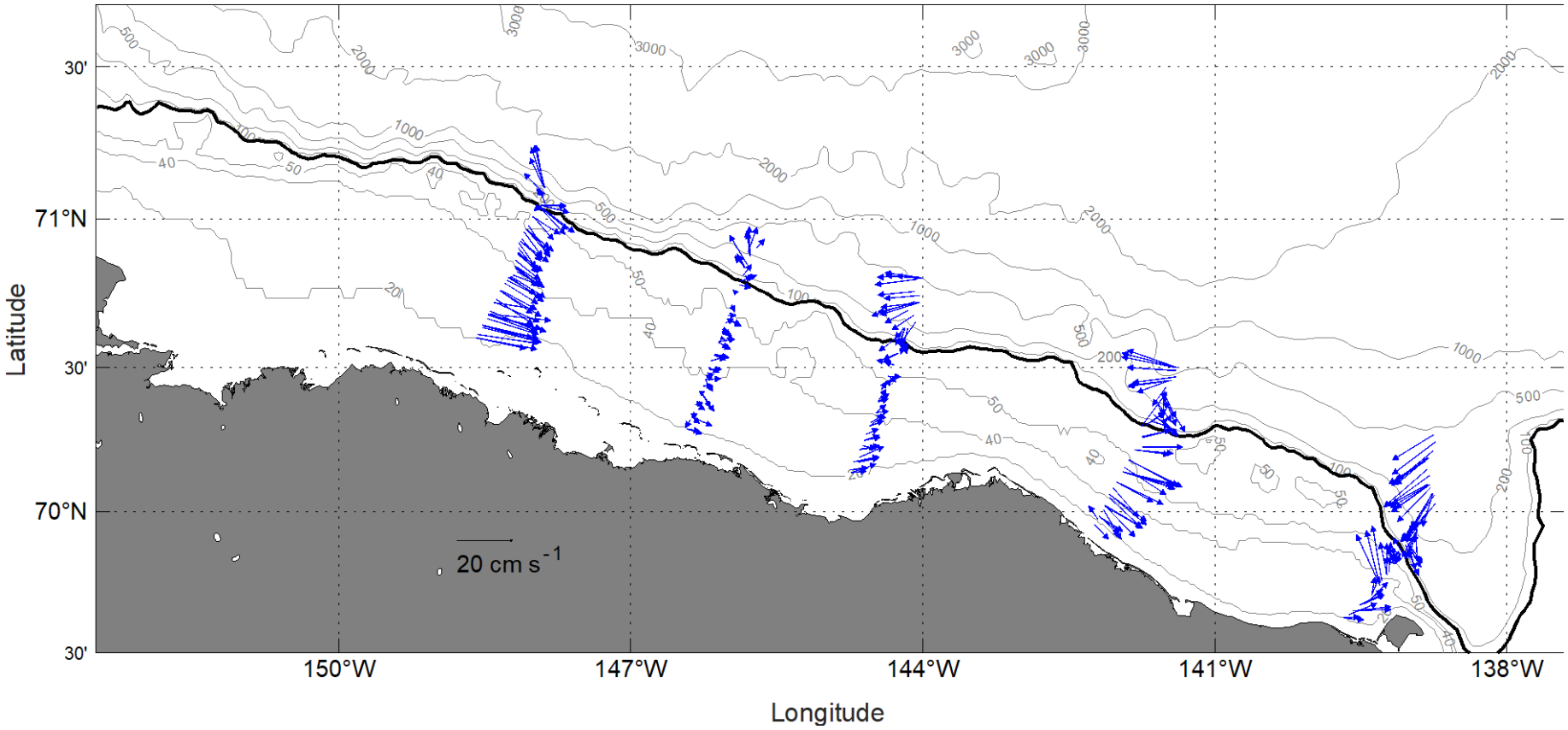
Depth-averaged flow 0–100m



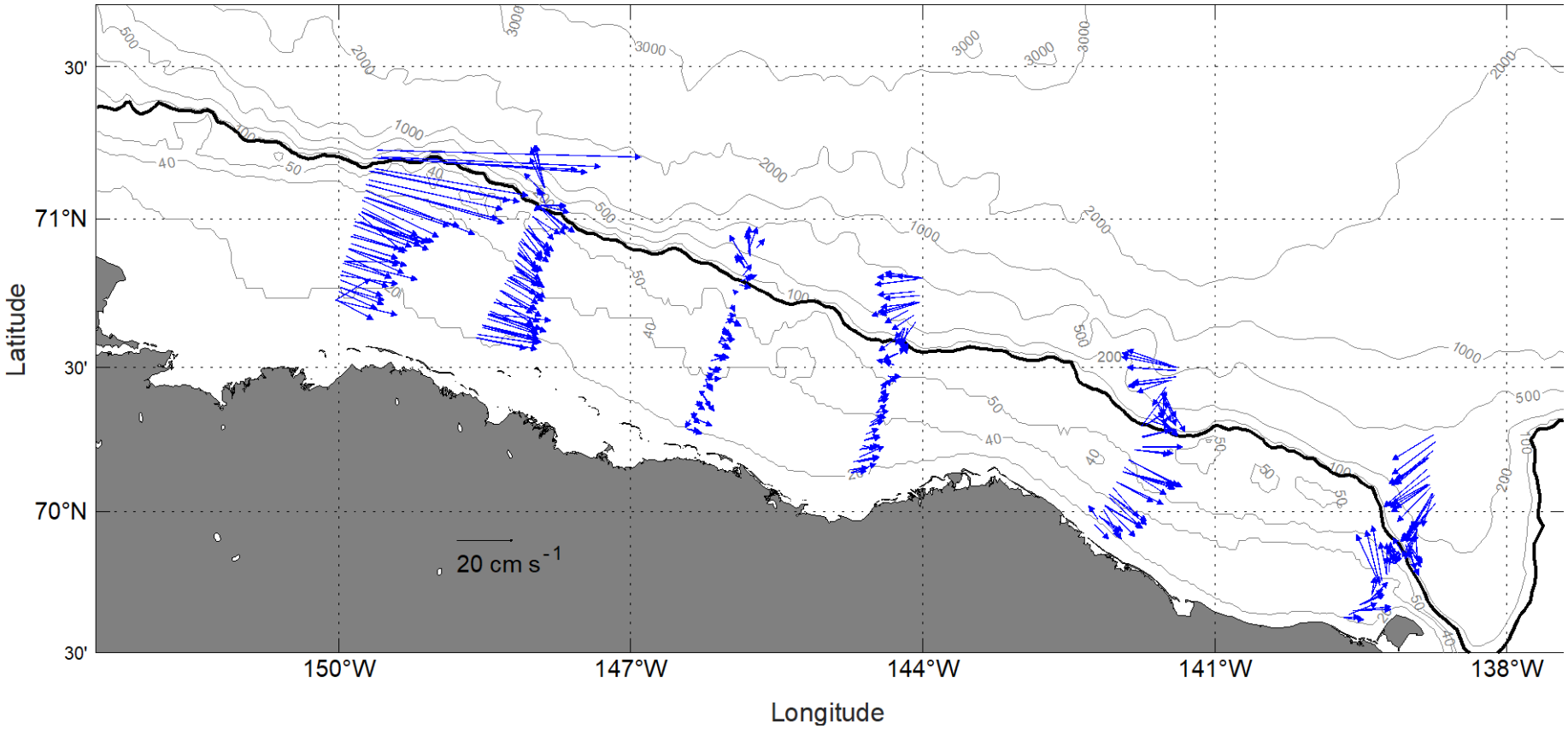
Depth-averaged flow 0–100m



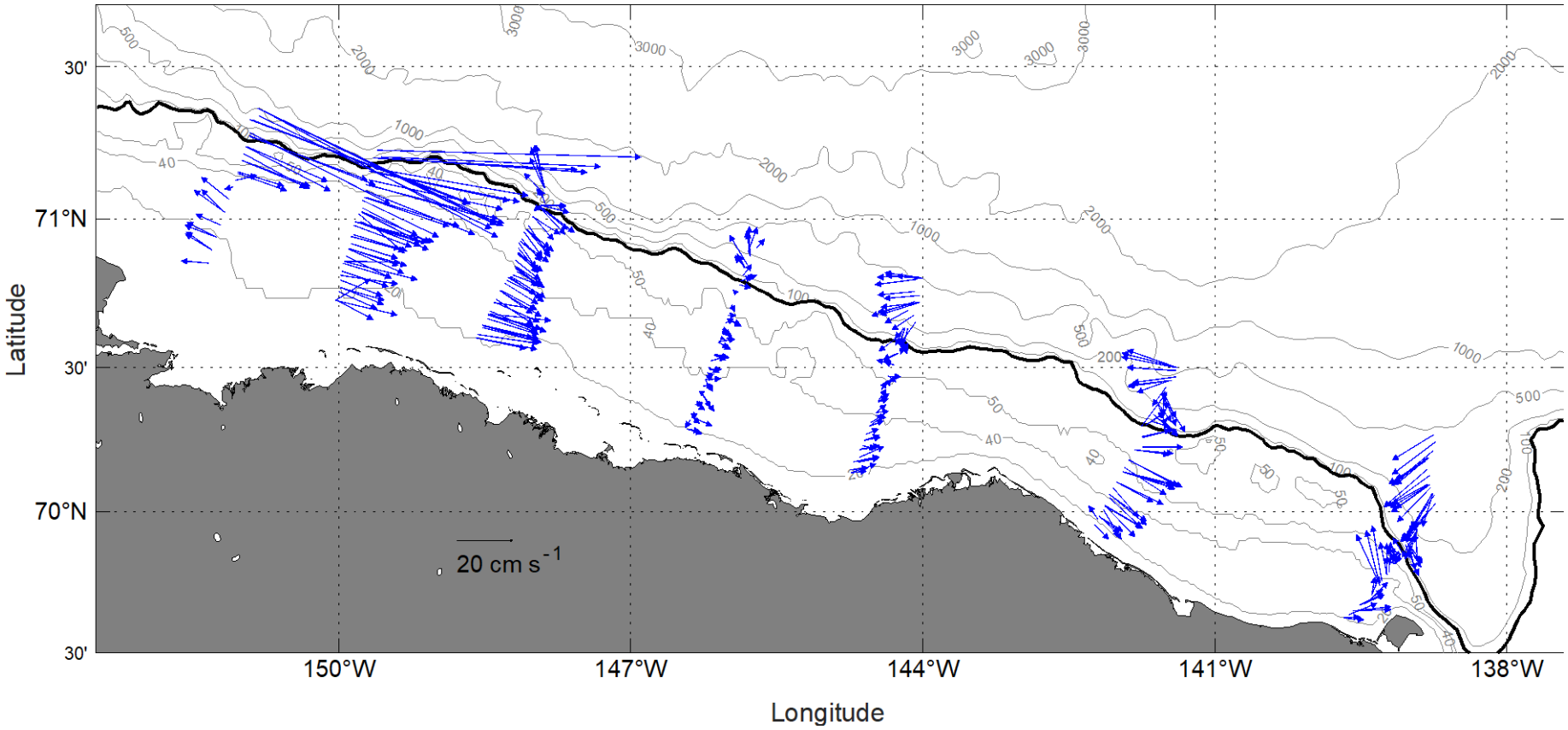
Depth-averaged flow 0–100m



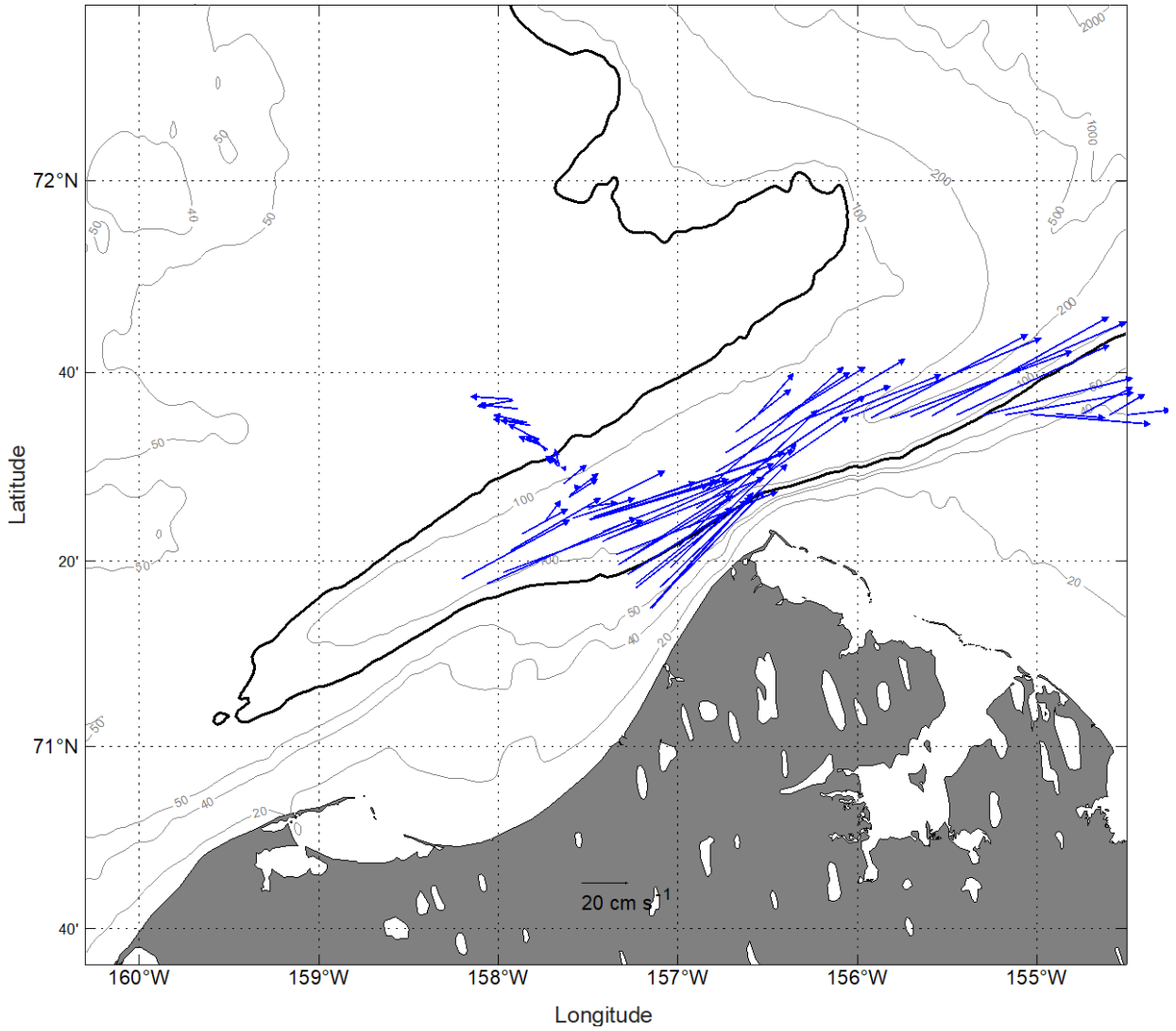
Depth-averaged flow 0–100m



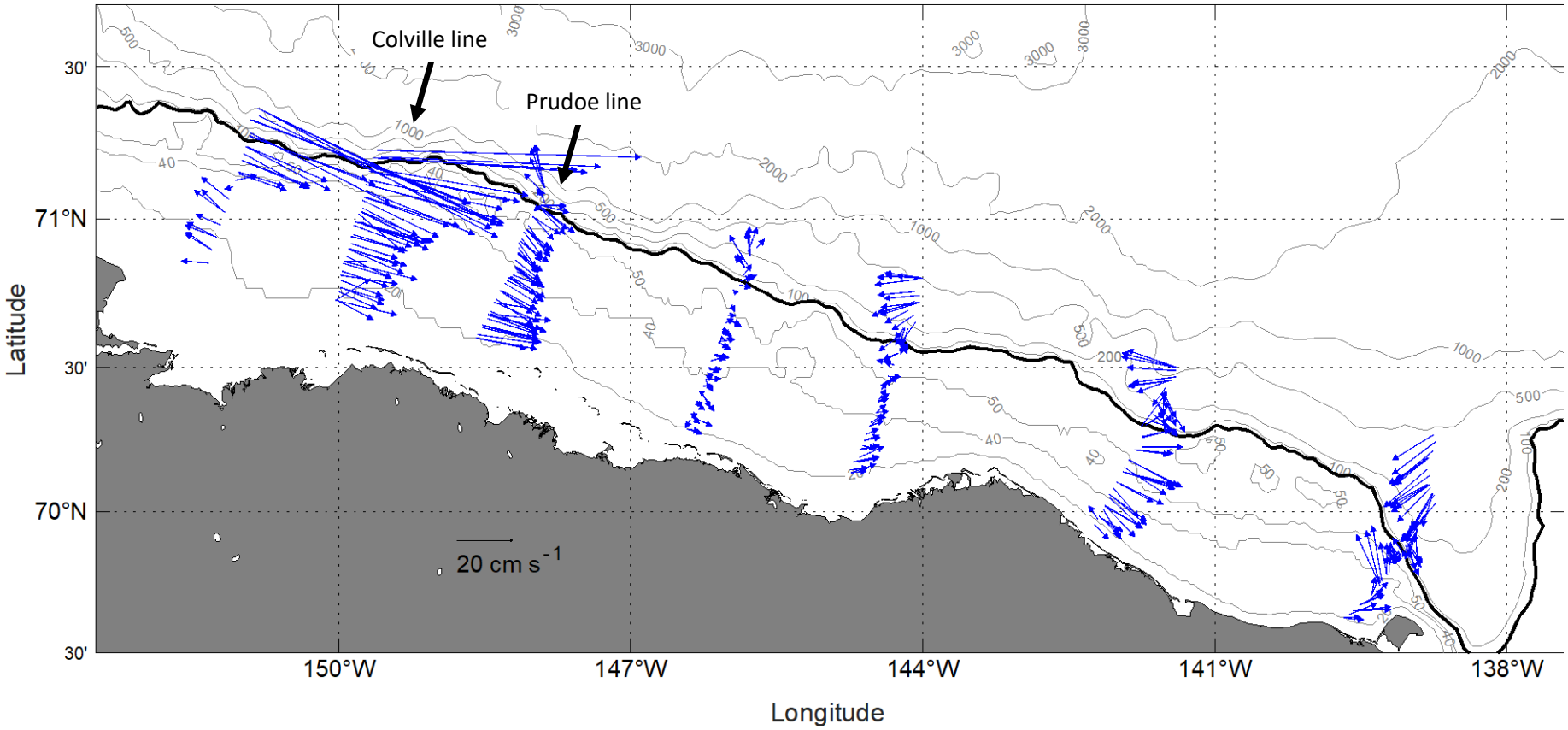
Depth-averaged flow 0–100m



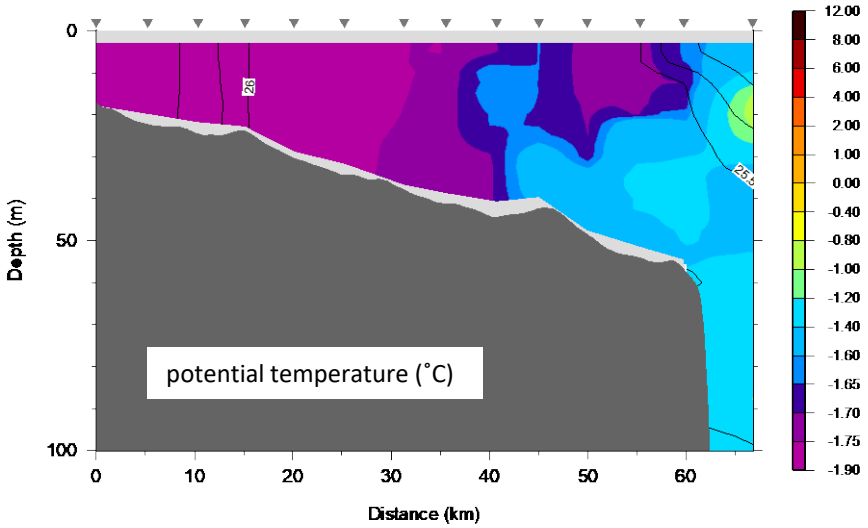
Depth-averaged flow 0–100m

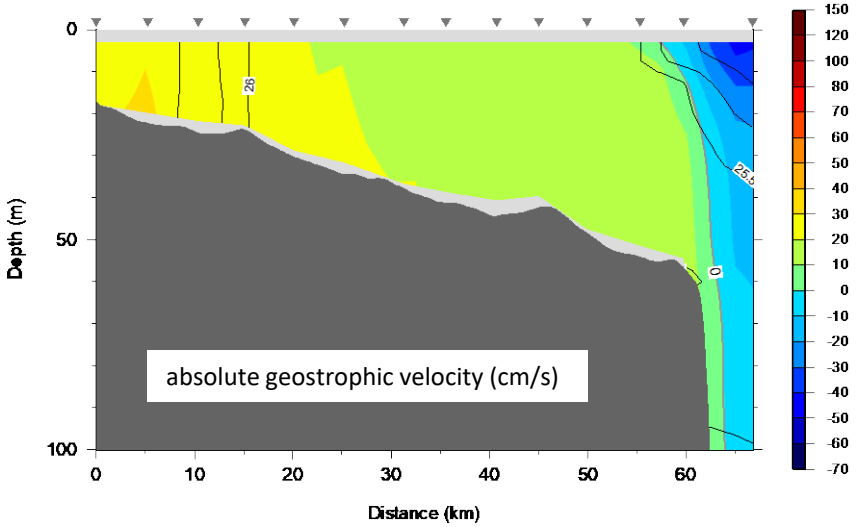


Depth-averaged flow 0–100m

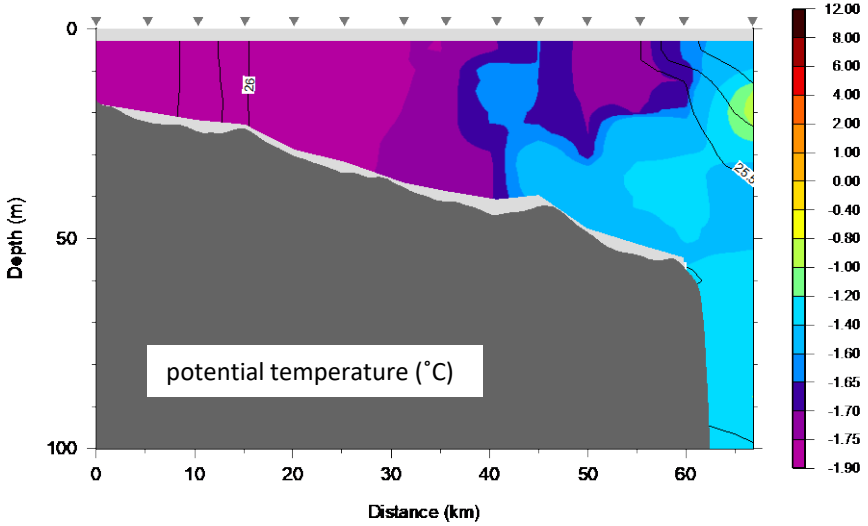


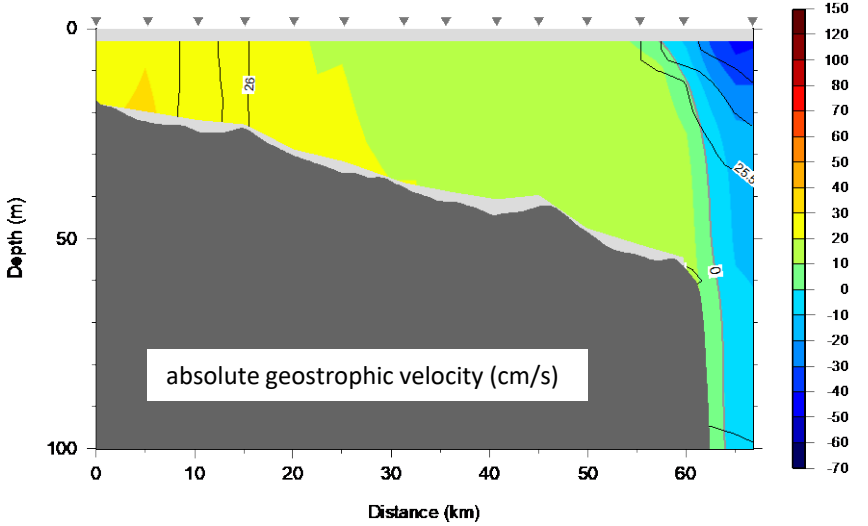
Prudoe Line


potential temperature (˚C)
Depth (m)
Distance (km)
0
50
100
0
10
20
30
40
50
60
26
25.5
12.00
8.00
6.00
4.00
2.00
1.00
0.00
-0.40
-0.80
-1.00
-1.20
-1.40
-1.60
-1.65
-1.70
-1.75
-1.90

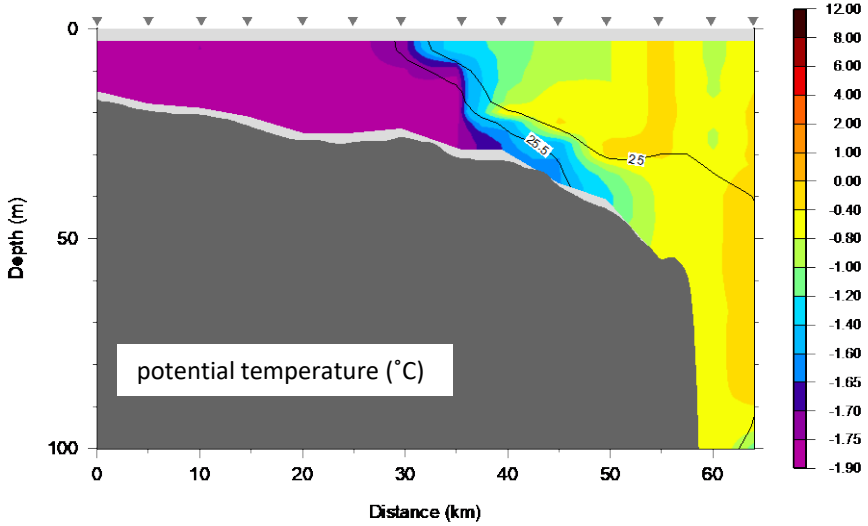

absolute geostrophic velocity (cm/s)
Depth (m)
Distance (km)
0
50
100
0
10
20
30
40
50
60
26
25.5
0
150
120
100
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70

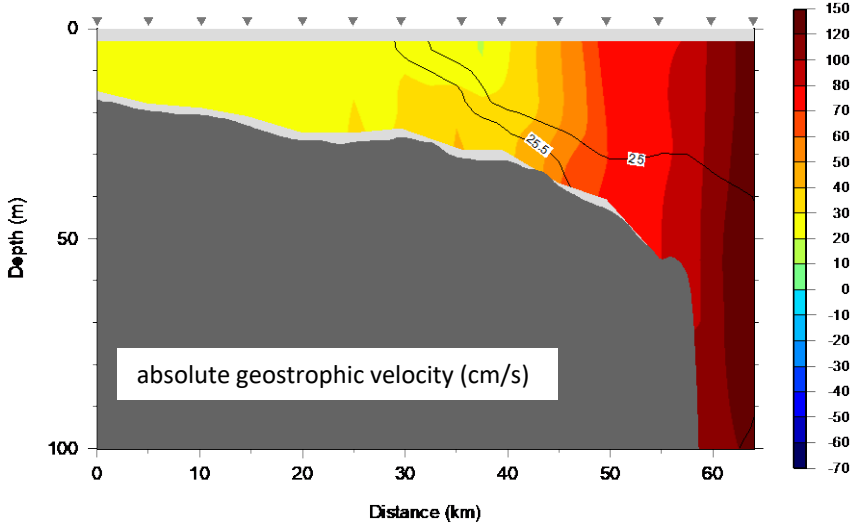
Prudoe Line

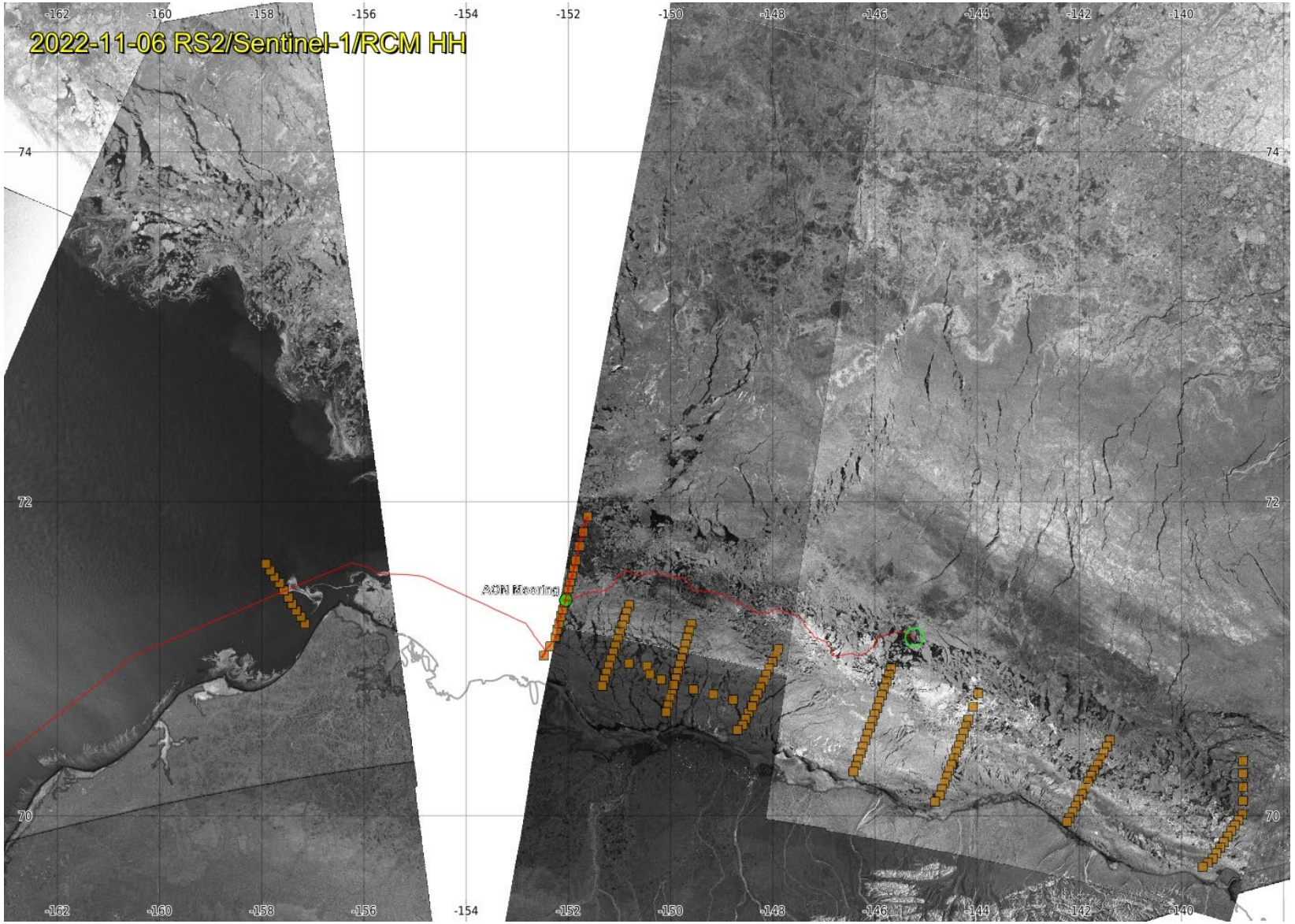




Colville Line







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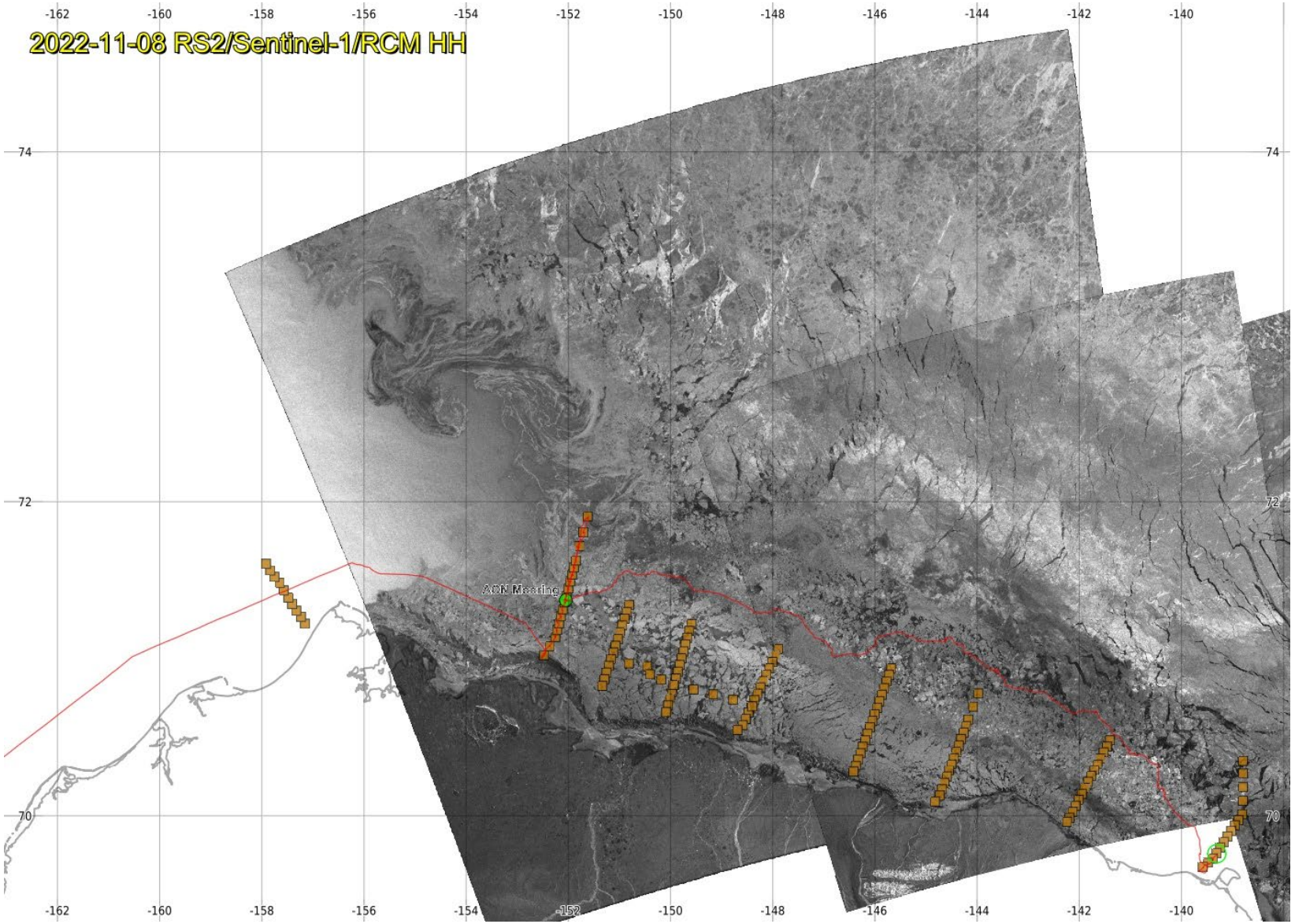
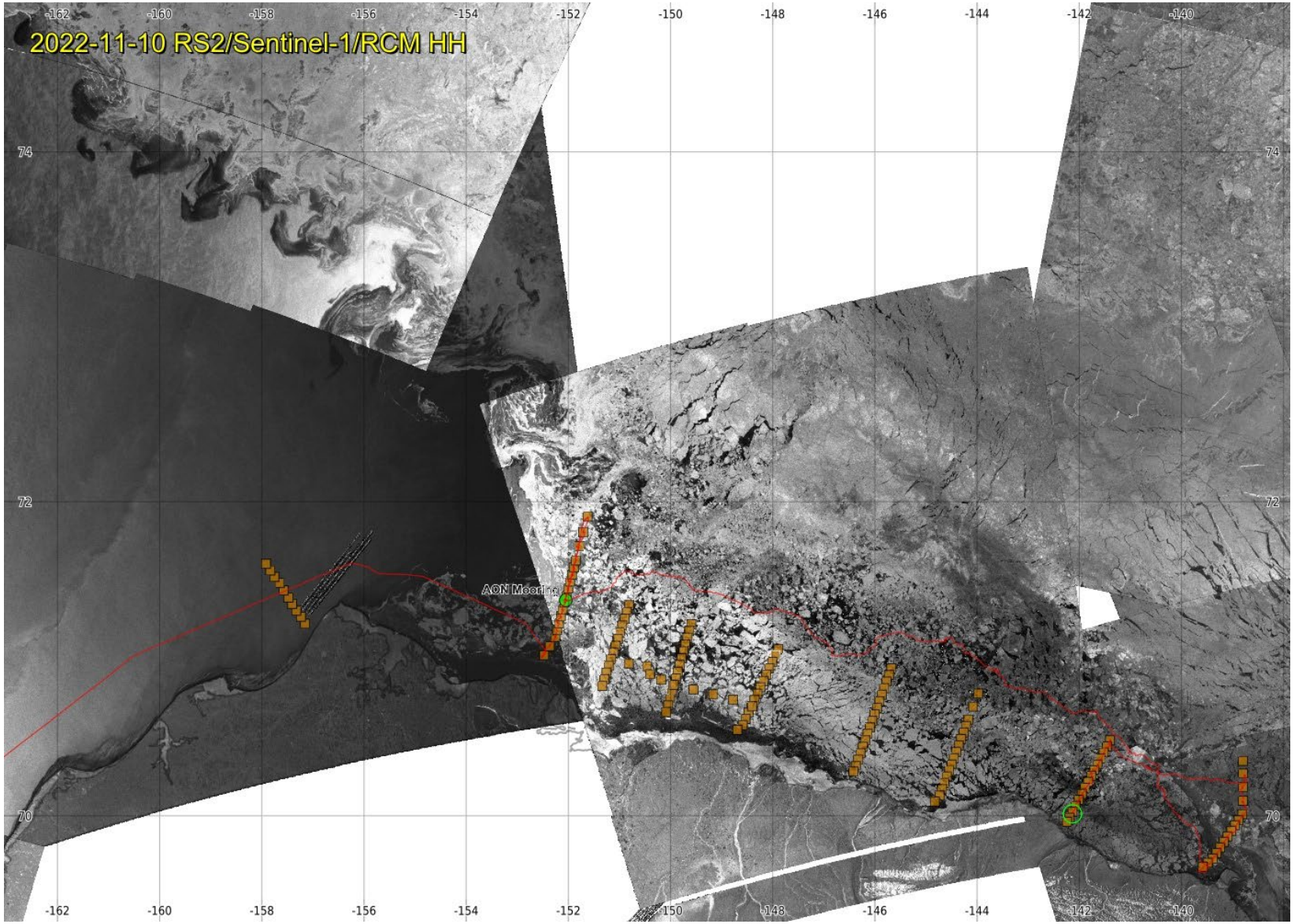
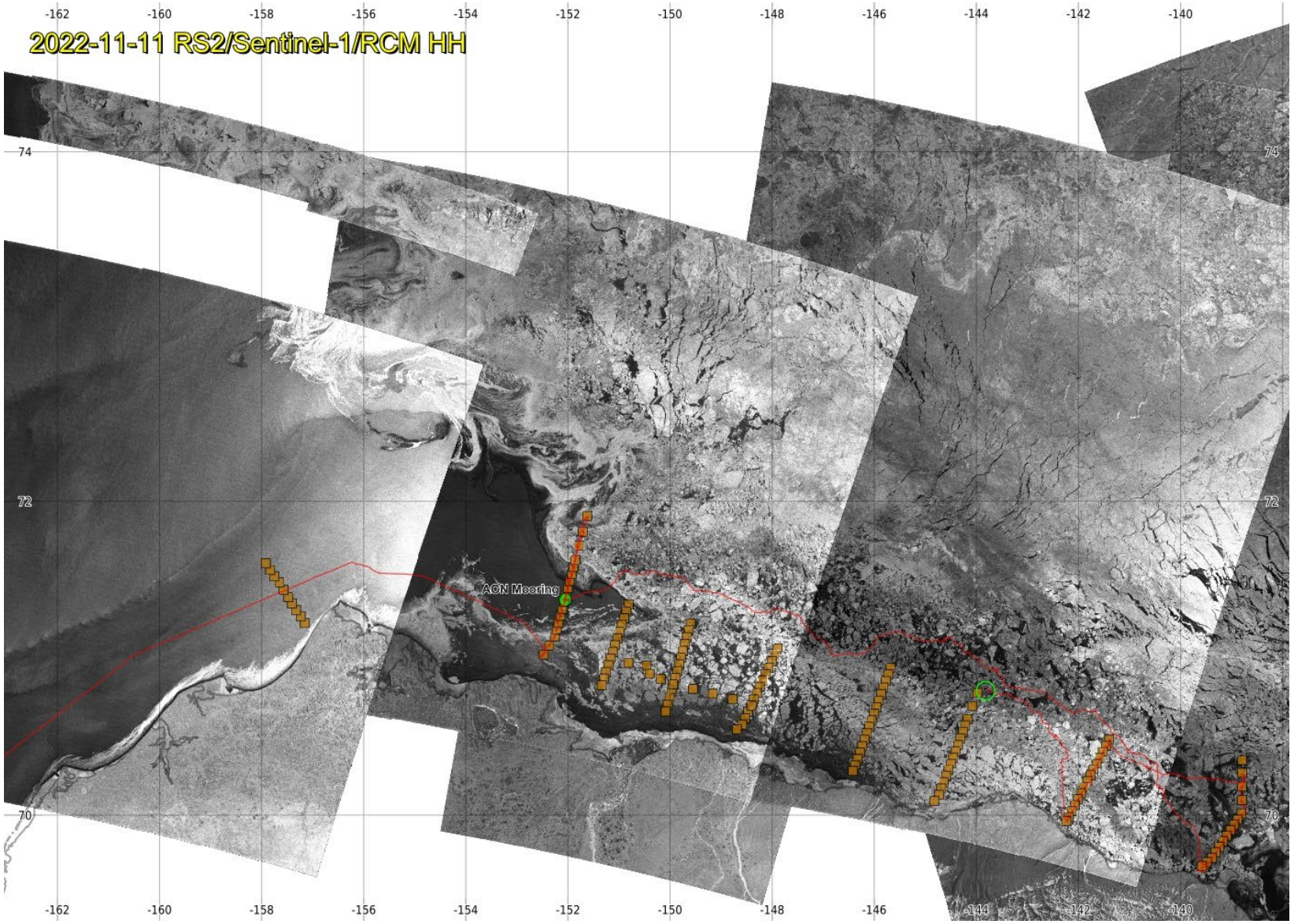


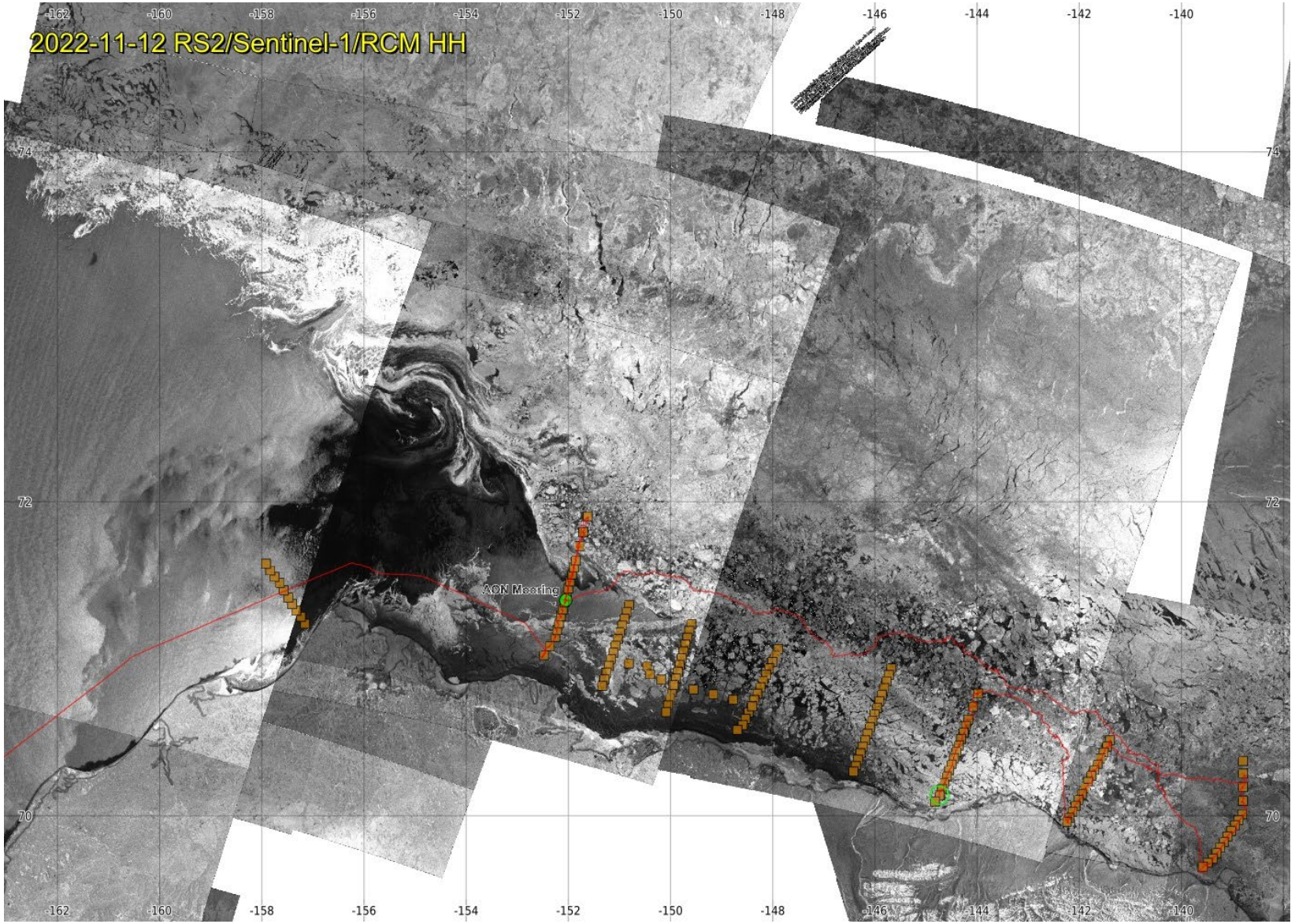
S. Roberts, UAF



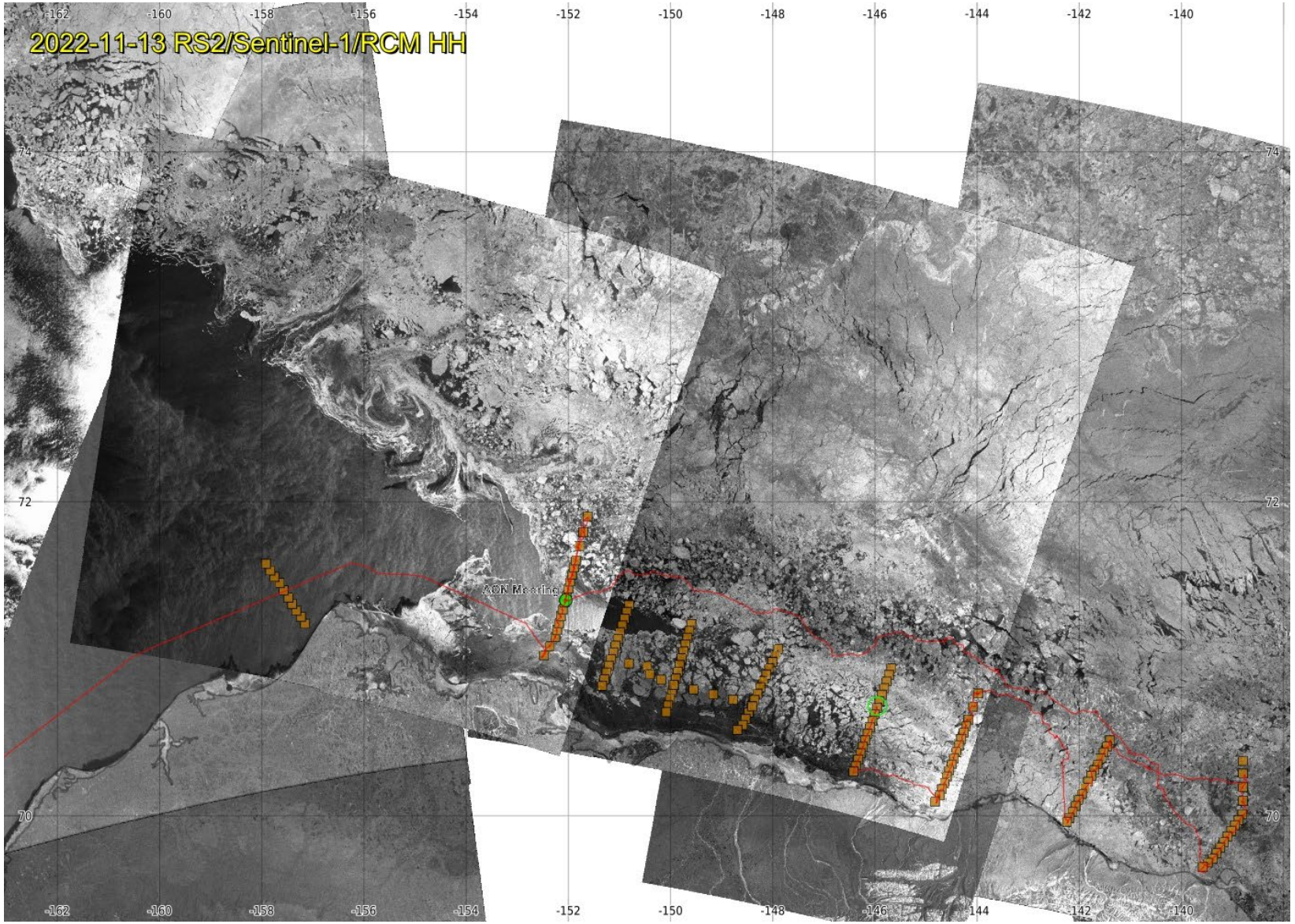
S. Roberts, UAF



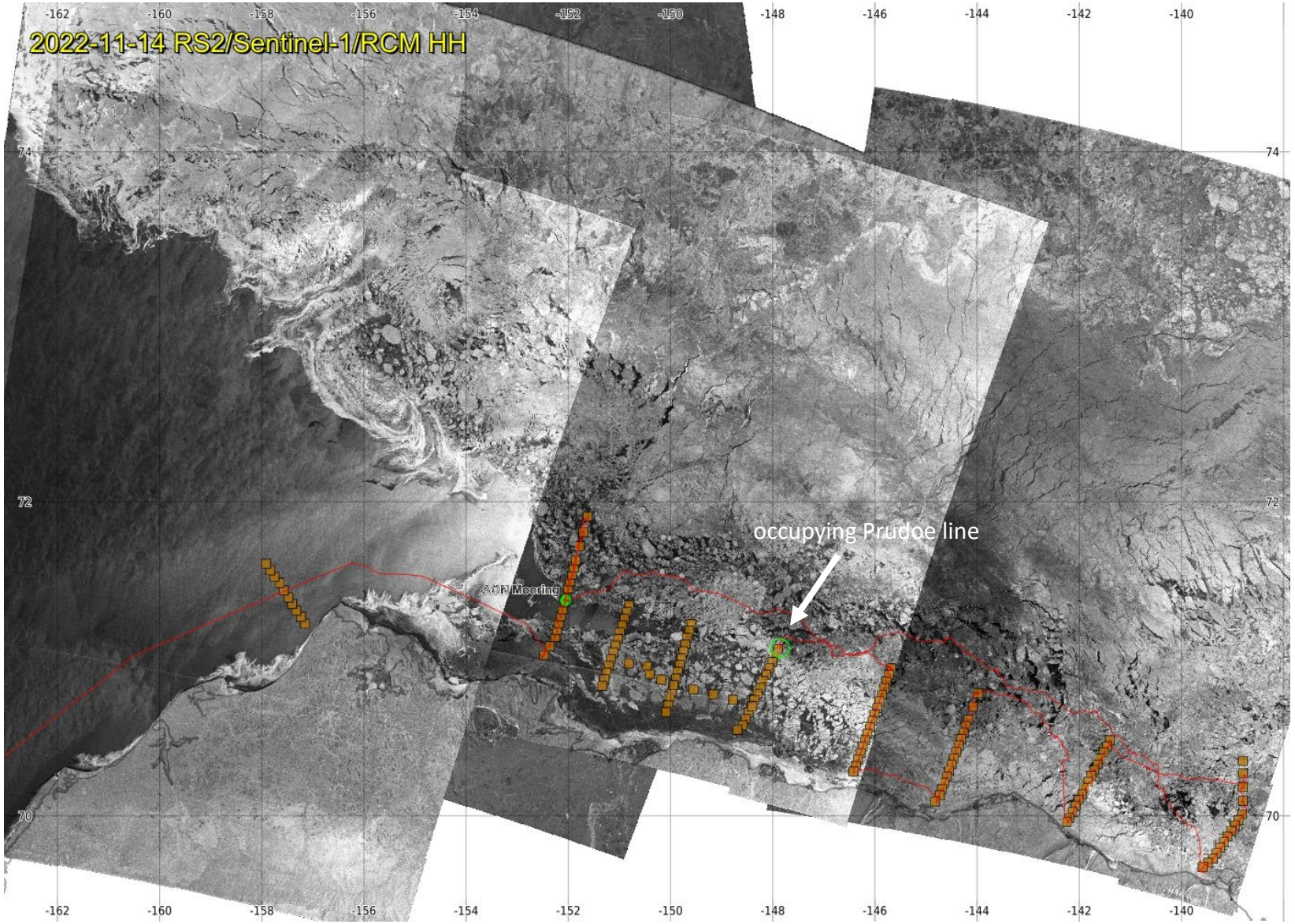
S. Roberts, UAF



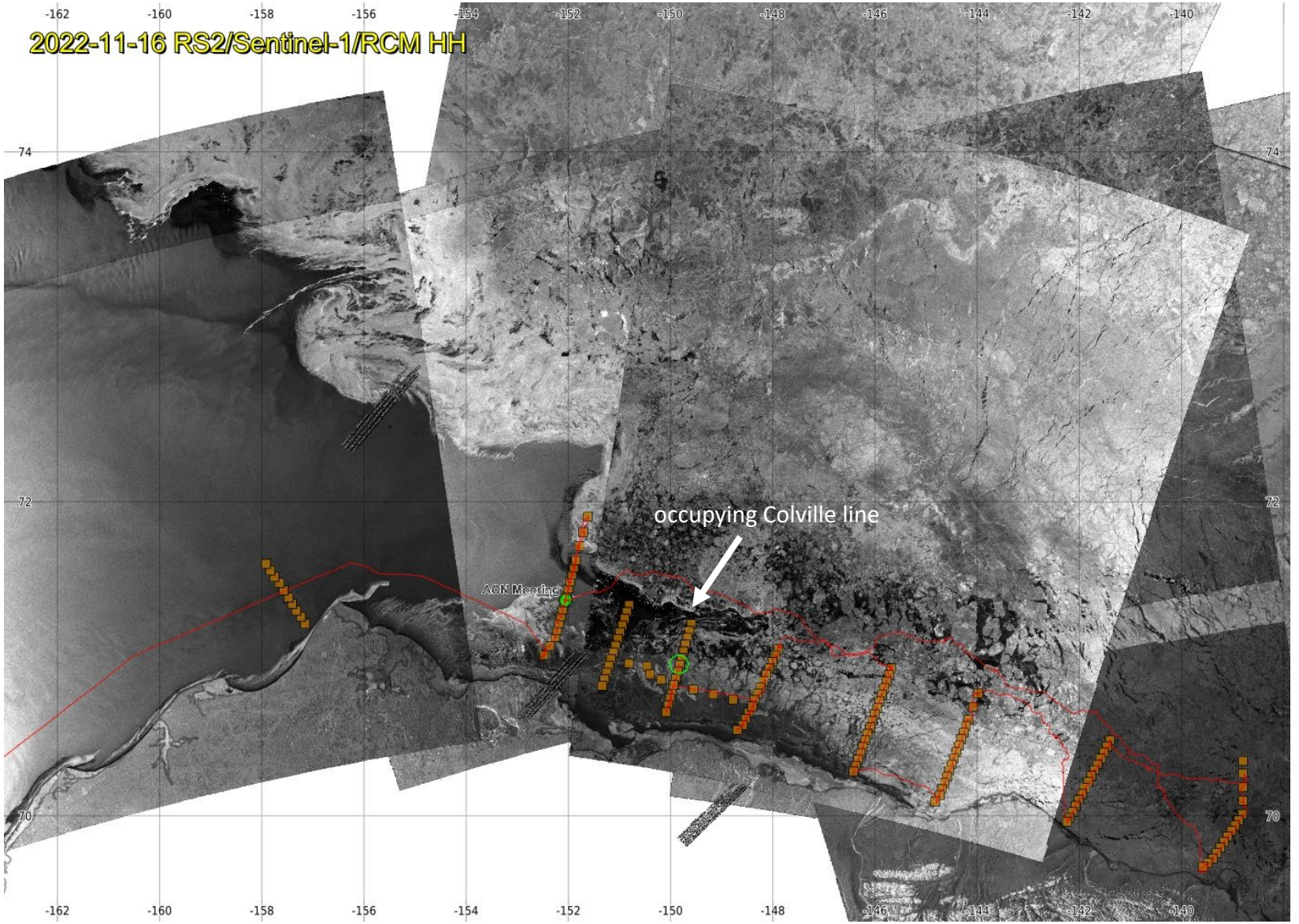
S. Roberts, UAF



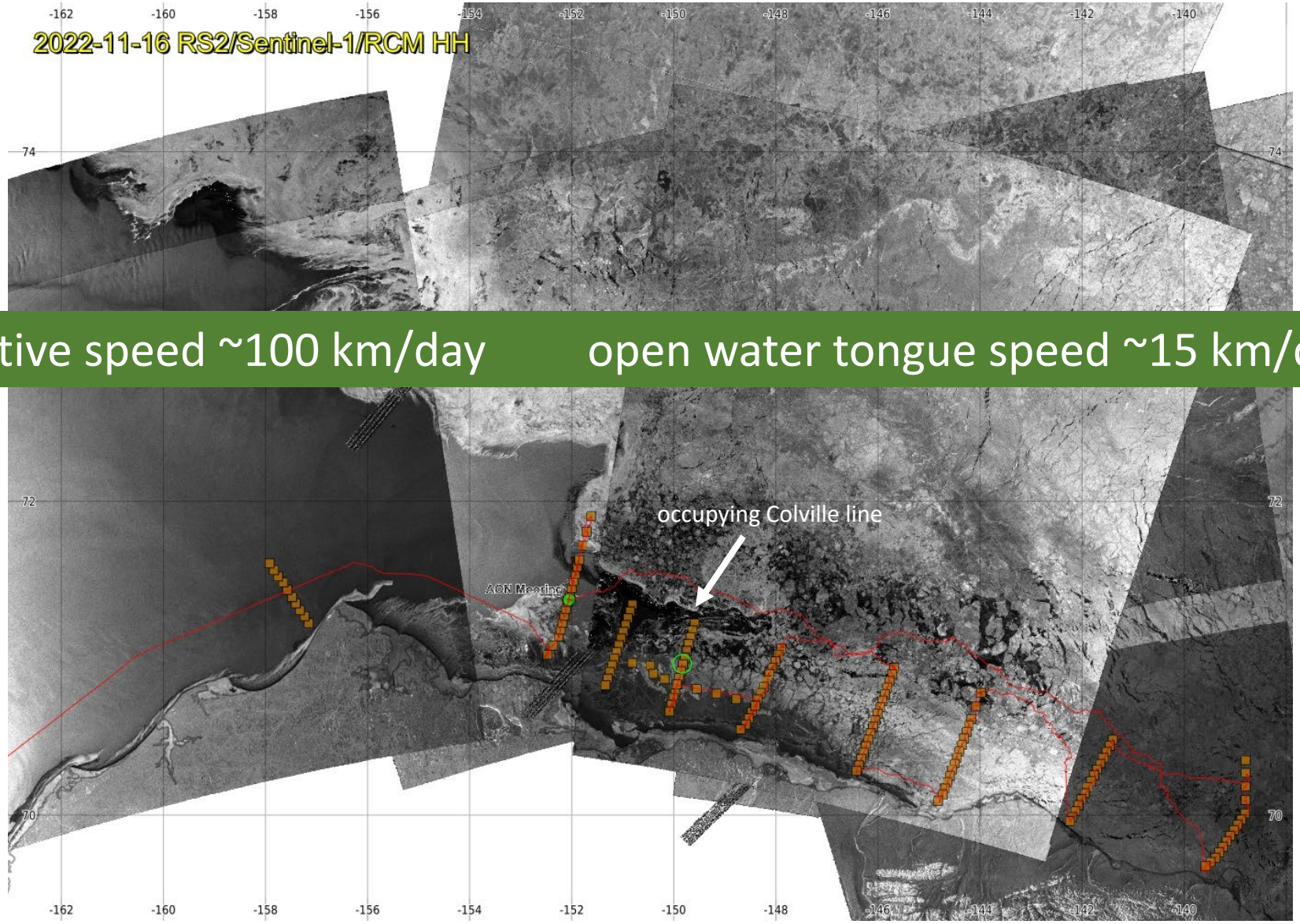
S. Roberts, UAF



S. Roberts, UAF



S. Roberts, UAF



Advective speed ~100 km/day open water tongue speed ~15 km/day

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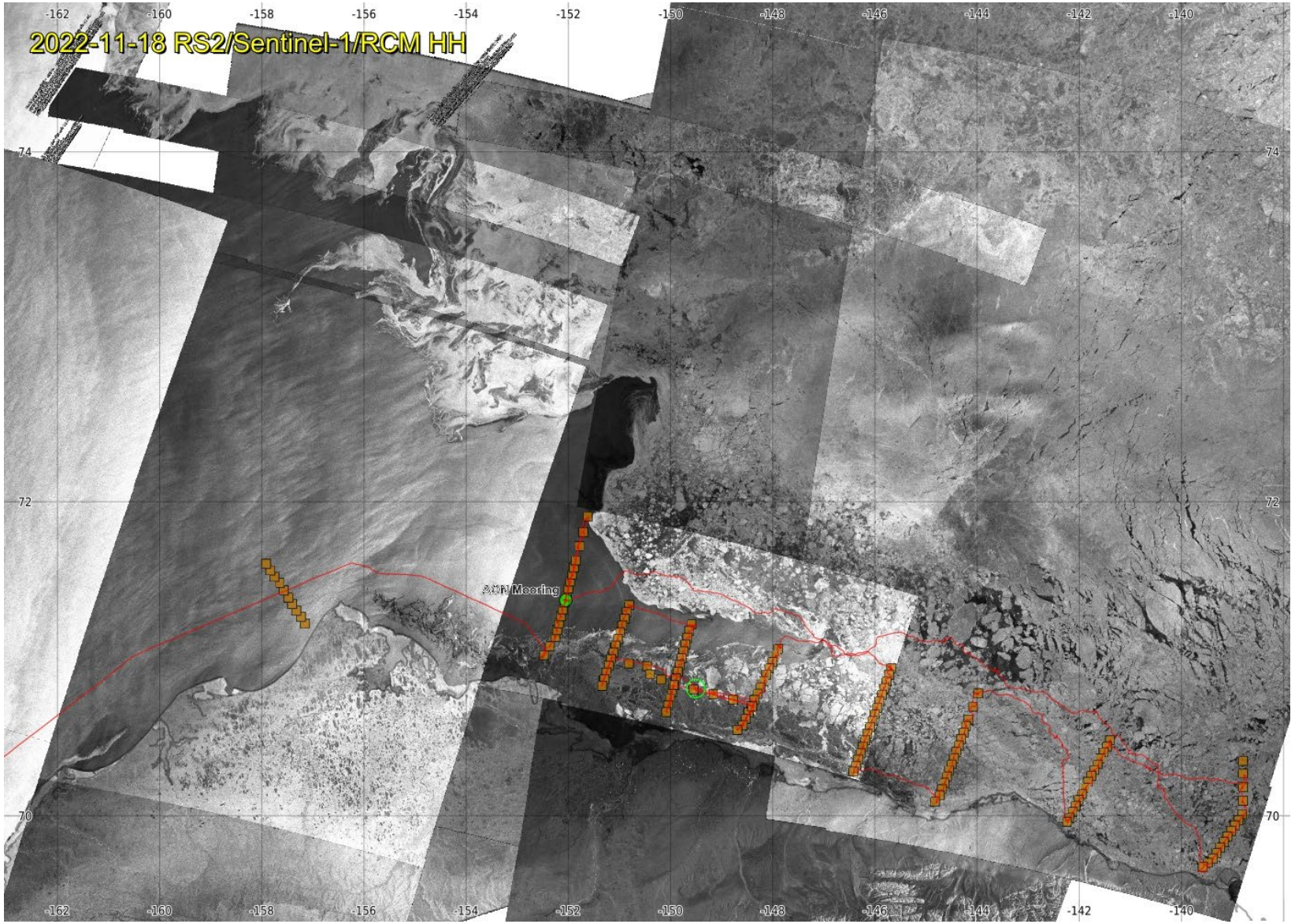

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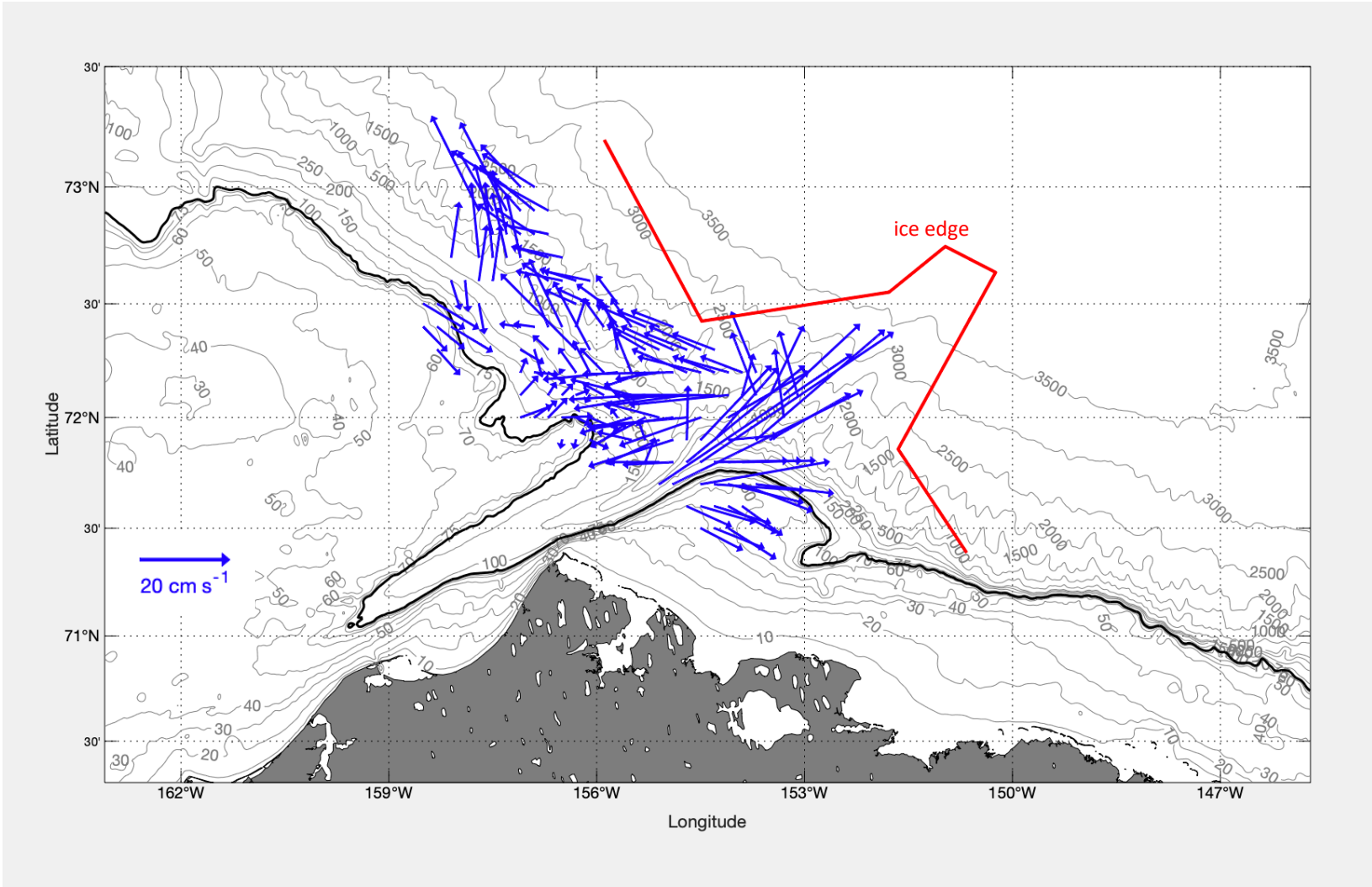
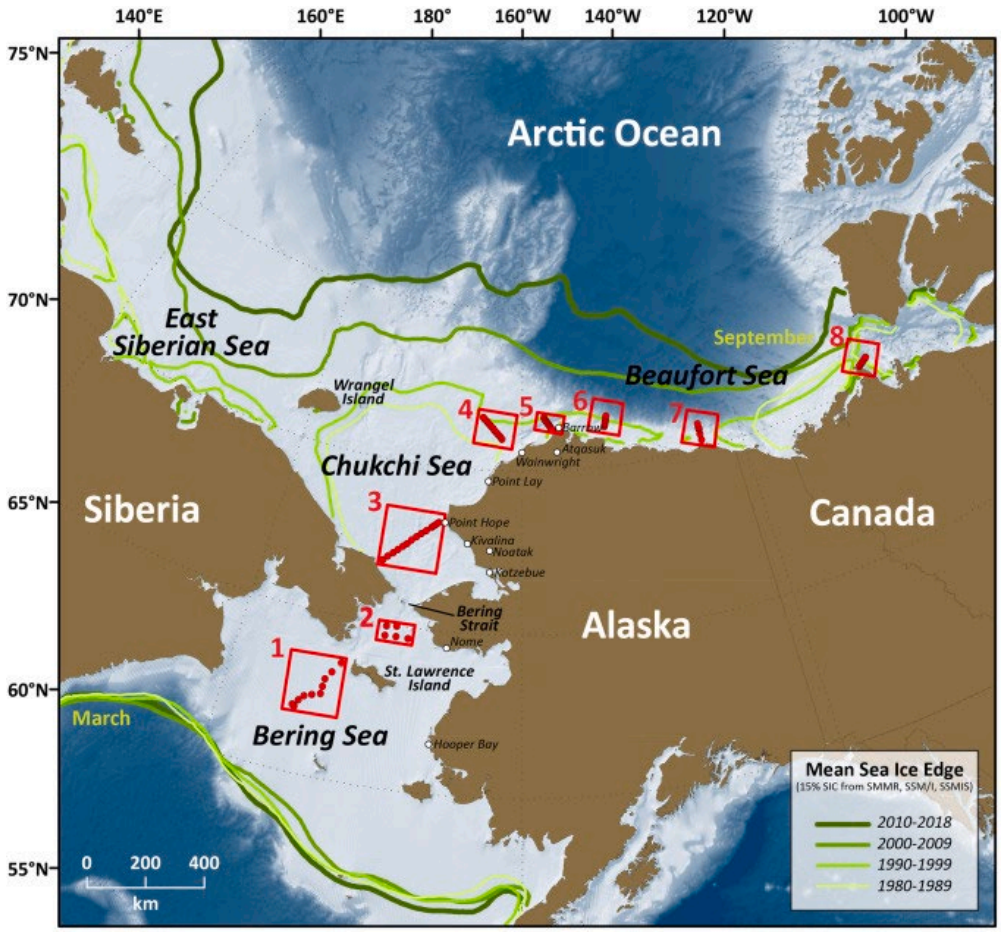
Autumn Barrow Canyon warm water outflow event: vectors (Nov 2018) and ice edge (Nov 2022)



On the cruise we occupied the following DBO lines

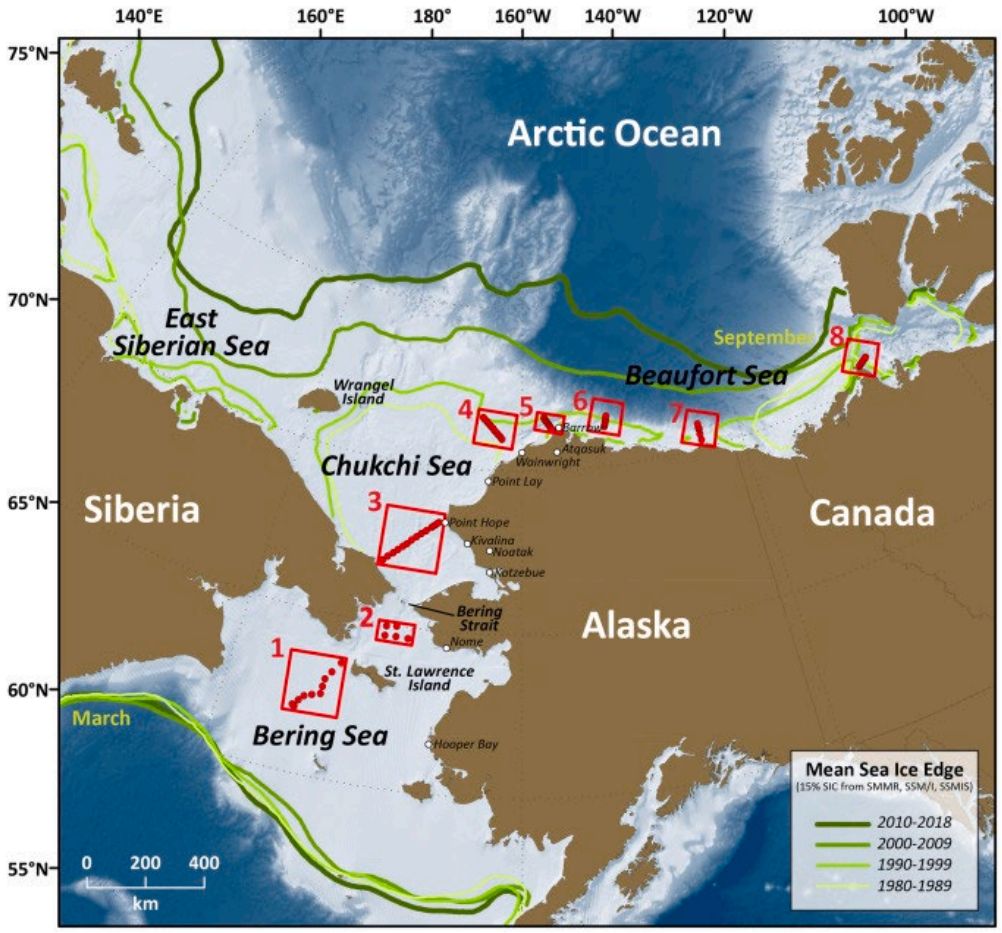
- DBO3
- DBO5
- DBO6
- Bering Strait



On the cruise we occupied the following DBO lines

- DBO3
- DBO5
- DBO6
- Bering Strait

171 CTD stations
69 surface sediment grabs
10 long cores



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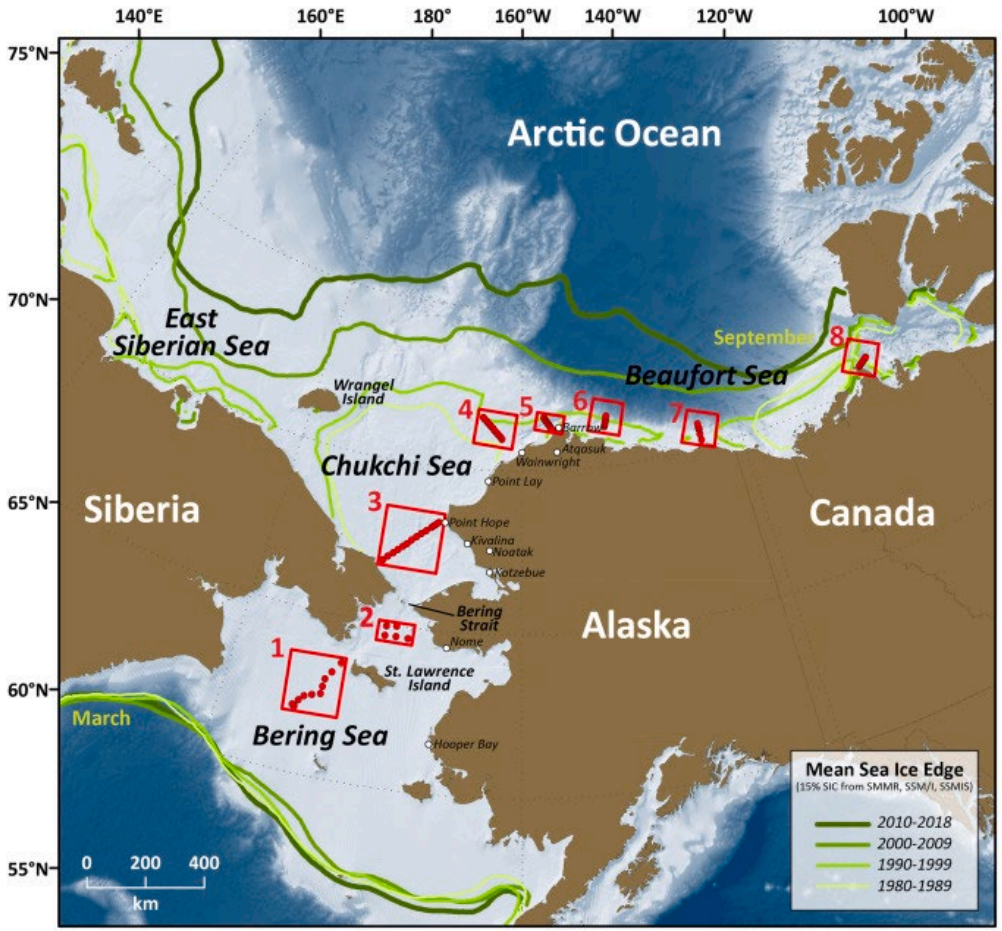

Acknowledgement: Canadian collaborator B. Williams


Thank you
photo by A. Pacini