Decision Support in the High Arctic

Five weeks of embedded deployment aboard the R/V Sikuliaq, October 10th-November 15th 2023

Michael Lawson NWS Anchorage/Alaska Sea Ice Program

February 9, 2024

Why is an ice analyst needed onboard?

- **Safety of the crew/science party/ship**
- **Thicker ice = less speed = more fuel = more time**
- **Limited mission time**
- **Ship *can* get stuck in the ice**

Powered by Esri

Nov11

R/V Sikuliaq vs. Coast Guard Cutter Healy

USCGC Healy

- Coast Guard's largest vessel
- Classified as a "medium ice breaker"
- Designed to break 4.5 ft. at 3 knots or ice 10 ft. thick when backing and ramming

- Healy has scientific research capabilities as well.

R/V Sikuliaq

https://www.uaf.edu/cfos/sikuliaq/

- Polar Class 5 ice capable research vessel
- "Ice capable" as opposed to "ice breaker"
- Can break 2.5 feet at 2 knots

- National Science Foundation owned ship operated by the University of Alaska Fairbanks
- Home port: Seward, AK
- Can accommodate up to 24 scientists and 22 crew

In port @ Dutch Harbor

What are the most important parameters?

1. **Multi-year ice** (cannot break, on the losing end of Force=mass x acceleration)
2. **General ice thickness** (speed decreases as thickness increases)
3. **Ice pressure** (from a meteorological perspective, convergence or divergence)

4. **Snow cover** (snow cover on ice is like sandpaper to the ship)
5. **Needs of the science party/what is the mission?** (open water for vehicle testing/suitable place to deploy vehicle or buoy)

The Mission

Arctic Mobile Observing System

Office of Naval Research funded mission

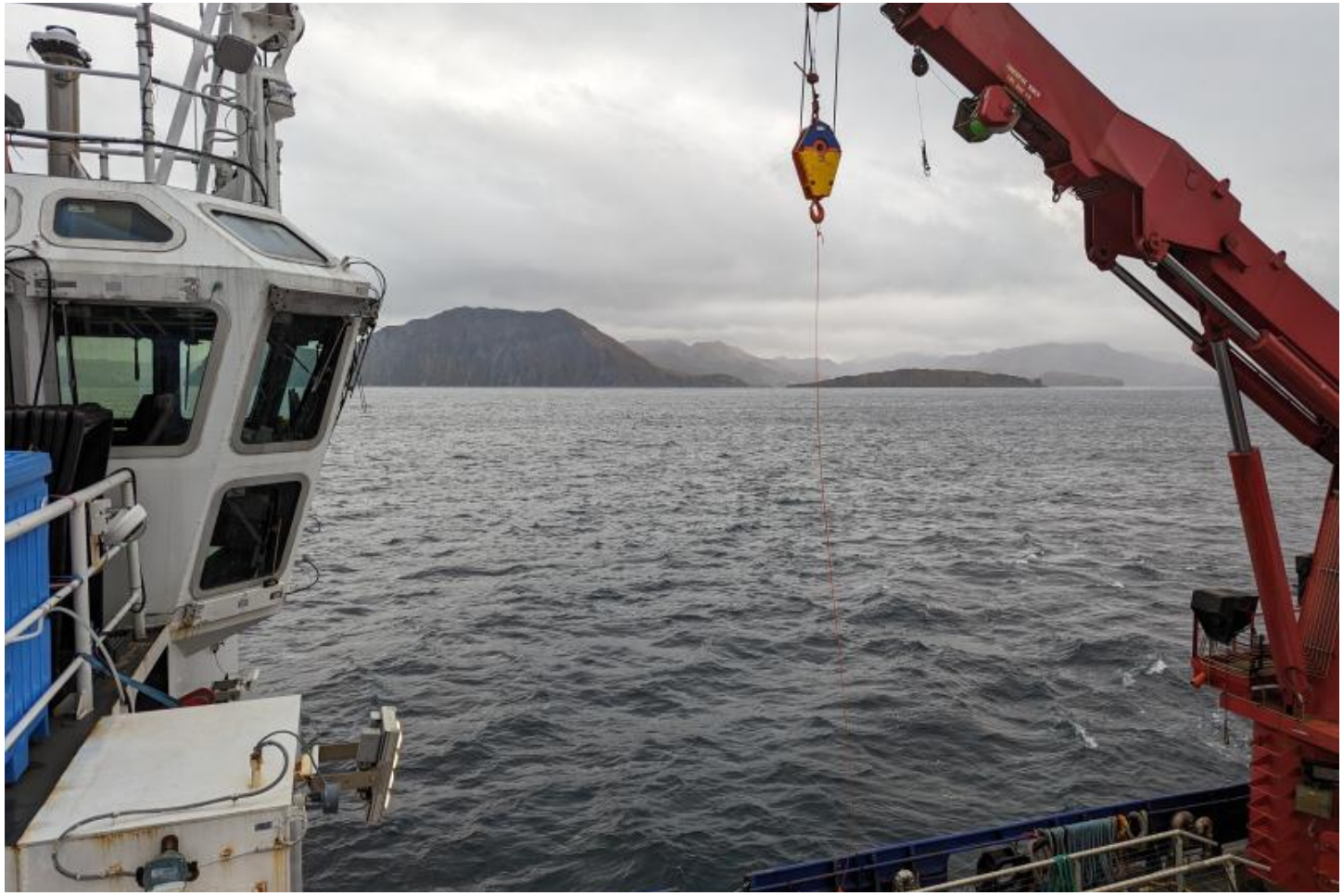
"a network of robotic oceanographic instruments making years-long autonomous observations of ocean and sea ice physics."

Challenges

- **Unprecedented:** Alaska Sea Ice Program has never deployed an analyst
- **IT issues:** Laptops relatively new, not powerful enough for the imagery load. Profiles not designed to be off-network
- **1st for Sikuliaq:** had their own ice analyst previously, never had an ASIP/NIC analyst

- **Time-shortened:** Engine troubles kept Sikuliaq in port an additional 10 days beyond original planned departure

Nov 6 position



What did the standard work day on the ship look like?

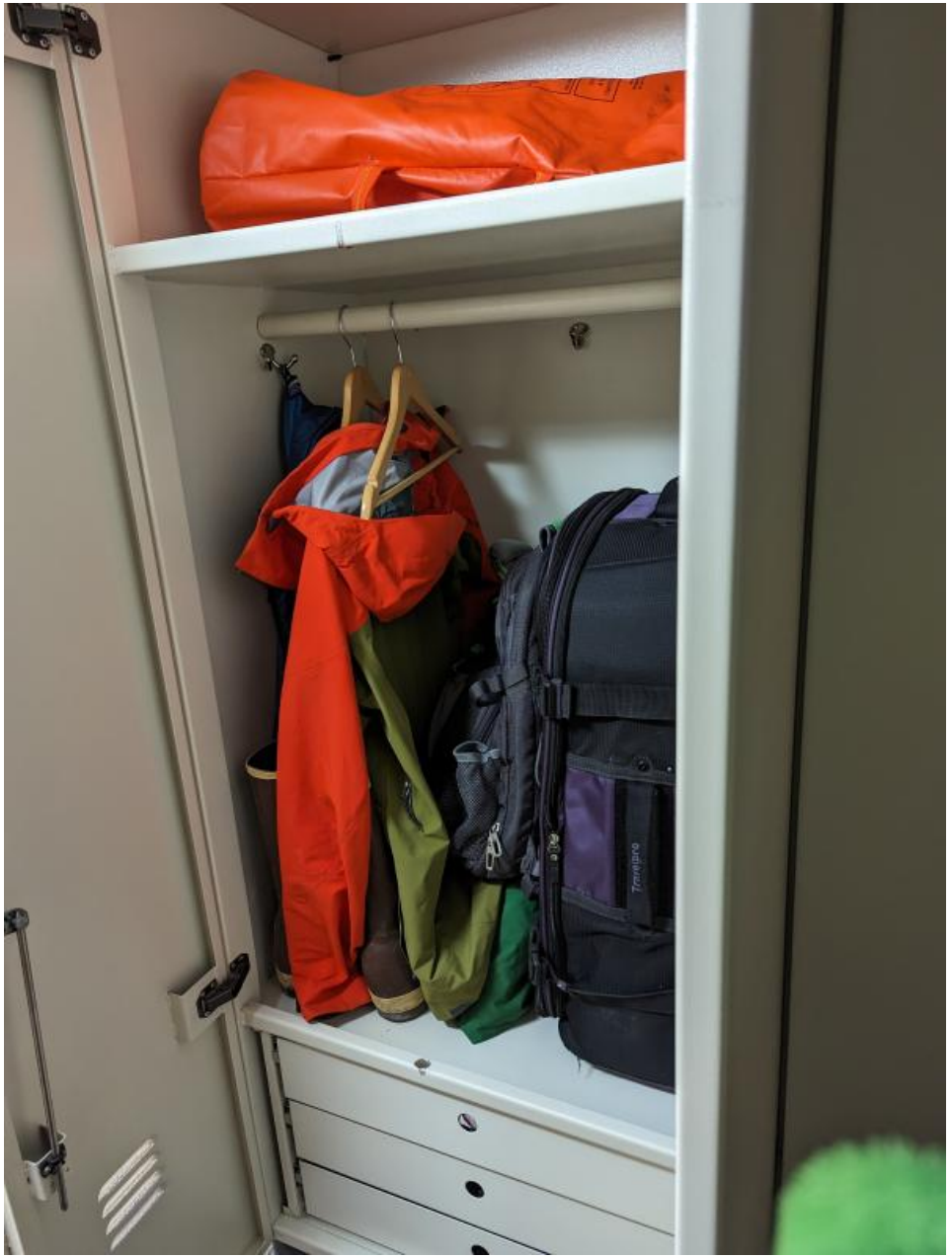
Process was refined over days and weeks but this is what I settled into after a couple weeks

On the back deck

6:00-7:00 am:

Wake up!

In the bunk



Locker in the stateroom

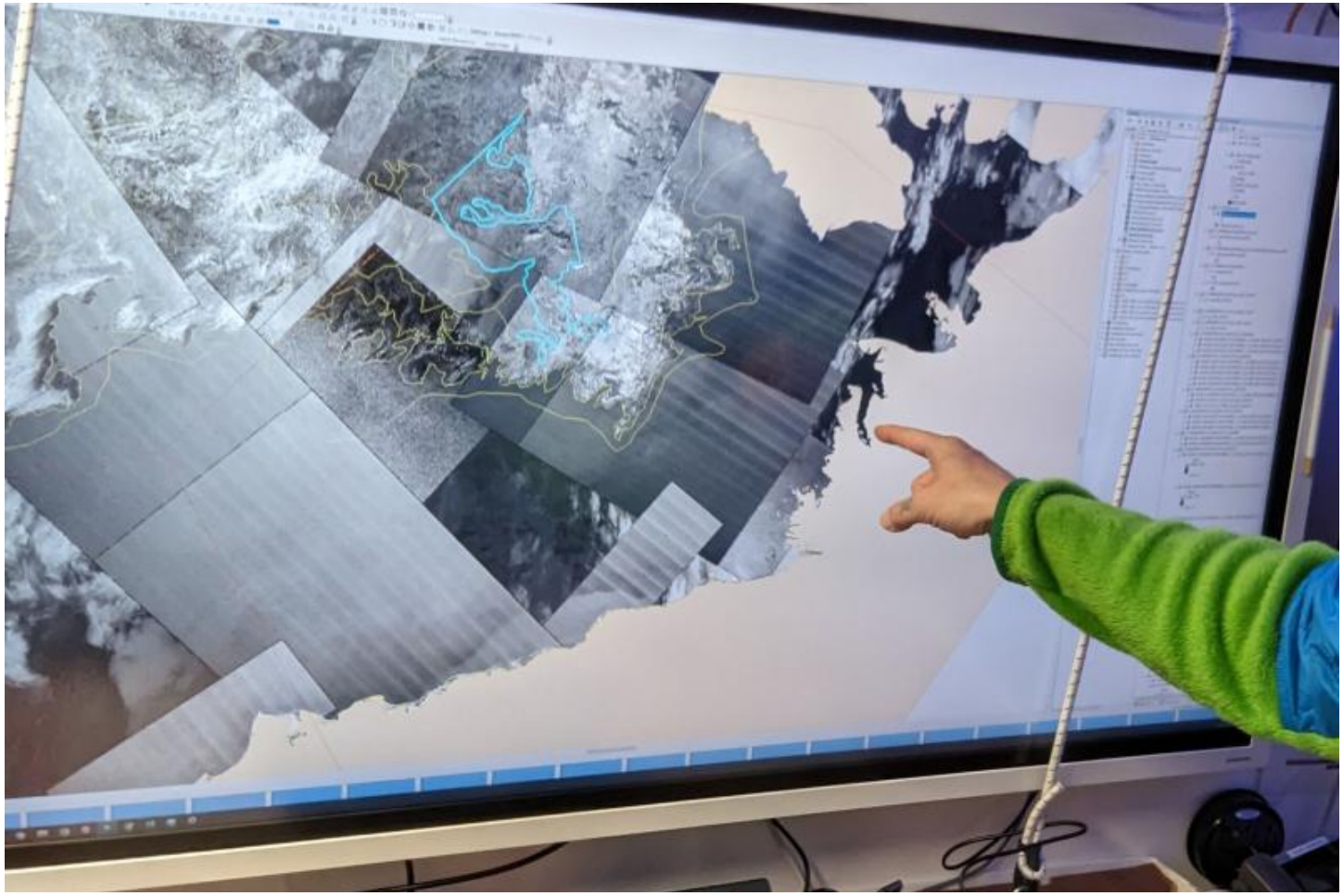
Office setup

- Work computer + TV for running ArcMap
- 2nd laptop for onboard map server, gathering data
- TV for SA, data display, ship cameras

- Window to observe ice conditions

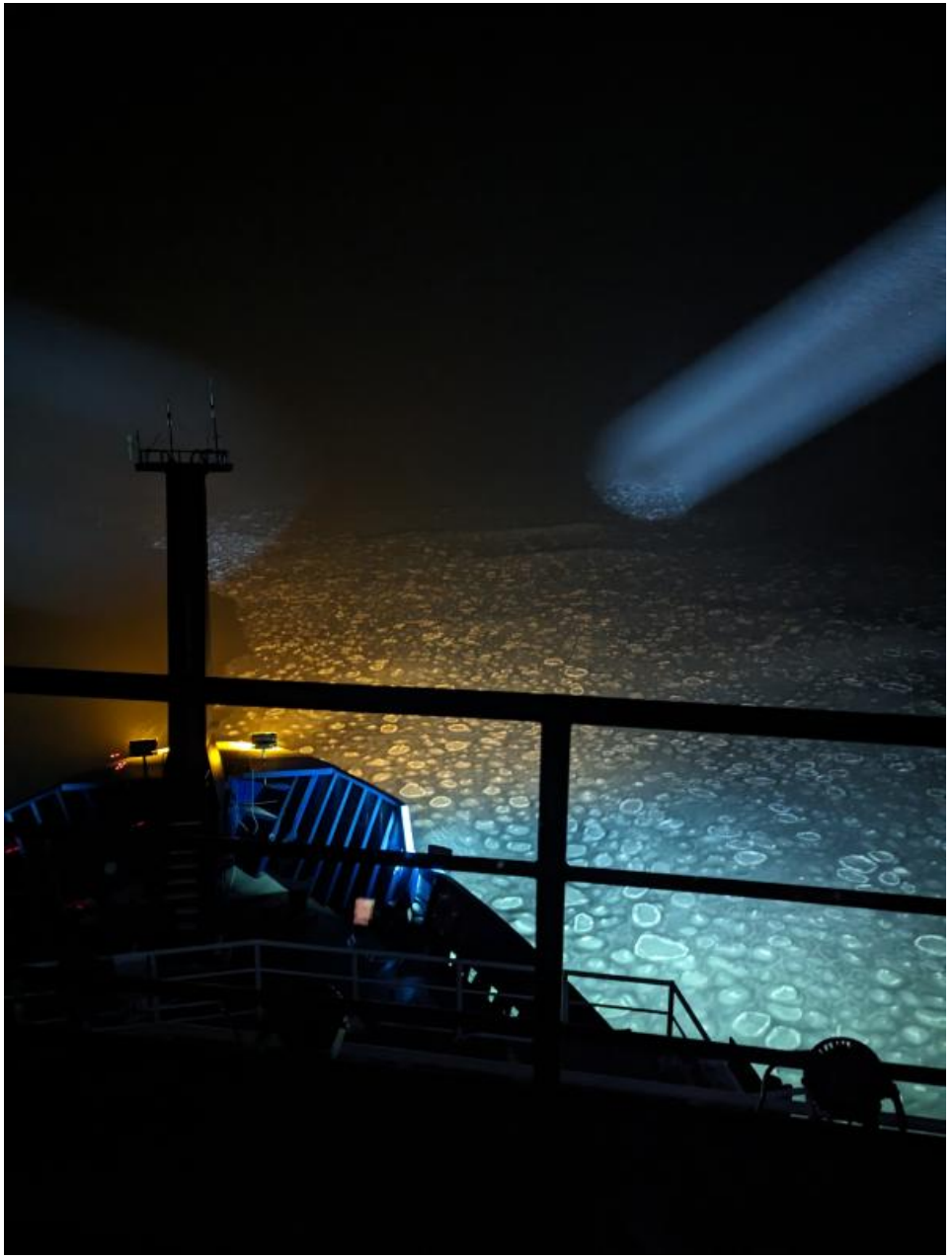
- Large screen for standing or briefing

On of the available data display options for situational awareness



6:45-7:15 am:

- Load imagery from ship server to computer
- Load imagery into ArcMap and get a quick look at conditions in case any questions arise at breakfast. Generally looking at last evening's SAR imagery and any new POES data (IR/DNB).
- Measure movements of features from yesterday's analysis to get a feel for movement on the whole or locally near the ship



7:15-7:25 am: Breakfast

Artwork in the galley

Shoutout to the Sikuliaq galley crew, the food was INCREDIBLE!

7:25-7:35 am:

Go up to the bridge to check in with Chief Mate/2nd Mate on changing ice and weather conditions overnight. Talk about what we're currently seeing and where it's going to go.

Local school outreach/tour while in port

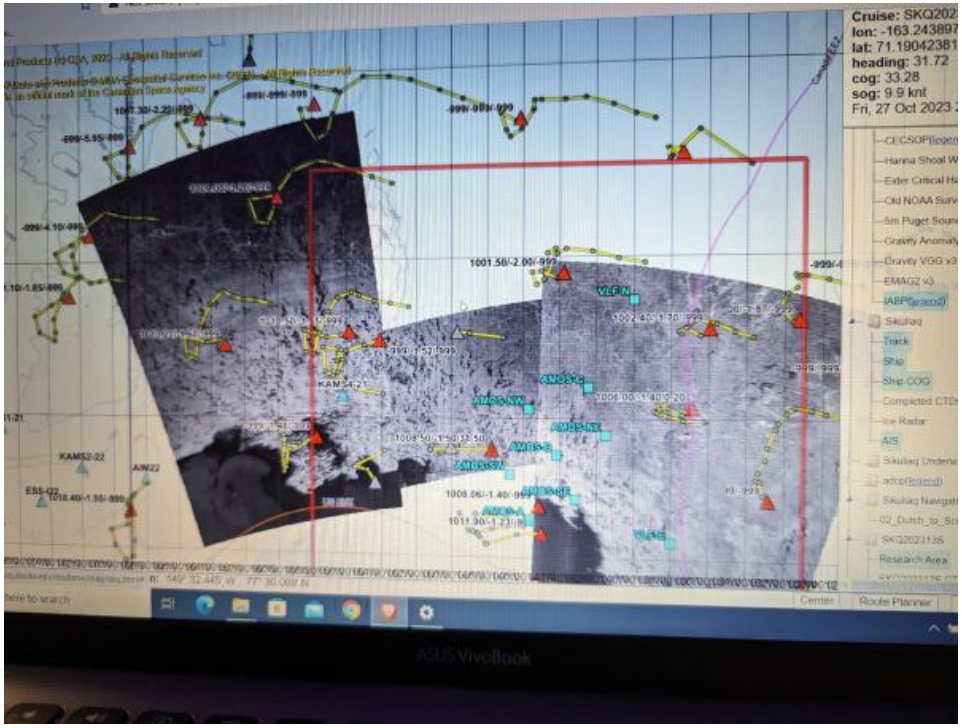
In port @ Dutch Harbor

7:35-9:50 am:

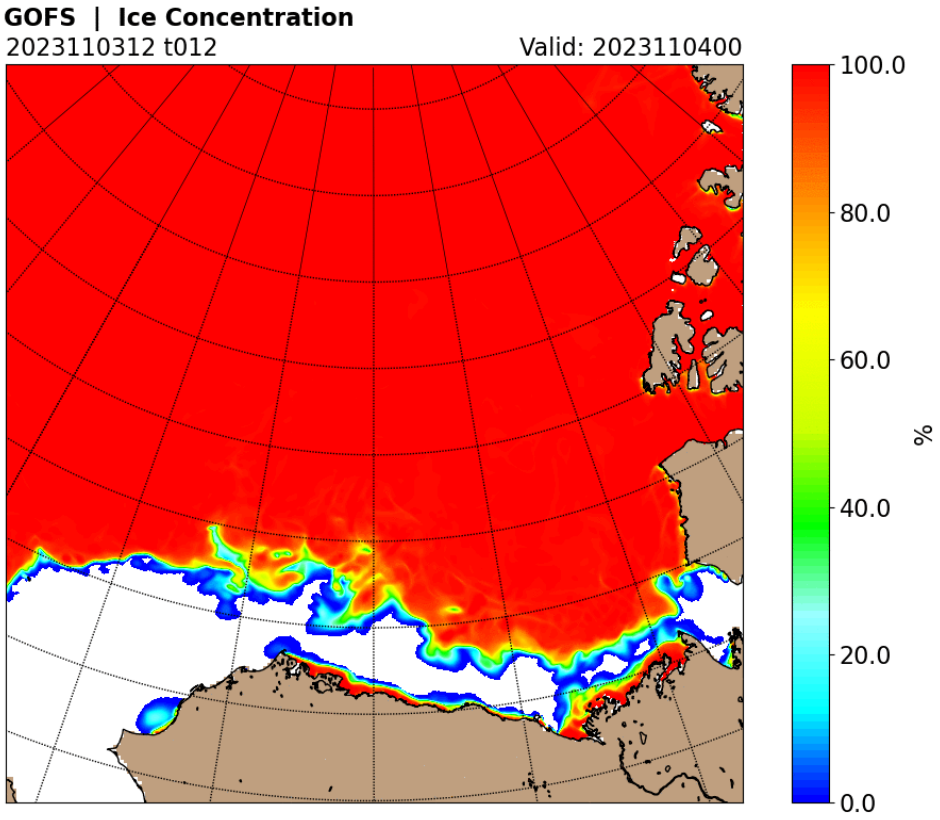
Prepare for daily 10 am ice briefing on the bridge.

- More detailed look at ice imagery. Examine synthetic aperture radar, infrared, day/night band
- Buoy analysis for ice drift
- SST analysis for freeze-up or melt potential

- Analyze meteorological models for the next 24-36 hours, generally only EC/GFS in the Arctic.
- Windy
- Weatherbell
- Tropical Tidbits



Buoy drift courtesy International Arctic Buoy Program


GOFS | Ice Concentration
2023110312 t012
Valid: 2023110400
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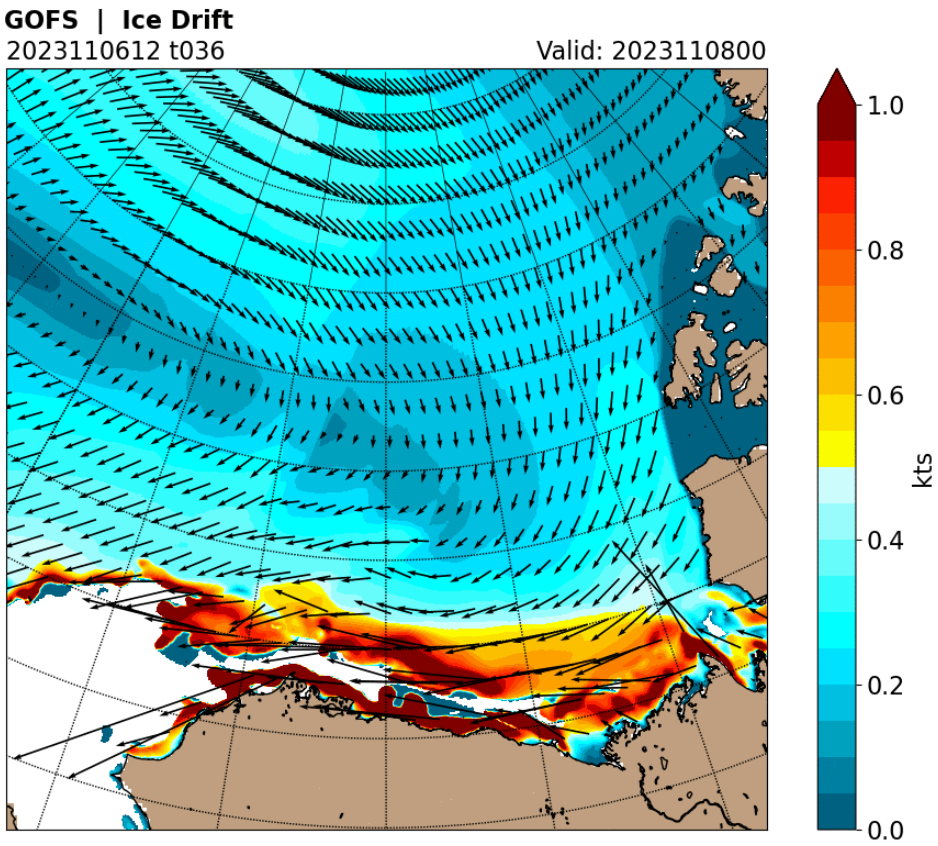
GOFS | Ice Drift
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GOFS | Lead Area Opening Rate

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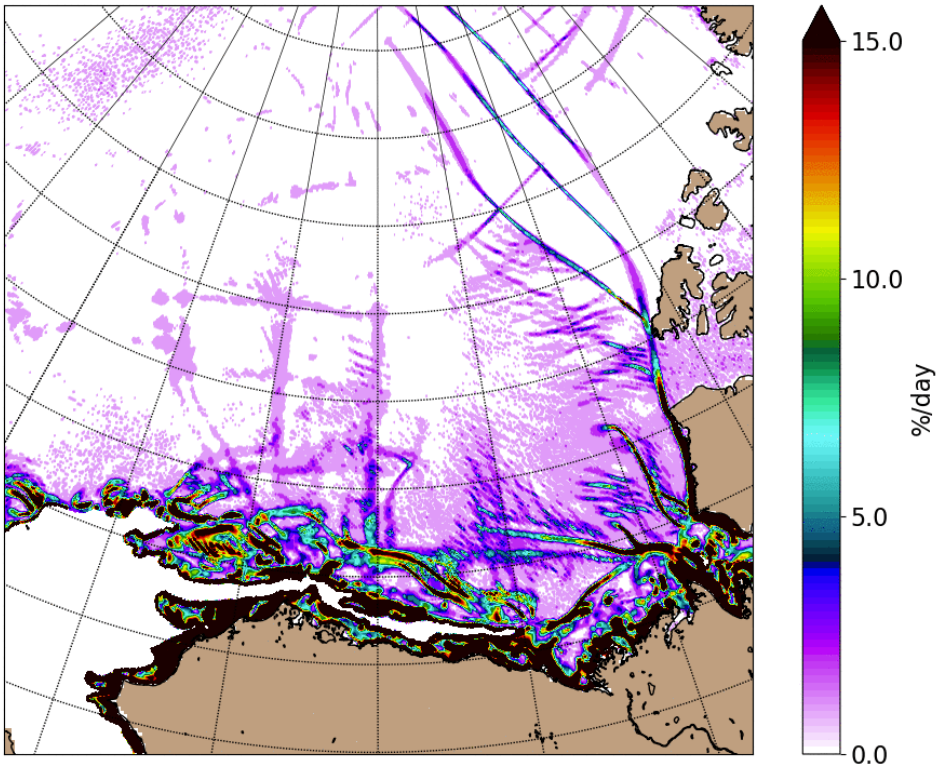

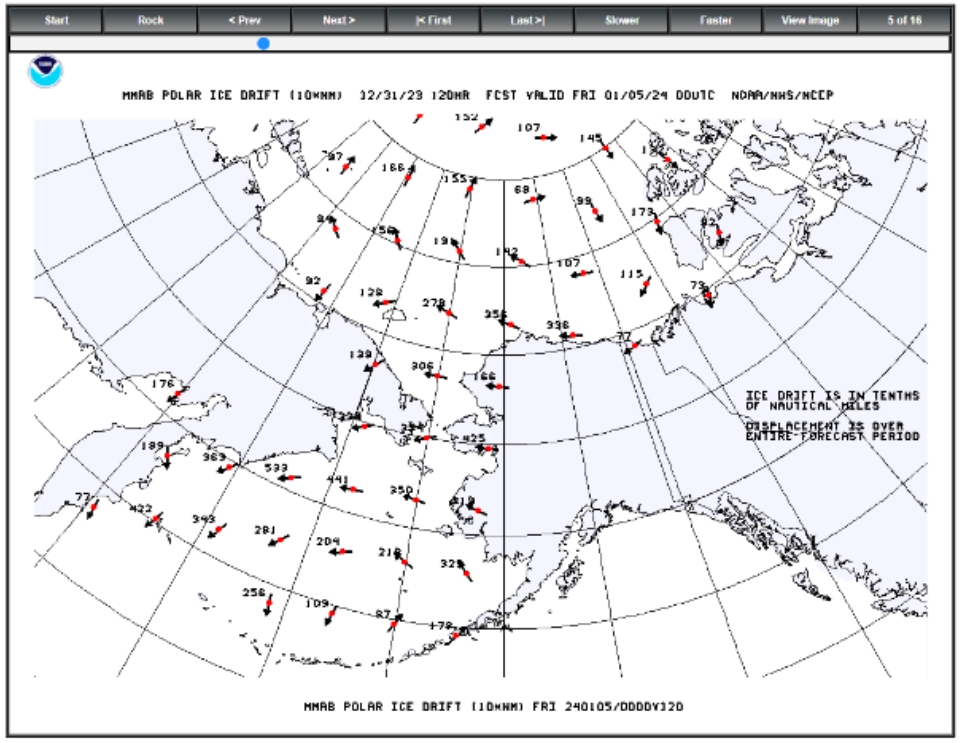
Start
Rock
< Prev
Next >
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Slower
Faster
View Image
5 of 16
MMAB POLAR ICE DRIFT (10KNM) 12/31/23 120HR FCST VALID FRI 01/05/24 0000Z NOAA/NWS/NCEP
ICE DRIFT IS IN TENTHS OF NAUTICAL MILES
DISPLACEMENT IS OVER ENTIRE FORECAST PERIOD
MMAB POLAR ICE DRIFT (10KNM) FRI 240105/0000V120

Drift model

10:00-10:30 am(or later): Ice/wx brief

Captain/Chief mate/2nd mate/3rd mate/Chief Scientist/Co-chief Scientist plus some science party and ship crew

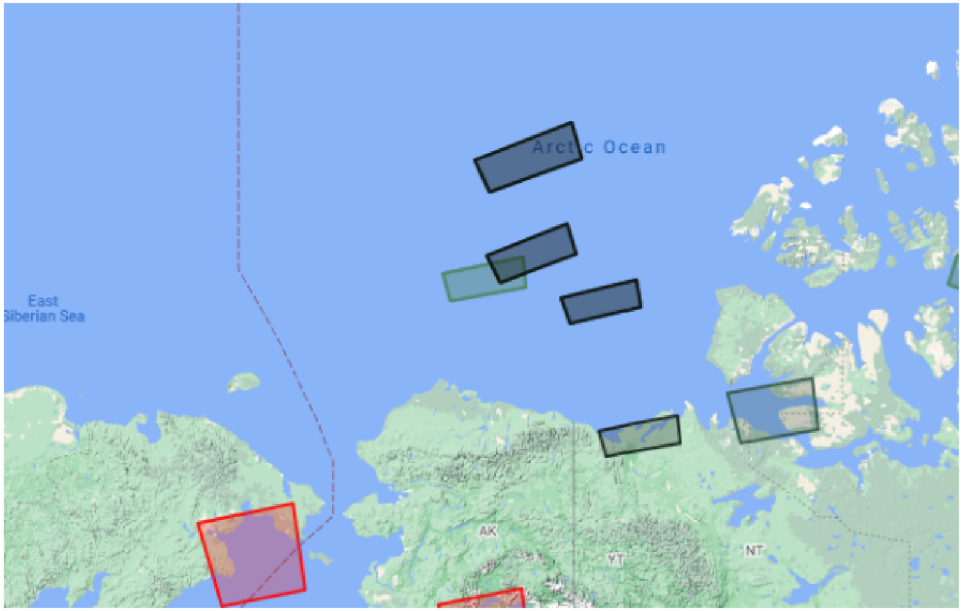
1. Start with current wx conditions(satellite: (**POES**!) describing major features) then shift to Windy to highlight winds/pressure/temperature.

2. Shift to current ice conditions, usually SAR (RS2/RCM). DNB to highlight leads if any. Point out generally thickness and floe size, any visible snow cover, open leads. Point out where multi-year ice is relative to the ship and AMOS array.
3. Shift to forecast wx, mainly temps and winds, and how it will affect ice in coming days.
4. Questions from the Captain/Mates/Chief Scientists or science party/crew

10:30-11:30 am:

Download morning imagery and get it into ArcMap. Get a look at it to see how it has changed from evening imagery in case there's imminent information to pass along before or during lunch.

https://www.star.nesdis.noaa.gov/socd/mecb/sar/sarwinds_rcm_rs2.php



Not so good SAR day

11:30-11:55: Lunch

No polar bear incidents on this cruise

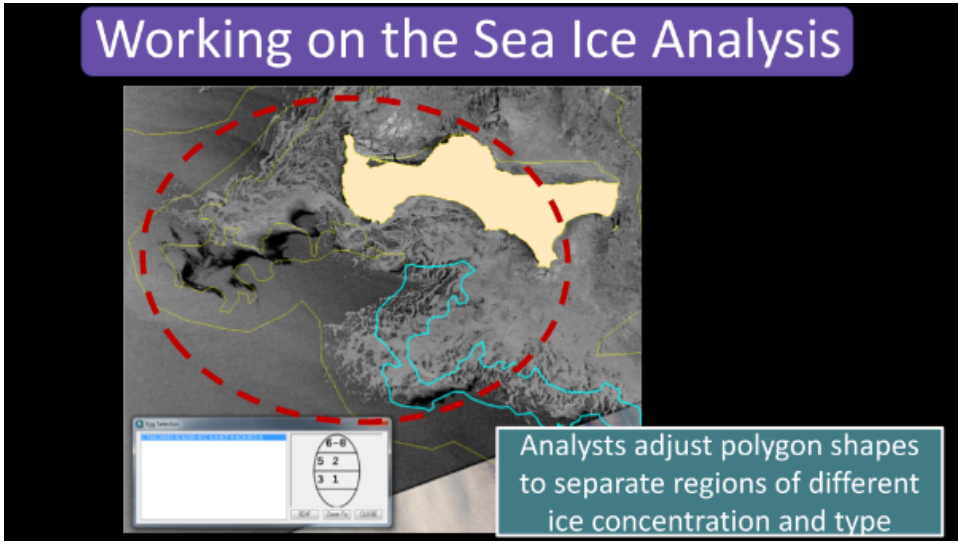
In the Halloween spirit!

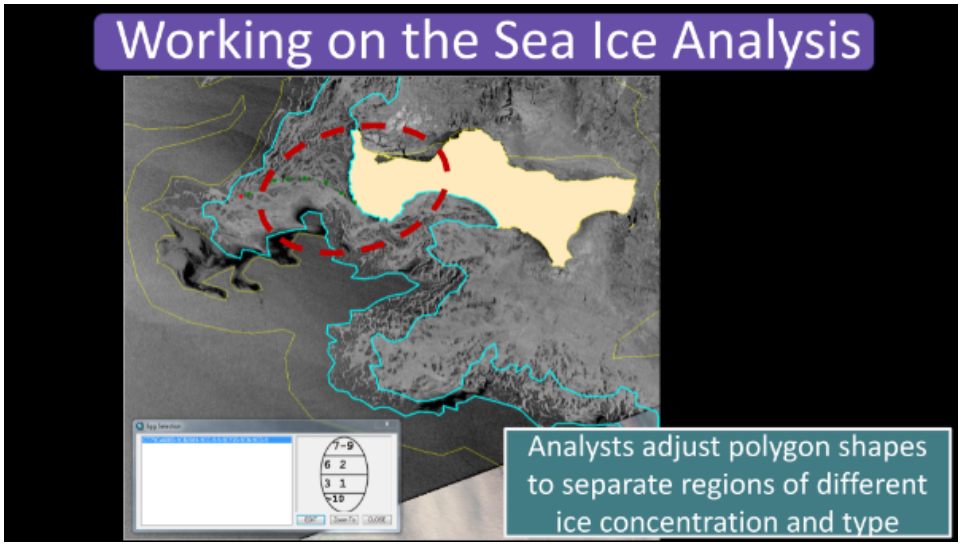
11:55 am-2:00 pm:

Analyze daily imagery in SIPAS. Adjust lines generally the same way I normally would for operations.

- Separate ice into various shapes and code the egg based on:
- Concentration
- Thickness

- Form

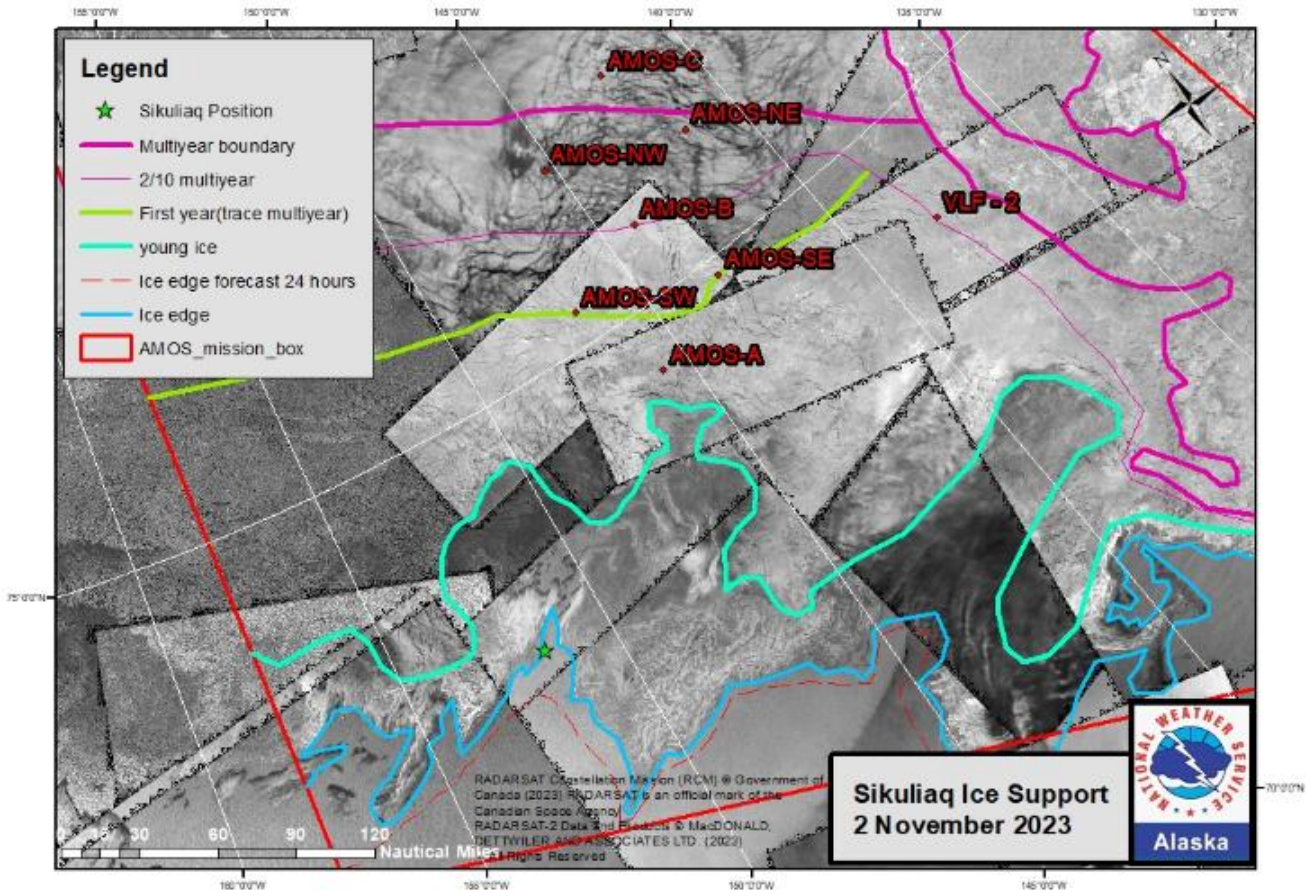

Working on the Sea Ice Analysis
Analysts adjust polygon shapes to separate regions of different ice concentration and type


Working on the Sea Ice Analysis
Analysts adjust polygon shapes to separate regions of different ice concentration and type

2:00-2:30 pm:

Check in with bridge on updates for current ice conditions

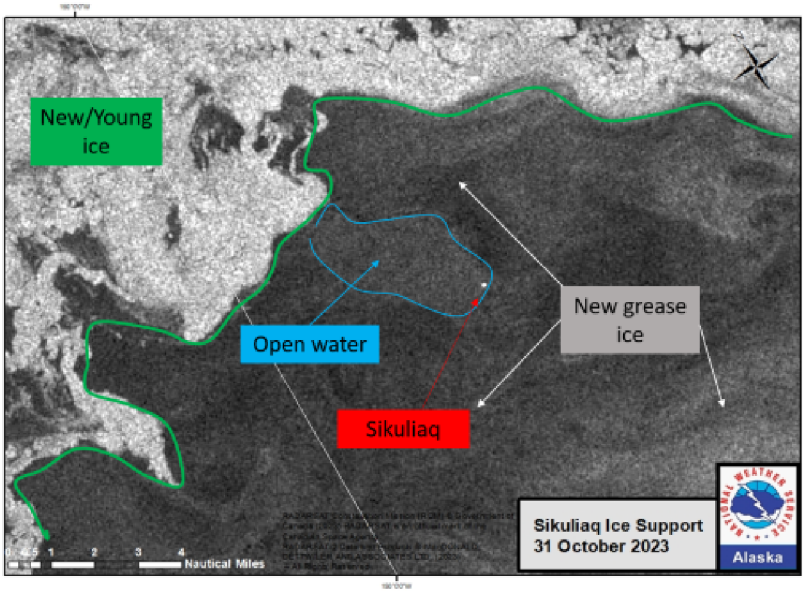
On the bridge



2:30-5:00 pm: Products

- Create daily summary email, highlighting the day's conditions, challenges, and a general map of ice conditions.
- Create a zoomed map focused on next day's operations regarding ice conditions.
- Create animations from POES data to better visualize ice motion.

- Look ahead at weather conditions further in the future.



Products continued

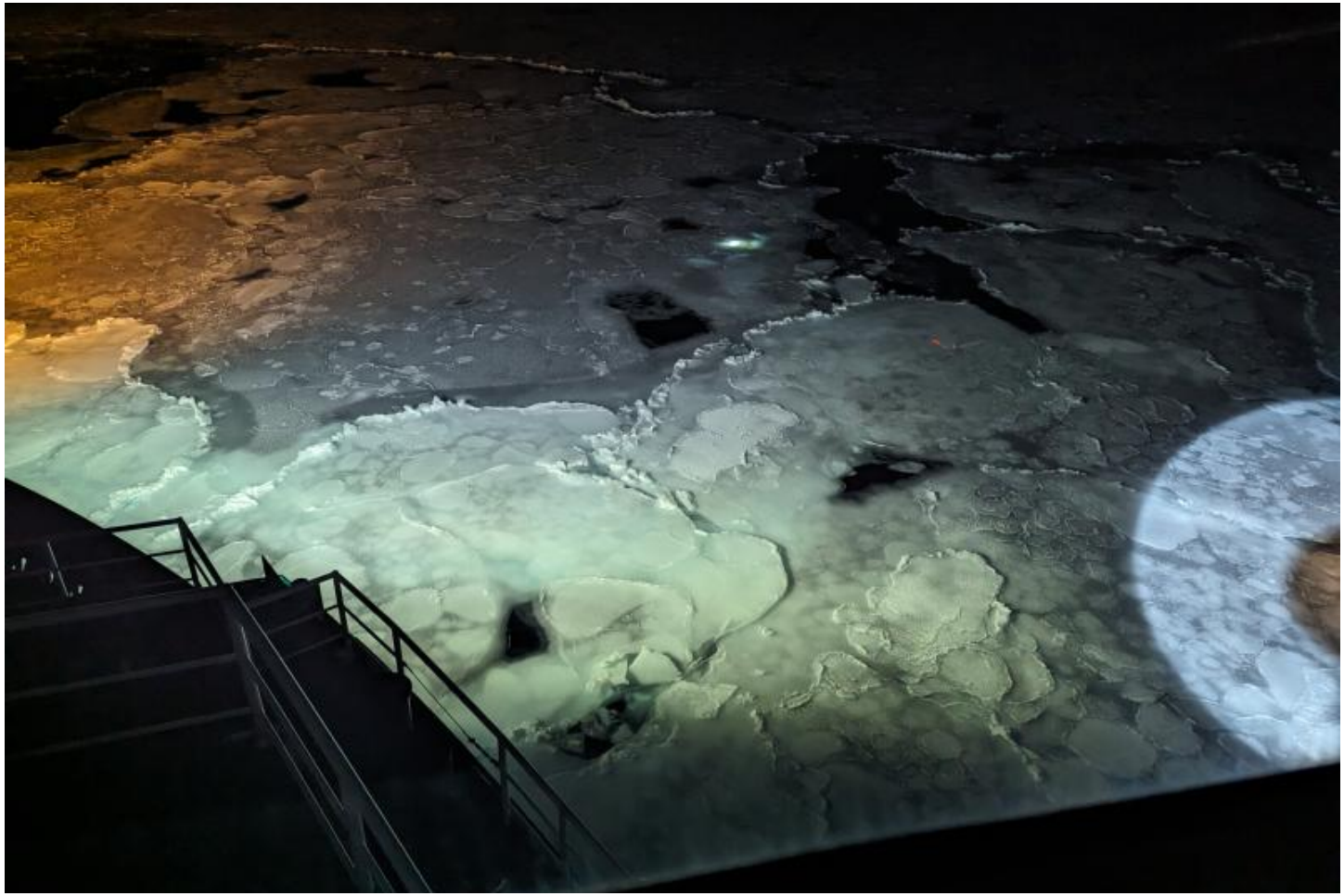
Usually a zoomed-in image focused on the problem of the next day geared toward ship operations or science objectives

Dinner: 5:00-6:00 pm

As one of my current co-workers (used to work on a ship) says:

"Good food is morale!"

Morale being served and consumed

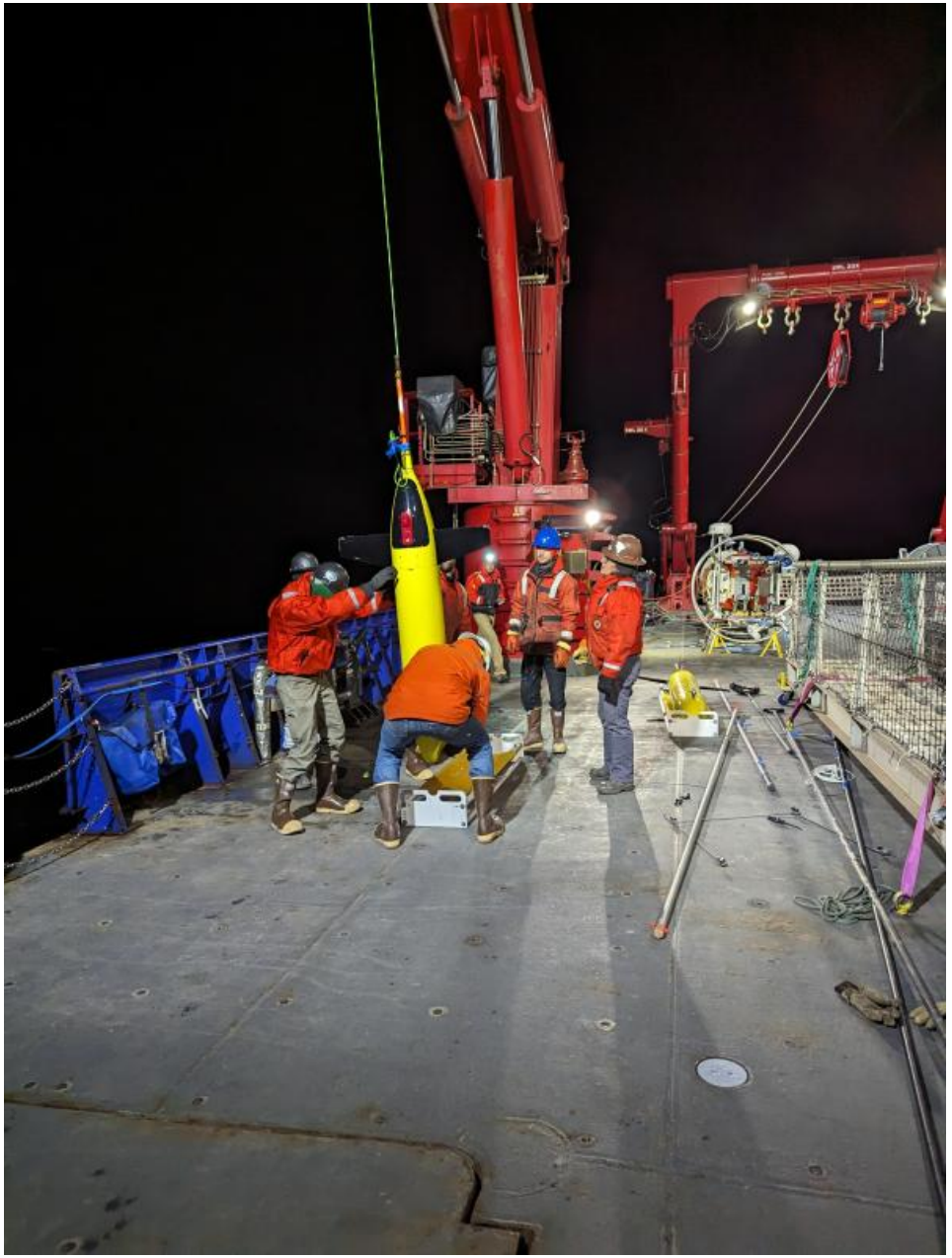


Evening updates 7:30-??:

Check in with evening SAR imagery. Usually was in by this point, sometimes not. Sometimes it was in but not over our area, so no new information.

If any new information came available I would check in with the bridge. A couple times evening operations dictated that a briefing

was needed after this point so a decision could be made on where to head overnight based on ice conditions.



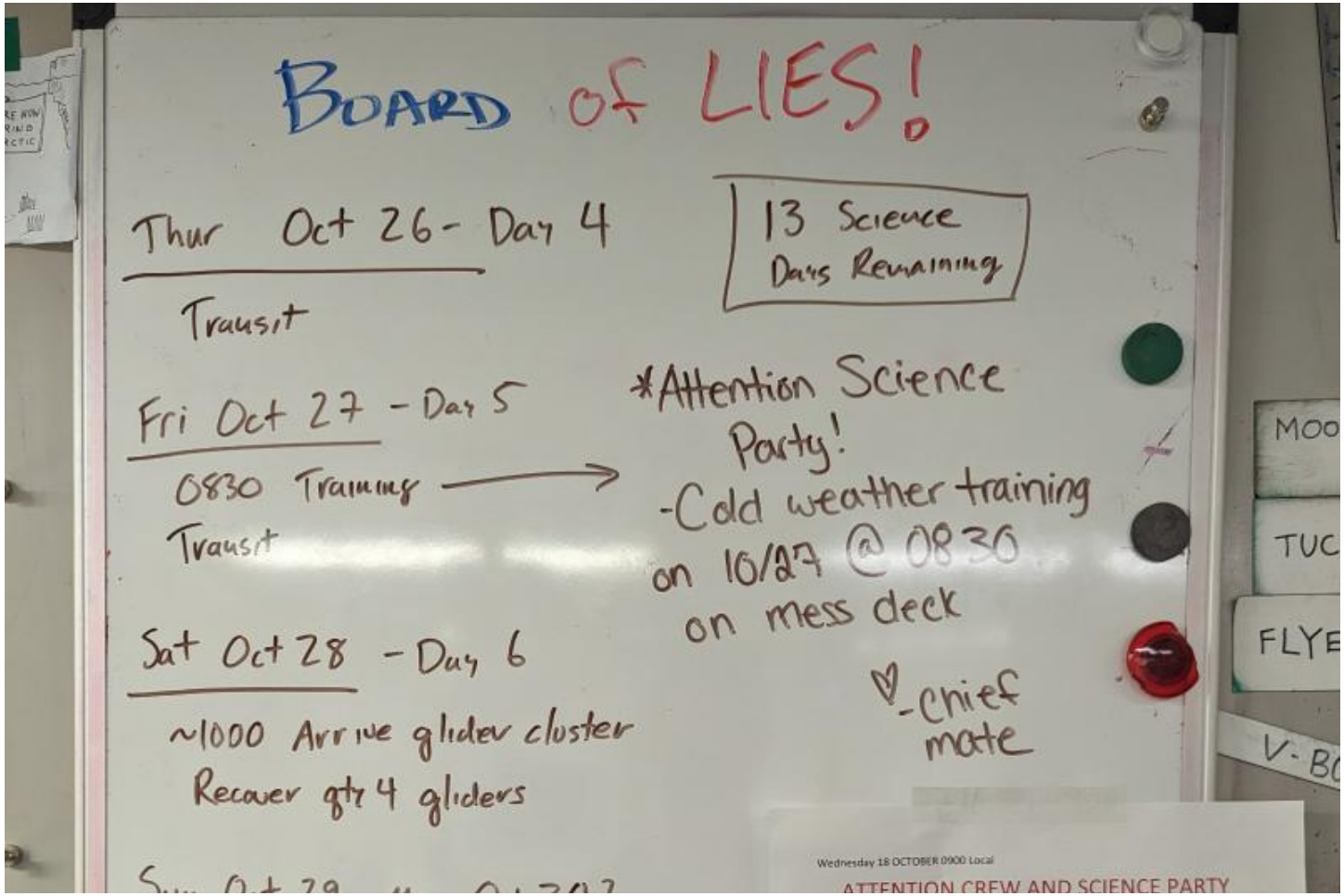
Recovery of science instrumentation from a previous cruise

Ship Life:

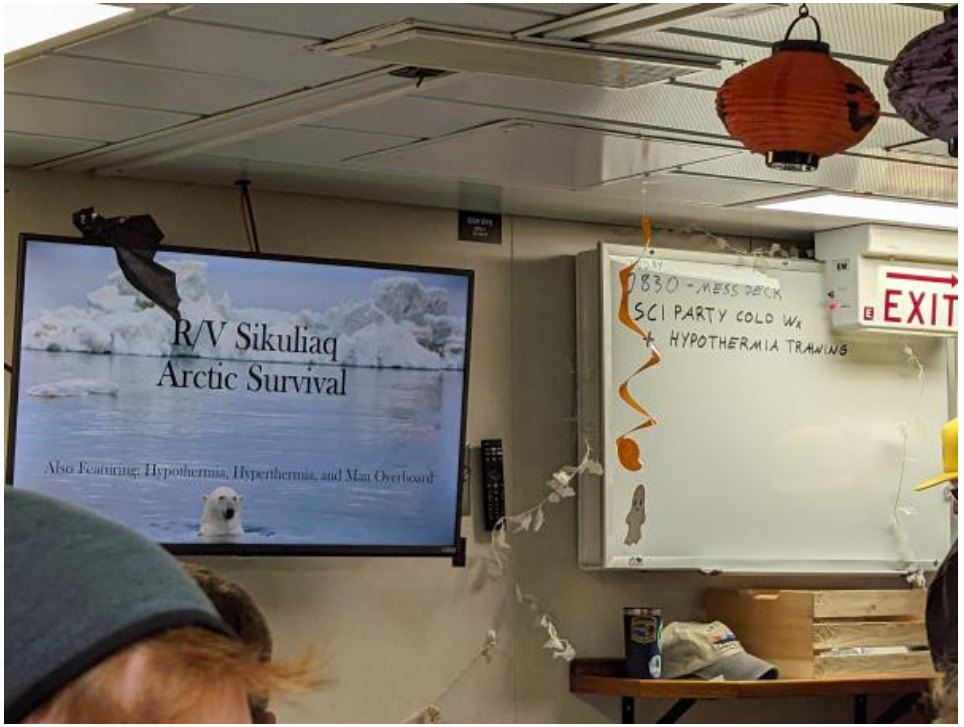
Drills:

- Abandon Ship
- Fire
- Muster

Capt. John explaining the intricacies of fire fighting on a ship while the crew trains in the background


BOARD of LIES!
Thur Oct 26 - Day 4
Transit
13 Science Days Remaining
Fri Oct 27 - Day 5
0830 Training
Transit
*Attention Science Party!
-Cold weather training on 10/27 @ 0830 on mess deck
♡-chief mate
Sat Oct 28 - Day 6
~1000 Arrive glider cluster
Recover qty 4 gliders
Wednesday 18 OCTOBER 0900 Local
ATTENTION CREW AND SCIENCE PARTY

Training:

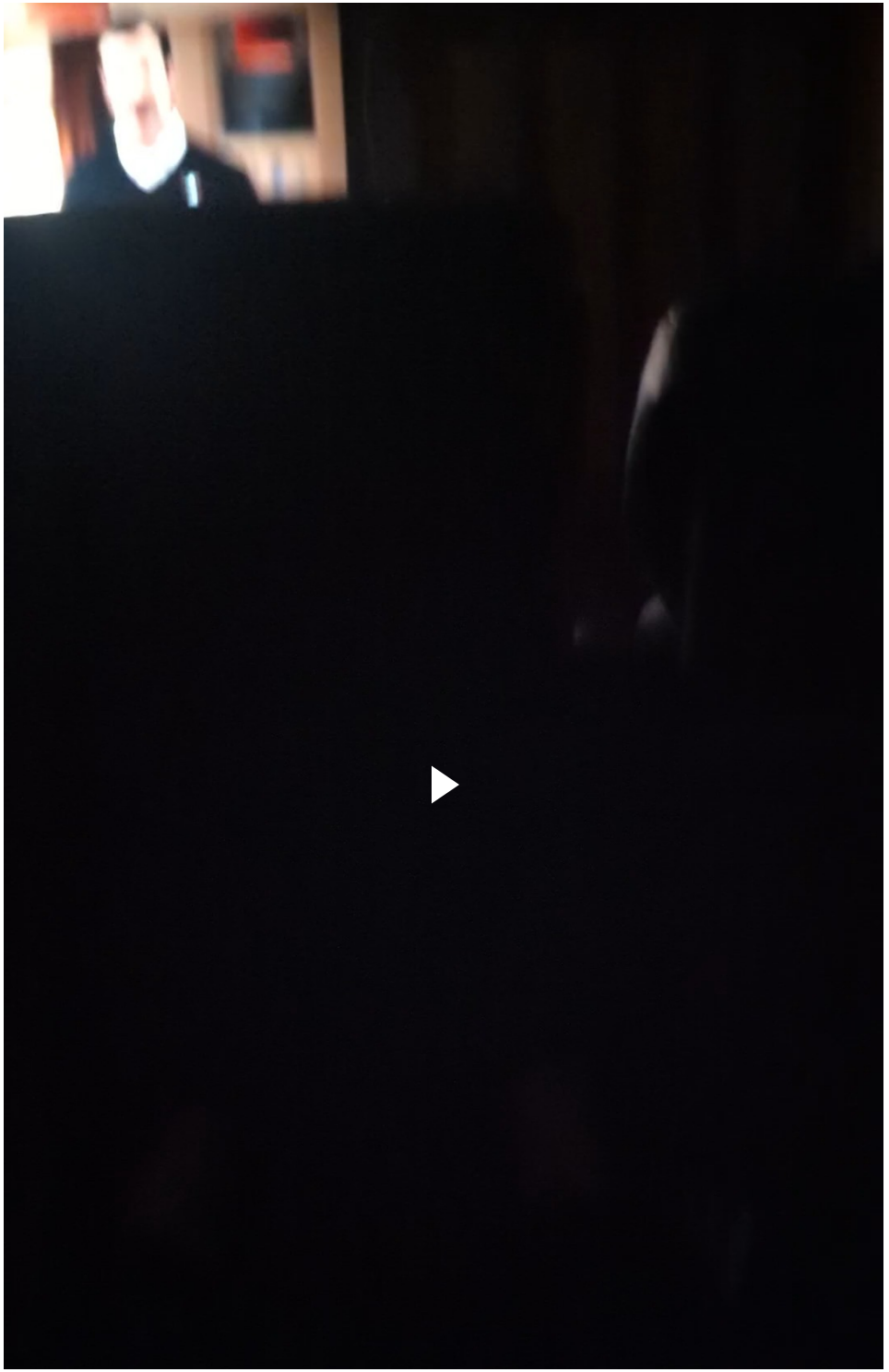

R/V Sikuliaq
Arctic Survival
Also Featuring: Hypothermia, Hyperthermia, and Man Overboard
0830 - MESS DECK
SCI PARTY COLD WX
+ HYPOTHERMIA TRAINING
EXIT

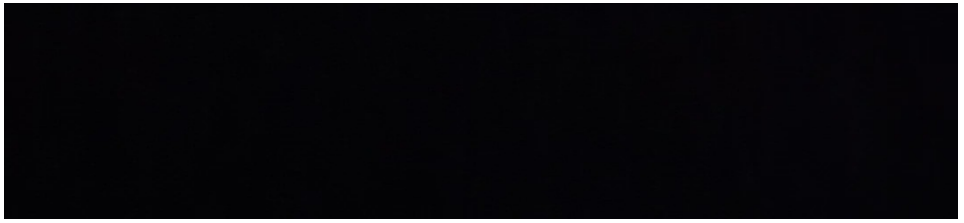

EXIT

Free-time:

TV/movies/video games in the lounge

Group watch of Hunt for Red October





Ted Lasso in some rough seas

Sauna time! AKA: Hyperthermic recovery chamber

October 10th-October 22nd

In port: Dutch Harbor

Looking toward Dutch Harbor proper

Bald eagle in the cemetery

Church of the Holy Ascension

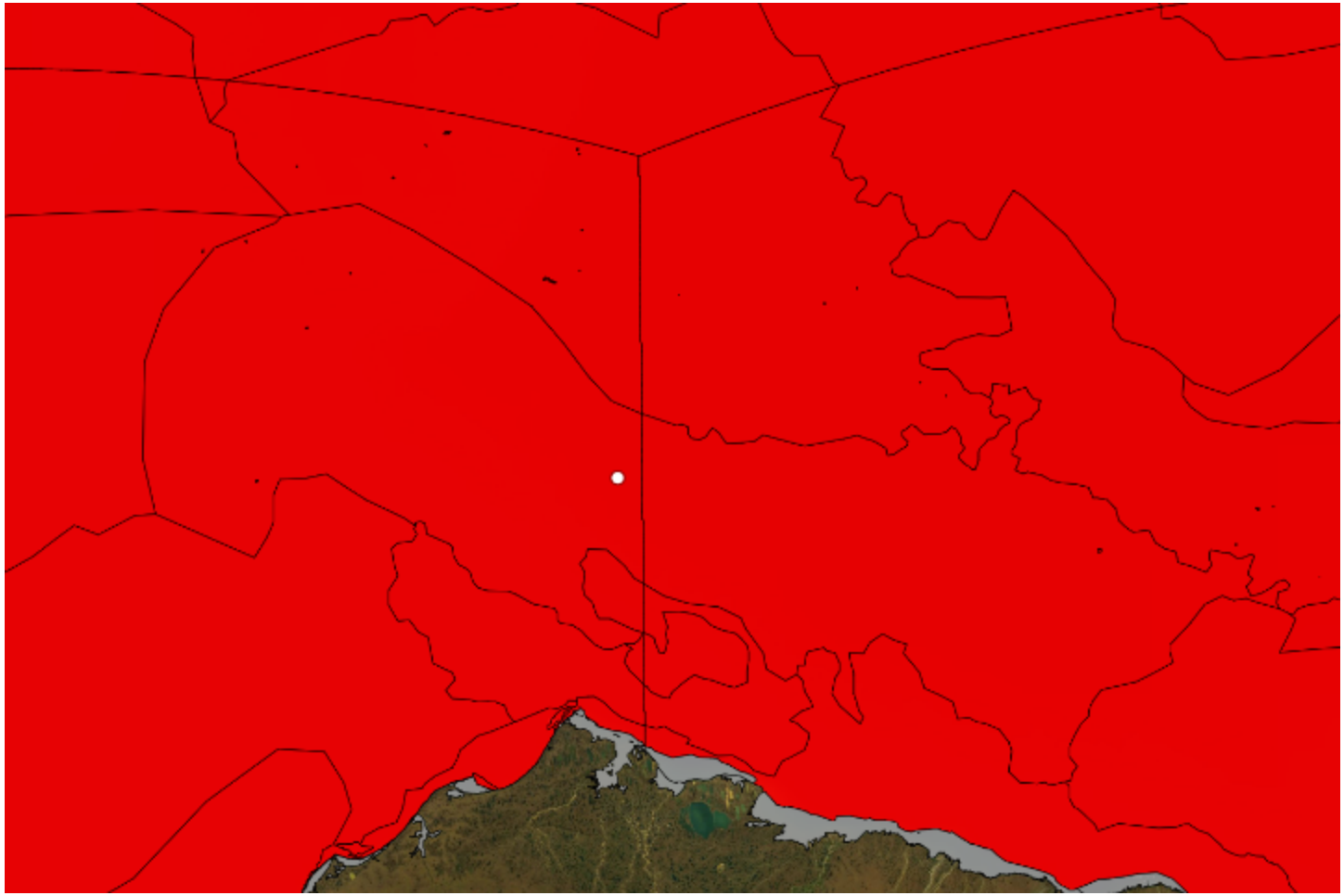
Coming out of Dutch Harbor into Unalaska Bay and incoming Bering Sea swell

Land-based ice possibly from the Milne Ice Shelf collapse in 2020

Additional Resources:

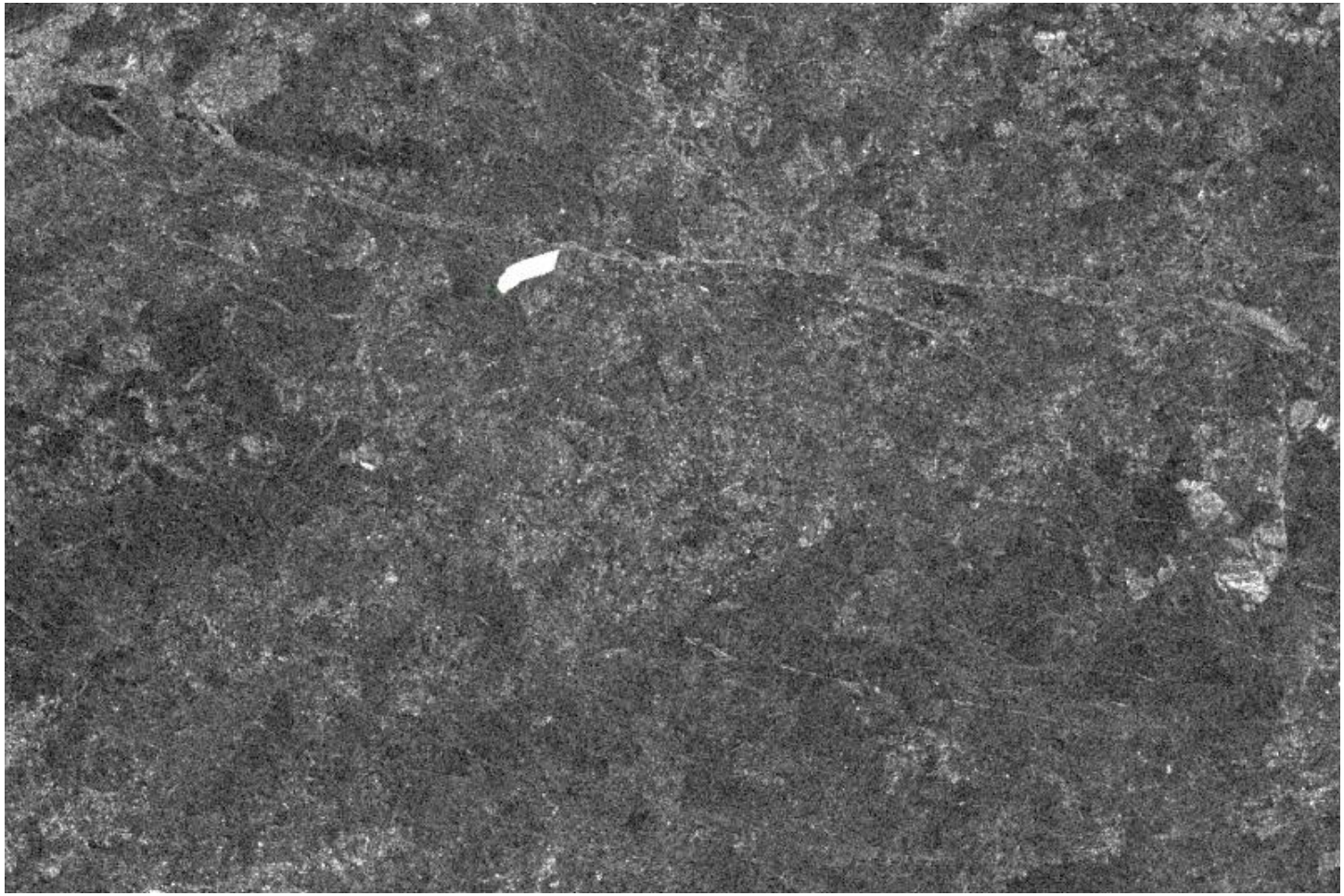
Milne Ice Shelf wiki

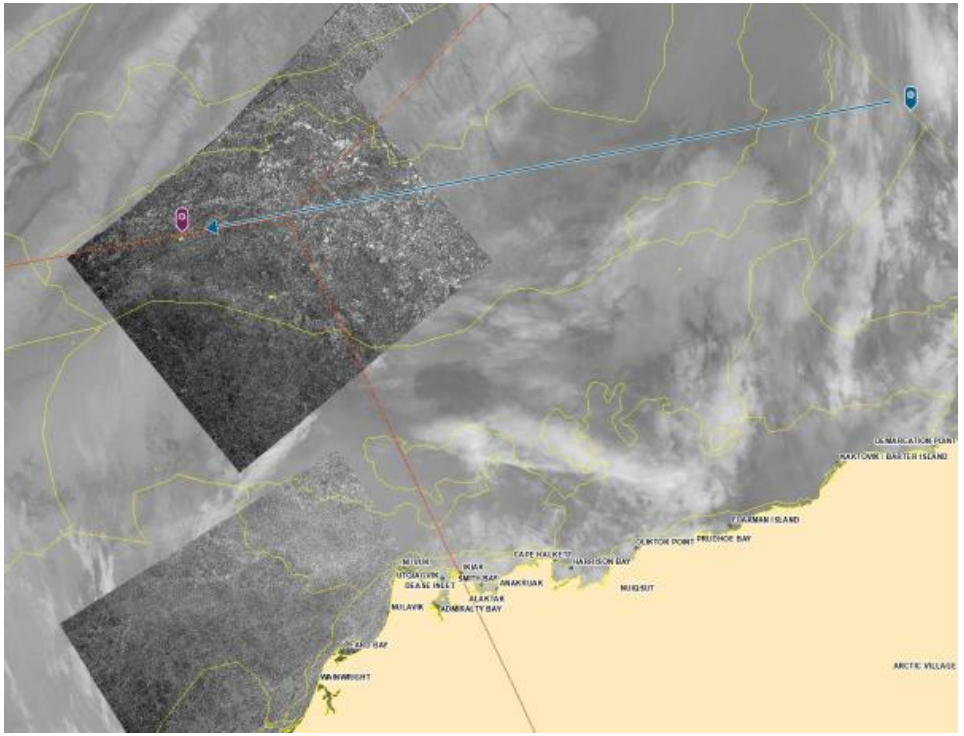
NESDIS article w/images



Current Iceberg Tracking

Alaska Sea Ice Program analysis via AOOS Data Portal





Position of iceberg on February 3rd roughly 500 nm to the west-northwest

International Arctic Buoy Program

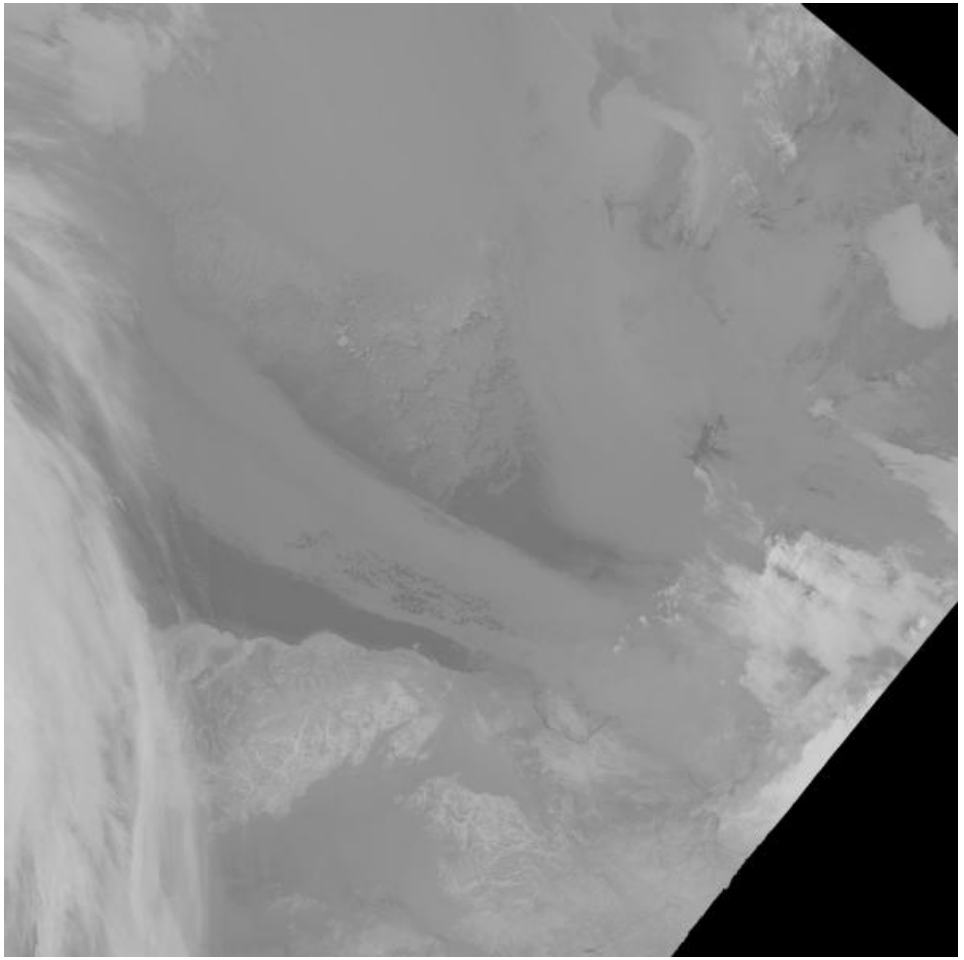
Website: Utqiagvik 2021

October 23: The definitive SAR imagery

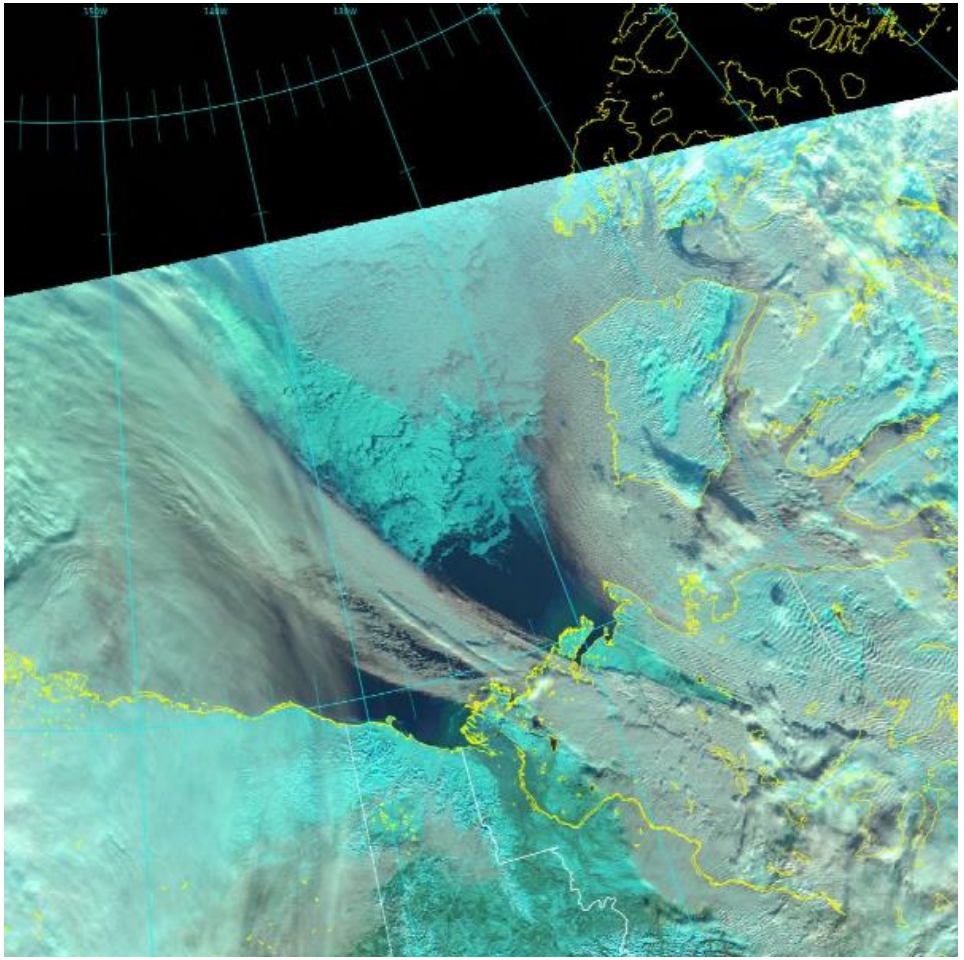
Powered by Esri

Oct23map

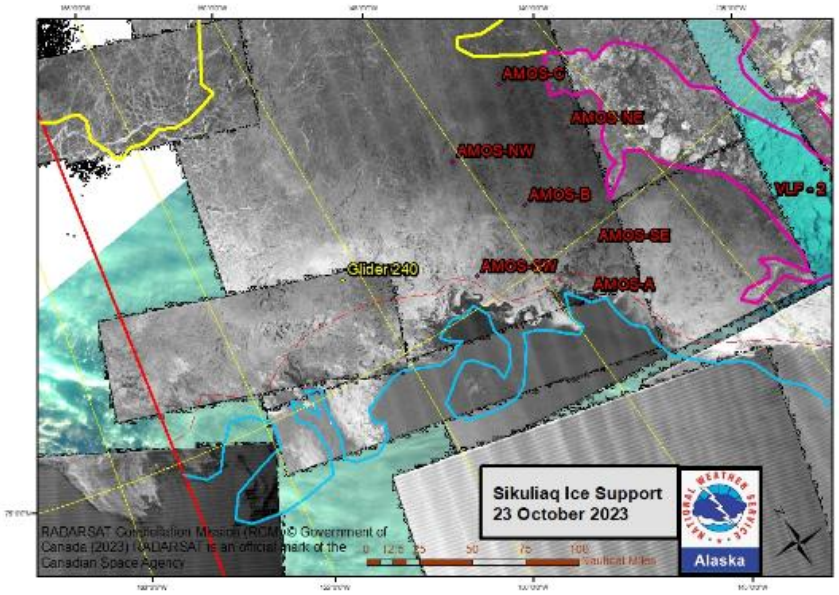
Stream of multi-year ice with low concentration multi-year ice within the mission area



Infrared image shows the first clear view of the pack of the trip.



Day Land Cloud image showing the break in the clouds. Clear sky helped make the SAR imagery very clear and detailed.


AMOS-C
AMOS-NE
AMOS-NW
AMOS-B
VLF-2
AMOS-SE
Glider 240
AMOS-W
AMOS-A
Sikuliaq Ice Support
23 October 2023
Alaska
RADARSAT Constellation Mission (RCM) © Government of Canada (2023) RADARSAT is an official mark of the Canadian Space Agency

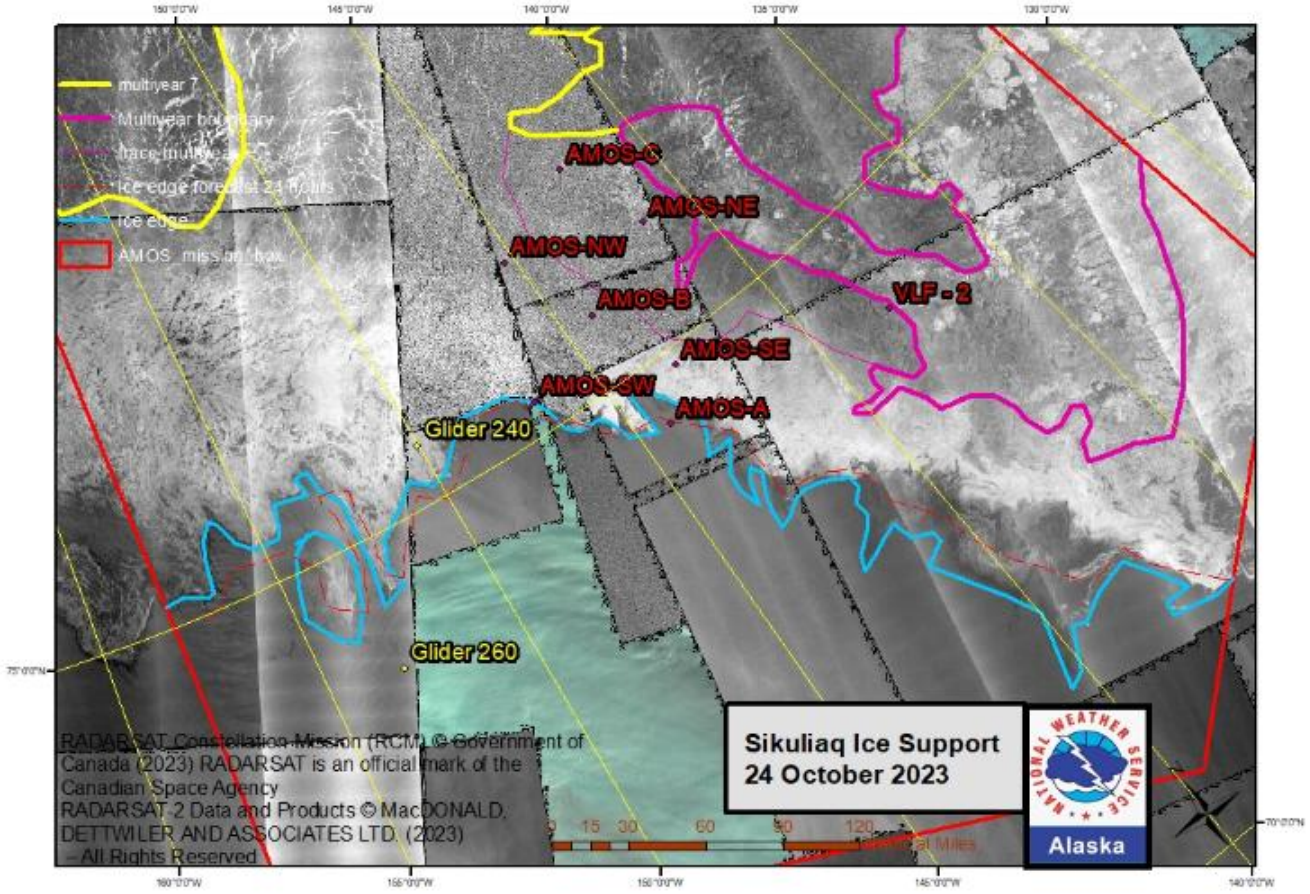
DSS graphic

Below shows the ice advance/expansion over the last reported position of SG240, while this is 3 days worth of imagery, the vast majority of the 60 nm advance happened in 24 hours from Oct 21 to Oct 22. Southerly winds have impinged on the ice over the last 12 hours and should continue through Tuesday morning, melting/retreating some of this new growth.

Support email:

Southerly winds have already begun to act upon the ice edge and will continue to do so for the next 24 hours or so. Expect a retreat of the edge and melt of much of the recently formed ice. **10-20 nm of retreat.**

- Magenta line: Oldest of the multi-year ice
- Yellow line: "younger" multi year ice, partially melted during last summer
- Blue line: ice edge
- Red-dashed line: Approximate 24 hour forecast



Oct 24

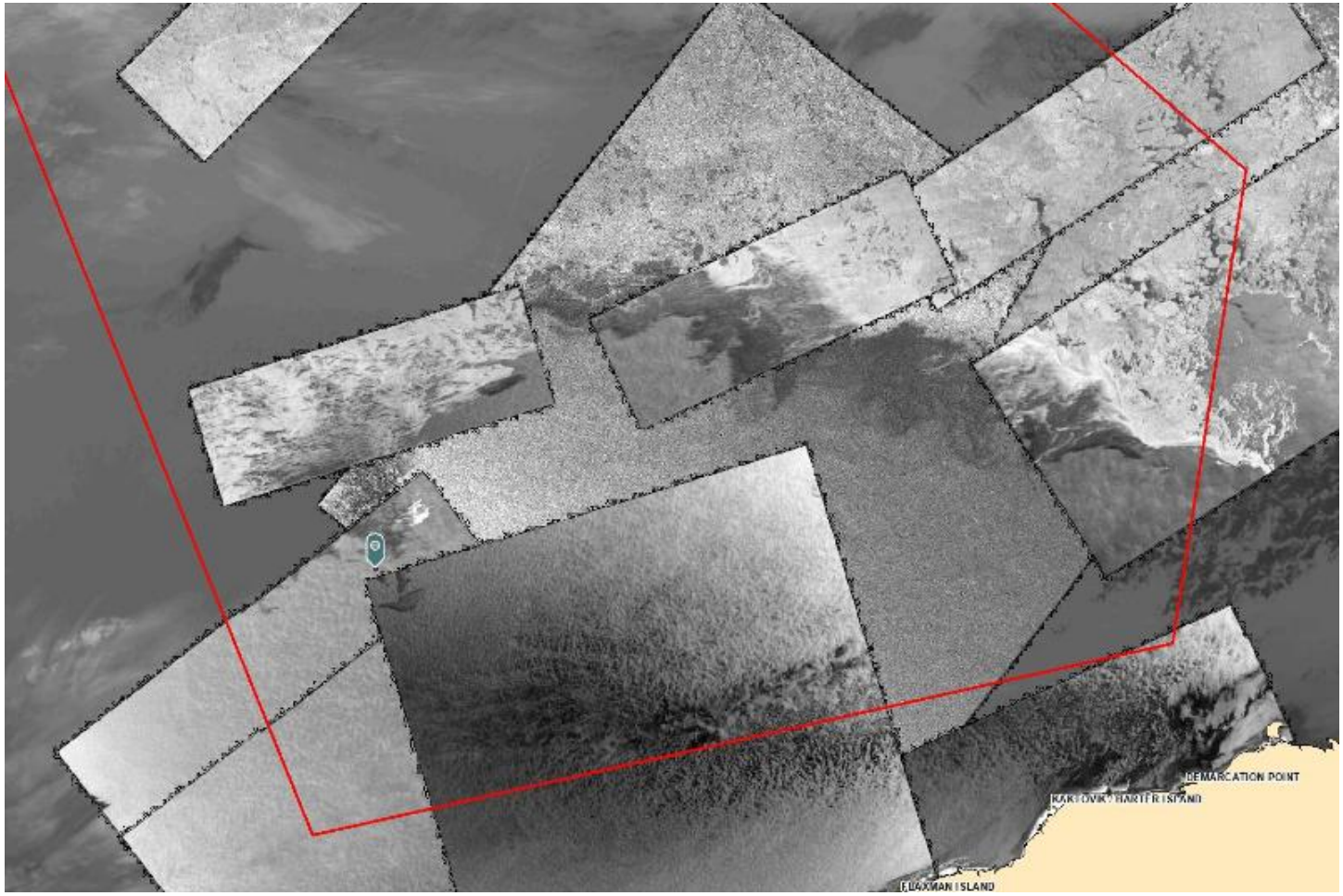
Update for evening 23rd and morning 24 imagery:

- Ice edge retreated 10-15 nm over the last 24 hours
- Updated position for glider 240 puts it in newer and melting ice closer to the ice edge
- Glider 260 added to the map (currently 22 nm south of closest ice)
- Westerly winds over the next 24 hours will advance the ice edge around 5 nm in the far western mission box while the remainder of the edge will remain unchanged or retreat 5-10 nm
- Higher concentration multi-year boundary moved 7 nm to the northeast.
- Trace multi-year exists to the northeast of AMOS-NW/AMOS-B/AMOS-SE
- Another round of light southerly winds will push the edge back on Thursday
- Looking ahead to Friday and Saturday, high pressure building over the southern Beaufort could promote widespread growth along the ice edge, however, air temperatures look marginally supportive at this point

Powered by Esri

Oct24location

October 28


DEMARCATION POINT
KAKTOVIK BARTER ISLAND
FLAXMAN ISLAND

Powered by Esri

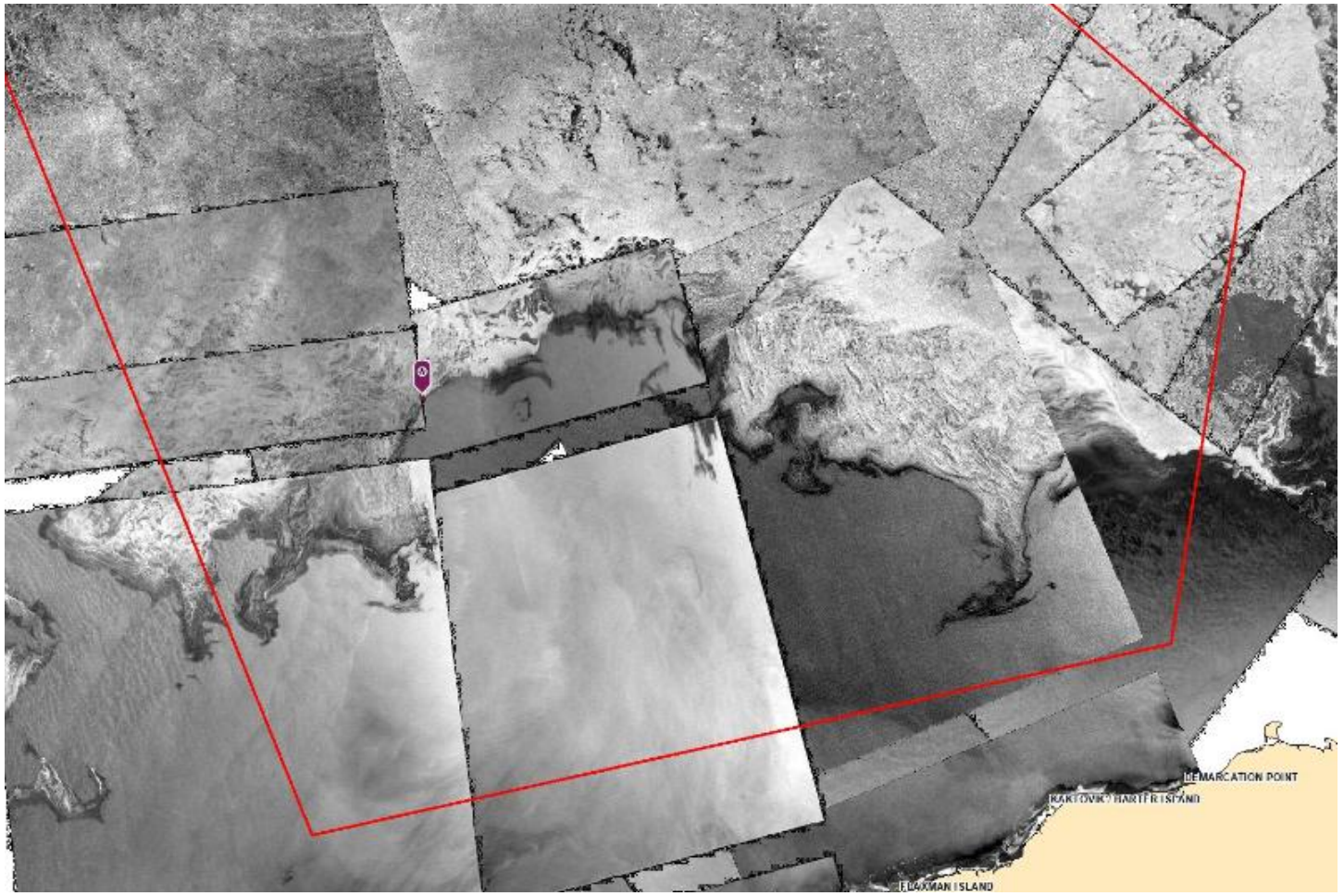
Oct28 location

Grease ice resembles an oil slick on the surface (lighter shades)
https://nsidc.org/learn/cryosphere-glossary/grease-ice

Grease ice (lighter shades). Note the absence vs presence of capillary waves in the water.

Grease ice (lighter shades)

https://en.wikipedia.org/wiki/Grease_ice



October 29: The Ice Edge

Powered by Esri

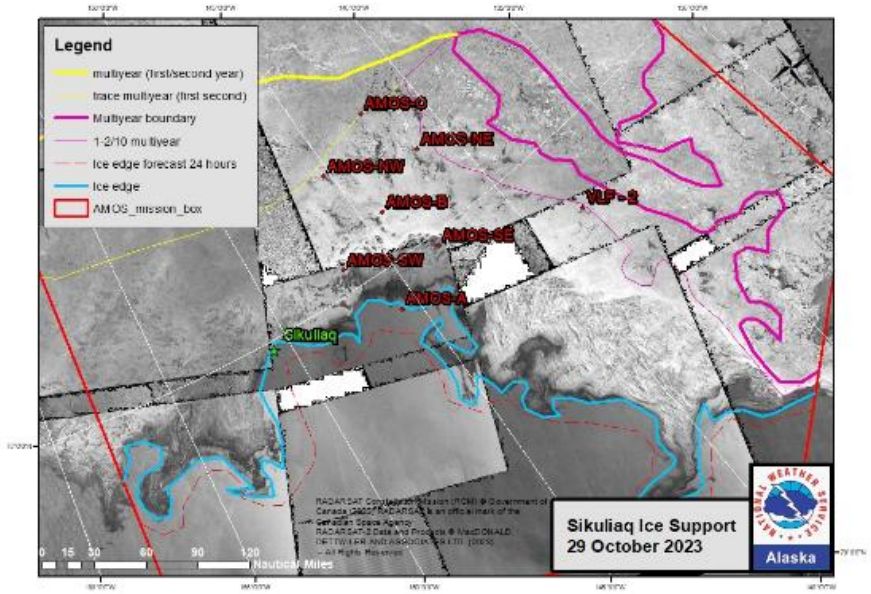
Oct29

Slushy pancakes for breakfast

Update for 10/29:

- Cold front passed the ship today, right around the time of the SAR imagery below
- In westerly winds of 15-20 kts expect the edge to advance 10-15 nm to the south-southeast in the next 24 hours with those rates continuing into late Monday night.
- Winds being to lay down on Tuesday which should spur widespread new ice growth in the wedge of open water pointing toward AMOS-A

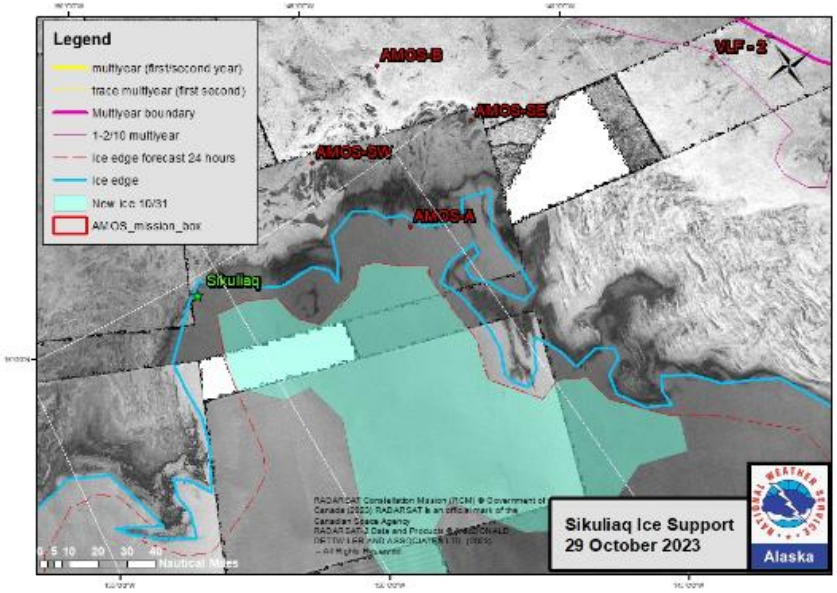
- Tuesday night into Wednesday is the pattern shift with high pressure over the Chukchi Sea bringing arctic air from the north. Expect much colder temperatures and expansion of the ice edge
- More potential for areas of multi-year ice to enter the northern portion of the AMOS array



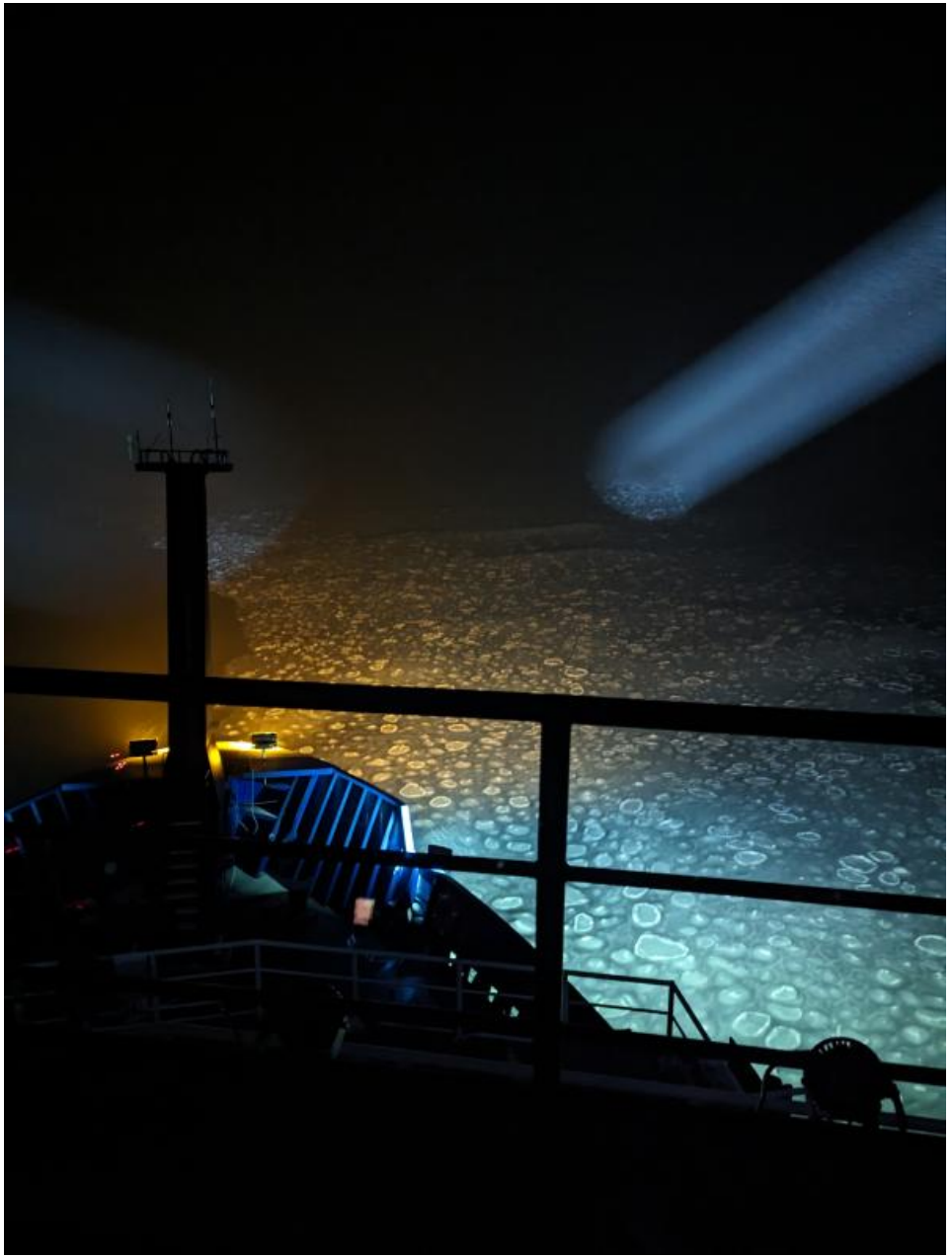
Zoomed map for ops 10/30:

- Westerly wind should keep new ice from forming, however sea surface temperatures are becoming more conducive (-1C over a large area)

- Expect the area below to freeze up in new ice once winds lay down on Tuesday morning

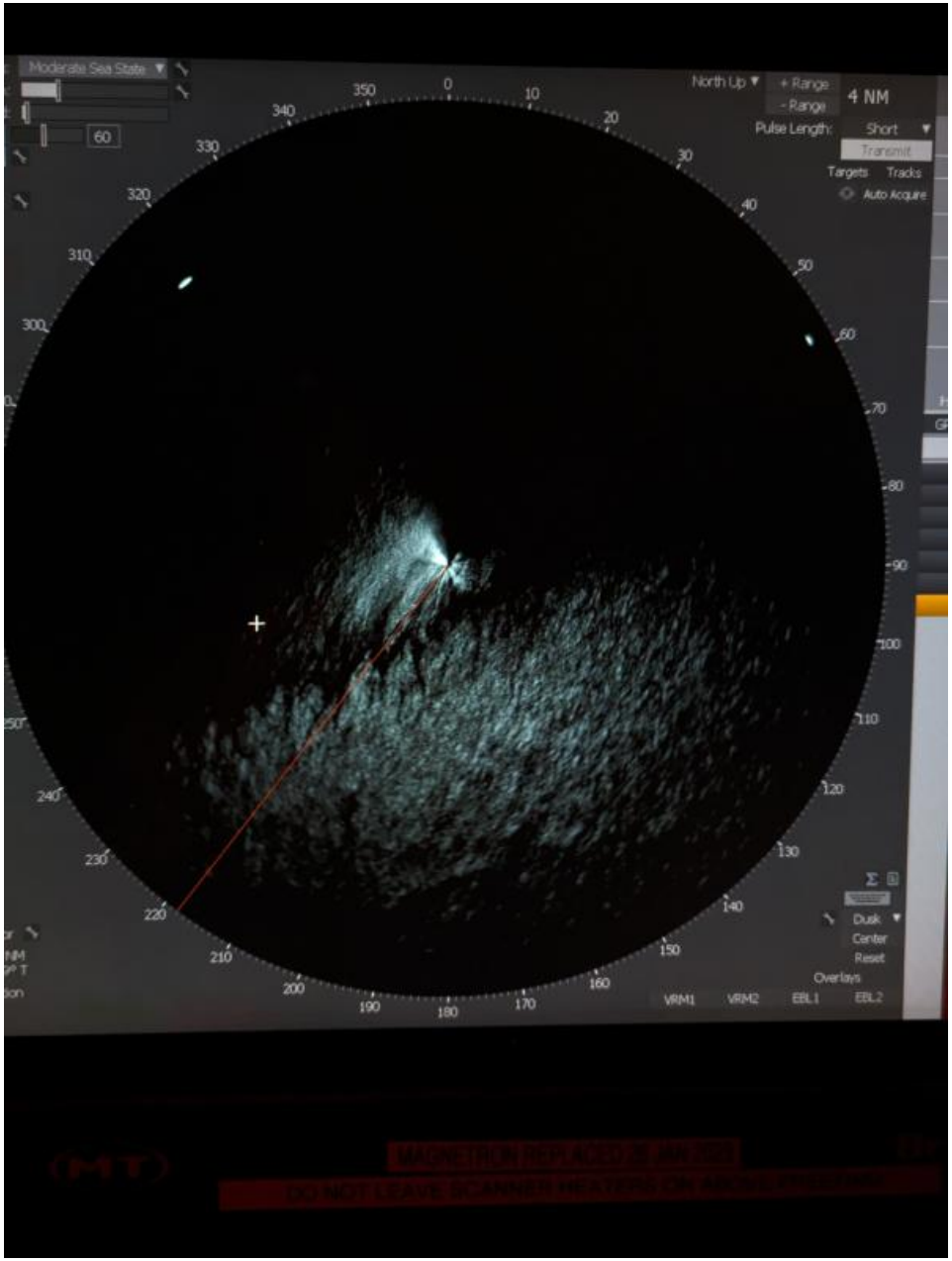


October 29th continued



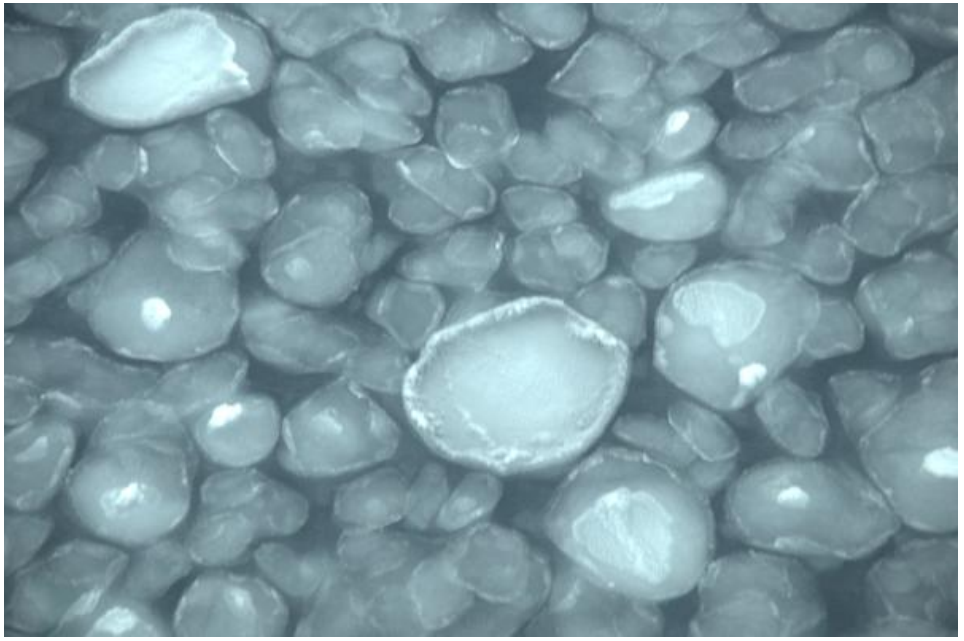
First (dark) morning in the ice

Multi-year floe, zoomed from 300mm lens



Two multi-year floes on the ice radar

Pancakes in daylight



Pancake ice

Powered by Esri

Oct30

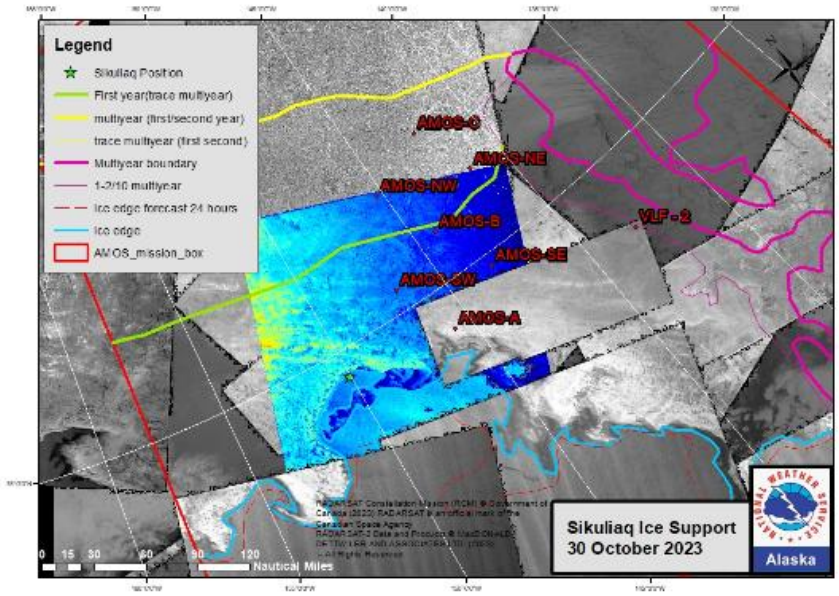
October 30th-November 3rd: Explosive growth

- Ice edge continues to drift southeast ~10-12 nm day which should continue to decrease with winds diminishing
- A ribbon of new ice formed last night to the south of Sikuliaq, potentially affecting vehicle operations Tuesday 10/31 (see zoomed map)

Looking ahead:

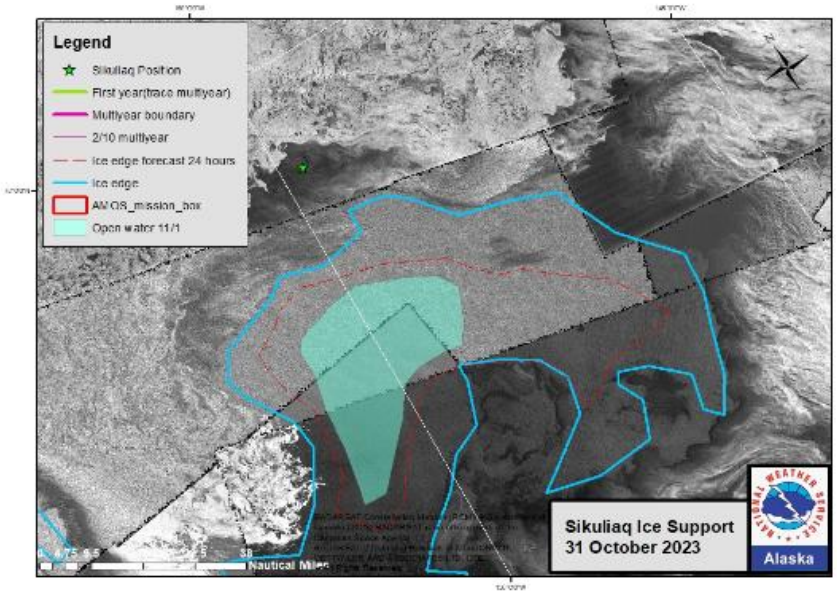
- Meteorological pattern change is upon us with increasing arctic air and northerly winds

- Increasing confidence in high pressure over the Chukchi will control the pattern for the next week
- Expect temperatures dropping into the single digits, possibly below zero with light northerly winds.
- Rapid expansion of the ice edge through the end of the week, encompassing much of the southern AMOS mission box
- Drift of first year with embedded multi-year ice into northern areas of the AMOS array

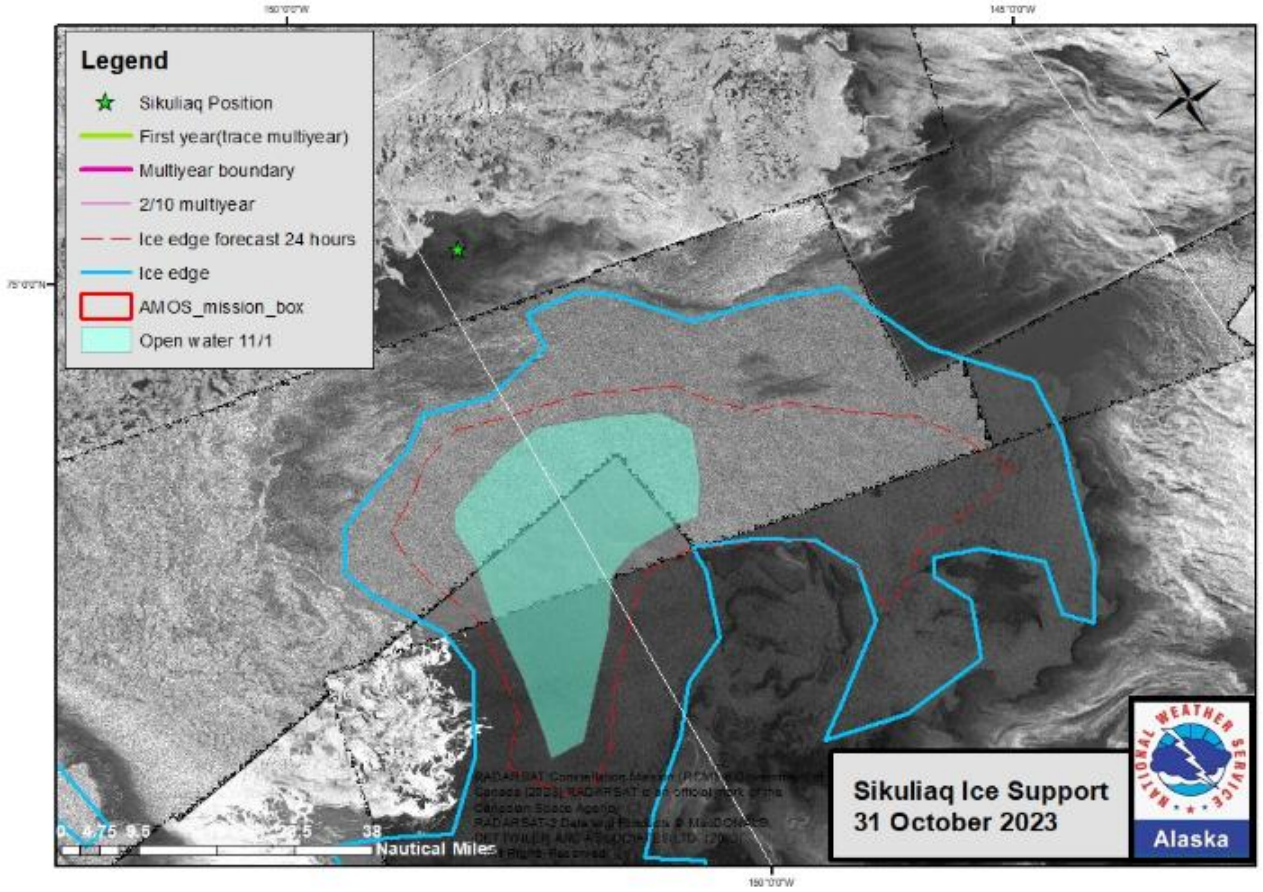


Zoomed image for vehicle operations 10/31:

- Moderate confidence of expansion of new ice growth up to 20 nm of current ice edge (red-dashed line)
- Higher confidence in the ribbon of new grease ice should continue to expand overnight leaving Sikuliaq in a pocket of open water
- Pack ice drift will slow as winds diminish



Map switched to highlight open water as opposed to new ice growth



October 31st: Freeze up all around

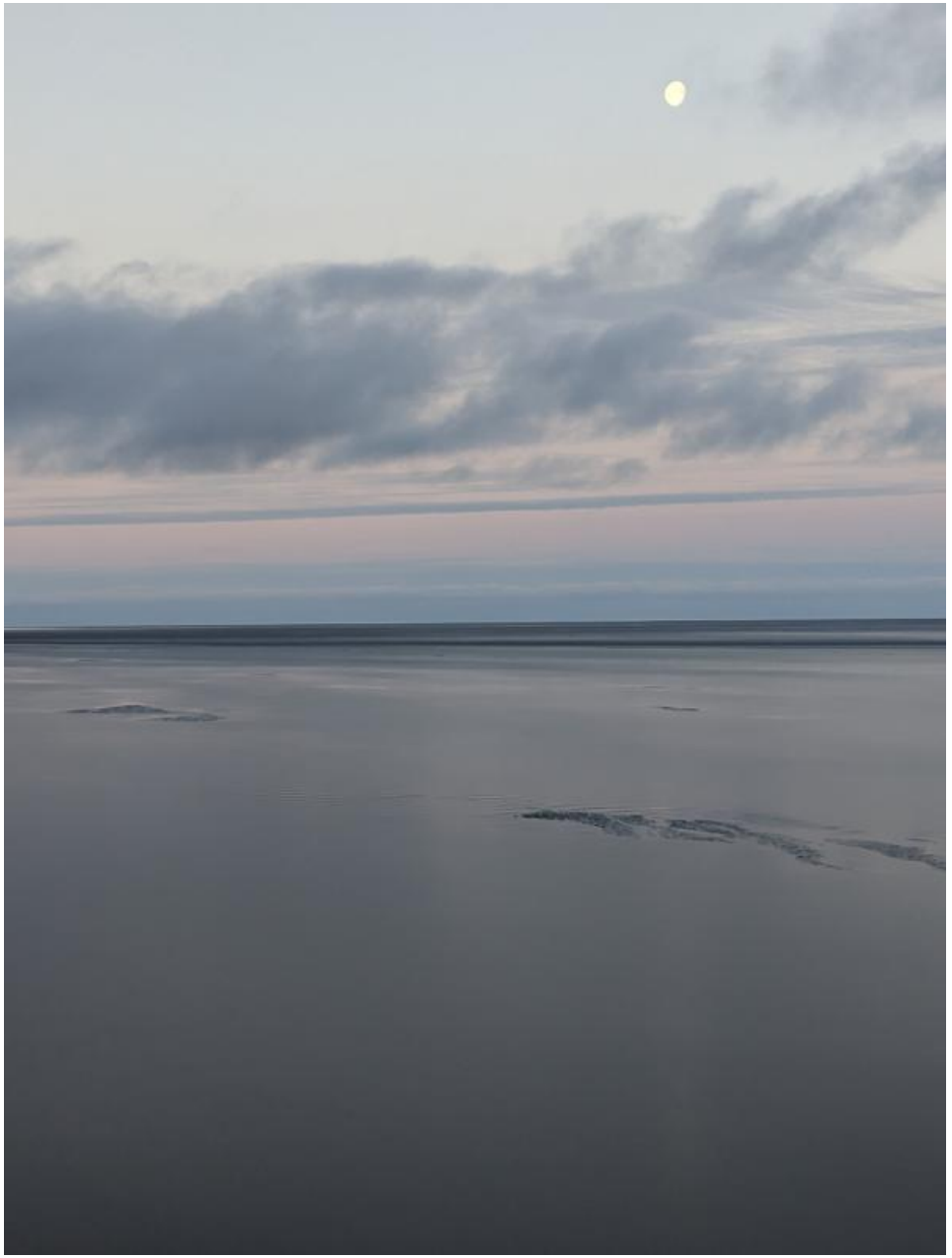
Powered by Esri

Oct31

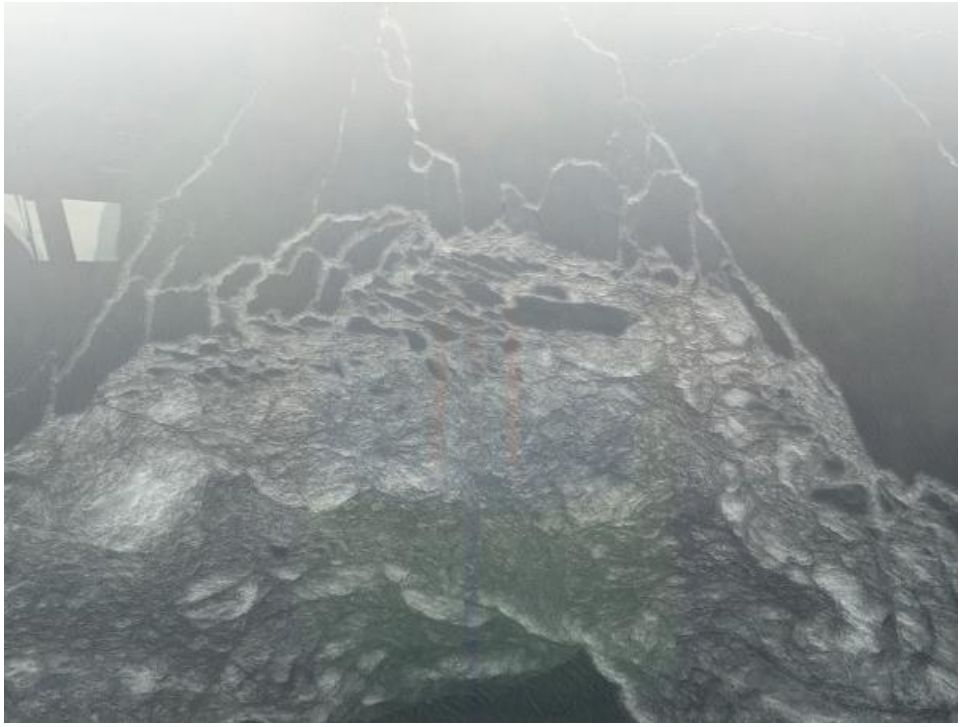
Grease ice begins to form in ribbons around the ship

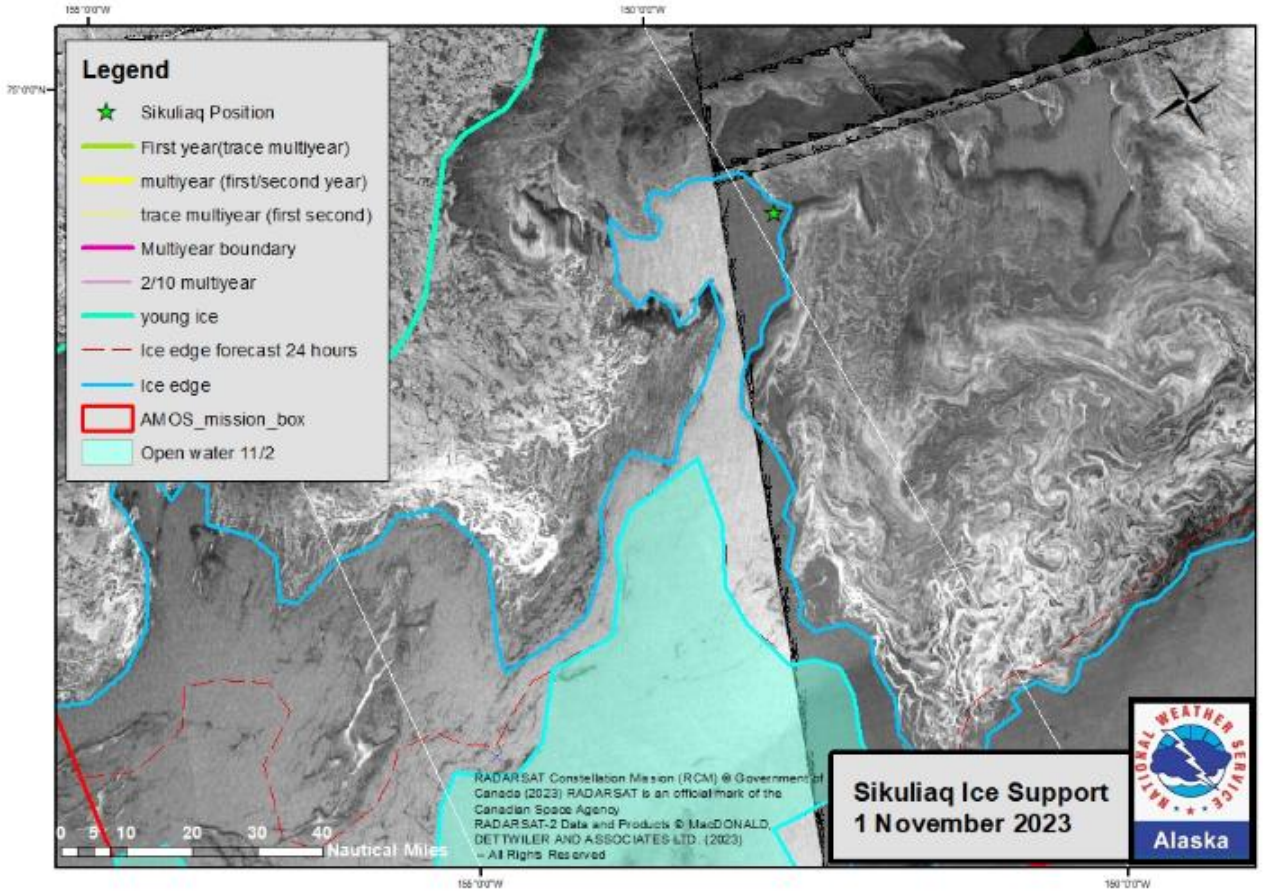
Open water and grease ice

Multi-year floe still lurking in the vicinity (possibly an iceberg?)



Grease ice trending toward nilas




Legend
Sikuliaq Position
First year(trace multiyear)
multiyear (first/second year)
trace multiyear (first second)
Multiyear boundary
2/10 multiyear
young ice
Ice edge forecast 24 hours
Ice edge
AMOS_mission_box
Open water 11/2
0 5 10 20 30 40
Nautical Miles
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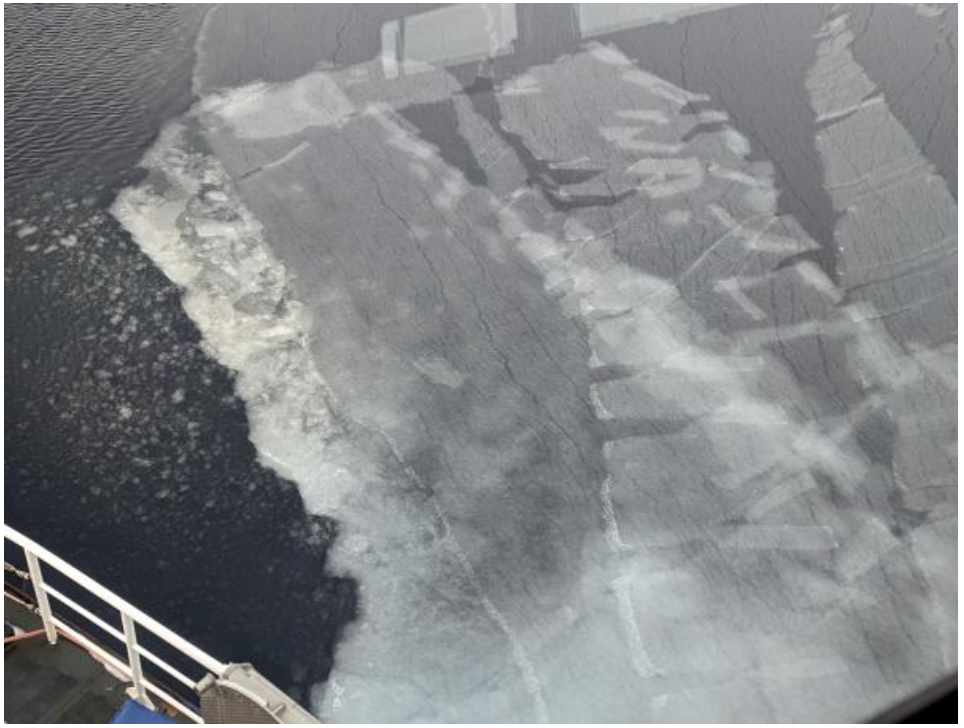
Sikuliaq Ice Support
1 November 2023
NATIONAL WEATHER SERVICE
Alaska

November 1

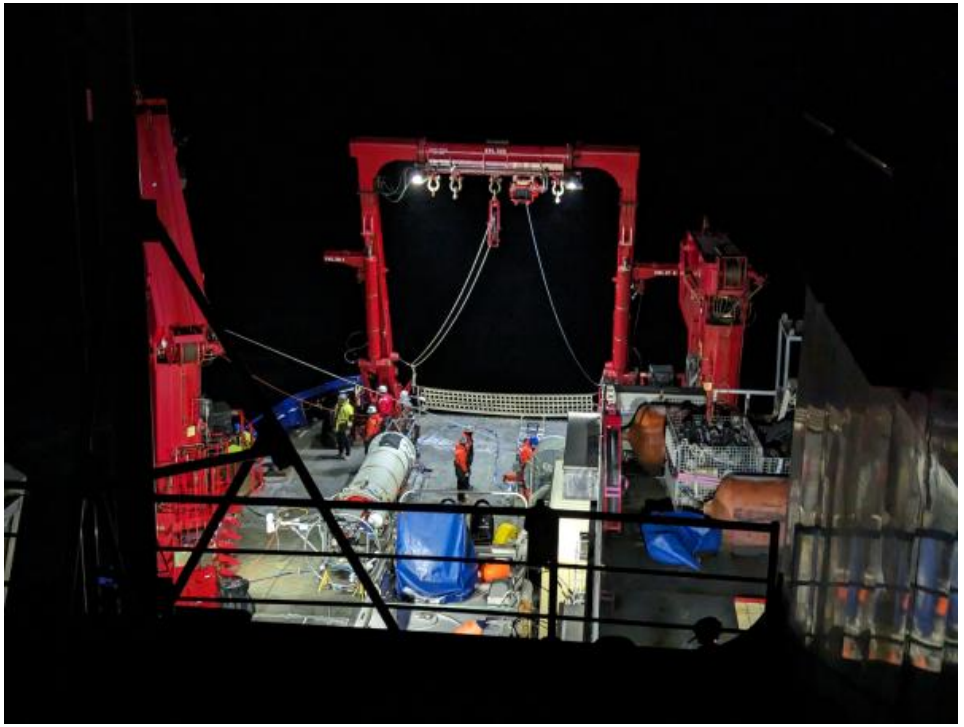
Powered by Esri

Nov1



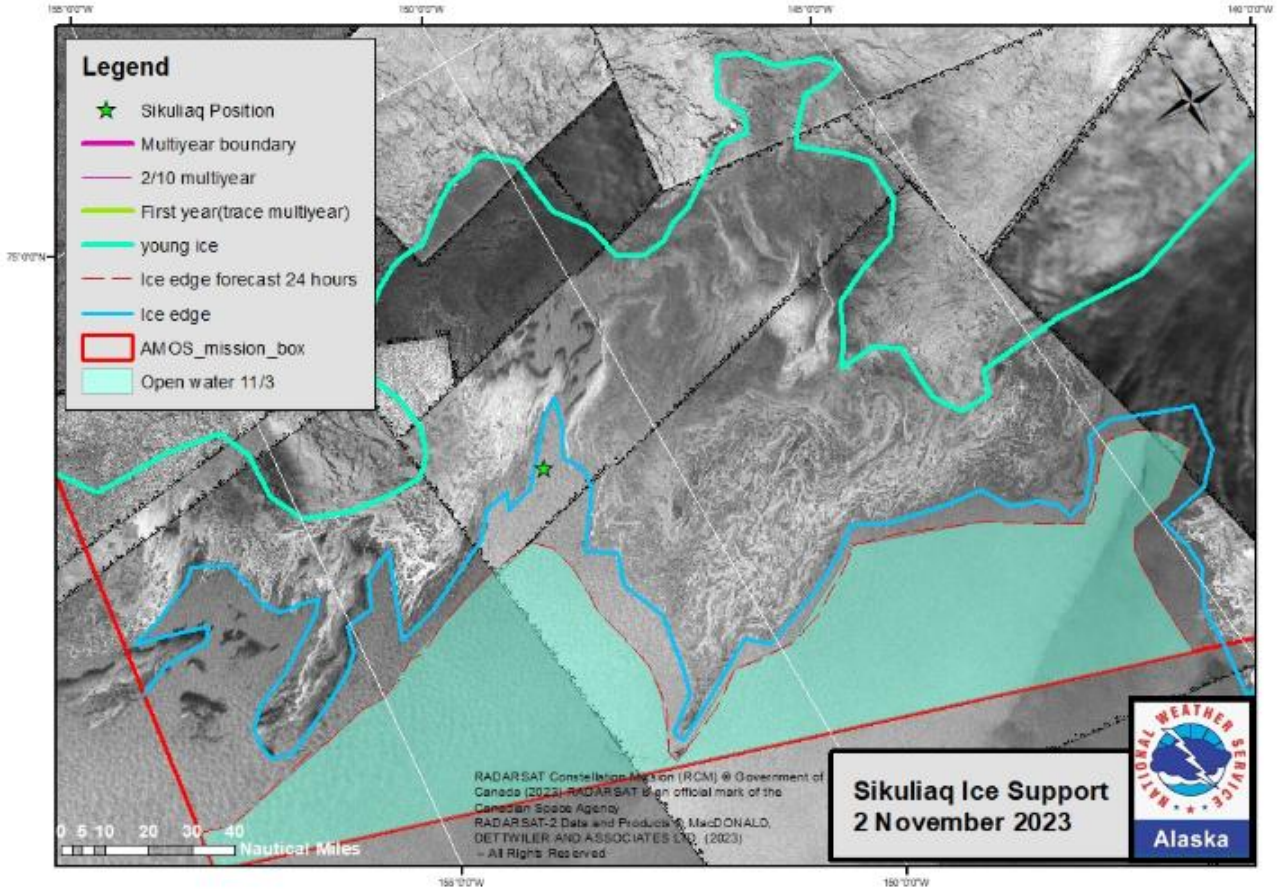
Nilas ice

Night ops



Night ops

Nov 1: ~3pm



November 2nd: Moving south

Powered by Esri

Nov2

Update for 11/2:

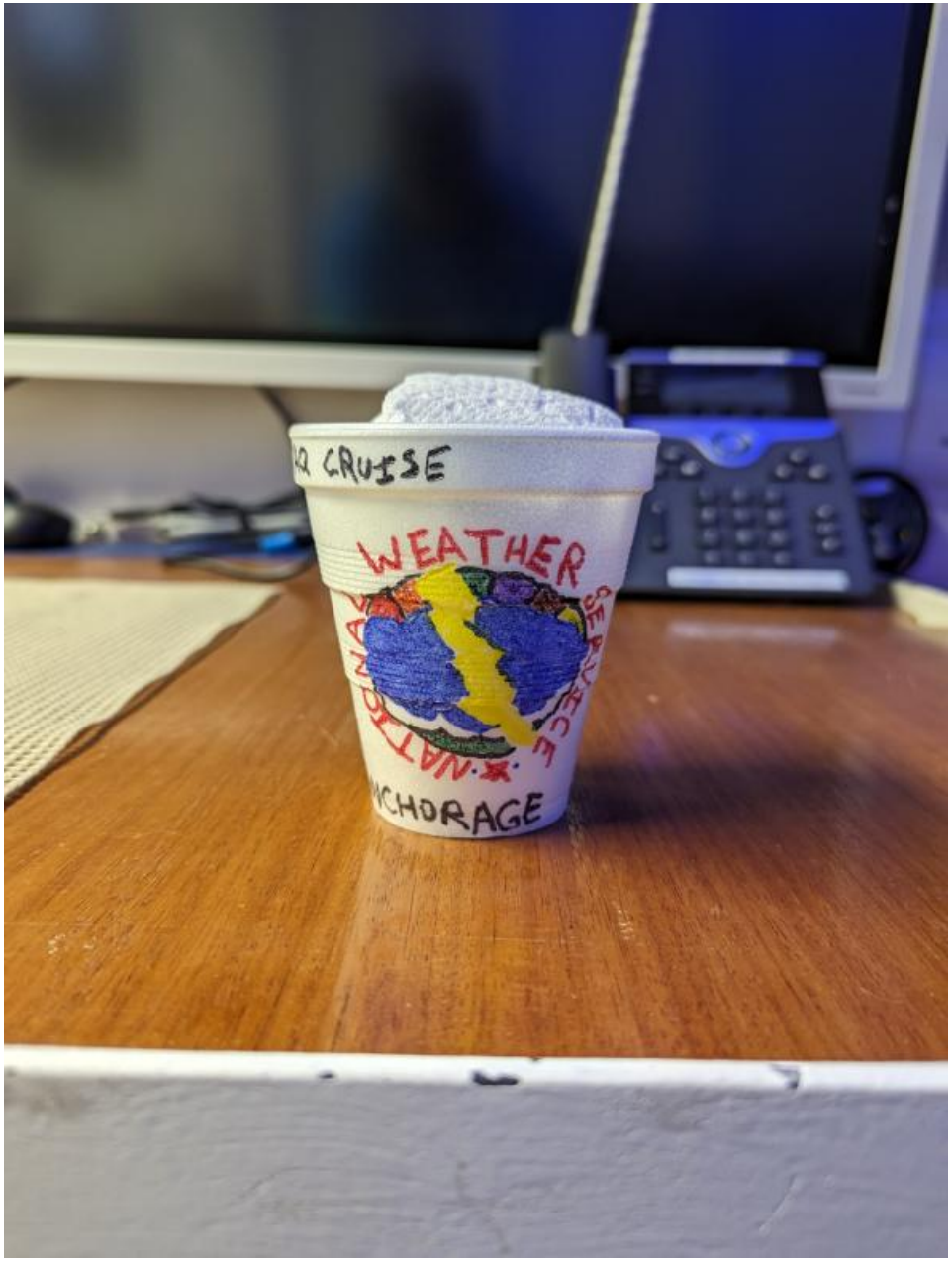
- Open water is getting tougher to find as the ice begins to close off the mission box. No good imagery over our location but we had to travel to the ship position on the map below to find open water
- The sea has **greased up around us** today while the pack continues to drift southward
- **Pack is drifting southwest ~10 nm/day** in continued northerly 10-20 kt winds
- Ice looks to be thickening at a good rate under this arctic air mass and light northerly winds

Zoomed image for vehicle operations 11/3(right):

- LIkely will have to travel even further south to find open water tomorrow
- Based on sea surface temperatures near 0 C, several large pockets should remain open for the next several days
- Expect continued freeze-up along the edge and further southward drift ~10 nm/day

Looking ahead:

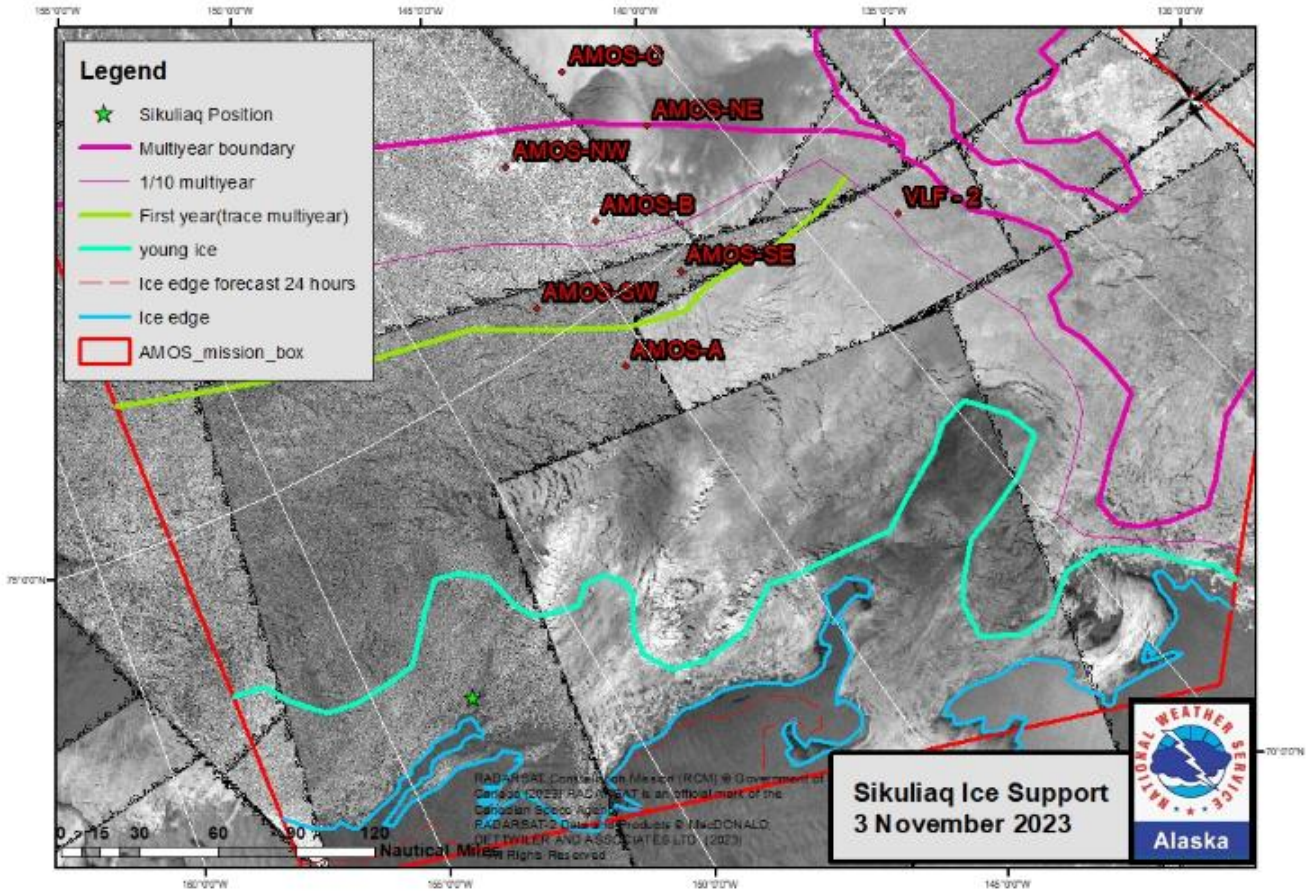
- Strong high pressure over the Chukchi remains in control, high confidence in weather and ice conditions through early next week
- As high pressure drifts to the north, a mainland low pressure system will exert more influence, bringing increasingly strong easterly winds to the southern Beaufort Sea
- Multi-year ice boundary will move to the westward, potentially toward the operations area
- Uncertainty increases in the day 7-8 time frame as the meteorological pattern changes and high pressure breaks down



Decorated foam cup

Conductivity, temperature, depth (CTD) instrumentation

Foam cups crushed by the ocean depths, FOR SCIENCE!



November 3rd: continuing southward

Nov3

Update for 11/3:

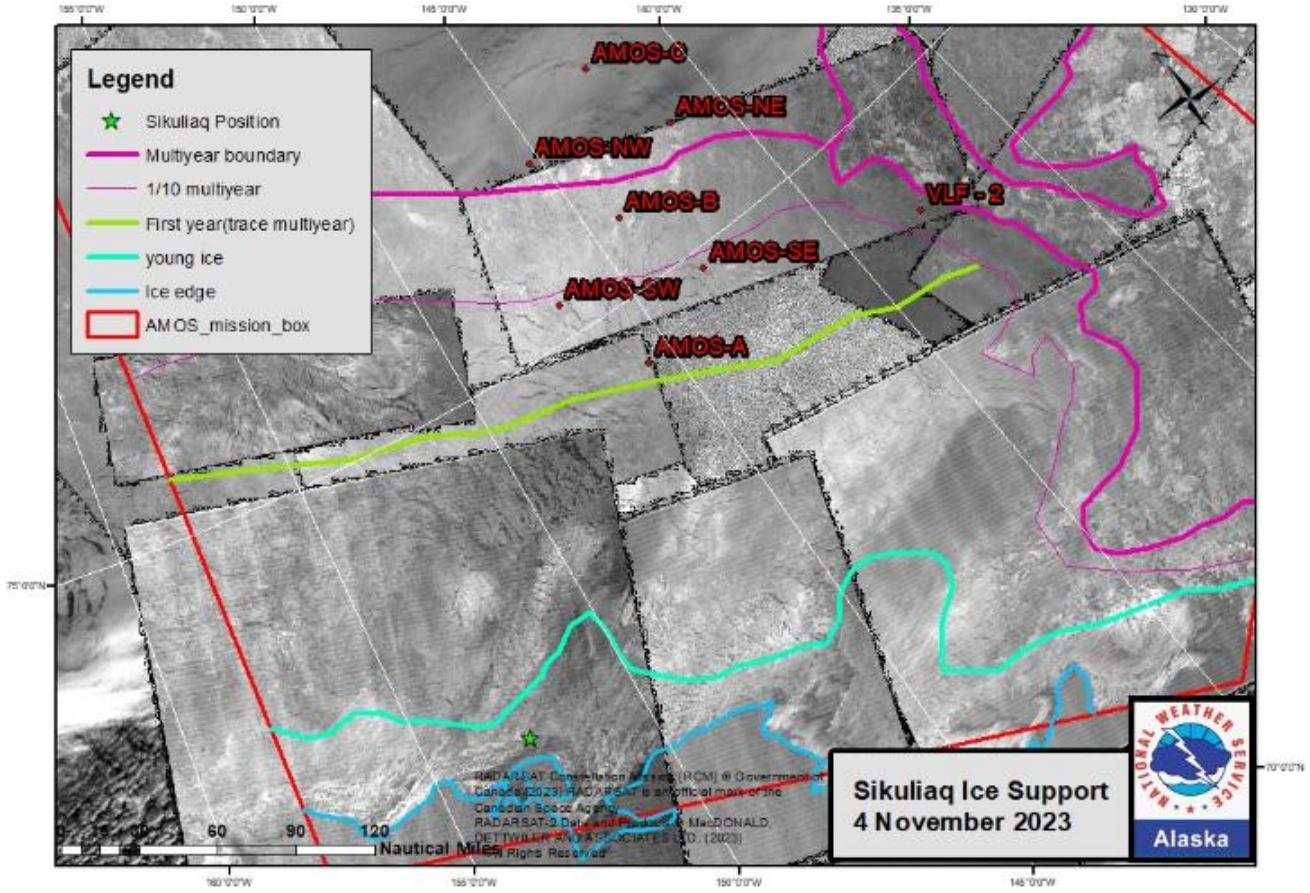
- Another day of starting in open water/grease and watching it freeze up around us. It seemingly only takes 10 hours under these conditions to go from frazil--->grease---->nilas
- The pack is thickening up fast as well with some of the sheets outside today looking like they are toward the upper end of new in the 2-3 inch range.
- The predominately young ice boundary is dropping southward fast as well (moreso due to thickening as opposed to drift). If we stay in this location I would not be surprised to see some young ice tomorrow (11/4).
- General drift in the pack remains ~10nm/day

- Ice to the far east and southeast AMOS box moving faster as it is aligning with prevailing Beaufort Gyre currents.

Ice already ~2 inches thick

Zoomed image for vehicle operations 11/4 (right image):

- Expect ice to continue to thicken, likely getting toward young ice
- Continued northeasterly winds in the 10-20 kt range with temperatures in the low teens



November 4th: Running out of open water

Powered by Esri

Nov4

Vehicle testing under the ice

Deployment of the ARTIE (Arctic Rescue Technology for Individuals and Equipment)

- Winds elevated above 20 kts kept the last open water in the mission box from freezing up, which helped for one more day of vehicle testing
- Boundaries within the pack keep drifting **southwest ~10 nm/day**
- Ice within the pack is growing rapidly underneath the single digit temperatures. **New to young only taking ~24-48 hours**.
- Much of the AMOS array looks to be in predominantly first-year thin ice
- Trace amounts to one tenth of multi-year ice near the southern array with concentration of 3 to 4 tenths toward the northern array.

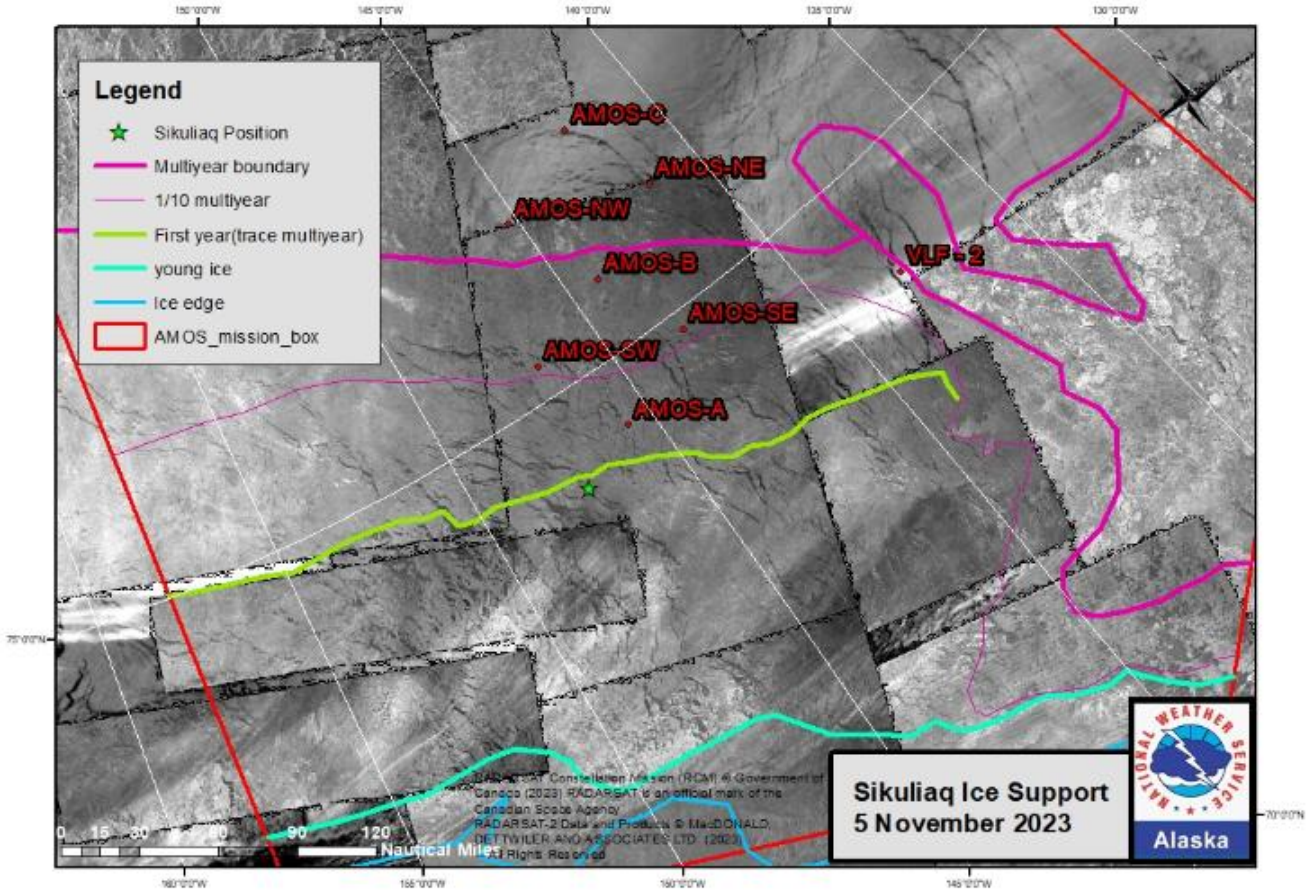
Zoomed image for Sikuliaq transit into the pack 11/5(right image):

- A **favorable corridor of new-young ice** exists toward AMOS-A location. This area was the last to freeze relative to the areas surrounding
- An area of **thicker young ice** exists to the **northwest**. This boundary was where Sikuliaq was doing initial open water testing at the ice edge before the arctic air outbreak

- N/S oriented leads within the array have been present for the last 24 hours or so

Looking ahead:

- High pressure shifts westward, but keeping the array area in light northwesterly winds.
- Temperatures dropping into the negative single digits
- Low pressure system moving from the High Arctic to the Canadian Archipelago the first sign of any active weather system by mid-week
- Forecast confidence remains high despite some model disagreement out through the end of the week



November 5th: Into the pack

Powered by Esri

Nov5

Update for 11/5:

- Sikuliaq started this morning in the lower end of young ice (4-6 in) and ended in the upper end of young ice (8-10 in), possibly nearing 12 in and first year thin.
- Leads have begun orienting more perpendicular to the wind field
- Temperatures dropped into the single digits with wind chills in the negative teens
- Sikuliaq is nearing the boundary of predominantly first year ice (12-28 inches)

Nearly sunrise

Close-up of snow/frost on the ice.

Near solar noon

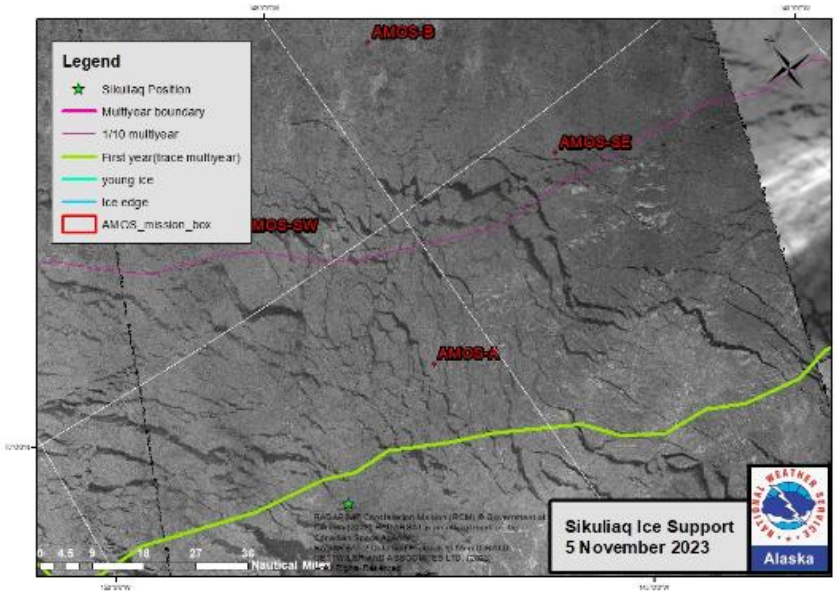
Wake propagating through the Nilas. Finger-rafting in the nilas producing unnaturally straight lines

Light pillar at sunset

Sikuliaq's wake at sunset

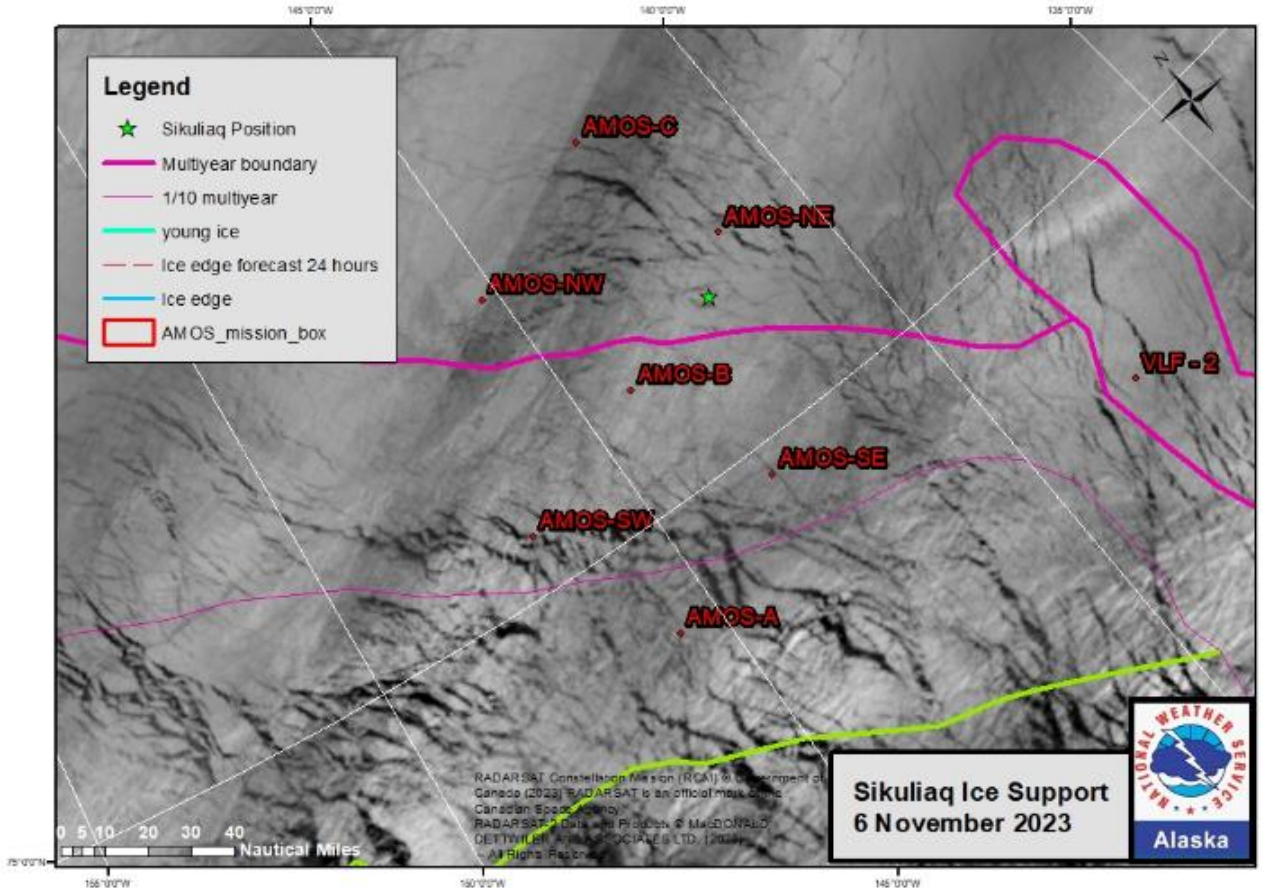
Zoomed image for transit 11/6 (below):

- Once we get past AMOS-A location, ice should be mostly first year thin with trace multi-year ice embedded
- Increasing chances of experiencing multi-year ice once we get north of the AMOS-SW to AMOS-NE line
- North of AMOS-B, better chances of 3 to 4 tenths concentration of multiyear ice



Looking ahead:

- As high pressure slides into the western Chukchi winds will turn more out of the **west ~10 kts** by mid-week
- Temperatures in the negative single digits
- Despite the high weakening, the Beaufort looks to remain quiet with no significant weather systems through the end of the week.
- Looking waaaaaayyyy ahead, model guidance hinting at a storm track pointed into the Bering Sea with extremely deep low pressure systems around the time of our Bering Strait passage.



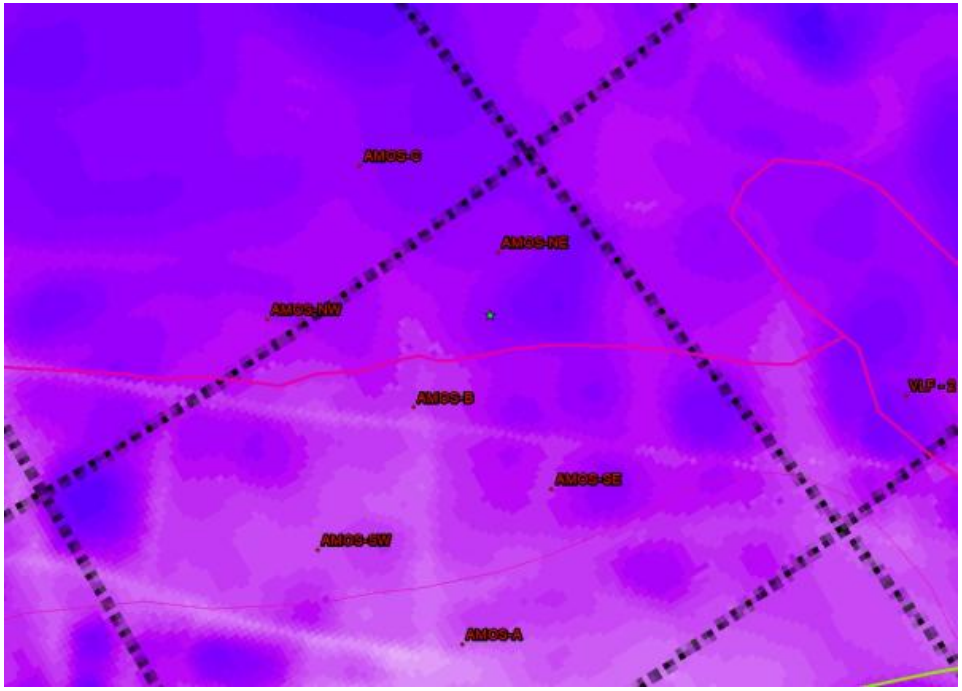
November 6th: Pushing northward

Powered by Esri

Nov6

Update for 11/6:

- Predominantly **first year thin ice today** with the biggest change being **2-3 inches of snow** on the ice.
- Continued northeasterly winds in the 10-20 kt range, opening up a series of N/S oriented leads for deployment tomorrow
- Encountered more and more ridging today, increased pressure? See GOFS ice strength prog below



GOFS Ice Pressure prog

First year thin ice (12-28 in) likely on the thinner end

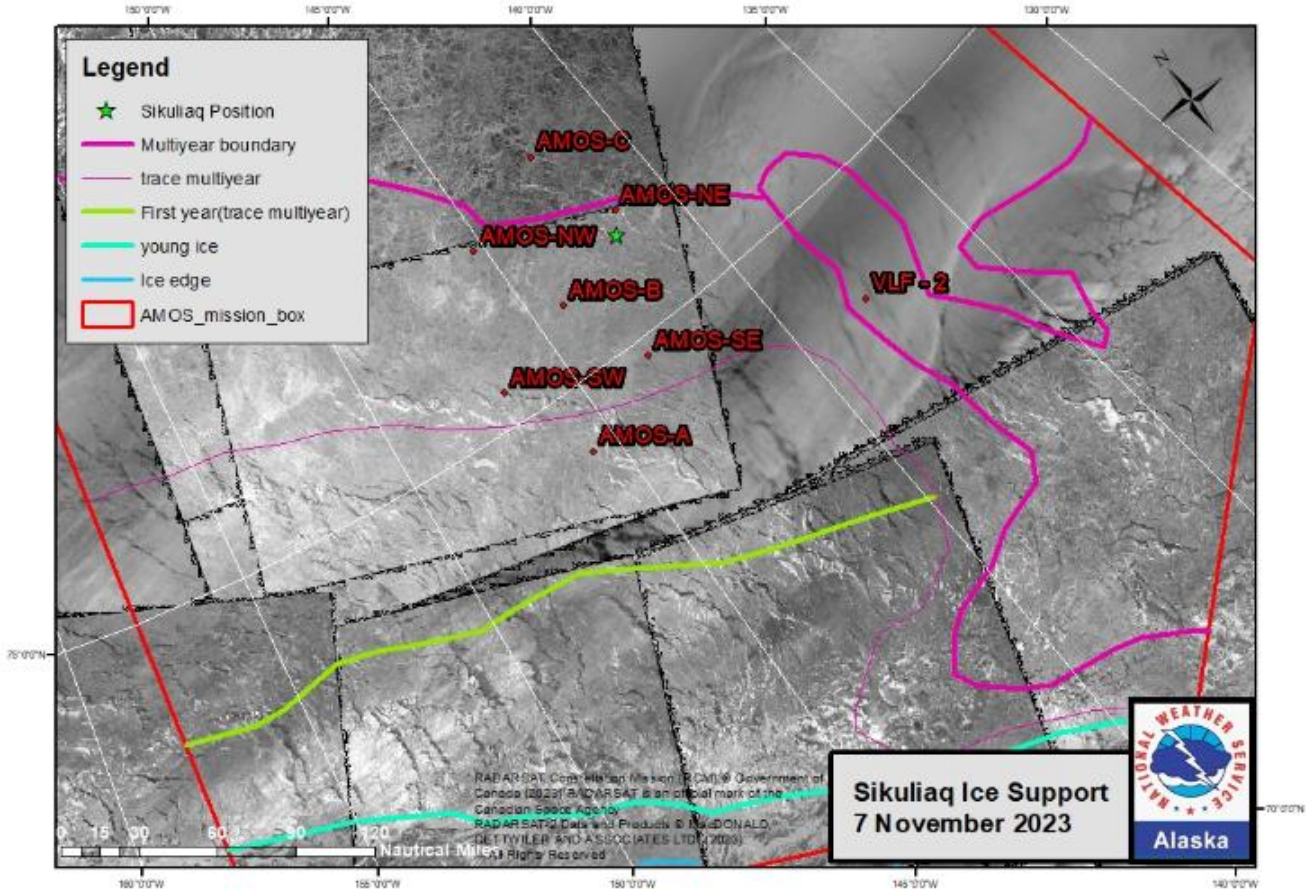
Ridging in the ice

Zoomed image for vehicle and buoy deployment tomorrow:

- Animation of Day Night Band between 10Z and 21Z today from NOAA-20, NOAA-21, and S-NPP show several possible lead targets to aim for
- Several lead targets in the AMOS-NE location
- Of note, Sikuliaq lights shown overnight, exploiting existing leads

Day Night Band showing overall pack movement and Sikuliaq exploiting leads

Pressure ridges between floes



November 7th: Deployment

Powered by Esri

Nov7

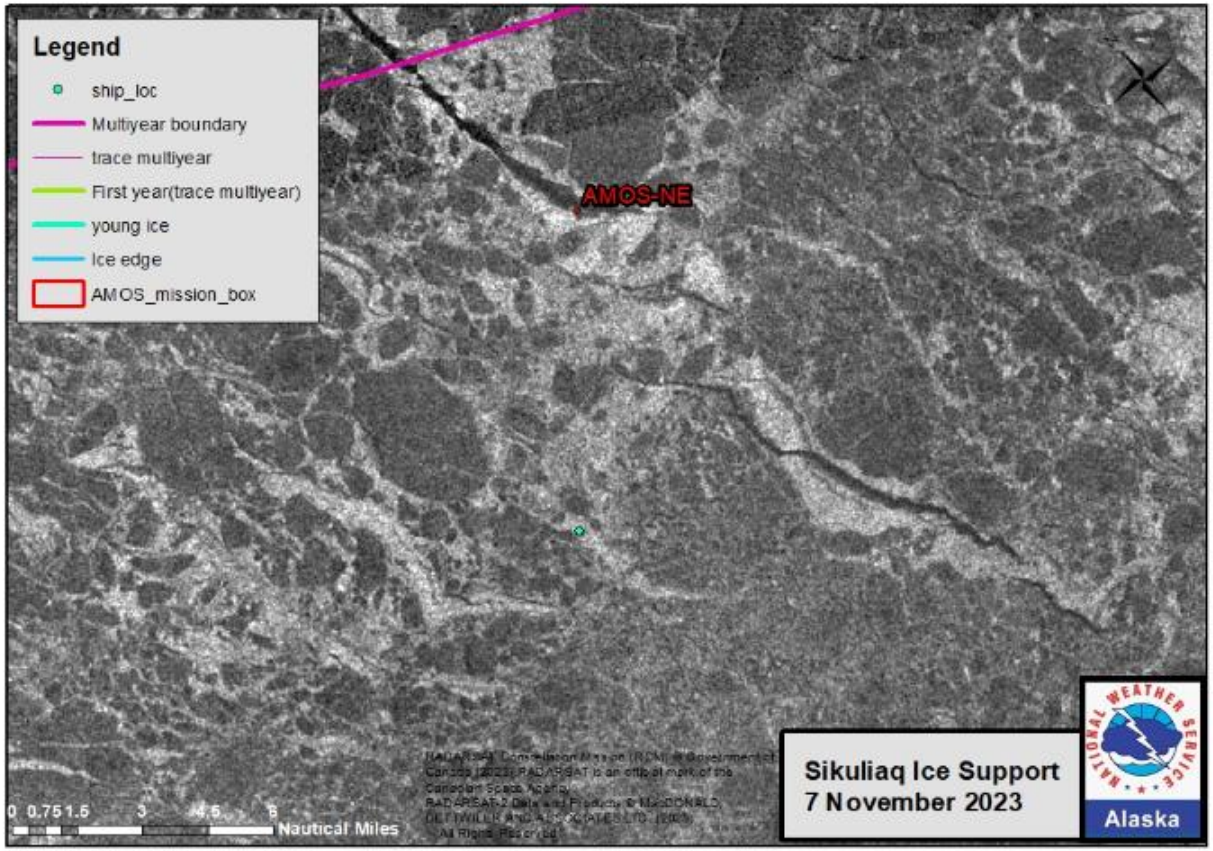
In lieu of a morning briefing as deck operations are ongoing here is a quick update:

Low pressure system aloft is seen in this series of infrared satellite images between 10z and 18Z today. Low stratus looks to be prevalent behind the front, but there is a clearing line working into the far northwest corner of the AMOS mission box
On the large scale, ice pressure looks to be relieving at these long duration northeasterly winds are opening up extensive lead structures in the southern mission box.
Model guidance has winds changing from northeast early Tuesday

to northwest on Wednesday, this *could* affect ice pressure as most of these leads have formed under the northeasterly winds

Zooming in on Sikuliaq's location we are drifting with the pack. Leads appear to still be opening in the AMOS-NE location, another indication pressure is not building in the general vicinity.
Model guidance has winds continuing to decrease through Wednesday, though model winds have been underdone by at least 5 kts the last 24 hours. I would expect some small increase in pressure as the winds shift but not much given the magnitude and directional differences of the wind.

Buoy deployment



Update for 11/7:

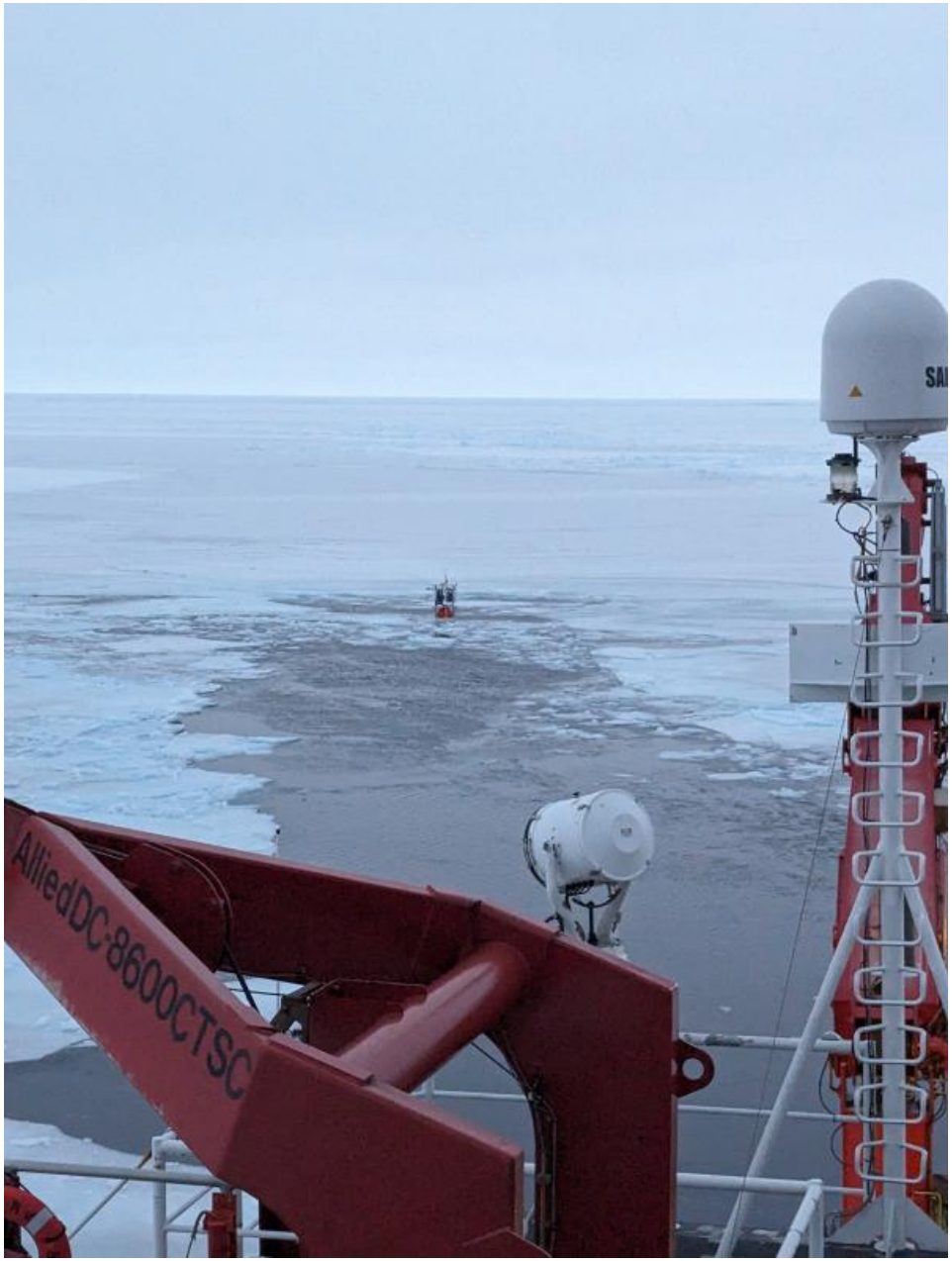
- Recalibrated multi-year lines to reflect what was seen on the transit northward. Only trace multi-year was observed.
- Northeast winds have turned more northerly through the day and are expected to continue to turn more northwesterly on Wednesday while dropping below 10 kts.
- The wind shift should have some effect on local ice pressure, but leads remained open as of early afternoon

Zoomed image for post-deployment testing (right):

- Ship location at the 1658Z RCM image marked below
- Vast floe 2.5 nm to the northwest of deployment location

Day Night Band animation loop for today 11Z-23Z

- Pack shows signs of wind shift from northeast to northerly. Noticeable drift southward in the later images
- Tough to gauge if leads are closing at this point, but looks like the big lead S of AMOS-C and NW of AMOS-NE is beginning to close



Buoy in the water/ice

Update for evening imagery 10/7:

- No RCM imagery over ships location as of 03Z image swath. MODIS Terra shows low stratus in IR overhead, preventing view of the ice.
- Likely no imagery until VIIRS imagery from SNPP/NOAA-20/21 around 8th, 10Z
- Sikuliaq's open water pocket is still intact with little change, hopefully a sign that pressure is not increasing after the wind shift through the evening (330-360 degrees from 22Z-06Z)

Second deployment of the ARTIE

November 8th: Deployment continued

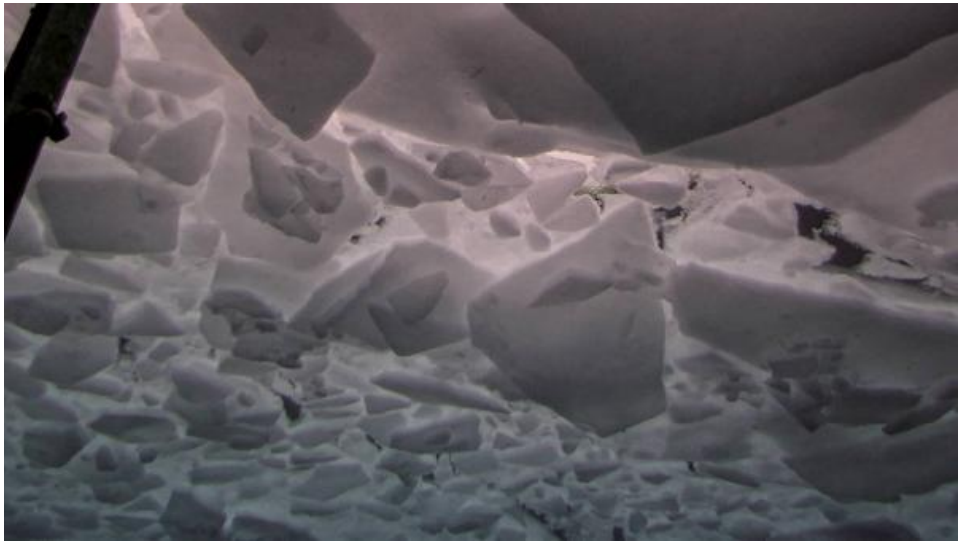
Powered by Esri

Nov8

Morning update:

Here's a super high resolution ICEYE image that was ordered last week.

- **Large formerly open lead ~1.5nm** across looks like a good target for glider deployment/CTD cast later today
- Stripmap scene of ICEYE **~3m resolution**
- Wind have solidly turned out of the NW, even westerly, would expect the change in ship/ice **drift to the SE to continue**



Buoy under the ice

Under the ice

More under the ice

Sikuliaq in frame

A handful of the science party with our arms up behind the bridge

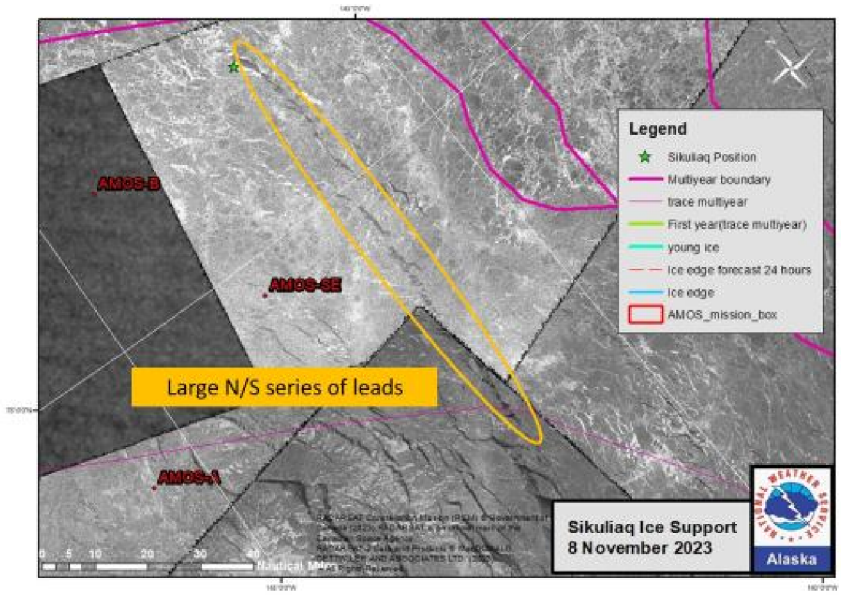
Afternoon Update for 11/8:

- Winds have turned out of the northwest today and given the ship and ice pack a slow southeasterly drift

- ICEYE imagery greatly helped operations/navigation today
- The recent high pressure has been aligning with the natural circulation of the Beaufort Gyre which has really sent an **area of multiyear ice** to the west across the southern Beaufort, likely in low concentrations. Floes in this plume have been moving **westward ~20 nm/day**

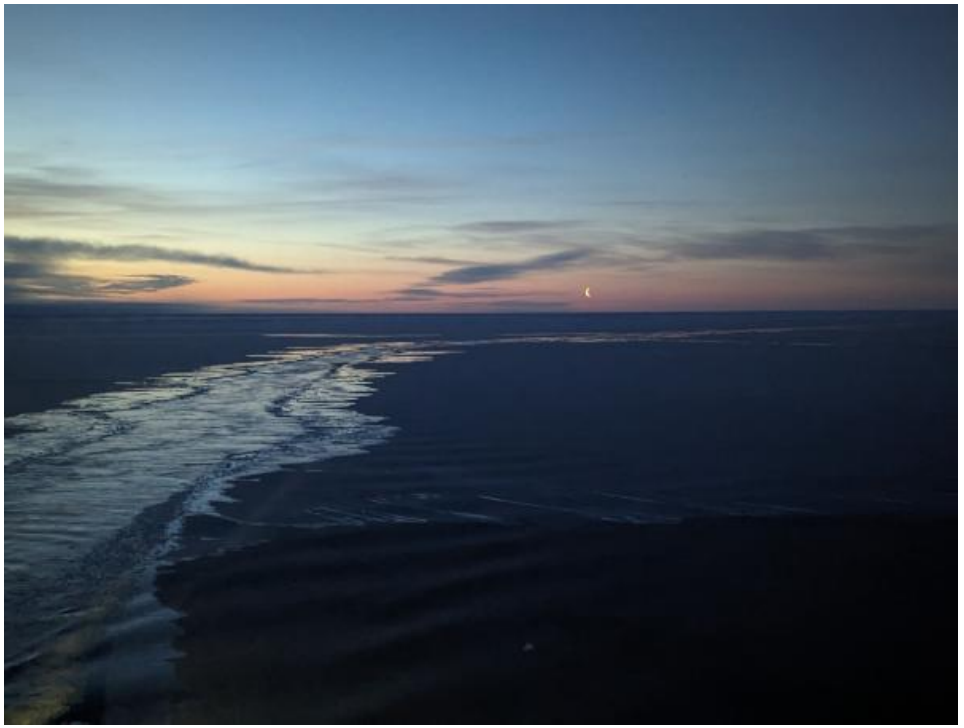
Zoomed image for possible transit 11/9 or 11/10 (below):

- For potential transit southward into thinner ice, a large system of leads is currently present.
- Given meteorological conditions over the next 48-72 hours I would expect this lead (or a new lead) to remain in the same relative place


Legend
Sikuliaq Position
Multiyear boundary
trace multiyear
First year(trace multiyear)
young ice
Ice edge forecast 24 hours
Ice edge
AMOS_mission_box
AMOS-B
AMOS-SE
AMOS-A
Large N/S series of leads
Sikuliaq Ice Support
8 November 2023
Alaska

Vortex aloft in longwave IR, credit: Carl Dierking/GINA

Snow cloud discriminator showing vortex and N/S lead system with Sikuliaq observation. Credit: Carl Dierking/GINA



Thick ice rubble

November 9th: Heading back south

Powered by Esri

Nov9

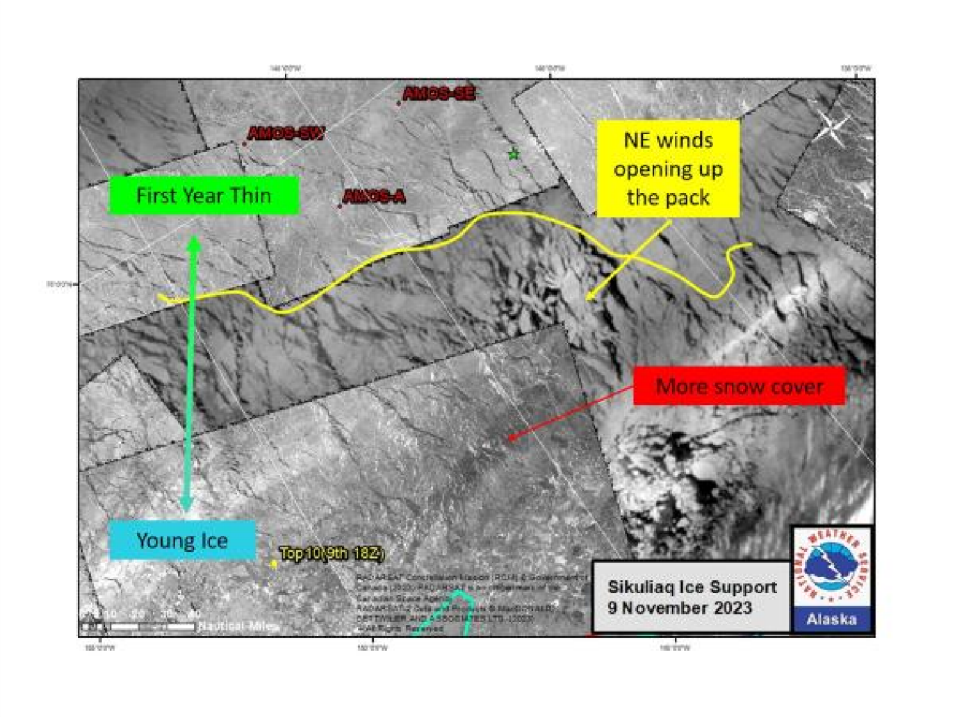
Update for 11/9:

- N/S lead has stayed mostly open save for a few pinch points and ridging to overcome.
- Ice thickness gradually decreasing with only trace multi-year observed.
- Currently, predominantly first-year ice

Zoomed image for turn westward and possible Top10 recovery (below):

- Ice pressure should continue to decrease as we enter the area that has been under the influence of stronger NE winds.

- Expect ice thickness to transition from first year thin to young as we continue southward
- Darker band on SAR image likely a band of thicker snow cover



Looking ahead to Nome:

- Model guidance in much better agreement and has been trending from Kamchatka Peninsula------>western Chukchi Sea with a mature, deep low pressure system Sunday into Monday
- Expect near gale force southeasterly winds around the time we exit the ice pack (Sunday into Monday) and head toward Bering Strait

- Warmer air mass, near freezing behind the warm front, hopefully less freezing spray
- **Still much uncertainty** regarding Bering Sea storm in the 14th/15th timeframe, but guidance is trending toward a further south and east track at this moment as we approach Nome

November 10th: Heading southward

Powered by Esri

Nov10

- Ice has been a mix of the upper end of young (8-11 inches) and some first year thin (12-15)
- A mixture of snow covered ice (dark in SAR) and frozen leads with frost flowers (bright in SAR)
- Trace multi-year has been all around, it's hard to make a boundary at this point as it's diffuse within the pack

Zoomed image for Top10 recovery 11/11 (below):

- Top10 seems to be in an eddy, could see ice motion or drift counter to the large scale wind drift (see animation below)
- Otherwise, expect mostly young ice with some areas of snow covered first year for the transit to Top10

Morning time lapse from the bridge

Nov 10 afternoon timelapse

IR animation from roughly 16Z to 23Z today. Top10 in an eddy from currents (Alaska Coastal Current?) interacting with the large scale ice drift

November 11th: Top 10 buoy recovery

Powered by Esri

Nov11

Update for 11/11:

- Possibility for multi-year ice remains as continuous NE winds have extended an area from the east
- Problem of the day was ice pressure due to currents/eddies
- As of the morning SAR imagery, coastal ice has met the pack further to the east of Utqiagvik (Image over Utqiagvik is from last eve)
- Expect ice free conditions near Pt. Barrow

Zoomed image of buoy recovery area (below):

- Sikuliaq had some tough going in the area of pressure outlined below. The two eddies and wind drift combined to increase pressure and areas of ridging

Buoy in an eddy between currents and wind driven drift

Iced up porthole

Powered by Esri

Nov14

Powered by Esri

Nov15

Loading into the work boat

Headed into Nome Harbor

Me, not paying attention to the role call

Thank you to:

- U.S. National Ice Center
- NWS Alaska Region Headquarters
- NWS Anchorage
- Alaska Sea Ice Program
- Sikuliaq crew/UAF team
- Woods Hole Oceanographic Institution

- Applied Physics Laboratory - University of Washington