R/H Sabvabaa: 2013 Operations & FRAM-2014 Plans

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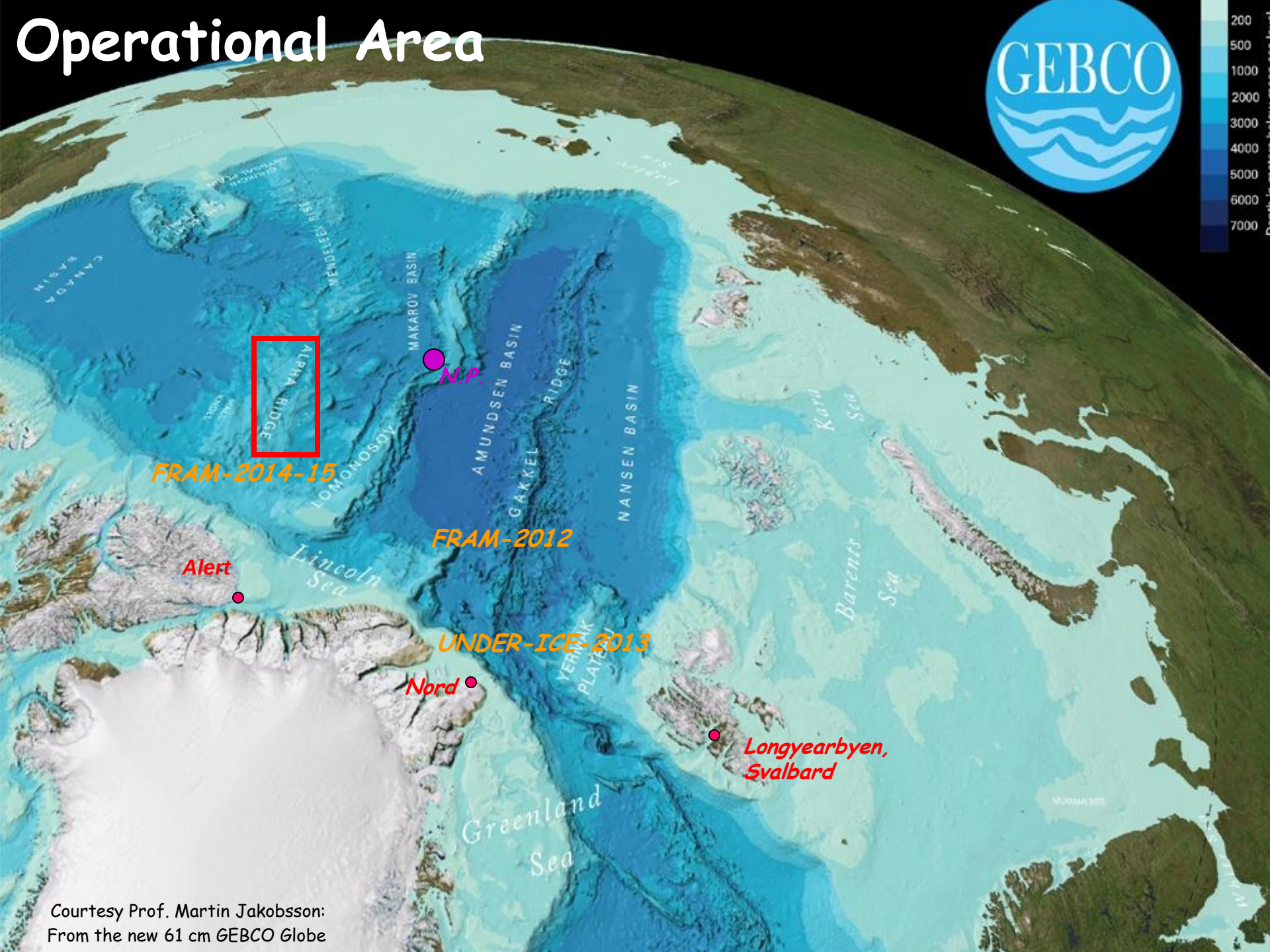
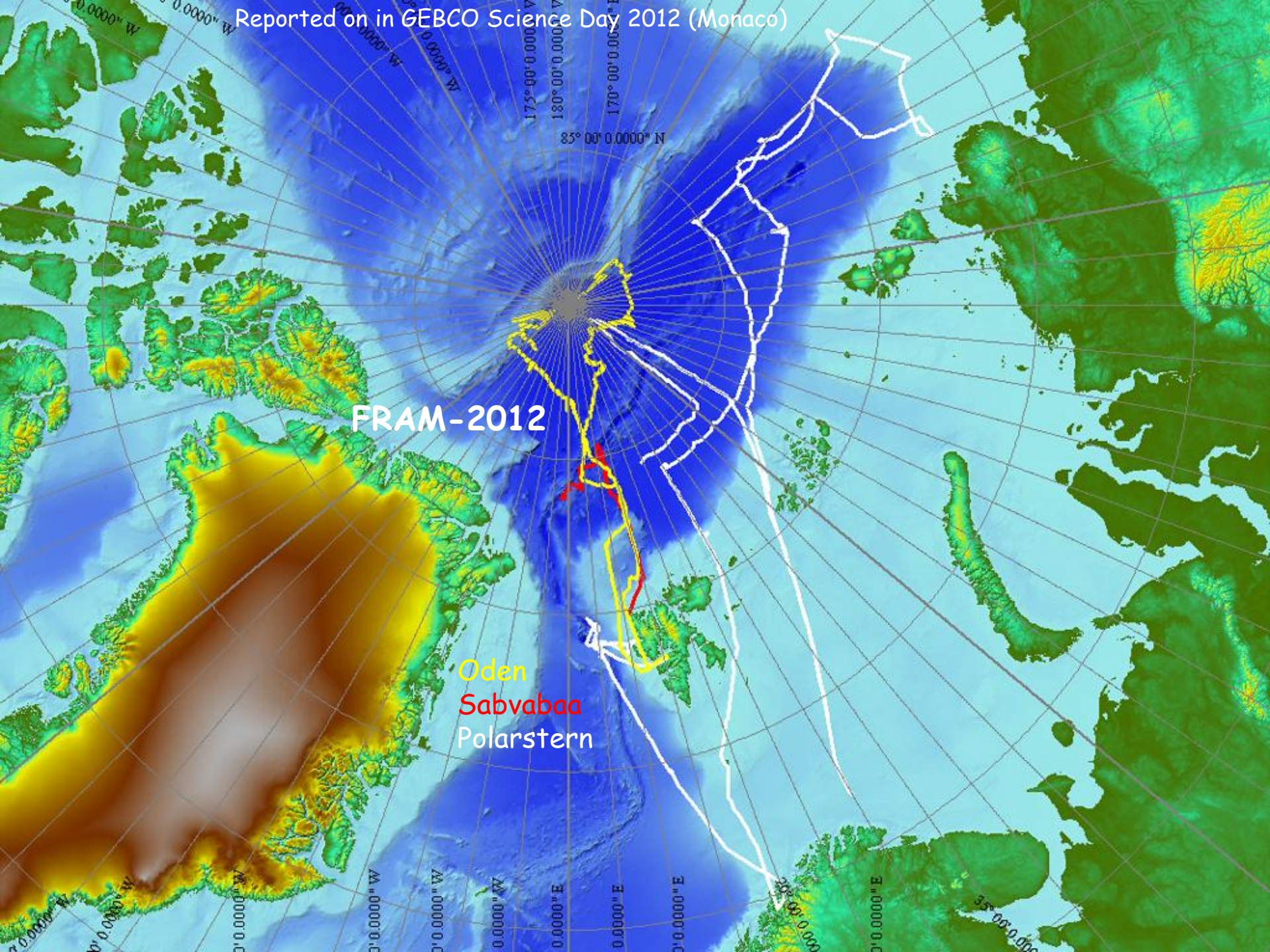
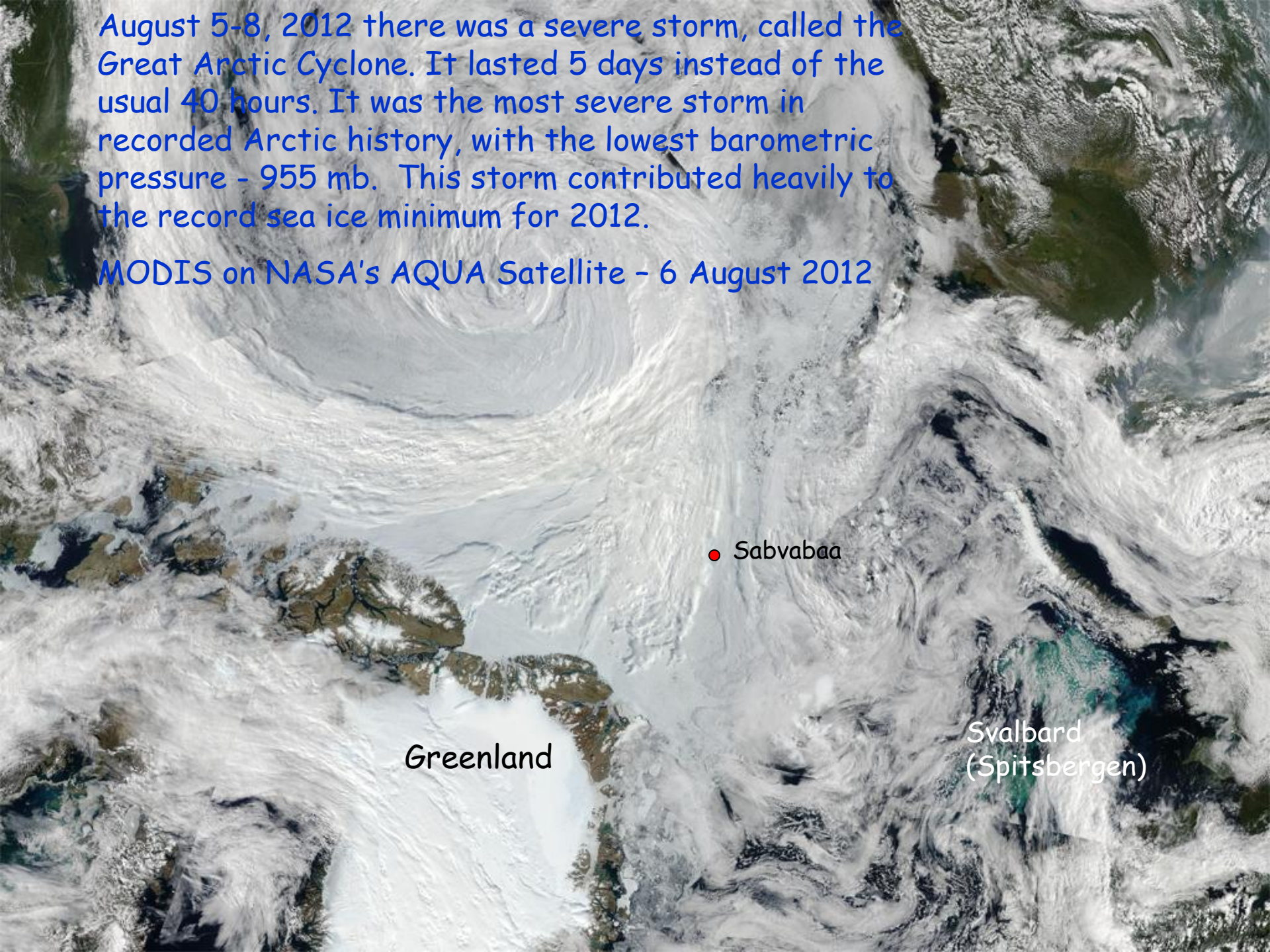
GEBCO Science Day, Venice, Italy, October 8, 2013

Operational Area



Courtesy Prof. Martin Jakobsson:
From the new 61 cm GEBCO Globe


Reported on in GEBCO Science Day 2012 (Monaco)
FRAM-2012
Oden
Sabvabaa
Polarstern


August 5-8, 2012 there was a severe storm, called the Great Arctic Cyclone. It lasted 5 days instead of the usual 40 hours. It was the most severe storm in recorded Arctic history, with the lowest barometric pressure - 955 mb. This storm contributed heavily to the record sea ice minimum for 2012.
MODIS on NASA's AQUA Satellite – 6 August 2012
Sabvabaa
Greenland
Svalbard
(Spitsbergen)

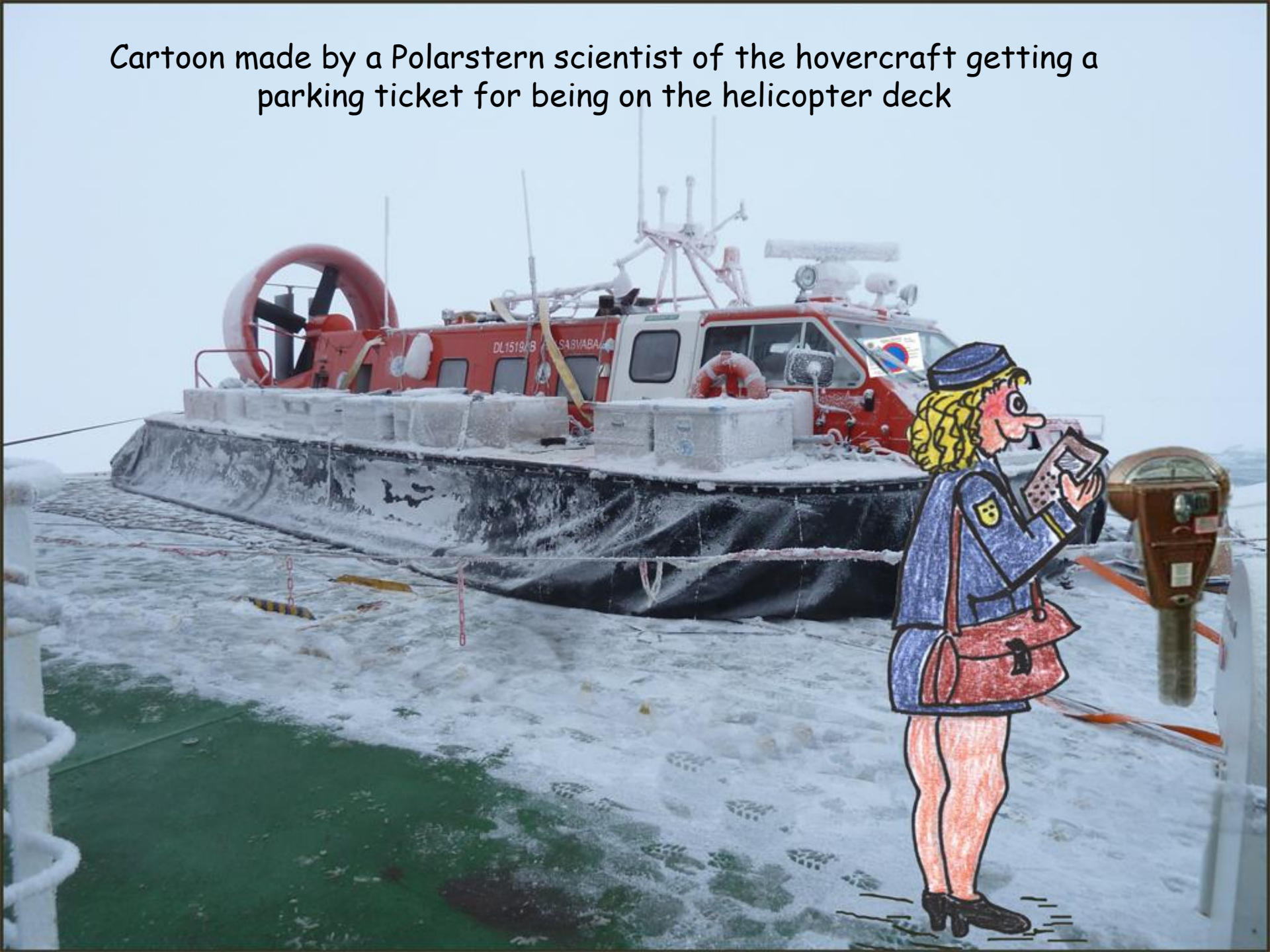
When it looked like the hovercraft, with only Prof. Yngve Kristoffersen aboard, would be unable to progress south because of extensive rubble ice and zero visibility 22 hours a day, AWI's icebreaker POLARSTERN diverted hundreds of kilometers to the west and recovered the craft.

AWI Icebreaker POLARSTERN slowly works its way through rough ice to the hovercraft, marking its location with a searchlight on the overcast.

Sabvabaa was surrounded by the ice pack in compression, with much irregular rubble ice. Almost looks like something out of Alistair MacLeans 1963 movie 'Ice Station Zebra'.


The lift to the helicopter deck took all of 15 minutes

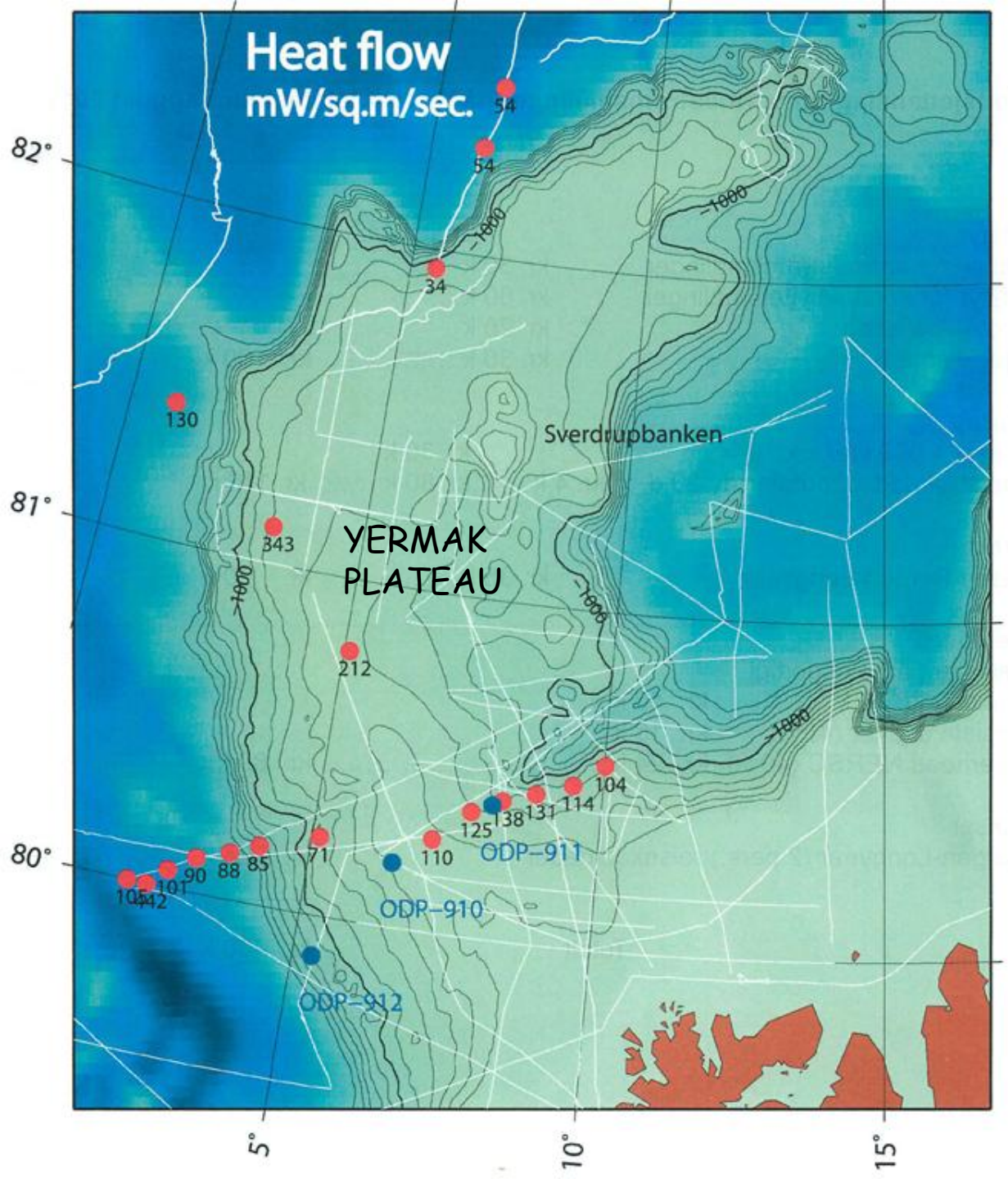
Cartoon made by a Polarstern scientist of the hovercraft getting a parking ticket for being on the helicopter deck



2013 Season:

June Repairs: Propellor change.

New lift fan: Retired Bergen University research vessel chief engineer Hans Bregge helps Yngve in Longyearbyen



The Plan for 2013 had two parts.

The **first** part was a trip aboard the vessel Norbjorn up to the icepack over the Yermak Plateau. There Cambridge University studied the damping of the ocean swell with distance from the edge of the ice pack.

We also tested out our 7 m long free-fall dart corer. Miniaturized internally recording thermistor outriggers were attached to the barrel and we attempted to penetrate deep enough to obtain heat-flow measurements.

This work was again funded by the Norwegian Petroleum Directorate.

July 2013: Ten days on the ice over the Yermak Plateau with Dr. Martin Doble of Cambridge University. Study of the damping of ocean swell by the ice pack using accelerometers. Unfortunately the seas were calm during that period. Also heat flow measurements using 7m dart corer.

Aeroquad Cyclone Quadcopter Test Flight

Note 3/8" kevlar laid out on the ice for the dart corer

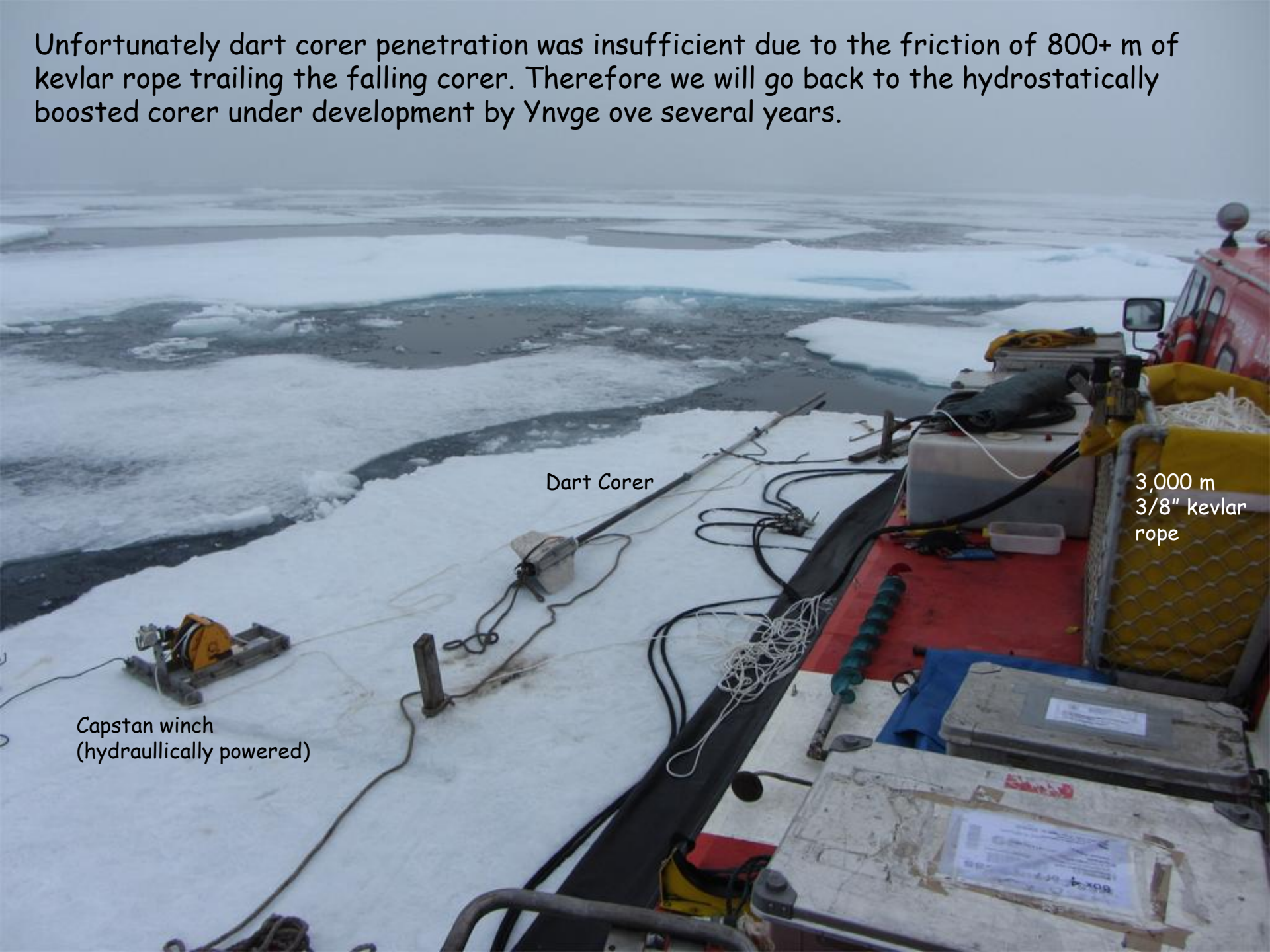
02/07/2013

First SABVABAA air photo using the Quadcopter


Swell spectra
accelerometer
package

The hovercraft has a very light environmental footprint. Only a small floe is needed for all manner of experiments.

Unfortunately dart corer penetration was insufficient due to the friction of 800+ m of kevlar rope trailing the falling corer. Therefore we will go back to the hydrostatically boosted corer under development by Ynvge ove several years.



Wind generator 500 watts in 20 kt winds

Outrigger autonomous thermistors

Dart corer with multiple heat flow thermistors – only 2+ m penetration

Tests of the hydrostatically-boosted corer aboard the R/V Hakon Mossby in Bergen. This will replace the dart corer whose speed at impact was insufficient due to the friction of the kevlar rope.


'Umbrella' to prevent the corer from jumping upwards when the piston is released upon contact with the bottom. The force on the piston is one atmosphere for each 10 m of depth.

Another problem addressed in mid-summer was the problem of visibility and picking a way through the rubble ice and pressure ridges.

A tethered helium aerostat or balloon with camera was acquired, but was deemed unsuitable. The solution instead was installation of an raisable telescoping pole with a wi-fi camera.

A wi-fi camera at the top transmits to a laptop in the cockpit.

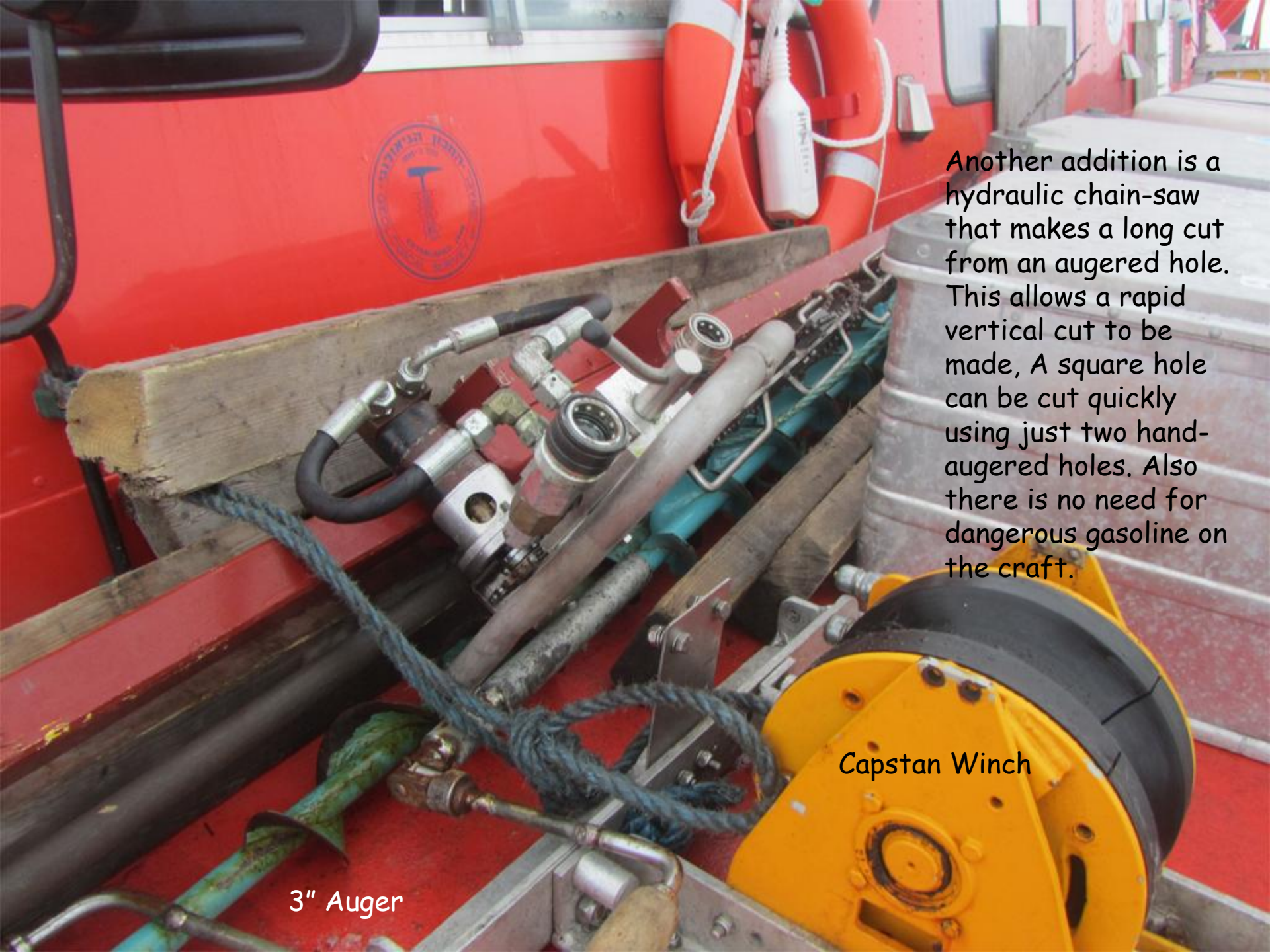
The 12 m pole extended in Longyearbyen.

A bicycle pump raises and lowers the ~20 kg periscope.

Hopefully this will allow easier navigation among pressure ridges and rubble ice.

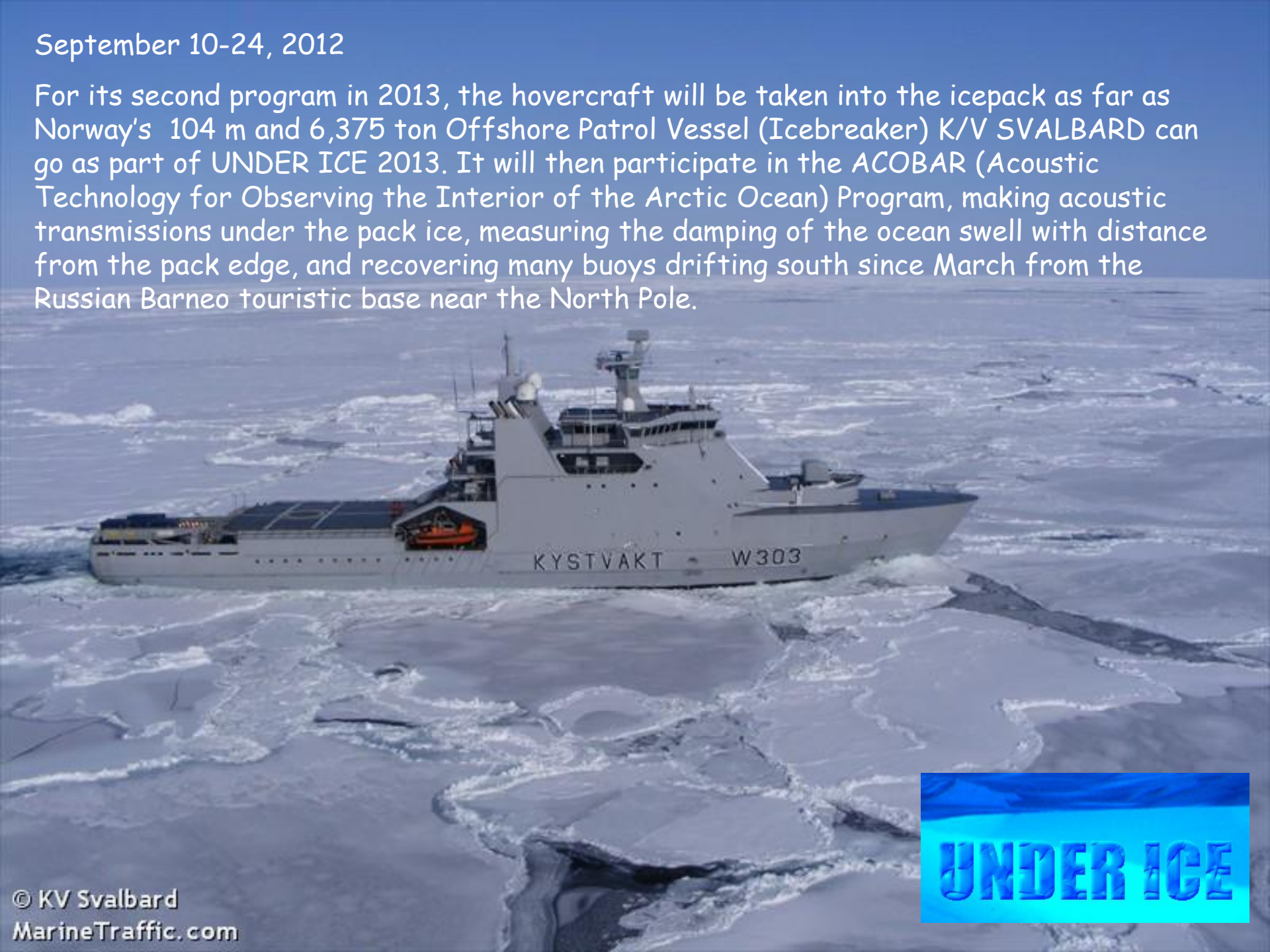
Underway the periscope may be used at 6 m height.

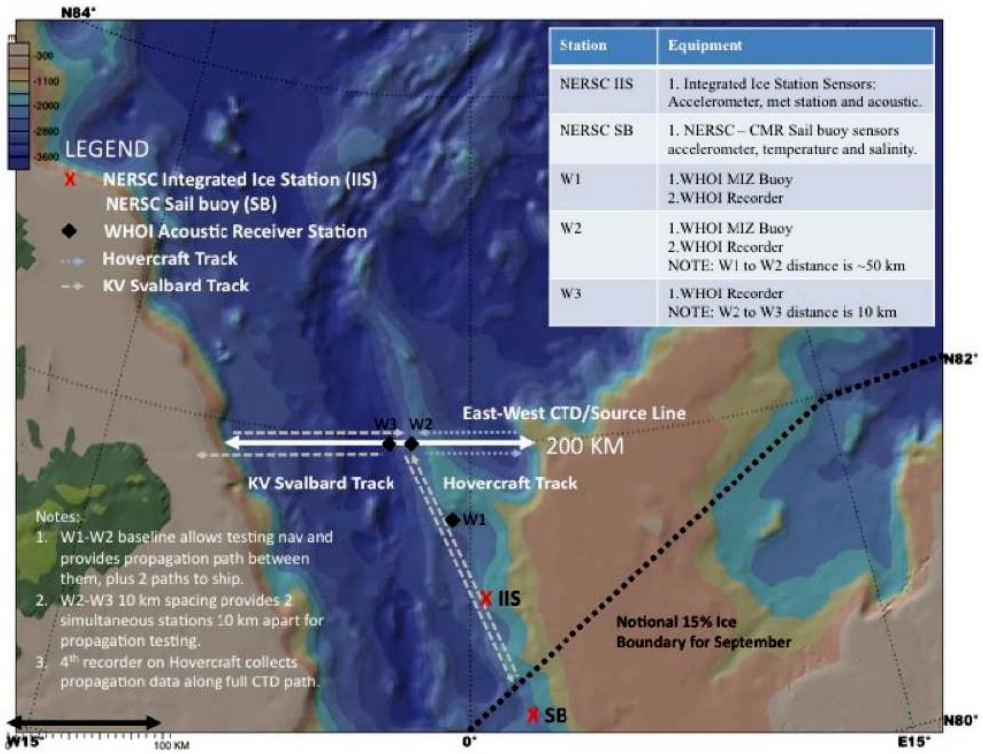
The Cockpit Laptop Display


Another addition is a hydraulic chain-saw that makes a long cut from an augered hole. This allows a rapid vertical cut to be made, A square hole can be cut quickly using just two hand-augered holes. Also there is no need for dangerous gasoline on the craft.
Capstan Winch
3" Auger

September 10-24, 2012

For its second program in 2013, the hovercraft will be taken into the icepack as far as Norway's 104 m and 6,375 ton Offshore Patrol Vessel (Icebreaker) K/V SVALBARD can go as part of UNDER ICE 2013. It will then participate in the ACOBAR (Acoustic Technology for Observing the Interior of the Arctic Ocean) Program, making acoustic transmissions under the pack ice, measuring the damping of the ocean swell with distance from the pack edge, and recovering many buoys drifting south since March from the Russian Barneo touristic base near the North Pole.





Christian Michaelsen Research (CMR) SailBuoy launched and recovered in the open sea

Kongsberg (iRobot) Seaglider recovered in the open sea

The UNDER-ICE 2013 Cruise Plan

CTDs and XCTDs every 10 km across the deep FRAM Strait

Sound transmissions to buoys ~100 and 980 Hz

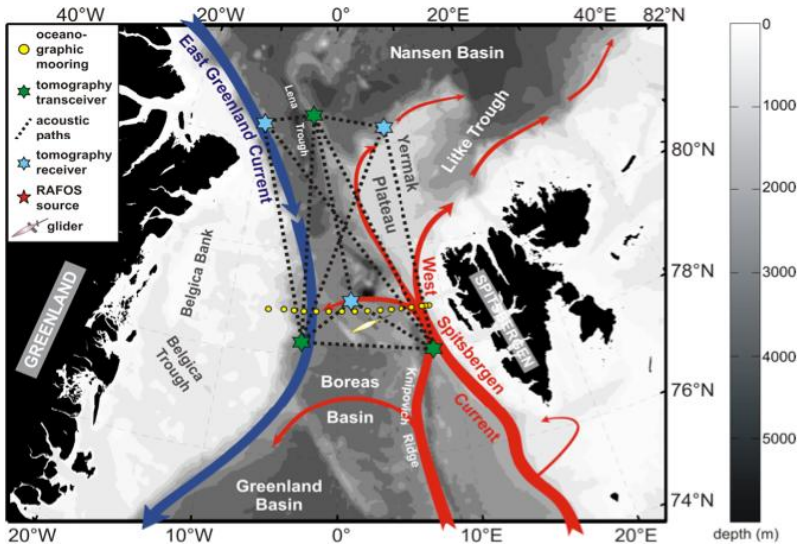
Temporary Buoy emplacements

Drift Buoy and SeaGlider recovery

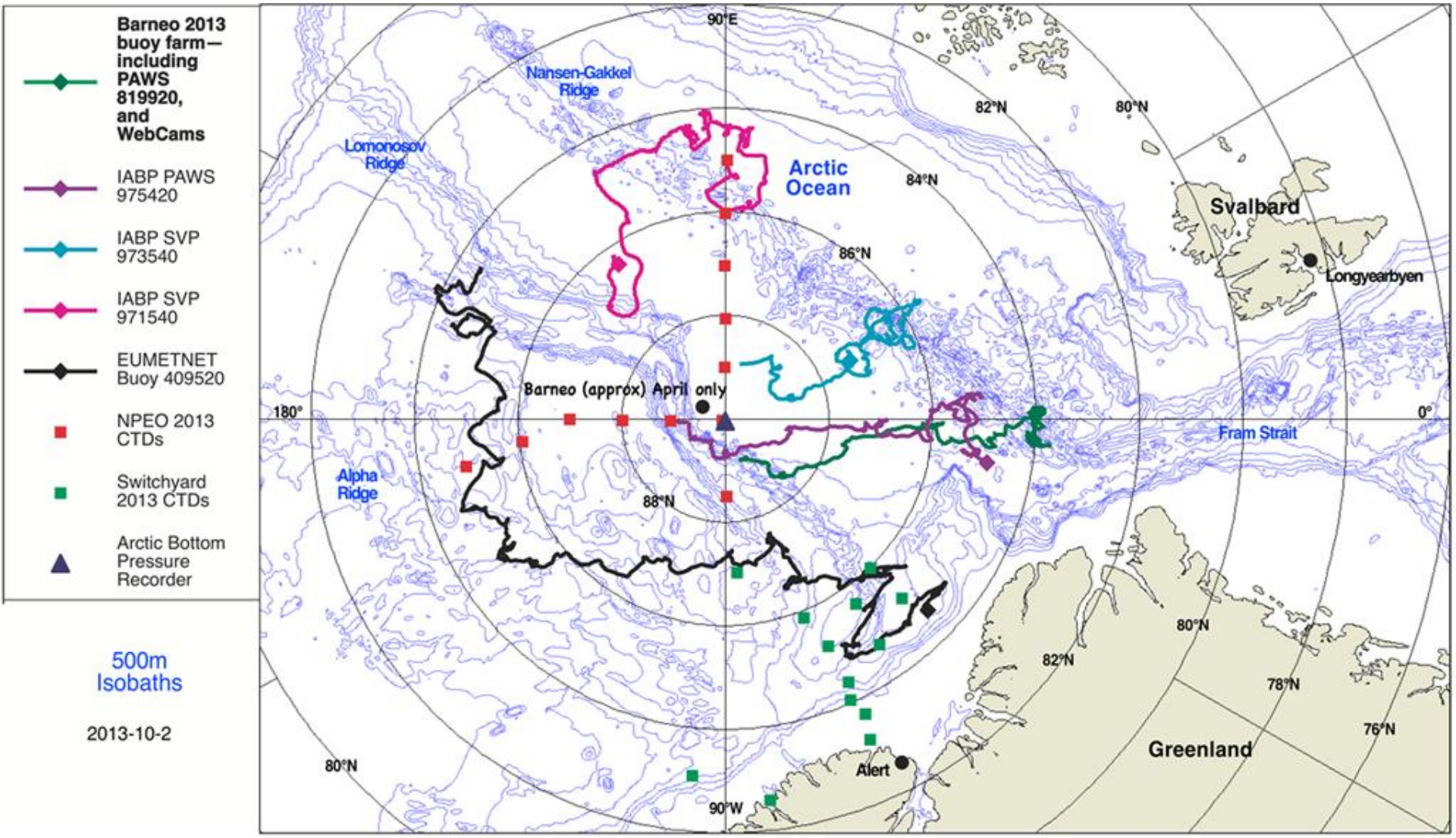
Use of our hovercraft as a satellite platform

CMR Sail Buoy launch and recovery

Unfortunately nothing of value to GEBCO



Sound transmission paths – SVALBARD to Buoys



Tracks of the Arctic Buoy Project (ABP) from their website as of 2 October 2013. The dark green line was the buoys emplaced in the 2013 Barneo base buoy 'farm' in April 2013. They were all recovered by the KV SVALBARD in September .

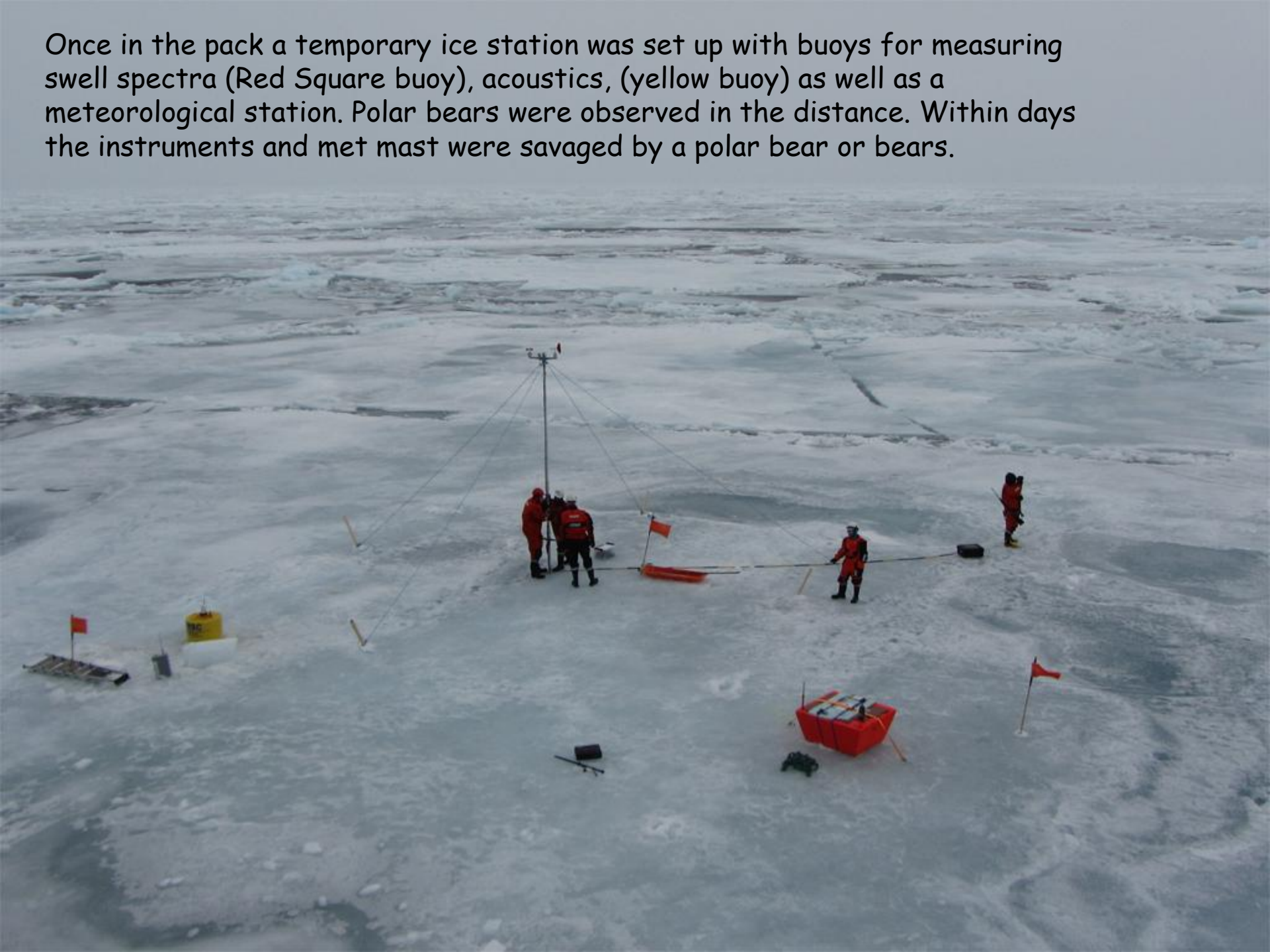
The R/H SABVABAA on the KV SVALBARD helo deck (no helicopters aboard but craft can also be put on the lower after-deck.).

Another view from the coastal road.

KYSTVAKT - Coast Guard in Norwegian

The first polar bear seen, at distances of 400 to 150 m.

Once in the pack a temporary ice station was set up with buoys for measuring swell spectra (Red Square buoy), acoustics, (yellow buoy) as well as a meteorological station. Polar bears were observed in the distance. Within days the instruments and met mast were savaged by a polar bear or bears.



Upon arrival at 82°N the hovercraft was lifted and placed on the ice. Its workplan was to proceed east and make CTDs every 10 km while also listening periodically to the 980 Hz transmissions from the SVALBARD for studing under-ice sound transmission.

Two NERSC personnel, Jon Erik Bergh (left) and Morten Johan Stette (right), preparing the hydrophone for receiving the sound transmissions. Note the capstan winch for the CTD lowerings to 1000 m.

Most days the visibility was very poor, down to 50 m.

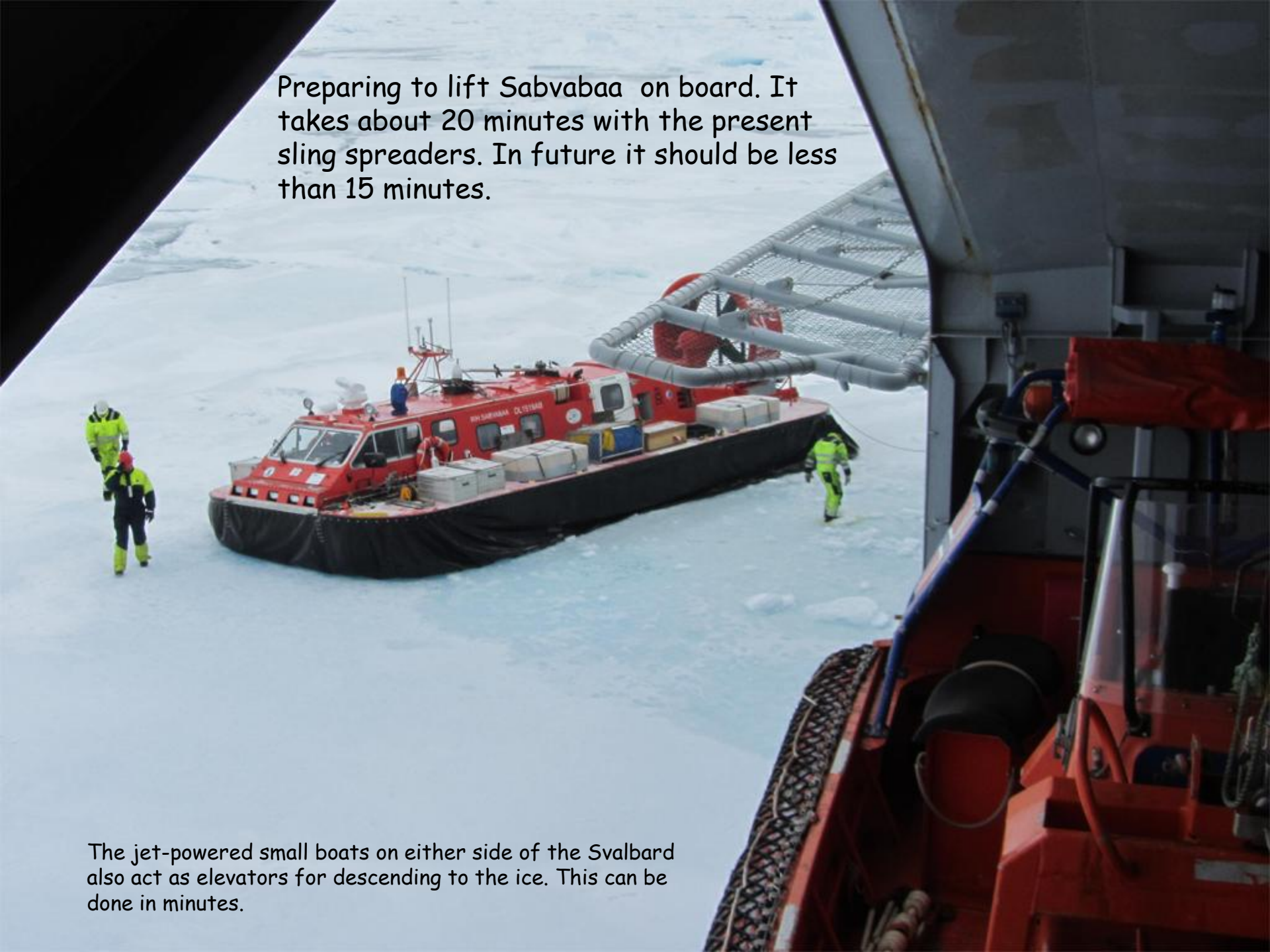
Morton and Jon at lunch and at work in the craft. Photos by Yngve.

On the third day the hovercraft reported on the Iridium satellite phone that the clutch for the propulsion propellor had failed.

Below is the telephoto image of the disabled hovercraft as the SVALBARD came back to pick it up. The craft had made a number of CTDs, as well as measuring currents at depth with its ADCP during sleep periods.

The approach of the icebreaker as the visibility improved.

A contrast in the size of these platforms.



Preparing to lift Sabvabaa on board. It takes about 20 minutes with the present sling spreaders. In future it should be less than 15 minutes.

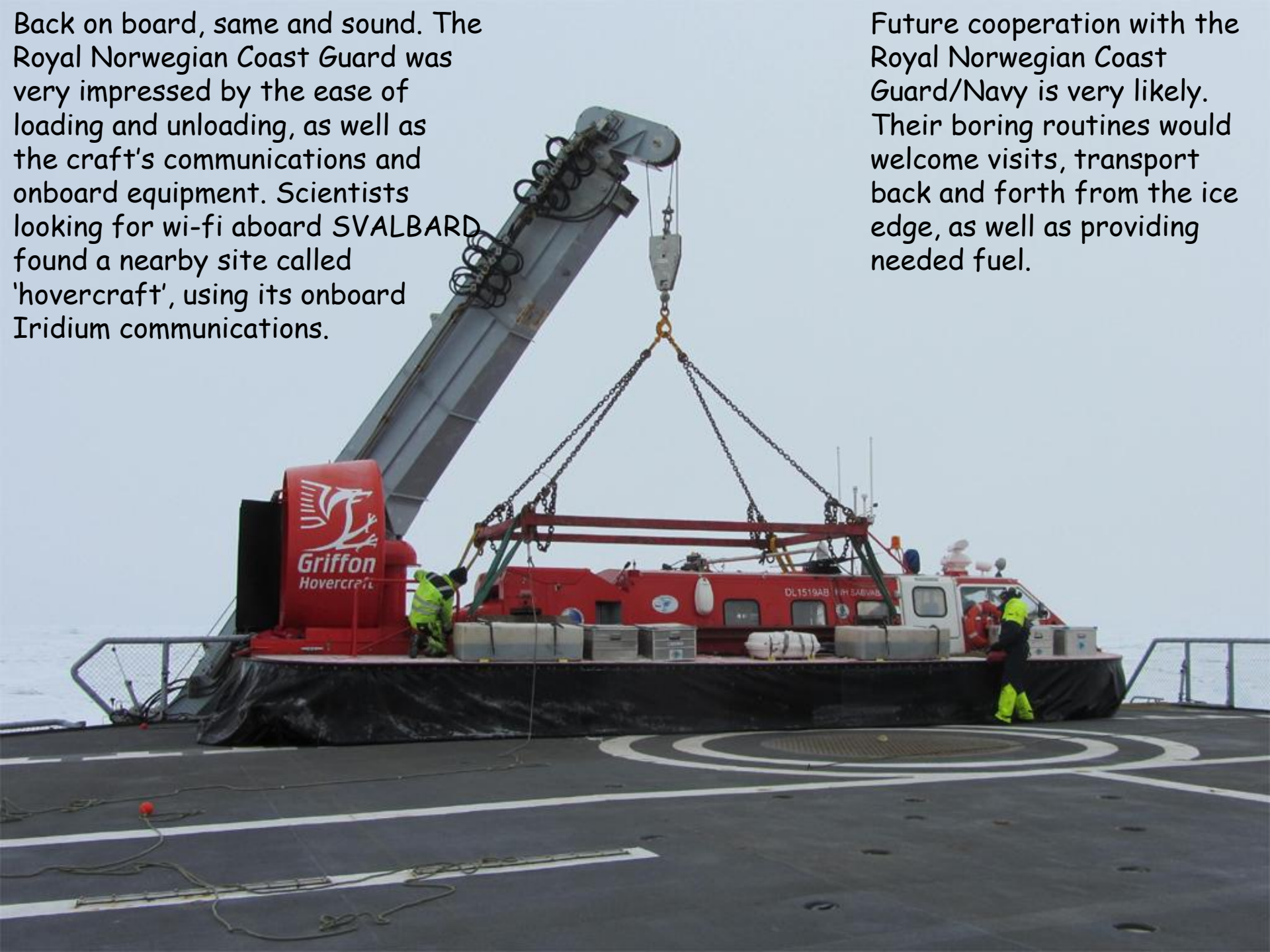
The jet-powered small boats on either side of the Svalbard also act as elevators for descending to the ice. This can be done in minutes.

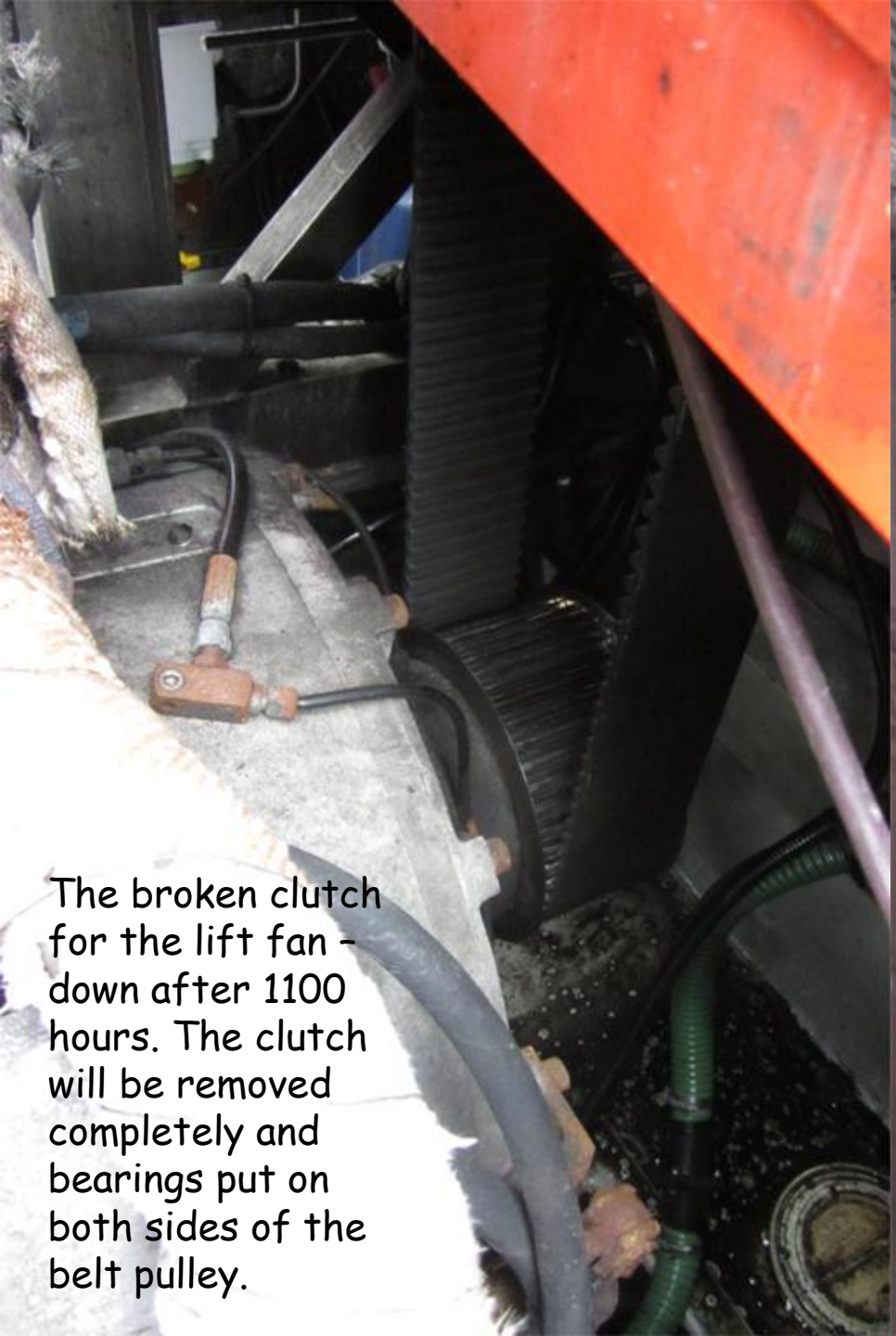
The SABVABAA is a magnet for polar bears. Note the footprints aft of the craft. Most are bear prints. The inset shows they are significantly larger than the boot prints.


The spreaders prevent the short scope of the ship's crane from collapsing the aluminum hull.

Back on board, same and sound. The Royal Norwegian Coast Guard was very impressed by the ease of loading and unloading, as well as the craft's communications and onboard equipment. Scientists looking for wi-fi aboard SVALBARD found a nearby site called 'hovercraft', using its onboard Iridium communications.

Future cooperation with the Royal Norwegian Coast Guard/Navy is very likely. Their boring routines would welcome visits, transport back and forth from the ice edge, as well as providing needed fuel.





The broken clutch for the lift fan – down after 1100 hours. The clutch will be removed completely and bearings put on both sides of the belt pulley.

There are very few continuous measurements of sea ice thickness in the Arctic.

SABVABAA's EM-31 electromagnetic probe was suspended off the port side from an extension ladder, and made measurements several times a second until the open ocean.

Sample readout on the laptop aboard SABVABAA

```
[IT] ============================
[IT] ========== Status ==========
[IT] Queue size (approx) ..: 0
[IT] Latitude .............: 83.263205
[IT] Longitude ............: -2.023282
[IT] Time .................: Sun Sep 22 06:19:03 2013
[IT] Sonar (distance) .....: 305.76 [cm] (high)
[IT] EM (distance) ........: 3.58 [m]
[IT] Ice thickness ........: 0.40 [m]
[IT] ============================
[IT] ========== Status ==========
[IT] Queue size (approx) ..: 1
[IT] Latitude .............: 83.263205
[IT] Longitude ............: -2.023282
[IT] Time .................: Sun Sep 22 06:19:03 2013
[IT] Sonar (distance) .....: 300.45 [cm] (high)
[IT] EM (distance) ........: 3.48 [m]
[IT] Ice thickness ........: 0.35 [m]
[IT] ============================
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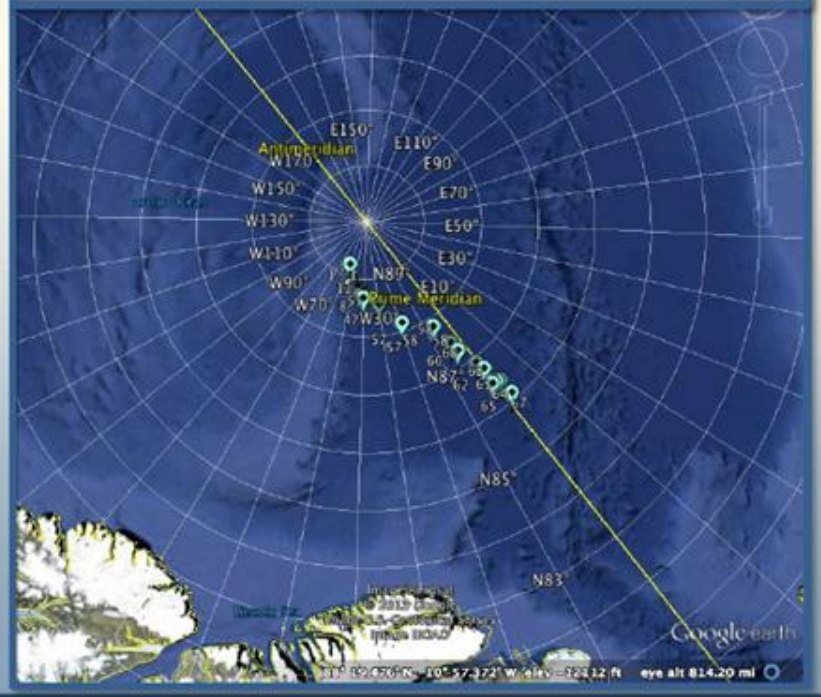
The first buoy to be recovered was the drifting WHOI/Scripps THAAW Buoy. The search for it from the bridge.

Thin-ice Arctic Acoustic Window (THAAW) Project

- Scripps/WHOI passive array deployed 13 April at North Pole
- 600 m hydrophone array below float
- 22 Hydrophone Modules w/precision thermistors
- 10 Seabird MicroCATs
- Records for 108 minutes beginning at 1200 UTC six days per week
- Sample rate 1953.125 Hz
- Currently drifting south


DARPA/SAIC simultaneously deployed a drifting source and a receive array further south



We passed within meters of the THAAW Buoy (THin ice Arctic Acoustic Window). It was precisely located by maneuvering in the general area and obtaining separate ranges to its acoustic transponder.

Next was the search for buoys emplaced near the North Pole in April 2013. In very low visability, the SVALBARD pushed through the remains of the Barneo station and the junk the Russians left behind.

Each year since 2002 the Russians have set up the temporary Barneo base near the North Pole. Tourists can reach the pole on foot, or via skis, dog-sled, ski-doos, helicopter (sky-diving) etc.

Remains of the bulldozer seen through the 50-100 m visibility. Note the fuel tank, gas cap etc. Many barrels, and snow vehicles were seen as the SVALBARD plowed through the remains of the Barneo floe in the fog, heading for the distant iAOOS buoy.

Small bulldozer for making the runway.

Buoys clustered near the center of the Barneo based were recovered first using ice chisels, chain saws, and hot engine water pumped out by firehose. Then we ventured farther afield to get the isolated iAOOS buoy.

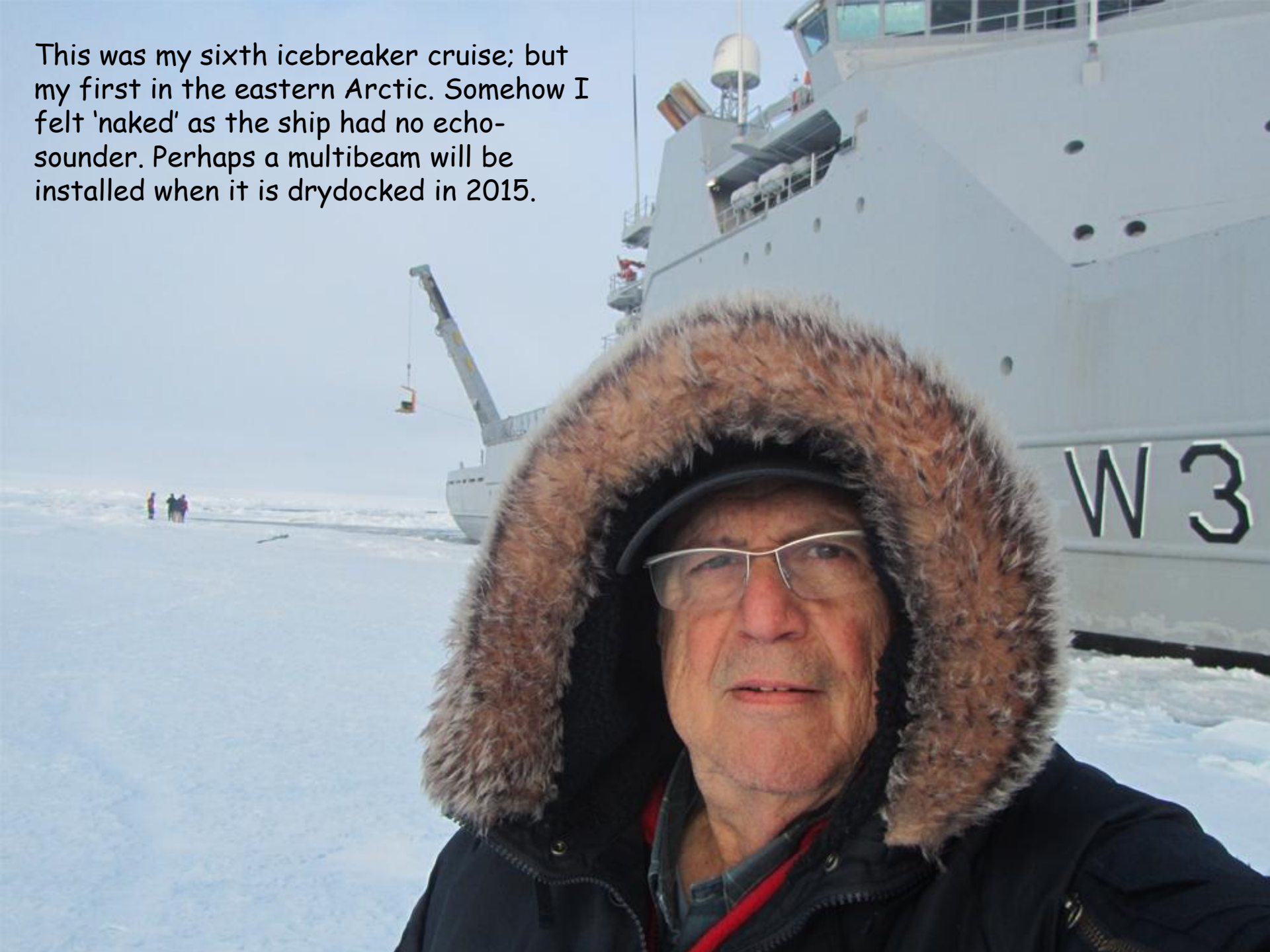
iAOOS Buoy emplaced by University of Paris oceanographer Dr. Christine Provost at the Russian Barneo North Pole station April 14, 2013

Portion of last webcam image transmitted to UW-APL from iAOOS as it was approached by the KV SVALBARD.


Recovery of the iAOOS buoy on 21 September
about 700 km farther south.

Yngve Kistoffersen watching recovery of the iAOOS . Yngve has lived aboard the SABVABAA for some 17 months, travelling more than 2000 nmi over ice, and the equivalent of halfway around the world since 2008.

The crew of the KV SVALBARD. A close-knit group of up to 44, 18 of them officers. The cannon forward can fire 3 57 mm shells per second.



This was my sixth icebreaker cruise; but my first in the eastern Arctic. Somehow I felt 'naked' as the ship had no echo-sounder. Perhaps a multibeam will be installed when it is drydocked in 2015.

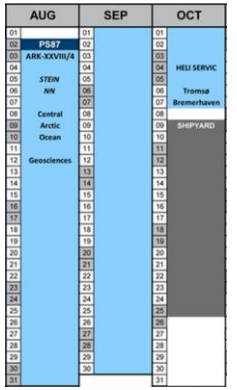
After two weeks in the ice we returned to Longyearbyen, Svalbard. All the scientific objectives had been met, and we had proved the advantages of working together with an icebreaker, despite the clutch problem which will be solved.

The ship attained 84°-04'N, 4°W, northeast of Greenland and over the southern Gakkel Ridge, a record for the Norwegian Coast Guard.


RIH SABVABAA DL1519AB
Griffon
Hovercraft

With the help of two pickup trucks from neighbors on the coal pier point, the hovercraft (on lift but without propulsion) was taken 1 km to its usual winter storage area. The Longyearbyen airport is in the background.

FRAM 2014-15 400 Day Drift across the Alpha Ridge 'Asteroid Impact Zone'

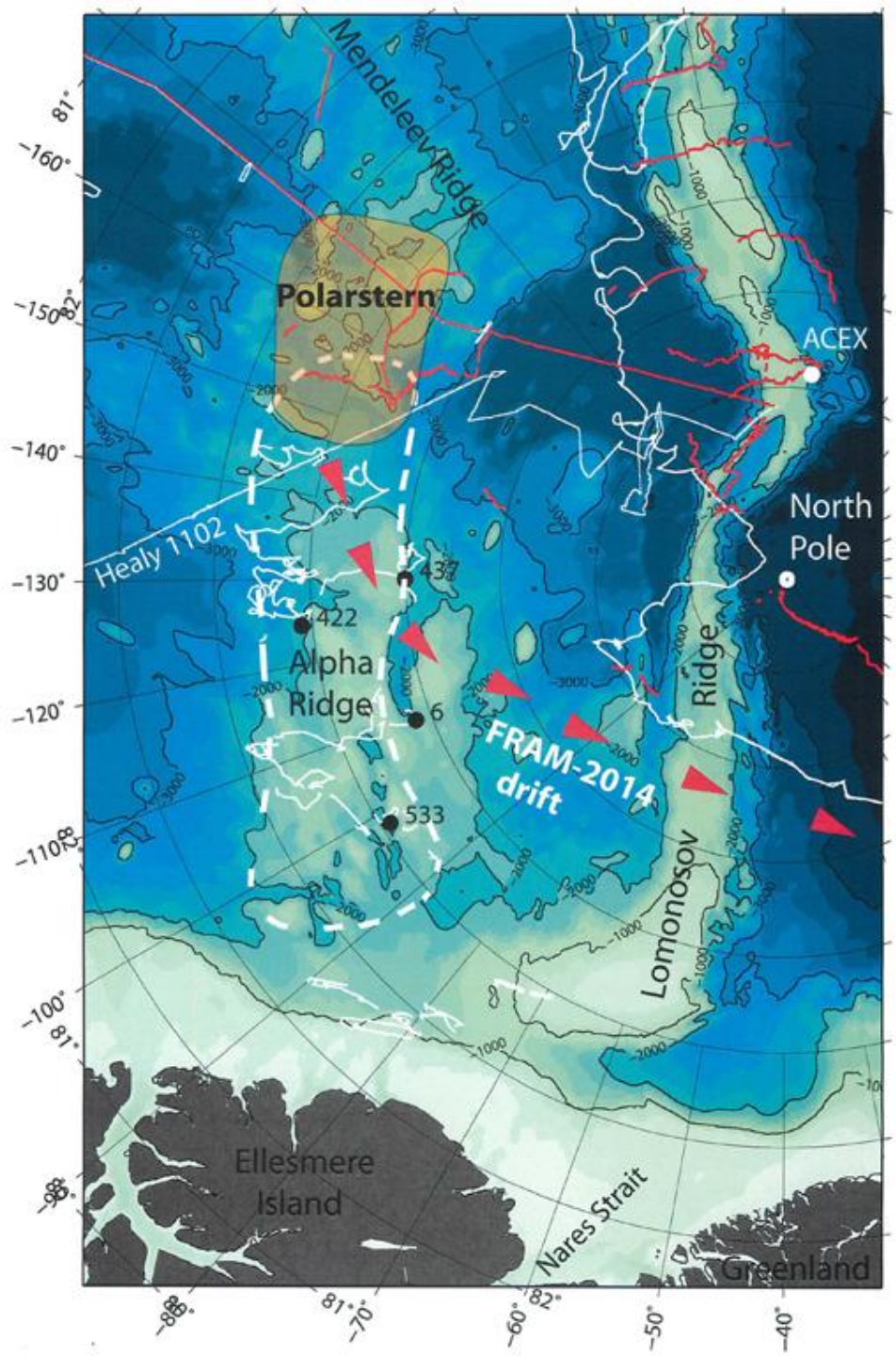


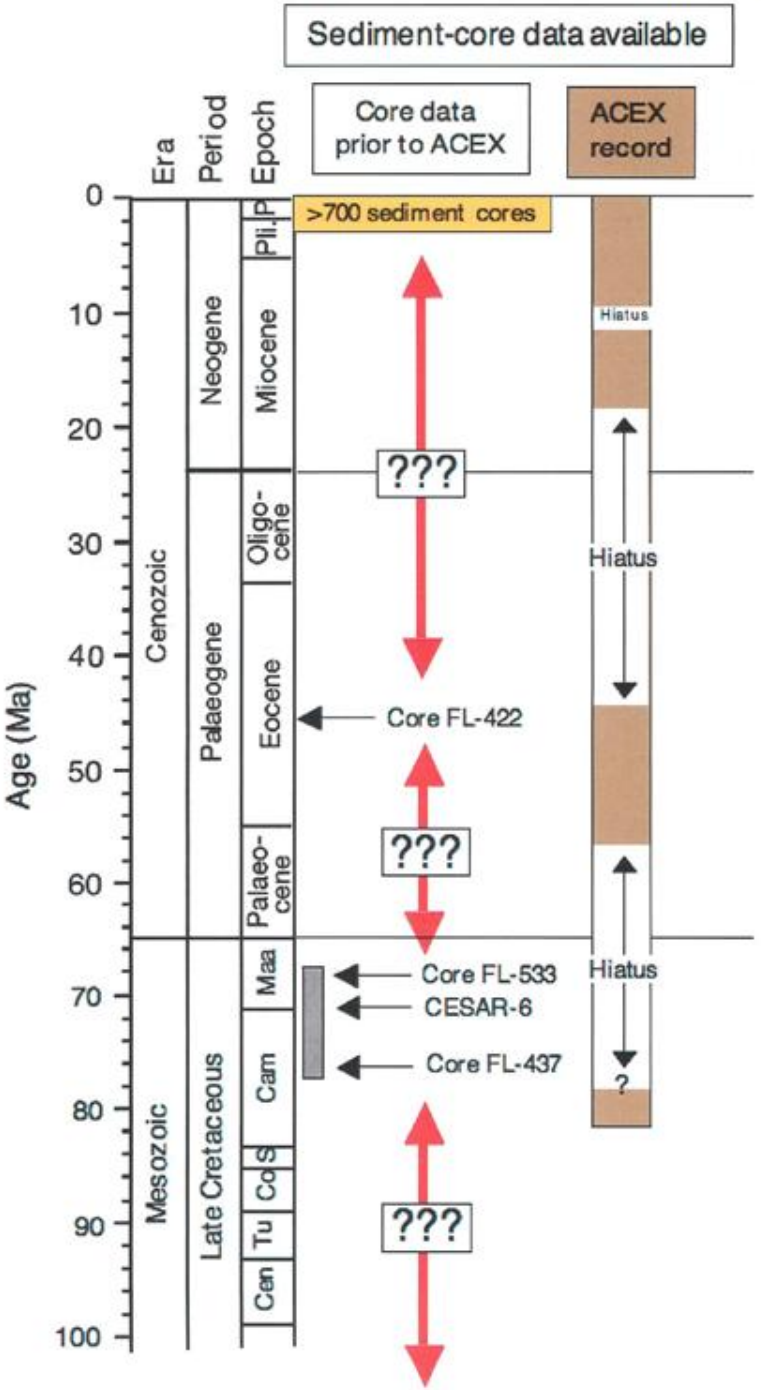
The plan for FRAM-2014-15 is to ship the craft to Tromso, where it will be picked up in early August by the Polarstern, embarking on 66 day cruise ARK-XXVIII/4. Prof. Dr. Rüdicke Stein is chief scientist of AWI's geological/geophysical cruise to the area of the Alpha Ridge.

The Sabvabaa will work together with the Polarstern, coring and dredging and doing seismic (airgun and CHIRP). Then, supplied for the winter with food and fuel for a crew of two, the craft will investigate the areas from which cores aged 45 to 78 my were raised. Four aircraft supply flights are planned for Spring 2015.

The usual transpolar drift of ice should deliver us to the Fram Strait area by Fall 2015.

Most of the white lines over the Alpha Ridge crestal regions are from my 1970 PhD thesis.


Mendeleev Ridge
Polarstern
ACEX
North Pole
Healy 1102
422
437
Alpha Ridge
6
FRAM-2014 drift
533
Lomonosov Ridge
Ellesmere Island
Nares Strait
Greenland
81°
-160°
-150°
-140°
-130°
-120°
-110°
-100°
-90°
-70°
-60°
-50°
-40°


Sediment-core data available
Core data prior to ACEX
ACEX record
Era
Period
Epoch
Age (Ma)
0
10
20
30
40
50
60
70
80
90
100
Cenozoic
Mesozoic
Neogene
Palaeogene
Late Cretaceous
Plio-P
Miocene
Oligo-cene
Eocene
Palaeo-cene
Maa
Cam
Co
S
Tu
Can
>700 sediment cores
???
Core FL-422
???
Core FL-533
CESAR-6
Core FL-437
???
Hiatus
Hiatus
Hiatus
?

Examples of the techniques to be used, other than coring and CHIRP subbottom-profiling.

20 in^3 Bolt air-gun and 6 channel digital streamer.

Knudsen 12 kHz echo sounder

Early 190 bar air compressor and air storage bottle. The solar cell was replaced by the wind generator, and a second generator will be used in 2014.

The capstan winch is hydraulically powered, as is much of the equipment. The craft carries 3000 m of 3/8" kevlar with 2,000 kg breaking strength.

The last of the manned long-term ice stations?

Russian NP-40 Ice Station

Grid: 81°48'36.61"N 132°58'4.94"W

Date: Collected 26 May 13

Joint Task Force (North)

For the 400 day drift we have to overcome worries about evacuation of the crew of two if problems arise. This last May this made news when an atomic icebreaker was dispatched to evacuate the crew of Russian Station North Pole 40. SABVABAA could easily run back and forth between these broken up floes.

The buoy placement and recovery during UNDER-ICE-2013 offered much time for discussions on continuing with SSPARR, the development of an autonomous drifting bathmetric buoy.

During the winter, I'll be in contact with Lee Freitag at WHOI about the possibility of producing 10 buoys for emplacement over the Alpha Ridge during the projected FRAM-2014-15 400 day drift over the Alpha Ridge.

Profile

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Applied Ocean Physics & Engineering
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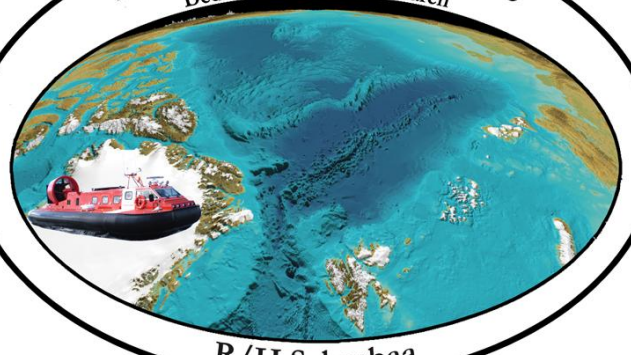
Education
B.S. University of Alaska Fairbanks, 1986, Electrical Engineering
M.S. University of Alaska Fairbanks, 1987, Electrical Engineering

Research Interests
Underwater acoustic signal processing including: time-delay estimation, beamforming, ultra-short baseline navigation, acoustic communication; underwater systems architecture, design and implementation; project engineering and project management.

Blodgett-Hall Polar Presence
Dedicated to Arctic Research



R/H Sabvabaa

Thank you for your attention